ADVANCES IN PLANTING MATERIAL PRODUCTION TECHNOLOGY IN SPICES

Chief Editor Dr S.K. Malhotra



Directorate of Arecanut and Spices Development

Department of Agriculture, Cooperation and Farmers Welfare Ministry of Agriculture and Farmers Welfare Government of India, Calicut 673005, Kerala

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ADVANCES IN PLANTING MATERIAL PRODUCTION TECHNOLOGY IN SPICES

(Proceedings of National Seminar on Planting Material Production in Spices 21-22, April 2016, Calicut)

Chief Editor Dr S.K. Malhotra



Directorate of Arecanut and Spices Development

Department of Agriculture, Cooperation and Farmers Welfare Ministry of Agriculture and Farmers Welfare Government of India Kozhikode 673005, Kerala

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Directorate of Arecanut and Spices Development Kozhikode

Golden Jubilee Year 2016 (1966-2016)



The Directorate of Arecanut and Spices Development was established in 1st April 1966, as a subordinate office under Ministry of Agriculture, Government of India. The Indian agriculture review team had recommended abolition of Central Arecanut Committee and Central Spices & Cashewnut Development Committee in 1965. Consequent upon the abolition of these committees the Directorate was constituted to look after the development of spices and arecanut at national level. The Directorate completes 50 years of its service in promotion of these crops which lead to the improvement in production & productivity.

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Preface

India is known as the legendary land of spices and its fame is as older as the Indian history. The diverse agro-climatic conditions prevailing in different parts of the country offer an enormous scope for cultivation of a wide variety of spices. Being the biggest maker and exporter of flavours, the future growth of spice industry largely depend on new and globally competitive technologies in production.

One of the most imperative factors contributing towards production and productivity is timely access to quality seed and planting material. Inadequacy of quality planting material is the major bottle-neck in production. There is immense scope to acquire self-sufficiency in planting material production, but lack of awareness and technical know-how hampers this objective. Our farmers still prefer to purchase planting material rather than producing their own. In order to transcend this situation there is need to increase perception on the expertise of advanced technologies in production. Since quality of planting material impinge upon the production, it is crucial to accrue the basic material from a genuine and reliable source. Efforts should be made to identify nodal centers for supply of elite planting material of spices. On this auspicious occasion, the Directorate of Arecanut and Spices Development, Kozhikode proposes to launch a web portal to link all certified nurseries in the country so that all the information about the availability of quality planting material could be accessed by everyone.

Considering these aspects a "National Seminar on Planting Material Production in Spices" is being organized on 21-22 April, 2016 at Hotel Malabar Palace, Calicut to discuss and deliberate on the advanced technologies in planting material production, the procedures and protocols assuring quality regulations and also state-wise availability and requirement of spices in the country. These deliberations will guide us in formulating policies at national level and definitely will provide an impetus for the growth and development of spice sector.

This book is a compilation of lead lectures and contributory papers presented by eminent researchers, farmer entrepreneurs working in the relevant areas throughout the country. We take this opportunity to place on record our heartiest gratitude to all scientific groups, state department delegates, innovative farmers who have bestowed vital information from their vast knowledge. These valuable contributions have raised the quality of compendium in a unique way as inclusive document on planting material in spices.

Homey Cheriyan Director

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कृषि मंत्रि

राधा मोहन सिंह RADHA MOHAN SINGH भारत सरकार MINISTER OF AGRICULTURE GOVERNMENT OF INDIA



4 April, 2016

MESSAGE

It gives me an immense pleasure to learn that the Directorate of Arecanut & Spices Development under Ministry of Agriculture & Farmers Welfare is organizing a "National Seminar on Planting Material Production in Spices" at Calicut from 21-22 April, 2016.

Horticulture, which includes fruits, vegetables, flowers, spices, plantation crops and medicinal and aromatic plants, has made appreciable growth during last decades owing to technological advancement and support of Government in mission mode for its adoption. However, availability of quality planting material continues to be an impediment. Vegetatively propagated crops have high risk for transmission of diseases, elimination of especially viral diseases inevitable to ensure the quality and health of planting material. Quality and elite planting material is the most important factor in improving the production of spices. Therefore, organization of the seminar is timely to analysis the achievements, identify the gaps and develop strategies to address the emerging issues for ensuring production of quality seeds and planting material in spices.

I compliment the organizers for their efforts in bringing all the stakeholders together to deliberate upon the issues of quality planting material which is vital for the success of horticulture in general and spices in particular.

I wish the seminar a grand success.

Radha Mohn

(Radha Mohan Singh)

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कृषि एवं किसानकल्याण मंत्रालय कृषि, सहकारिता एवं किसानकल्याण विभाग Government of India Ministry of Agriculture and Farmers Welfare Department of Agriculture, Cooperative & Farmers Welfare

भारत सरकार

S.K. PATTANAYAK *Secretary*



It gives me immense pleasure to learn that the Directorate of Arecanut & Spices Development is organizing a National Seminar on "Planting Material Production in Spices" at Calicut from 21-22 April, 2016.

It is a well-known fact that good quality planting material is the basic requirement of a grower. Government of India has also been placing emphasis on area expansion programme in horticultural crops, including spices in order to achieve higher production and for helping farmers realize better returns. There is also a felt need for creating awareness in use of quality planting material.

I am sure the national seminar being organized at Kozhikode will provide an ideal forum to discuss the issues confronting the research and development needs of planting material and come up with practical solutions.

I compliment the Directorate of Arecanut & Spices Development for organizing this seminar and wish every success.

Satatanayte

(S.K.Pattanayak)

Date : April 4, 2016.

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भारत सरकार कृषि एवं किसान कल्याण मंत्रालय कृषि, सहकारिता एवं किसान कल्याण विभाग कृषि भवन, नई दिल्ली - 110 001

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Government of India Ministry of Agriculture and Farmers Welfare Department of Agriculture, Cooperative and Farmers Welfare Krishi Bhavan, New Delhi - 110 001

Dated: 31st March, 2016

MESSAGE

I am pleased to know that Directorate of Arecanut and Spices Development is organizing two days National Seminar on "Planting Material Production in Spices' at Calicut from 21-22 April, 2016.

Seed and planting material is the most important input for the success of development of Horticulture, which includes fruits, vegetables, flowers and spices. Horticulture research and development got the focused attention only in late 80's for the development as enterprise, considering its significance in diversification for effective land use planning. Efforts made in research and development have been highly productive in terms of increased production, productivity and export of horticulture produce. Mission mode approaches and targeted research have enabled to develop seed production technology for large number of horticultural crops including spices. Since most of spices crops are propagated vegetatively and there is a risk for transmission of diseases. The Government has also taken up issues further to create enabling environment in production and delivery of quality seeds and planting material through various programmes but availability still continues to be a major constraint. Thus this two days deliberation aims to discuss technological advancement and critical gaps to develop strategies to address the issues for resolving the problem for seed and planting material. I am sure the recommendations of the seminar shall be a guiding force for future of quality seeds and planting materials in spice crops.

I wish the seminar a grand success and compliment the organizers for their efforts.

Shouldstin (S.K.Malhotra)

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SESSION - I

Advances in planting material production technology of vegetatively propagated spice crops



Planting material production technology in vegetatively propagated perennial spice crops - black pepper, nutmeg, cinnamon, cambodge and tamarind

Nybe EV¹, Mini Raj N², and Kandiannan K³

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Introduction

Now a days, spices sector is gaining overwhelming response from Indian farmers for being one of the agriculture sectors wherein assured profit could be achieved in most of the crops. Attracted by high return, low management requirements and agro climatic suitability, the area under perennial spice crops especially nutmeg has registered an increasing trend during the last pentinnium in South India.

Perennial spices such as black pepper, nutmeg, cinnamon, cambodge and tamarind are integral part of our life and consumed one or the other way in daily life. Area and production of these spices during 2013-14 were 123,810 ha and 50,870 t; 18,900 ha and 12,780 t; 330 ha and 50 t; 58,590 ha and 188,130 t; 58,720 ha and 191,750 t, respectively, except cambodge for which official data on area and production are not available. Concentration of these spices is mainly in Western Ghats and adjoining areas and to some extent in Eastern Ghats and North Eastern hill regions. Non-availability of adequate quality planting material is always felt as one of the important production constraints in these spices. Vegetative propagation is much preferred compared to seed due to segregation of seedlings, long gestation period etc. In this paper the planting material production techniques of the above mentioned spices are discussed.

1. BLACK PEPPER

Black pepper (*Piper nigrum* L.) is a climbing vine, which requires support to trail. The climbing shoot is called 'main shoot' or 'leader shoot', botanically 'orthotrope', have long internodes; the side branches grown from main shoot are 'laterals', botanically 'plagiotrope', have shorter internodes which bears the spike. The buds present in the base of the main shoot will sprout and creep on the ground (if it is not trained to grow erect along the support) and are called 'runners' which are commercially used for the production of planting material (2 or 3 node cuttings) in India and elsewhere. The 'terminal shoot' or 'top shoot' with a few laterals also serve as planting material. The advantage of using this as planting material is that it will have laterals while planting itself compared to cuttings made from runners wherein laterals will be produced only after 12 to 18 months of planting. This method of production of planting material is common in Malaysia, Indonesia and Vietnam. A few terminal shoots may branch out and hang and such shoots are called 'hanging shoots' which are not used for planting material production. When 'laterals' or 'side branches' are used for production of planting material, the resultant plant will not be a vine, it will grow as a bush and is called 'bush pepper'.

Black pepper can be propagated through seeds as well. Seed propagation is not in vogue due to heterozygous nature of crop. Plants produced from seeds take more than five years for first bearing, whereas, vegetative cuttings produce first spike during second or third year of planting.

Conventional method

Runners from pre-selected healthy mother plants of regular high yielders are kept coiled on wooden pegs fixed at the base of vines to prevent the nodes to contact with soil. Runners are collected in Feb-March, cut into two or three node cuttings that are planted either in sand beds or polythene bags filled with potting mixture after trimming the leaves. Farmers also use orthotropic top shoots for planting as it establish quickly and flower early, however, it may be difficult to get the same in large number. The cuttings are kept in protected place under shade to maintain a humid and cool atmosphere. Regular irrigation with rose can or sprinklers are also essential. The cuttings will produce new sprouts within 3-4 weeks of planting and are ready for field planting in May-June with sufficient roots and 4-5 leaves. Senanayke and Kirthisinghe (1983) found that pepper cuttings under 50 per cent shade and irrigation every 3 days produced longest shoots, had the highest number of roots, largest leaf area and the greatest dry weight at 95 days after planting. The next best treatment was 35 per cent shade with daily irrigation. Hegde (1983) observed that three node cuttings of Panniyur 1 pepper vine rooted better than 1 or 2 noded cuttings. Seneviratne et al. (1985) reported that Panniyur 1 cuttings produced longest shoots with larger leaf, better rooting and high dry weight of roots and 3 - 4 leaves under 50 per cent and 75 per cent shade at 84 days after planting. Mathai et al. (1974) observed maximum sprouting of 75 per cent when cuttings were planted in June. However, increased sprouting and rooting were noticed when planting was done from March and June. Datta et al. (2003) reported that the second fortnight of March was the ideal time for propagation of black pepper through runner vine cutting in Teri zone of West Bengal.

Rooting media

Rooting media play an important role in establishment of cuttings. In general, soil, sand and FYM/Compost in 2:1:1 ratio is recommended. However, researchers found that either single or combinations of different component would serve as potting media. FYM, sand, soil (1:1:1) and soil + leaf mold (7:3) were reported to give better rooting (Yufdi and Hayani, 1991). Rooting percentage of 90-100 was reported in medium consisting of perlite + sand mixture (Mustafayeva, 1985). Sridhar et al. (1989) reported that the highest rooting percentage was obtained with sand. Potting mixture with vermicompost produced taller cuttings and had more number of leaves (Thankamani et al., 1996). Kandiannan et al. (2000) reported that combined inoculation of biofertilizers with potting mixture enhanced the growth of cuttings. A medium consisting of coir pith compost, granite powder and FYM in 2:1:1 proportion with Azospirillum and Phosphobacteria has been recommended for the production of vigorous rooted cuttings in places where sand is scarce (Thankamani et al., 2007a). Miniraj et al (2014) reported better rooting and root characters in the medium coir pith compost+soil (0.25:1). Thankamani and Sreekala (2008) reported the beneficial effects of bio-control agents Trichoderma harzianum, Pseudomonas fluorescens and VAM (Vesicular Arbuscular Micorrhiza) in nursery. Potting mixture should be disinfected before planting the cuttings. Solar energy can be effectively utilized for solarization of potting mixture. For solarization, beds of 1 meter width, 20-30 cm height and convenient length may be prepared after removing the pebbles present in the soil surface. Adequate quantity of organic manure may be incorporated in the soil after digging and irrigate the beds at the rate of 5 l/m^2 . The beds may be covered with polythene sheet of 300 gauge thickness. Edge of the sheet should be sealed with soil to keep it in position so as to maintain the required temperature. Adequate soil moisture is necessary during solarization to increase the thermal sensitivity of the target organism, to improve heat

conduction in the soil and to enable biological activity. Solarization should be done during March to May under Indian conditions when the solar radiation is most intense and the soil should be covered for 45 to 60 days. Solarized potting mixture in combination with nutrient solution consisting of urea, super phosphate, potash and magnesium sulphate in 4:3:2:1 produces vigorous rooted cuttings (Thankamani *et al.*, 2007b).

Growth regulator

In general, pepper cuttings are prepared from one year old shoots. The use of growth regulator would improve the rooting and establishment. Leite and Infrozato (1966) subjected softwood and hardwood cuttings to 15 h treatment by immersing their bases in distilled water or in 50 mg/l solution of either IAA or NAA and obtained the highest rooting of 62.5 per cent in NAA. Larcher (1970) observed that three node pepper cuttings dipped in 2 per cent IBA before planting improved rooting percentage; with respect to root number and root length compared to untreated cuttings. Choudhary and Phadnis (1971) obtained best result in rooting of leaf buds of pepper cuttings with Seradix B, IBA+ IAA at 25 or 50 ppm and IBA at 50 ppm. Pillai et al. (1982) indicated that the cuttings dipped in IBA solution (1000 ppm) for 45 seconds is the optimum treatment for early inducement and better development of roots in pepper cuttings. Aboa and Solidum (1991) reported that IAA at 150 ppm enhanced rooting in black pepper nodal cuttings. Sasikumar and Johnson (1992) found that single node cuttings planted in poly bags and kept in pits covered with poly sheets with frequent water sprays gave about 90 per cent rooting without any hormone treatment. Application of 25 per cent cattle urine gave the same effect as 2000 ppm IBA in terms of fresh and dry weights of roots and the number of roots per cutting (Superman et al., 1990). Kandiannan et al. (1994) reviewed the uses of growth regulators in black pepper production and reported beneficial effects on establishment of cuttings. Sujatha (1997) obtained 90 per cent rooting in 2 node cuttings dipped in 1000 ppm IBA and kept in poly tent, with regular watering. Yufdy and Ernawati (1987) found that cuttings soaked in 25 per cent coconut water for 12 h increased shoot and root length, number of roots and shoot diameter of black pepper rooted cuttings. However, Sujatha et al. during 2004 noted that IBA had no positive influence on rooting of pepper. Miniraj et al. (2014) reported early sprouting along with better root and shoot characters when the cuttings were dipped in charcoal paste prior to planting.

Bamboo method of Rapid multiplication

In order to meet the large scale demand, a rapid multiplication method was developed and popularized and first demonstrated by Bavappa and Gurusinghe (1978), and later modified by Sivaraman, (1988). The cuttings from primary vines and runners had almost similar rooting ability. Single node cuttings taken from ground runners are multiplied under bamboo method would produce more cuttings for commercial planting. A suitable leveled area having good drainage is needed for rapid multiplication. Overhead shade may be provided by using 50 per cent shade net or with coconut leaves. The semi-permanent shed size may be 24 x 6 m (or suitable size). Four trenches of 30 cm wide, 45 cm deep and of convenient length may be taken. Trenches are filled with soil, sand and farmyard manure in 1:1:1 proportion. Bamboo poles of 8-10 cm diameter are selected and cut into 1.25-1.50 m long pieces and split into halves keeping the septa intact. Coal tar is smeared to prolong the life of bamboo splits. The split bamboos are arranged at an angle of 45° alternatively either side on straight wooden poles or strong supports fixed on small supports from ground and tied each other with coir rope at the free end. Rooted cuttings are planted in the trench, one for each bamboo split. As the cuttings start growing, bamboo should be filled with rooting mixture composed of farmyard manure, coir dust and sand in equal proportion. Each tender node is carefully tied to the bamboo using banana fibre, so that every node is in contact with the rooting medium. For rapid growth, daily irrigation through rose can is essential. Nutrient solution consisting of urea (1 kg), super phosphate (0.75 kg), muriate of potash (0.5 kg) and magnesium sulphate (0.25 kg) in 250 litres of water may be used for drenching the vine once in a month with 250 ml/ plant. Alternatively, drenching the vines with cowdung solution once in a month also encourages plant growth in the nursery (Kandiannan *et al.*, 1998). When the vines reach the top of the bamboo, the tip should be nipped off and crushed the vine at the base at 3^{rd} or 4^{th} node from the ground, to activate the buds. After 7-10 days, the vines are cut at the crushed point and removed from the bamboo with the roots intact and with the adhering soil. The cut vines are separated into single nodded pieces. Plant each cutting in a polythene bag filled with potting mixture consisting of soil, sand and farmyard manure (1:1:1) or solarized soil enriched with biocontrol agents.

After planting in the bamboo, the first harvest of cuttings can be done after $3-3\frac{1}{2}$ months and the subsequent harvest at every $2-2\frac{1}{2}$ months. Each rooted vine can give about 10 cutting in one harvest and about 40 cuttings will be obtained in a year. Multiplication rate is 1:40. A shed of 24 x 6 m would accommodate 600 bamboo splits. On an average 20,000 cuttings can be produced annually by this method. The method is thus advantageous for producing a large number of rooted cuttings within a short period, throughout the year. The cuttings are also vigorous with good root system leading to more than 90 per cent establishment in the field.

Serpentine method

Another novel propagation technique in black pepper is the serpentine method (Thankamani *et al.*, 2004). The rooted cuttings kept in polythene bags are trailed horizontally and each node is pressed into the polythene bags with potting mixture arranged one after another with midribs of coconut leaves made into V" shape. Once twenty nodes get rooted in the bag, first 10 will be separated by cutting at the inter nodes. The cut ends will be pushed back into the potting mixture and kept in shade for further growth .The cuttings would be ready after three months for field planting. On an average, 60 cuttings will be obtained in a year by this method from each mother cutting. Serpentine method can be followed throughout the year, it is simple, cheap and quick and suited to small and marginal farmers. Recovery percentage is higher compared to rapid multiplication technique.

Pit method

Pit method for propagating black pepper utilizing single nodes of field grown vines was developed at IISR. A pit of 2x1x 0.5 m dimension is to be prepared under a cool shaded area. Single nodes having 8-10 cm length with their leaf intact taken from runner shoots of field grown vines are to be planted in polythene bags with a potting mixture having soil, sand and cow dung in 1:1:1 proportion. Care should be taken to keep the leaf axil above the potting mixture at the time of planting. Around 150 polythene bags can be accommodated in a pit of above size. Then the pit should be covered tightly with polythene sheet. Cuttings should be watered at least five times a day with rose can. Within three weeks, the cuttings will start producing roots. When rooting starts, watering may be reduced to three to four times a day. After one month, healthy shoots start emerging from the leaf axil. At this stage it is advisable to keep the pit open for about one hour per day so that the cutting will not suffer from any shock when they are taken out of pit. After two months of planting, the cutting can be taken from the pit and they can be kept in a shaded place and may be watered twice in a day. These cuttings will be ready for field planting after about another 2.5 months. By this method, 80-85 per cent success could be obtained. This method is simple, cheap and quick. Cuttings are ready to plant in the fields after about 4-4 1/2 months compared to six months in bamboo method and well suited to small and marginal farmers. Since single node is used instead of three nodes in conventional method, more number of cuttings can be produced from unit length of runner. Pit method is not common.



Bed method

In this method, raised beds with height of 10 to 15 cm, 1.5 to 2.0 m width and convenient length can be made in suitable medium (coir compost and vermicompost at 3:1 ratio) under protected polyhouse (Anandaraj *et al.*, 2014). The bed has to be treated with bio-control agents like *Tricho-derma* spp. The cuttings are planted one side (width side) of the bed and vines are allowed to creep on the bed so that each node strikes root and when it reaches the end of the bed, entire strip is harvested and each node with a leaf and root are separated individually and planted in protray or ploy bags for further establishment. The separation of each node could be done when the entire vine is trailing on the bed. After a week when the bud is activated, it can be taken out and planted in protrays.

Vertical column method

The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2m column having one foot diameter made with half an inch plastic coated welded wire mesh filled with composted pasteurized coco peat and vermicompost @ 3:1 ratio fortified with bio-control agent *T. harzianum* in hi-tech poly house of fan and pad system with temperature of 25 to 28° C and relative humidity 75 to 80 per cent. Eight to ten cuttings can be planted around each vertical column. The cuttings are allowed to trail on the column and it takes four to five months to reach the top and produce more than 20 nodes. Each vine invariably produce laterals (plagiotropic branches) within four to five months time at 12^{th} to 15^{th} node, whereas, vines allowed to grow horizontally on the bed with same medium also produce similar number of nodes but will not produce plagiotropic branch. The advantage of vertical column method is that three types of cuttings *i.e.*, normal single node cuttings, top shoots with lateral branch and laterals (plagiotropes) for making bush pepper can be produced (Anandaraj *et al.*, 2014).

Trellis method of Rapid multiplication

Comparatively open areas are good for this method. Take trenches of 30 cm width and 50cm depth and fill with dried and powdered farm yard manure and top soil. Plant rooted cuttings at closer spacing. Irrigate regularly. After the cuttings are established, give NPK@10:5:5. Trail the vines on wire trellis erected at 45-50^o slope. As they grow further, tie the vines to the trellis. Vines planted in June will grow to a length of 2m by February by which time they can be cut retaining 3-4 nodes. The vines will again sprout and continue to give cuttings. The vines thus obtained are cut into 2-3 noded pieces and kept for rooting (Sujatha and Nybe, 2012).

Bush pepper

Bush pepper is becoming popular now a days in homestead farming and urban horticulture. Scarcity of labour for harvesting is another factor which has prompted farmers to go for intercropping of coconut and other perennial plantation crops with bush pepper. Lateral branches are used for bush pepper production. One year old laterals with 4-5 nodes are planted in poly bags filled with potting mixture and kept in mist chamber for rooting. Leaf blades on the cuttings are half cut before planting. Rooting is slow in bush pepper, which may take 2-3 months after which the cuttings are shifted from mist chamber to shade net house. After one month they can be used for planting. Bush pepper can also be made by grafting lateral shoots on *P. colubrinum*. Bush pepper starts yielding from first year onwards. When grown in the field as inter crop in coconut, spacing of 2m x 2m is to be provided which will accommodate 2500 plants/ha. Studies at Kerala Agricultural University has shown that varieties P 2, P 5 and Pournami are good yielders as bush pepper in coconut plantation (Sujatha and Nybe, 2012).

Grafting

In areas where there is water logging and incidence of foot rot (*Phytophthora capsici*) as in Kerala and Assam, grafts on *P. colubrinum* rootstock has been recommended. *P. colubrinum* is a marshy species resistant to *Phytophthora capsici*. *When P. nigrum* is grafted on to *P. colubrinum*, the resultant graft is found to escape the *Phytophthora* infection through roots. The growth of plant will also be vigorous on *P. colubrinum*. *P. colubrinum* cuttings are raised in polybags and six month old cuttings can be used as rootstocks for grafting. Scion is taken from healthy bearing vines and grafted by cleft/wedge method with slight modification. Success of grafting is 90-95 per cent. After two months, grafts can be planted in the main field. *P. colubrinum* can also be planted directly in the field and grafting done *in situ* on two to three shoots to get faster development of the bearing column. If anyone of the grafted shoots are damaged, the other shoots will compensate or even grafting can be done on fresh shoots. The same grafting technique can be used for making bush pepper for field planting as well as for poly house cultivation. Farmers are growing grafted pepper particularly in areca plantations in Karnataka. There are 10-15 year old grafted black pepper plantations in Kerala giving good yield.

In Brazil, there are reports that the resistant grafts died after 4th year (Alconero*et al.*, 1972) and in Sarawak, Malaysia, 'Kutching' grafted to resistant 'Balancotta' did not survive beyond the fruiting stage (Purseglove *et al.*, 1981).

Plant protection measures in the nursery

Maintenance of health and hygiene is of at most importance in black pepper nursery. Select only healthy and disease free mother vines for collection of runners and laterals. Make sure that the mother vines are not virus infected. Virus indexing before starting nursery can eliminate viruses to a great extent. Provision of good ventilation, adequate sunlight and drainage in the nursery is of prime importance as the activities are concentrated in the rainy season.

Solarisation of soil in the summer months followed by enriching the potting mixture with *Trichoderma harzianum* and *Pochonia chlamydospora* can take care of the soil born fungi and nematodes. The nursery should be sprayed with 2 per cent *Pseudomonas fluorescence* at weekly intervals as a prophylactic measure. One or two foliar applications of 1 per cent Bordeaux mixture can be given if required. Copper oxy chloride at 0.02 per cent may be used alternatively. Infestation of scales and mealy bugs are sometimes noticed in the nursery. Foliar application of Quinalphos 0 .05% will control these insects. If magnesium deficiency is noticed as interveinal chlorosis, spray 0.1% MgSO4.

Micro propagation

Micro propagation protocol has been standardized in black pepper . Techniques for direct and indirect organogenesis have been standardized (Shylaja and Nair,2000)).Shoot tip and eye bud explants were found to be the best explants for *in vitro* culture.MS medium with 10 ppm BA resulted in speedier establishment of cultures. Better rooting was observed in Knudson medium containing 5ppm NAA. A mixture of 1:1 V/V vermiculite and sand was found good for establishment of plantlets after sterilizing with 0.1% emisan. The TC derived black pepper plants successfully established in the field with more than 80% survival. High amount of somaclonal variation was reported from callus cultures.(Shylaja.,1996).

2. NUTMEG

Nutmeg (*Myristica fragrans* Houtt.) yields two spices *viz.*, nut and mace. Among the tree spices, it is a major and highly remunerative spice crop. In India, nutmeg is mostly cultivated in Kerala and parts of Karnataka, Tamil Nadu, Maharashtra, Andaman and Nicobar.



Nutmeg is an evergreen tree with dense foliage. It is usually dioecious, though occasionally male and female flowers are found on the same tree. Nutmeg being a strictly cross pollinated crop, plants differ in growth, vigour and yield. The height, spread, number of secondary branches, crown volume and crown surface area revealed the variability in nutmeg fruit yield positively (Haldankar *et al.*, 2004). Miniraj *et al.* (2014) have reported considerable variation among the genotypes with respect to growth and production in the nutmeg growing tracts of Kerala. Further, they also observed that, the range of fruit weight from 69.75 g to107.92 g, seed weight from 11.0 g to 15.0 g and mace weight from 2.13 g to 4.68 g under Kerala conditions. Since nutmeg and mace are of economical importance, elite trees possessing both these economic traits would help in increasing the productivity to a great extent.

Propagation

Nutmeg can be propagated by seeds as well as vegetative means. The percentage of success in the vegetative methods of propagation is between 38 to 80 per cent.

Propagation by seeds

The first step is to select high yielding female trees. A female tree in the age of 15-20 years yielding above 3000 fruits per year with a single dry kernel weight of above 10 g and single dry mace weight of 2 g can be considered as an elite tree. The seeds are collected from such regular bearing and high yielding trees during the peak period of fruit bearing (Flach, 1966).Tree split fruits are collected and seed separated from the fruit and mace. Seeds are to be sown immediately after extraction as the germination falls when sown three days after extraction. They can be preserved in moist sand or moss for 3-7 days in poly bags or other containers having suitable rooting medium (Madhusudhanan and Babu,1994; Gunasekaran *et al.*, 2000).

Small and immature seeds have low germination (Shanugavelu and Rao, 1977). Seeds may be sown in nursery beds, baskets, ploythene bags or other containers having suitable rooting medium (Krishnamoorthy, 1987). Seed germination will begin after about four weeks and maximum germination could be seen between 50 to 80 days (Kannan, 1971a). A higher percentage of germination was observed in nuts collected from female trees growing nearer to male trees (Perrl, 1938).

Seeds treated with 200 ppm gibberellic acid recorded 75 per cent germination (KAU, 2001) while, seed treatment with thiourea recorded 88.28 per cent germination (Haldankar *et al.*, 2007). In a study on germination of nutmeg seeds at Dapoli, Maharashtra, higher germination percentage was recorded in seeds sown in rice bran (82.3%) followed by sand (82%) and sand+rice bran (81.7%). Same medium also recorded minimum time for the first emergence. In rice bran, sand+rice bran and sand, emergence started at 21.17 days, 28.10 days and 28.50 days respectively (Khandekar *et al.*, 2006). Abirami *et al.* (2010) studied seed germination and seedling growth in nutmeg using the different media. The potting mixture, soil: sand: coir dust: vermicompost in a ratio of 1:1:1:1 gave better results and also, that supports seed germination and seedling growth in nutmeg. Sprouted seeds are transplanted immediately to polythene bags since delay may cause damage to root system (Krishnamoorthy, 1987); they are potted and allowed to remain in the pots for about 12 to 18 months prior to planting in the main field.

Variation exists among the nutmeg genotypes for germination (Haldankar *et al.*, 2005). The variations recorded for germination percentage, period required for germination and seedling growth parameters were significant. The selection traits of nutmeg genotypes at seedling stage on the basis of vigour of number, length and breadth of leaves, collar thickness and petiole length would help to identify genotypes for propagation .

Seed nursery

Miniraj *et al.* (2012) have given the seed nursery techniques to be followed in nutmeg. Select a shady area for nursery. Raised nursery beds of about one meter width and convenient length are taken. Apply well decomposed and powdered cattle manure and sand and mix well with the soil. Sow the seeds shallow about 2cm deep with the flat portion facing down. Cover thinly with sand and mulch with leaves. Irrigate daily, seeds sprout in 45 days and germination may extend up to 60-80 days. At the needle stage (before unfurling of leaves) the sprouts are transferred to poly bags filled with potting mixture. The grown up seedling at appropriate stage can be used for planting in the main field or for vegetative propagation. The seedlings will segregate into male and female at varying proportions. Research to determine the sex at the seedling stage has not yielded conclusive results so far.

Vegetative propagation

Vegetative propagation has got the advantage of overcoming the dioecy problem in nutmeg and thus to considerably reduce the pre bearing period. Due to the cross pollinated nature of the crop; it also helps in the multiplication of superior types. For these reasons, clonal propagation has become popular now a days.

Cuttings

Very little work has been done on rooting of cutting in nutmeg. In earlier study, Nichols and Pryde (1958); Nichols and Cruickshak (1964) have reported rooting of semi-hardwood cuttings to be successful in Trinidad and Grenada. However, these rooted cuttings failed to establish after the field planting.

Reports from Wageningen on rooting of cuttings in a poly house with mist humidifier were also not positive (Flach, 1966). The high amount of tannins and phenolic compounds present in the stem may probably hinder root formation. No reports are available on this aspect from India; there is great scope for further studies on production of adventitious roots in nutmeg by manipulation of these factors.

Air layering

In New Guinea, about 60 per cent rooting was reported in a period of six months but the rooted layers failed to sustain in the filed (Deinum, 1949). A very low rate of success of 8.5 per cent was reported by Nichols and Cruickshank (1964) in Grenada.

Budding

Budding is the most popular method of vegetative propagation in nutmeg. Rootstocks other than *M. fragrans* have been used for budding in nutmeg. *M. beddomei*, *M. malabarica* and *M. succedanea* were used as rootstocks for *M. fragrans* and a success of 26 per cent was obtained on *M. succedanea* (Postma, 1935). *M. fragrance, M. beddomei* and *M. malabarica* are used as rootstocks in Kerala with varying degrees of success. Budded plants on *M. beddomei* exhibit enlargement below the bud union at later stages. Even though the wild rootstocks possess capacity to withstand water stress and heavy winds, their performance is not uniformly good at different locations and hence Kerala Agricultural University recommends *M. fragrans* as the ideal rootstock for nutmeg (Miniraj *et al.*, 2014). In a study at IISR, Kozhikode, *M. malabarica* exhibited relative tolerance to water stress and *M. fragrans* and *Gnema canerica* appeared as drought susceptible(Krishnamurthy *et al.*, 2006).

Nursery budding

Both patch budding and forket budding are commercially adopted in nursery budding of nutmeg. Budding is done at the green as well as brown stage of the bud stick. Beena (1994) has reported maximum success of 66.66 per cent with forket budding on *M. fragrans* and *M. beddomei* rootstocks during the month of December. In another study, both brown and green patch budding gave high success percentage on various rootstocks. Maximum success was for green budding on *M. beddomei* (70%) followed by brown budding on *M. beddomei* (60%) (Lissamma *et al.*, 2012).

The technique of budding standardized at Kerala Agricultural University is as follows: Healthy seedlings of 8 months to two years can be used for budding. Take straight shoot bud sticks from elite mother trees; separate the bud carefully without any bruises. Remove carefully a slightly larger patch of skin from the rootstock and do the budding. Both the rootstock and scion should be in the active growing stage and the budding is to be done immediately after the separation of the bud wood. Bud wood taken from the apical region of the tree will be more vigorous (Miniraj *et al.*, 2012). In the case of green budding, the leaf supporting the bud can be retained on the bud patch for easiness in the budding process. The bud union is fastened with polythene ribbon and the plants are kept under shade under good care and management. Success of bud union can be ascertained after 45 days after which the rootstock is bended down above the bud union. The sprouts after reaching single tier stage are ready for field planting. Best season for budding in Kerala is July to September. In summer the success is below 25%.

Field budding

In situ budding standardized by Kerala Agricultural University, is now being followed by nutmeg farmers, to solve the problem of dioecy and the long juvenile phase. Forket method of budding is done on brown trunk above the first whorl of branches (Beena, 1994) on 2-5 year old seedlings in the field. Best season for *in situ* budding is July with about 30 to 50 per cent success. Budding on brown trunk could be done with maximum success in three year old plants followed by four year old ones. As the age advances, per cent of sprouting reduced. Sprouting percentage was maximum in 3 to 5 years aged plants. Field budded plants grow fast primarily because of their well developed root system. It has also been observed that retaining a branch of the rootstock (which happens to be male plants) for production of male flowers is good for improving the fruit set.

Grafting

Various grafting techniques like approach grafting, soft wood grafting and epicotyl grafting are successful in nutmeg.

Epicotyl grafting

Epicotyl grating is the most widely adopted propagation technique in nutmeg (Mathew and Joseph, 1982). Epicotyl grating is being done on *M. fragrans* (Krishnamoorthy and Mathew, 1985) and also on wild species, *M. beddomei* and *M. malabarica* (Mathew and Joseph, 1982). However, *M. fragrans* was found to be the most ideal rootstock. Though grafting could be carried out during all the seasons, on *M. fragrans*, the best result of 80 per cent success was recorded during the month of August in 20 to 30 days old seedlings (Krishnamoorthy and Mathew, 1985). Prior defoliation is not a prerequisite for this technique in nutmeg. It is essential to provide a cover of polybag on scion stick especially in non rainy season, whereas it is not essential when high humidity prevails (July). The location of scion stick did not influence the success of epicotyl grafting. September was found to be the most favourable season for epicotyl grafting in nutmeg (Haldankar *et al.*, 1999a).

In Maharashtra, Karnataka and in some parts of Kerala, epicotyl grafts are produced using plagiotropic or side shoots. These grafts are slow growing during the initial years and will be bushy in appearance. Special training would be required to get canopy development in these grafts. The only advantage of these grafts is the short stature which facilitates easy harvest and other cultural operations. However, on a commercial scale side grafts are not desirable.

Softwood grafting

Softwood grafting is practiced in nutmeg in Maharashtra. It was revealed that the month of May will be best for softwood grafting with maximum success (80 %) followed by June (54 %) and July (50 %). The medium matured to fully matured scion sticks of 4 to 6 months old were preferred for softwood grafting. Retention of one terminal leaf on the scion sticks recorded 75 per cent success. Prior defoliation of scion sticks, except the terminal leaf, for apical bud swelling was advantageous and recorded 70 per cent success. The retention of the leaves on rootstocks did not influence the success of softwood grafting (Haldankar *et al.*, 1997).

The success in softwood grafting differs according to the scion variety. The variation among genotypes for sprouting, survival and growth parameters was statistically significant. The graft survival has strong negative correlation with leaf width. Maximum graft sprouting was associated with faster production of new leaves with less breadth and longer petiole (Haldankar *et al.*, 2003). Very little studies have been conducted to understand the influence of rootstock on the performance of grafts. Khandekar *et al.* (2006) studied softwood grafting in nutmeg to find out best time (month) for sprouting, survival and growth of grafts. Maximum sprouting was recorded in July and August months followed by June.

Approach grafting

The approach grafts on nutmeg can be prepared through out the year. High percentage of graft take was recorded on both, cultivated nutmeg (*M. fragrans*) rootstock (40 to 90 %) and wild nutmeg (*M. malabarica*) rootstock (30 to 100%). The mortality after separation of the grafts was high as 30 per cent on cultivated nutmeg stock and 50 per cent on wild nutmeg stock (Haldankar *et al.*, 1999b). In Kerala too, approach grafting is practiced by a few progressive farmers to multiply their elite trees.

Production of orthotropic scions

Nutmeg tree exhibits branch dimorphism. The tree produces two different types of shoots. The straight growing orthotropic shoots or the vegetative shoots and the side growing plagiotropic shoots or the fruiting branches. The tree has a tendency to produce large number of plagiotropic shoots and very few number of orthotropic shoots. Attempts to induce orthotrops in nutmeg by physical as well as chemical treatments have not yielded positive results. Unavailability of sufficient orthotropic shoots is a major limiting factor in budding/grafting of nutmeg. Raising a close planted scion bank will ensure steady supply of straight shoot bud sticks year round (Miniraj *et al*, 2012). Rema *et al.* (2008) applied different measures to induce orthotropic shoots from plagiotropic grafts, it was observed that the frequency of occurrence of orthotropic shoots was low and is very cumbersome. In certain cases, production of orthotropic shoots was observed from plagiotropic grafts of 7-10 year old. As this phenomenon is rare, this cannot be a confirmatory method for converting the graft architecture.

Top working

Identification of sex in the seedling stage in nutmeg is not possible with the available information. The sex of the trees can be identified only after 6-7 years when they start flowering. Generally,

male and female trees are produced in 1:1 ratio. Since one male tree is sufficient for every 10 female trees for pollination, the rest of the male trees available in the plantation can be made productive by converting them to female trees by top working. Top working can be done by budding (Beena and Kurian, 1996) or by grafting (NRCS, 1990). The top worked trees yield from the third year onwards. One or two branches of the female trees can also be top worked with male scions so as to avoid planting of male trees. Unproductive female trees can also be made productive by top working. Trials on topping of male trees indicated that cutting the trees above the first tier during August was found to be the best with regard to sprout production and reducing the time for sprouting. Successful graft union was obtained by wedge grafting during March with scion shoots having mature leaf and full green stem and stock having two months growth (Rema *et al.*, 2000; Rema *et al.*, 2009).

Micropropagation

Micropropagation of nutmeg would be an ideal method for rapid propagation of male or female trees. *In vitro* experiments are in progress at IISR, Calicut, Kerala Agricultural University, Vellanikkara and Indian Cardamom Research Institute (ICRI), Myladumpara to develop protocols for multiplication of nutmeg. Nutmeg is highly recalcitrant to tissue culture especially owing to the heavy leaching of phenolics and literature on its *in vitro* propagation is scanty. Direct somatic embryogenesis was achieved in leaf explants of juvenile plants and also from intact and fragmented zygotic embryos in MS media with kinetin, 2,4-D, NAA and activated charcoal 0.3-0.5% (Iyer *et al.*, 2000; Iyer, 2007; Iyer *et al.*, 2009). AM medium at half strength of major nutrients and full strength of micronutrients with a hormonal combination of BAP,NAA and 2,4,D at 1mg/l and 0.5 mg/l respectively was found to the best for initial culture establishment of seed-ling explants. Phloroglucinal (40mg/l) in combination with IBA (2mg/l) gave superior results in the induction of roots in established shoot tip cultures (KAU, 2001). Micro grafting using *in vitro* produced shoots as scion and two month old *invitro* or *invivo* seedling as root stock was found successful in nutmeg (KAU, 2001).

3. CINNAMON

Cinnamon (*Cinnamomum verum* Bercht. & Presl.) is the oldest known spice by man. It is also known as 'Ceylon cinnamon' or 'true cinnamon'. The true cinnamon is a native of Sri Lanka and was introduced in to India by the British in the 18th century. Sri Lanka produces the largest quantity and the best quality of quills of true cinnamon. *C. verum* is a moderately sized, bushy, evergreen tree growing up to 18 m tall, low branching, trunk stout up to 60 cm diameter; bark thin pale brown, up to10 cm thick and strongly aromatic.

Cinnamon is a cross pollinated crop (Joseph, 1981) and wide variability has been observed in yield (Ponnuswami *et al.*, 1982; Krishnamoorthy *et al.*, 1992), quality of produce (Krishnamoorthy *et al.*, 1988), oil content (Krishnamoorthy *et al.*, 1991; Paul and Sahoo, 1993) and other morphological characters in the seedling progenies (Krishnamoorthy *et al.*, 1992). Being a cross pollinated crop, vegetative propagation is necessary for producing homozygous high yielding population and for propagation of elite lines. Cinnamon could be propagated easily through cuttings and layering. No other conventional method of vegetative propagation has been reported in cinnamon.

Propagation

Cinnamon can be propagated from seeds and cuttings of young three leaved shoots. However, propagation by seeds is easier and is the most common practice even though it is not advisable due to the heterozygous nature of the tree.

Ripe seeds are collected from mother plants with desired characteristics such as:

- 1. Erect stem with smooth bark
- 2. Vigorous growth
- 3. Ease of peeling the stem bark
- 4. Resistance towards pests and diseases
- 5. Chemical composition of the oil (viz., high oil content of the bark and leaves and desired chemical characteristics of oil)

Propagation by seeds

Common method of cinnamon propagation is through seeds (Joseph, 1981). Seeds are extracted from ripe fruits from the selected mother trees with desirable characters. Seeds are sown immediately after collection, otherwise viability gets reduced. Seeds are sown in nursery beds or in pots filled with a mixture of sand, cattle manure and soil in the ratio 2:2:1. Kannan and Balakrishnan (1967) obtained the maximum germination percentage (94) by sowing seeds on the third day after harvesting. After 40 days, there was complete loss of viability. Under normal conditions, seeds germinate within 20 days (Krishnamoorthy and Rema, 1988). Seeds may be sown in rows of 12 cm apart in nursery beds and covered with thin layer of soil. Radhakrishnan (1992) observed that July to August will be the best time for sowing. Beds may be watered and shade should be provided during early stages. From beds, seedlings are transplanted to polythene bags when they reached the height of 15 cm. Polythene bags of 30 cm x 15 cm size filled with soil, farm yard manure and sand (3:3:1) are used (Krishnamoorthy and Rema, 1988).

Vegetative propagation

In cinnamon, cutting and air layering are commonly practiced methods of vegetative propagation.

Cutting

As the crop produces abundant adventitious roots, single nodded cuttings with 1 or 2 leaves could produce roots within 40 days under humid conditions (CPCRI, 1985). Rooting can be enhanced by the use of growth regulators. Rema and Krishnamoorthy (1993) reported that IBA and IAA @ 2000 ppm were effective for rooting of terminal shoots with 73 and 65 per cent success, respectively. Softwood cuttings treated with NAA 500 ppm resulted in 22.5 per cent rooting whereas hardwood cuttings treated with IBA 2500 ppm resulted in 45 per cent rooting (Vadivel *et al.*, 1981). The rooting could be further increased by hormonal treatment of the etiolated cuttings. Etiolated cuttings treated with IAA 200 ppm resulted in 82 per cent success (NRCS, 1990). Wide variability exists in the rooting response of various cinnamon lines (Rema and Krishnamoorthy, 1993). Variation in rooting during different seasons and among different lines could be associated with the endogenous level of auxins, reducing and non reducing sugars, nitrogen, carbohydrate, C:N ratio, phenols, etc (Purushotham *et al.*, 1986; IISR, 1996). Nageswari*et al.* (2000) found 50 per cent rooting when hard and semi-hard wood cuttings were treated with IAA 100 ppm, while Ananthan and Chezhiyan (2002) reported 82.6% rooting of hard wood cuttings with NAA at 2500 ppm.

Air layering

Semi-hardwood cutting was found to be ideal for air layering in cinnamon (Ranaware *et al.*, 1994; Rema and Krishnamoorthy, 1993). Air layering of cinnamon using gallic acid (100 ppm),



a phenolic compound, resulted in 80 per cent rooting (Banergee *et al.*, 1982). Rooting can also be obtained in non girdled shoots treated with NAA 2500 ppm or in combination with IBA 100 ppm (Bhat *et al.*, 1989). Application of IBA 3000 ppm resulted in 70 per cent rooting in semi hard-wood cuttings (NRCS, 1990). Girdling enhances physiological activity which is manifested by increased starch and IAA in the girdled region (Poll *et al.*, 1991). Various rooting material can be used for layering depending upon their availability and capacity to retain moisture. Evaluation of different rooting media for layering indicated that sphagnum moss was ideal (89 % success) followed by soil (Ranaware *et al.*, 1994). Seasonal variation was also observed in rooting of air layers. A rooting of 68 per cent was observed in July followed by 65 per cent in June in Maharashtra with no rooting during January and February (Ranaware *et al.*, 1995). Air layers treated with IBA 250 ppm registered 90 per cent rooting in the month of August (KAU, 2001). Rooting medium sphagnum moss was found better than sand and saw dust in equal proportions. According to Ananthan and Chezhiyan (2002a), IBA 4000 ppm registered maximum percentage of rooting and survival of cinnamon layers.

4. CAMBODGE (MALABAR TAMARIND)

The dried fruit rind of cambodge or Malabar tamarind (*Garcinia gummigutta*) is hard and dark brown in colour. It is rich in acids and possesses marked antiseptic properties. The principle acid in the fruits of Malabar tamarind is identified as (-) hydroxyl citric acid 51 to 55 per cent. Cambodge is a small to medium sized tree with round, hemispherical, conical or pyramidal crown with horizontal or drooping branches which are orthotropic and plagiotropic. The tree is dioecious exhibiting male and bisexual types. Cambodge is commonly propagated through seeds; seeds of cambodge are dormant and take a long time for germination.

Seed propagation

The seeds of cambodge or Malabar tamarind are recalcitrant and loose viability fast. They do not germinate once dried. This necessitates the collection of fresh seeds for immediate sowing. The fruits of Malabar tamarind ripe in June- July during the monsoon season, when seeds can be collected from the fruits. Collected seeds are washed and spread on a floor under a roof for 20 days and sown afterwards in bags (2 seeds/bag) or in beds. This is done in the months of August-September. The best way to keep seeds viable is to keep them in moist sand under shade and may be kept intact upto one year. Natural regeneration is quite common along the river banks because the seeds get protected by moist soil conditions. The seed remain dormant for about 8 to 9 months and take 10 months for germination. Seeds sown with seed coat intact and removal of seed coat is the best method compared to chemicals to get enhanced germination in 2-3 months time (Sara *et al.*, 2000). The author further reported good germination with GA₃ and 10 to 20 per cent polyembryony but advised sowing in beds and transplanting at 2 leaf stage to avoid tap root injury.Seed dormancy is a major problem in cambodge. Joseph *et al.* (2007) reported that soaking cambodge seeds in hydrogen peroxide (30%) for 30 minutes was effective in breaking the dormancy.

The following seed treatments are recommended by Kerala Agricultural University for ensuring good seed germination.

- 1. Remove seed coat without injury to cotyledon and sow 3 cm deep. Germination starts in 20 to 25 days.
- **2.** Remove seed coat, soak in GA_3 (250 ppm) for 6 min, as well as soak in macozeb (4 g/ litre) for 2 min and sow in bags, water daily, germination starts in 16 to 20 days.
- **3.** Transfer seeds to a 20×25 cm size poly bag with 30-50 ml water. Tie the bag tight with air using rubber band. Keep for germination for 10 to 12 days. Sow germinated seeds in bags or beds. One bag will hold about 500 to 750 seeds.

Grafting

Softwood grafting is found best for propagation of Malabar tamarind (Haldankar *et al.*, 1993; Sara *et al.*, 2000) though the use of root suckers has been suggested (Shinde *et al.*, 2001). Bush habit will be useful for high density planting and back yard planting in kitchen garden. To achieve this, orthotropic shoots arising from the main stem (Sara *et al.*, 2000) or root suckers arising from the base of yielding tree may be used (Shinde *et al.*, 2001).

In Malabar tamarind, June to October is the best time for graft success coinciding with the humid period though grafting is possible throughout the year (Sara *et al.*, 2000). Three to four months old scion of 15 cm length of light green colour was found to be the best (Sara *et al.*, 2000) and neither pre curing nor covering scions with poly covers had any effect in graft success even in summer months under poly shed conditions (Mathew *et al.*, 2004). It is recommended to use primary branches with whorled leaf arrangement, 6 to 10 cm long and leaves partly removed as scion. The age of seedling suitable for grafting in Malabar tamarind is 12 month old (Sara *et al.*, 2000).

Top working of Malabar tamarind is suggested to convert non-bearing trees in which the trees are pruned in February- March and the newly emerging shoots are cleft grafted with scions from desired trees during rainy period (Sara *et al.*, 2000).

4. TAMARIND

Tamarind (*Tamarindus indica* L.) belonging to the family Fabaceae; is a native of tropical Africa. It is distributed throughout the tropical countries of the world with the highest population in India. Tamarind is a hardy tree; grows well under warm climatic conditions of tropical and subtropical countries.

Tamarind trees are generally raised on roadsides, in backyards or on the bunds of the field and in wastelands. In India, tamarind has been in commercial demand since long time. At present, the tamarind plantations available in the country are mostly seed propagated. Being a cross pollinated crop, it does not produce true to type plants, resulting in variation in size and quality of fruits. This necessitates the clonal propagation of elite trees. Various vegetative methods of propagation have been reported in tamarind and high yielding varieties are being distributed through these methods.

Propagation methods

Tamarind is generally propagated through seeds. It does not produce true to type, due to heterozygosity since the flowers are cross pollinated. Prolonged juvenile phase is one of the problems associated with tamarind propagation (Karle *et al.*, 1997). Therefore, vegetative propagation of superior genotypes is necessary for shortening juvenile phase, production of uniformly growing trees and to assure the quality of produce. Non conventional methods of propagation *viz.*, tissue culture techniques are also gaining momentum recently.

Seed propagation

Seeds should be collected from high yielding tree in March- April month. The petioles that hold the fruit to the tree are very strong and the pods should, therefore, be removed by clipping in order to avoid damage to the fruit (NAS, 1979). The pods should be dried in the sun and the seeds removed from the pulp manually. Seeds are washed and dried in the shade, stored in well-ventilated gunny bags or paper bags in a cool place.



The seeds are exalbuminous and consist of an outer hard brown testa. The seeds are normally sown directly in sand and germination commences within 5 to 10 days. The young plant grows best in porous soil in shade; very sensitive to frost. Generally, no pre treatment is found necessary for germinating the seed. Some *et al.* (1990) scarified seeds using 7 per cent H_2So_4 , washed and dried, and then stored in sealed containers for 52 weeks at 4°C. The germination percentage after 20, 28 and 52 weeks was satisfactory, but showed little improvement over untreated seed (Some *et al.*, 1990). Seeds soaked in cow urine and cow dung solution increased germination (Sankararayanan *et al.*, 1994). At times the ends of the seeds are sliced off to enhance the germination.

Germination is found to be maximum in heavy seeds than light seeds due to rich nutrient contents in the former. Seedlings attain plantable size of 30 cm and above within three to four months. Seedlings are raised in the nursery and are transferred to deep bamboo or other deep containers. Two years old transplants are better than one year old.

The behaviour of tamarind seed is orthodox (Ridley, 1981; Hong *et al.*, 1996). Fresh seeds retain viability for at least six months when kept at ambient temperature in dry conditions. Under field conditions, viability is more than a year when the seeds are well dried, mixed with sand and kept in air tight containers. Seeds could be stored for several years in air tight packs at 10° C with 7 to 15 per cent moisture content (Hong *et al.*, 1996).

The germination of fresh or well preserved seed may vary from 65 to 75 per cent. In Malawi, seeds thoroughly cleaned and soaked in water overnight resulted in more than 80 per cent germination (Prins and Magehembe, 1994).

The best medium for seed germination is sand or soil mixed with cow dung. Chattopadhyay and Mohanta (1988) reported that seed germination could be encouraged by using cow dung and sand in the propagation medium. However, a nursery potting mixture containing three parts of top soil, one part of sand and one part of compost can be successfully used for germinating tamarind seed. Seeds may be sown in deep polythene nursery bags in order to accommodate the tap root without casing and distortion and abnormality.

Seedlings grow rapidly in the early stages and produce a long tap root which may attain 30 cm or more within two months of germination (Troup, 1921).

Vegetative propagation

Tamarind can be propagated vegetatively by many methods. Proven methods include stem cuttings, air layering, patch budding or grafting on to seedling rootstocks Vegetative propagation is preferable to seed propagation as seed propagation does not produce true to type progenies.

Propagation by cuttings

The easiest and cheapest method of propagating tamarind is by stem cuttings. Although vegetative propagation through rooting of stem cuttings was reported to be unsuccessful by Mascarenshas *et al.* (1987), a number of other reports have claimed an efficient response. Swaminath *et al.* (1990) developed an effective technique for propagation through mature stem cutting over middle or basal cuttings for rooting of tamarind. In mature stem cutting, IBA at 1000 ppm was found to enhance rooting in 10 to 15 days. Navaneetha *et al.* (1990) reported that semi hardwood cuttings produced 19.6 per cent rooting followed by softwood cuttings (11.25 %) with 1000 ppm IBA treatment and more than 48 per cent of them survived..

A technique using softwood terminal cuttings has been developed by Srivasuki *et al.*, (1990). Shoots bearing new flushes of fully turgid leaves are collected and immediately dipped for 10



seconds in 1000 ppm of indole butyric acid (IBA) and in 50 per cent isopropyl alcohol. They were planted in vermiculite/ perlite (1:1) and placed in a mist propagator with 70 to 80 per cent humidity. Use of IBA was found to increase the rooting besides reducing the time taken for root initiation.

Soft or semi soft stem cutting (15 to 20 cm) excised from 1 to 2 years old branches is rooted (Swaminath *et al.*, 1990). The cuttings are wrapped in moist cloth after removal from the tree and dipped in IBA (1000 ppm) and planted in a sand bed in a mist chamber. Buds and roots initiated after 20 days, leaves are formed after about 45 days. Softwood cuttings are better than semi hardwood and hardwood cuttings.

Air layering

Air layering or gootee method of propagation is successful in tamarind. Navaneetha *et al.* (1991) and Nachegowda (1997) reported the positive influence of hormone (IBA, NAA and IAA) treatment on rooting of layers. Navaneetha *et al.* (1991) used wet saw dust or coir fibre to cover the cut portion and then a polythene film was wrapped around the etiolation medium and tied on both ends by a string. As regards etiolation medium, saw dust proved superior to coir fibre. Root length and number was more in the beginning of the rainy season (mid-June to mid-July); lowest at the end of the rainy season (mid-September to mid-October). Hanamashetti and Sulikeri (1997) studied the genotypic response to air layering in tamarind. There was significant difference among the genotypes in respect of root parameters. The survival per cent of layers varied from 11.11 per cent to 100 per cent. Significantly high survival of layers was observed in NTI-60, 61, 31 and 15.

Studies by Duarte *et al.* (2002); revealed that air layering was the most suitable method for tamarind propagation. The effect of indolyl butyric acid and gibberellic acid on the root growth of tamarind seedlings was also proved in his trials. Patil (2004) studied the response of different genotypes to air layering in tamarind and found that the range of rooting varied from 16.66 to 60 per cent in different varieties.

Grafting

Different methods of grafting have been tried in tamarind with varying degrees of success.

Approach grafting

Approach grafting is a reliable method and up to 95 per cent success can be achieved (Swaminath and Ravindran, 1989). Nadagoudar and Basavanneppa (1997) found approach grafting as an ideal propagation method due to various advantages such as easiness, cost effectiveness and higher establishment rate. Seasonal influence on success of approach grafting has been reported by Biradar (2001). Higher per cent of graft success was recorded during second fortnight of June (88.88%) followed by second fortnight of May (77.77%) and first fortnight of November.

Veneer grafting

Veneer grafts are made 8 cm high on the rootstock and immediately after the stock is cut above the graft union. This method is reported to give about 50 per cent success (Amin, 1978; Purushotham and Rao, 1990).

Softwood grafting

Softwood grafting was shown to be the best grafting method in terms of successful union and survival rates (Navaneetha *et al.*, 1990). The age of rootstock is important for success. Scions pre conditioned for 30 days prior to grafting on to 6 and 9 months old rootstocks resulted in 69 to 72



per cent success at 60 days. Grafting success has been attributed to the fact that rootstock of this age contain a higher proportion of reducing sugars to total sugars than at other ages (Karale *et al.*, 1997; Satisha *et al.*, 1997). Karale *et al.* (1997) concluded that softwood grafting in March-April on to 8 months old seedlings of 22 to 32 cm height and 0.3 to 0.4 cm diameter was highly successful. Similar results were also observed by Sathisha *et al.* (1997).

Age and maturity of rootstock on success of softwood grafting has been reported by Biradar (2001). Higher per cent of sprouting (93.33%) was recorded when grafting was done on six months old rootstock followed by 5 months old rootstock (43.33%). Patil (2004) studied the age of rootstock for softwood grafting. Higher per cent of success and survival was noticed in softwood grafting done at the age of 7, 8 and 9 months old rootstocks.

Giri and Lenka (2007) standardized the suitable time for softwood grafting in tamarind. The highest percentage of success was found in August (73.66%) followed by June (69.00%). Palande *et al.* (2005) studied softwood grafting at monthly intervals under Rahuri, Maharashtra conditions. Results revealed that maximum success and growth were obtained when grafting was conducted in May-June and October using 8- to 10-cm long scions.

In Thailand, a dwarf rootstock has been identified for tamarind based on morphological characteristics, such as internode length and leaf area. These characters were correlated with the number of stomata on the leaves. An attempt to reduce canopy size by intergeneric grafting on other leguminous species has not been successful.

Cleft grafting

In green wood cleft grafting studies, Nachegowda (1997) found that grafting during May recorded maximum graft success (80%) followed by April (76.7%) and June (70%) and least success was in February month of grafting (26.7%). This technique can be very well adopted for the large scale multiplication of tamarind clones. Shinde *et al.* (1997) claimed to have produced thousands of using wedge grafting which were made available to the farmers.

Patch budding

Pathak *et al.* (1991) reported success in patch budding (96%) and modified ring budding (94%). Singh and Singh (2007) studied patch budding and soft-wood grafting round the year to standardize method and time of propagation in tamarind. Among the two methods of propagation, patch budding in the month of July-August and soft wood grafting in the month of April-May may be adopted for multiplication of elite tamarind genotypes.

CONCLUSION

Perennial spice crops such as black pepper, nutmeg, cinnamon, camboge and tamarind can be propagated by seeds as well as by vegetative methods. The best method suited to each crop and region may be chosen depending on the multiplication rate, cost effectiveness, skilled labour availability, uniformity in the field establishment, pre-bearing period, etc.,. Maintaining pest and disease free mother gardens for collecting cuttings or scion is important. Potting mixture is important for any nursery, the composition may vary with availability of components such as compost, FYM, coirdust, soil, sand etc.,. Good media should free from pest and pathogen, support young plants in nursery with adequate nutrients, moisture and anchor for good growth. Quality planting material is very essential for successful establishment of plantations and accredited nursery would ensure the quality. All those who involved both government and private in the value chain should put earnest effort to produce and supply high quality material by using efficient production techniques.
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Production of quality planting material in vegetatively propagated annual spice crops - ginger and turmeric

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Introduction

Ginger and turmeric belonging to the family *Zingiberaceae*, are two annual spice crops contributing to the national economy of India. Ginger (*Zingiber officinale* Rosc.) is one of the oldest known spices, esteemed for its aroma, pungency and medicinal properties. It is a tropical spice crop adapted for cultivation even in regions of subtropical climate. Being a shade loving crop with shallow root system, it is suitable for intercropping in coconut and arecanut gardens and in homesteads. Ginger is grown mainly as a rainfed crop in Kerala. In North Central India, it is grown as an irrigated crop. India is the largest producer of ginger. The crop occupies the largest area in Assam followed by Gujarat, Meghalaya, Arunachal Pradesh, Sikkim and Karnataka (<u>www.</u>indianspices.com).

Turmeric (*Curcuma longa* L.) is an ancient and sacred spice of India. The crop can be grown in diverse tropical condition from mean sea level to 1500m above MSL and is adapted to different soil types. India is the world's largest producer of turmeric. It is a major annual spice, grown as a rainfed crop in Kerala adapted to the coconut based cropping system. The crop occupies major share of area in Tamil Nadu, Telengana, Andhra Pradesh, Karnataka and Gujarat (www.indianspices.com).

Knowledge about the cultivars and high yielding varieties, planting materials available in the crops and method of producing good quality planting materials are important in the scenario of production of quality planting materials. Several traditional cultivars are available in both the crops which differ in yield and quality attributes. Similarly, high yielding varieties have been released from Central institutes and State Agricultural Universities. Both the spices are propagated vegetativly using rhizome bits. Seed rhizome bits of 15-25g weight with one or two viable buds are generally used for planting. The protocols for micropropagation were also standardized in both the crops. Tissue culture derived plantlets are not used for commercial planting as time taken for rhizome formation and to get normal size as that of conventional production is more. However, microrhizomes induced *in vitro* could be used for production of disease free nucleus planting materials. Pro-tray raised bud transplants being popularized now-a-days for planting in both the spice crops have helped to reduce seed rate considerably, suitable for mitigating the climate change and the propagules are suitable for high tech precision farming both under open and poly house conditions.



A. Production of quality planting material in ginger

1. Traditional cultivars and high yielding varieties

Several traditional cultivars of ginger are recognized in India which differ in yield and quality attributes . These cultivars grown in different ginger growing areas are generally named after the localities where they are grown. Some of the prominent indigenous cultivars are Maran, Himachal , Kuruppampadi, Ernad, Wayanad and Nadia. The exotic cultivar Rio-de-Janeiro has become highly popular in India.

Adoption of high yielding, disease free seed rhizomes is of paramount importance for the success of seed production programmes. Adoption of HYV helped to bring considerable increase in yield and quality of the produce. Kerala Agricultural University has released three high yielding high quality ginger varieties with high content of *gingerols* and *zingiberene* (Shylaja et al.2010 and Shylaja et al.2014). There are eleven high yielding varieties of ginger released from various research stations (Table-1).

Variety	Freshmean yield (t/ha)	Maturity (days)	Dy Crude Oleo recovery(%) fibre(%)		Oleoresin(%)	Essential oil(%)		
Indian Institute of Spices Research, Kozhikode – 673 012, Kerala								
IISR Varada	22.6	200	20.7	4.5	6.7	1.8		
IISR Mahima	23.2	200	23.0	3.3	4.5	1.7		
IISR Rejatha	22.4	200	19.0	4.0	6.3	2.4		
High Altitude Research Station, Orissa University of Agriculture and Technology, Pottangi, 764 039, Orissa								
Suprabha	16.6	229	20.5	4.4	8.9	1.9		
Suruchi	11.6	218	23.5	3.8	10.0	2.0		
Suravi	17.5	225	23.5	4.0	10.2	2.1		
Subhada	18.0	210	22.4	3.4	10.4	2.0		
Y.S. Parmar University of Horticulture and Forestry, solan, Himachal Pradesh – 173 230								
Himagiri	13.5	230	20.6	6.4	4.3	1.6		
Kerala Agricultural Uni	versity, Thriss	ur – 680 656, I	Kerala					
Athira	21.0	220-240	22.6	3.4	6.8	3.1		
Karthika	19.0	220-240	21.6	3.7	7.2	3.2		
Aswathy	23.0	220-240	19.7	3.5	7.5	3.3		

Table 1. High Yielding Varieties of ginger

2. Planting materials

2.1 Seed rhizomes

Seed rhizomes account for about 40 per cent of total cost of production in ginger. Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 15-20 g with one or two viable buds. The seed rate varies from region to region and with the method of cultivation adopted. In Kerala, the seed rate varies from 1500 to 1800 kg/ha. At higher altitudes the seed rate may vary from 2000 to 2500 kg/ha. (Aiyadurai 1966; KAU, 2011 ; Jayashree et al. 2015a). Size of planting material has direct relationship with yield (Timo 1982). The size of the seed rhizomes varies from place to place and cultivar to cultivar. Trials with rhizome bits of different weights namely, 15g (Kannan and Nair 1965), 20 - 30 g (CSIR 1976), 15 - 19 g (Mohanty et al. 1990), 20 - 25 g (AICRPS 1992) were reported/adopted.

(Jayashree et al. 2015a)

Seed rhizome extraction (i.e., removal of seed planted after establishment of crop) has been practiced by local farmers for many years in the Hills of Sikkim and Darjeeling, India. By extracting the seed rhizome, farmers get back their investment on seed. But the wound created while detaching seed rhizome may serve as an entry point for pathogens (Rai and Gurung, 1997).

2.2 Bud transplants

Detached sprouts from mother rhizomes were tried as planting material in late 70s. Nair (1977) reported the use of detached sprouts of 4-6 cm height as planting material in ginger. The separated mother rhizome could be used as vegetable ginger. He reported the average yield of 1.16 kg green ginger per plant under Ambalavayal conditions of Kerala from detached sprouts.

Mahesh and Karla (1998) reported the effect of growth regulators and mulching on growth and yield of detached sprouts. Five-gram pieces of ginger cv. SG-713, planted in nursery beds, were transplanted in the field after 30, 60 and 90 days of sowing and treated with mulches and Ethrel (ethephon) in Solan, Himachal Pradesh. There was a significant increase in the yield with an increase in age of transplants. The highest yield among the age treatments (1.08 kg) was recorded from 90-day-old transplants and the lowest yield (0.48 kg) was recorded from 30-day-old transplants. Highest yields among mulch treatments (0.79 kg) and Ethrel treatments (0.82 kg) were recorded from the black polyethylene and the 200 ppm Ethrel treatment. The maximum yield per plot (1.27 kg) was observed in 90-day-old transplants treated with farmyard manure (FYM). Oleoresin contents were high with FYM, 100 ppm Ethrel and from 30-day-old transplants.

The effect of plant growth regulators on the growth and yield of ginger sprouts (cv. *Himgiri*) was studied in Solan, Himachal Pradesh, India, during 1997 and 1998 by Nath and Korla (2001). NAA, IAA, and IBA were applied to detached sprouts for 2 h only before planting in trays (1 ppm) or before transplanting in the field as well (0.5+0.5 ppm). The highest sprout survival rates (89.85 and 97.28%) were obtained with NAA and IAA at 0.5+0.5 ppm. IBA at 1 ppm gave the tallest plants (46.83 cm) with the highest number of leaves (31.45). All growth regulator treatments, except IBA at 0.5+0.5 ppm, were on a par with regard to the number of tillers. The heaviest rhizomes (49.62 g) and the highest yield (27.13 q/ha), net return (Rs. 15 333), and cost benefit ratio (1:0.039) were obtained with 1 ppm IBA. Ramana et al. (2003) has also reported the favourable effect of IBA. Transplants raised from seed rhizomes (about 5 g bits) in the nursery and planted in the field after 60 days with the onset of monsoon after treating with NAA or IBA (1 ppm) produced higher rhizome yield in Himachal Pradesh.

Though transplanting in ginger is not conventional, it is found profitable. A transplanting technique in ginger by using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost. The yield level of ginger transplants is on-par with conventional planting system. The technique involves raising transplants from single sprout seed rhizomes in the pro-tray and planted in the field after 30-40 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds (Prasath et al. 2014).

Technology

- Select healthy ginger rhizomes for seed purpose
- Treat the selected rhizomes with mancozeb (0.3%) and quinalphos (0.075%) for 30 min and store in well ventilated place
- One month before planting, the seed rhizomes are cut into single buds with small piece of rhizomes weighing 4-6 g.



- Treat the single bud sprouts (mancozeb 0.3%) for 30 min before planting
- Fill the pro-trays (98% well) with nursery medium containing partially decomposed coir pith and vermicompost (75:25), enriched with PGPR/*Trichoderma* 10g/kg of mixture
- Plant the ginger bud sprouts in pro-trays
- Maintain the pro-trays under shade net house
- · Adopt need based irrigation with rose cane or by using suitable sprinklers
- Seedlings will be ready within 30-40 days for transplanting

2.3 In vitro microrhizomes

In vitro microrhizomes are very useful for production of disease free planting materials. Among the various factors tested for rhizome induction, only sucrose (9% or 12%) was found to significantly influence rhizome formation in cultures . Experiments involving substitution of sucrose with other sugars and varying the volume of the culture medium indicated that the greater availability of carbon energy source rather than the osmotic effect of sucrose was responsible for rhizome formation. The highest germination rates of rhizomes upon transfer to soil resulted from rhizomes produced on medium containing 12% sucrose (Bhat et al. 1994). Maximum yield of rhizomes has been reported under continuous light (Sharma and Singh 1995). Temperature was also reported to be the most important factor in determining rhizome formation during the growth period. A 16/8 h (day/night) photoperiod, light intensity of 40% of full sunlight and air temperature of 22-30°C resulted in optimum rhizome growth and photosynthetic ability (Hyun et al. 1997).

Microrhizomes were successfully produced from tissue-culture derived shoots by transferring them to liquid MS medium supplemented (per liter) with 1mg BA, 2 mg calcium pantothenate, 0.2 mg GA3 and 0.05 mg NAA/ for shoot proliferation (Sharma and Singh 1995). After 4 weeks of incubation, the medium was replaced with microrhizome induction medium, consisting of MS salts supplemented with 8 mg BA and 75 g sucrose. Microrhizome formation started after 20 days of incubation in stationary cultures at $25\pm1^{\circ}$ C in the dark. Microrhizomes with 1–4 buds and each weighing 73.8-459 mg were harvested after 50-60 days. After storage for 2 months in moist sand at room temperature, 80 per cent of the microrhizomes sprouted, producing roots and shoots. Another protocol perfected by Rout et al. (2001) involves shoot multiplication of ginger by meristem culture on a MS basal medium supplemented with 26.6 µM BA, 8.57 µM IAA, and 1111.1 µM adenine sulfate and 3% (w/v) sucrose. In vitro rhizome formation from in vitro-raised shoots was achieved on MS medium supplemented with 4.44 μ M BA, 5.71 μ M IAA, and 3–8% (w/v) sucrose after 8 weeks of culture. The microrhizomes sprouted in a soil mixture within 2 weeks of planting. The sprouted plantlets survived under field conditions with normal growth . In vitro-grown rhizomes of ginger grew well, when grown on the carbonized rice husk: peat medium (5:1 ratio) (Cho et al. 1997). Plant acclimatization has been reported to be successful with laboratory hardening under 85 iE m⁻¹ s⁻¹ light for seven days then plants were transplanted. The percentage of established plants and sanitary conditions tended to be better in the presence of sand only or sand in combination with other media. It is possible to obtain a multiplication rate of 70,000 plants/ rhizome/year. In vitro production of micro rhizomes in ginger was also reported by Babu et al.(2005) and Zheng et.al (2008), Abbas et al.(2014) and Singh et al.(2014).

Among the three ginger cultivars taken for the study (cvs. Mahima, Rejatha and Varada), cv. Rejatha showed superiority in two trials and cv. Mahima responded more in the field condition. The pathogen free nature of the in vitro microrhizome was confirmed using disc culture method. The microrhizome and minirhizome technology developed in this study holds better promises for

large scale production of pathogen free seed rhizomes in ginger (Archana *et.al* (2013 a and 2013 b).

3. Production of quality seed rhizomes

3.1 Selection of site

Ginger is not cultivated continuously in the same field due to the exhaustive nature of the crop and incidence of diseases caused by soil borne pathogens. A gap of two years may be given for cultivating ginger in the same piece of land. It is a shade loving crop and 25 per cent shade is found ideal for better growth and yield (Sreekala and Jayachandran, 2002). Virgin forest soil rich in humus is the best soil for its cultivation. It prefers medium loam soil with high humus and good drainage. The depth of soil should be least 30cm. The optimum pH range of the soil is 6 to 7 (Purseglove *et al.*1981).

3.2 Preparation of land

Clear the field during April - May and burn the weeds, stubbles, roots etc. *in situ*. Prepare the land by ploughing three or four times or by digging. Prepare raised beds of convenient length (across the slope where the land is undulating), 1 m width and 25 cm height with 40 cm spacing between beds. Provide drainage channels after every 25 beds on flat lands (Nybe and Miniraj, 2005).

3.3 Season and method of planting

The best time for planting ginger is during first fortnight of April, after the receipt of pre-monsoon showers. Due to late pre monsoon showers and prevalence of very high temperature during April-May due to climate change, it is advantageous to take up planting of ginger in the second fortnight of May. Adjust planting time in ginger so as to get moderate showers at the time of planting, plenty of rainfall during growth period and a dry period of one month prior to harvest. Plant rhizome bits with viable healthy buds facing upward in small shallow pits of 4-5 cm deep at a spacing of 25 x 25 cm. In general, planting depth varies with size of planting unit, soil type, and soil moisture content (Kandiannan *et al.*, 1996). The seed rate varies from region to region and method of cultivation. In Kerala, the seed rate adopted is 1500-1800 kg/ha.

3.4 Manuring

Ginger is an exhaustive crop and requires heavy manuring and mulching to obtain high yield. Requirement of nitrogen (N) is the most critical among the major nutrients. For quick growing crop like ginger, fertilizer containing a high proportion of water-soluble P_2O_5 is needed for better yield (Sushama and Jose, 1994). Only under high rates of K application the crop can be grown successfully under shaded conditions (Jayaraj, 1990). Secondary nutrients are also essential for the healthy growth of ginger. However, deficiency of secondary nutrients is less since very large quantities of FYM and leaf mulch are applied. Need based application of micronutrients is recommended for ginger.

Cattle manure or compost is applied to beds and planting pits. Apply *Trichoderma* amended cowdung- neemcake mixture to planting pits to control soil borne pathogens (Vilasini, 1996).

Apply FYM 30t/ha and N:P₂O₅:K₂O 75:50:50: kg/ha/year. Full dose of P₂O₅ and 50 per cent of K₂O is applied as basal. Half the quantity of N is applied 60 days after planting. The remaining quantity of N and K₂O is applied 120 days after planting (KAU, 2011).

The growth of ginger can be classified into three distinct periods: a phase of active vegetative growth (90-120 days after planting), a phase of slow vegetative growth (120 to 180 days after



planting), and a phase of senescence (180 days to harvest). The pattern of rhizome development also followed the same trend except that the development of rhizome continued up to harvest (Johnson, 1978). According to Johnson, the total uptake of N, P and K progressively increased with advancing periods of crop growth, and the uptake by the leaf and pseudostem progressively increased up to 180 days after planting and decreased thereafter. However, the uptake by rhizome steadily increased till harvest.

3.5 Mulching

Immediately after planting, mulch the beds thickly with green leaves @ 15 t/ha. Repeat mulching with green leaves twice @ 7.5 t/ha, first 45-60 days and second 90-120 days after planting. Grow green manure crops like daincha and sunn hemp in the interspaces of beds and use them for second mulching of ginger (Valsala et al. 1990).

3.6 After cultivation

Remove weeds by hand-weeding before each top dressing of fertilisers and mulching. Repeat weeding according to weed growth during the fifth and sixth month after planting. Earth up the crop after each top dressing and avoid water stagnation in the plot.

3.7 Plant protection

3.7.1 Pests

a. Shoot borer

Shoot borer (*Conogethes punctiferalis*) is the most serious pest of ginger. The larvae bore into pseudostems and feed on internal tissues resulting in yellowing and drying of leaves of infested pseudostems. The prescence of bore hole on the pseudostem through which frass is extruded and the withered yellow central shoot are characteristic symptoms of pest infestation. The shoot borer could be controlled by spraying dimethoate or quinalphos at 0.05% and by mechanical control (removing dead heart and burning). Shoot borer infestation if not controlled effectively, the plants will succumb to the attack of soft rot and bacterial wilt pathogens.

b. Rhizome scale

Rhizome scale (*Aspidiotus hartii*) infests rhizomes in the field at later stages of development and also in storage. Adult scales are circular, light brown to grey and appear as encrustations on the rhizomes. They feed on sap, attack dormant buds, rhizomes become shrivelled and desiccated affecting its germination. The pest can be controlled by treating seed material with quinalphos 0.05 % for 30 minutes before storage and before planting.

3.7.2 Diseases

a. Soft rot

Soft rot is the most destructive disease of ginger which results in total loss of the crop. The disease is soil and seed borne and is caused by *Pythium* spp. The collar region of the affected pseudostem becomes water soaked. Rotting spreads to the rhizome resulting in soft rot. Foliar symptoms first appear as yellowing of lower leaves. Yellowing of leaves proceeds upwards followed by drooping, withering and drying of pseudostems. For control of rhizome rot, select sites with proper drainage, select seed rhizomes from disease free areas, treat seed rhizomes with 0.3 per cent mancozeb. When incidence of rhizome rot is noted in the field, dig out the affected plants and drench the beds with 0.3 per cent mancozeb. Inoculation with native arbuscular mycorrhiza,

Trichoderma sp. and *Pseudomonas fluorescens* at the time of planting is recommended as biocontrol methods.

b. Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* is also a soil and seed borne disease. Water soaked spots appear at the collar region of the pseudostem and progress upwards and downwards. The disease symptom first appears as loss of turgidity of leaves, curling of leaf margins and plants wilt. The leaves of the infected plants become orange yellow at the margins with a band of green area on either side of the mid rib. Shoots of diseased plants show vascular discolouration. The affected pseudostem and rhizome when pressed gently extrudes a milky ooze from the vascular strands. Selection of sites with proper drainage, collection of seed rhizomes from disease free areas and seed treatment with streptocycline 200ppm for 30 minutes are the precautions to be adopted for the control of the disease. If disease is noticed in the field, dig out the affected plants and drench the beds with 0.2 per cent copper oxy chloride.

In a trial to find out alternatives for banned pesticides, soil drenching with flusilazole 2ml/l, rhizome treatment with 2% Pseudomonas fluorescens and soil drenching copper hydroxide 2g/l and rhizome treatment with mancozeb and combined soil application of bleaching powder (15g/bed) + lime 250g/bed and the organic treatment -rhizome treatment and soil drenching with *Pseudomonas fluorescens* 2% + cowdung slurry 2% and Bioconsortium are effective against all three ginger diseases viz. soft rot, rhizome rot and bacterial wilt (KAU,2015).

c. Leaf spot

The incidence of leaf spot caused by *Phyllosticta zingiberi* appears as chlorotic specks. Spots of various sizes with whitish centre, dark brown margin and yellow halo around the spot are seen. In advanced stages, leaf turns brown and dries up. The disease spreads through rain splashes during intermittent showers. The incidence is severe when grown in open condition. The disease can be controlled by spraying 1per cent Bordeaux mixture or 0.3 per cent mancozeb.

3.8 Harvesting, seed preparation and storage

For seed purpose, the crop can be harvested $at 7\frac{1}{2}$ to 8 months maturity, when the pseudostem dries off completely. Harvesting should be done without injuring the seed rhizomes. Removal of pest and disease affected rhizomes completely from the plot at the time of harvest will help to reduce the inoculum for succeeding crop.

After harvest, trim off the fibrous roots attached to the rhizomes, remove soil from the clump and select seed rhizomes. Soak selected seed rhizomes for 30 minutes in a solution of mancozeb and quinalphos to give terminal concentration of 0.3 per cent of the former and 0.05 per cent of the latter. Dry the treated rhizomes in shade by spreading on the floor and store the rhizomes in pits $(1 \times 1 \times 1 \text{ m})$ dug under shade on a layer of sand or saw dust spread on the bottom. It is advisable to spread layers of leaves of *Glycosmis pentaphylla (panal)*. Cover the pits with coconut fronds. Examine the stored rhizomes at monthly intervals and remove the rhizomes that show signs of rotting. Provide one or two holes for better aeration. Treat seed rhizomes once again with the above fungicide and insecticide before planting also (KAU, 2011)

In order to obtain good germination, proper storage of seed rhizomes is essential. The seed rhizomes should be stored properly so that rotting, shriveling, dehydration and sprouting can be avoided until the next planting season. Maintaining a storage temperature of $22 - 25^{\circ}$ C make the growing buds fat and strong and temperature higher than 28° C in the long run make the buds thin



and weak. If the storage humidity is too low, rhizome epidermis may loose water and wrinkle thus affecting the sprouting speed and bud quality.

Zero energy cool chamber (ZECC), is found ideal for storing fresh ginger. Studies on storage of "seed pieces" of ginger showed that, the number of days to germination decreased with length of storage period while percentage germination and yield increased from 0 to 42 days storage. However, germination and yield were consistently lower after 35 days storage. This anomalous behaviour may be due to secondary dormancy during which the seed pieces lost their dormancy up to 21 days of storage but regained or entered into secondary dormancy at 35 days and again lost dormancy after 42 days (Timpo and Oduro 1977).

Ginger seed rhizomes were subjected to 15 different storage treatments in 1994. Storage in 100gauge polyethylene bags with 3% ventilation covered with dry sand was the most effective treatment, recording the lowest weight loss (26.9%), sprouting percentage (12.32%) and disease incidence (9.07%) during storage. This method also gave the highest values for recovery of healthy rhizomes after 3 months of storage (90.92%) and sprouting when planted in the field (88.34%) (Chandrappa et al. 1977). Rai and Hossain (1998) compared the three traditional methods of storage of seed rhizomes at Sikkim and Darjeeling hills and reported that storage in soil pits was the best method for small scale growers.

3.9 Economics of seed rhizome production

The average fresh yield of rhizomes from high yielding varieties is around 20 t/ha. The selected seed rhizomes (after removing cut and damaged rhizomes) available for storage after first seed selection will be around 17t /ha. The recovery of seed rhizomes after storage of 3-3½ months will be around 70 per cent. The quantity of seed rhizomes available after storage and second seed selection (done after storage) will be thus 12t /ha. At the sale price of Rs.100/ kg of seed, an amount of Rs.12,00,000/- could be expected from one hectare of seed production plot. Deducting the costs towards cultivation and storage of seed rhizomes, a net profit of Rs.5, 00, 000/- could be expected from one hectare of seed production plot.

Practical tips on production of quality seed rhizomes in ginger

- Select soils with high organic matter content and good drainage with a soil depth of 30cm and pH of 6-7. Virgin forest soil rich in humus is the best soil.
- Do not cultivate ginger continuously in the same piece of land, a gap of two years may be given for cultivation.
- Adjust planting time in ginger so as to get moderate showers at the time of planting, plenty of rainfall during growth period and a dry period of one month prior to harvest.
- Take raised beds of 25 cm height and ensure proper drainage in the field.
- Mark healthy and disease free beds in the field when the crop is six months old and still green for collection of seed rhizomes.
- Use good quality seeds free from pests and diseases and treated with a fungicide and an insecticide.
- Use bio control agents like *Trichoderma* and *Pseudomonas* for the control of soil borne pathogens
- Grow green manure crops like daincha and sun hemp in the inter spaces for use in second mulching



- Adopt chemical and mechanical methods for the control of shoot borer
- Take all precautions for the control of soft rot and bacterial wilt diseases
- Do clean harvesting by removing small rhizome bits, pest and disease affected rhizomes completely from the plot.

B. Production of quality planting material in turmeric

1. Traditional cultivars and high yielding varieties

A number of cultivars are available in the country and are known mostly by the name of locality where they are cultivated. Cultivars can be grouped into three based on maturity period as short, medium and long duration. Some of the popular cultivars are Duggirala, Tekkurpet, Sugandham, Amalapuram, Erode local, Salem, Alleppey, Moovattupuzha and Lakdong. The improved varieties of turmeric released from ICAR-Indian Institute of Spices Research, Kozhikode and their salient features are given in Table 2.

Variety	Meanyield (fresh)(t/ha)	Crop duration(days)	Dry recovery(%)	Curcumin (%)	Oleoresin (%)	Essential oil(%)	
ICAR-Indian Institute of	f Spices Rese	earch, Kozhiko	de				
Suvarna	17.4	200	20.0	4.3	13.5	7.0	
Suguna	29.3	190	12.0	7.3	13.5	6.0	
Sudarsana	28.8	190	12.0	5.3	15.0	7.0	
IISR Prabha	37.5	195	19.5	6.5	15.0	6.5	
IISR Prathibha	39.1	188	18.5	6.2	16.2	6.2	
IISRAlleppey Supreme	35.4	210	19.3	6.0	16.0	4.0	
IISR Kedaram	34.5	210	18.9	5.5	13.6	3.0	
Tamil Nadu Agricultural University, Coimbatore							
Co 1	30.0	285	19.5	3.2	6.7	3.2	
BSR 1	30.7	285	20.5	4.2	4.0	3.7	
BSR 2	32.7	245	20.0	3.8			
High Altitude Research Station, OUAT, Pottangi, Odhisa							
Roma	20.7	250	31.0	6.1	13.2	4.2	
Suroma	20.0	255	26.0	6.1	13.1	4.4	
Ranga	29.0	250	24.8	6.3	13.5	4.4	
Rasmi	31.3	240	23.0	6.4	13.4	4.4	
Surangi	23.4	180-200	28.0	4.5-6.5	12.7	4.6	
Tirhut College of Agricu	ilture, RAU,	Dholi, Bihar					
Rajendra Sonia	42.0	225	18.0	8.4	10.0	5.0	

Table 2. High yielding turmeric varieties

ICAR Research Comp	lex for NEH Re	egion, Shillong,	Meghalaya				
Mega Turmeric 1	23.0	310	16.4	6.8	-	-	
Kerala Agricultural Ur	niversity, Thriss	sur					
Kanti	36.5	240-270	20.0	7.2	12.1	5.2	
Sohba	33.7	240-270	19.3	7.4	15.9	4.2	
Sona	37.5	240-270	18.9	7.1	18.0	4.4	
Varna	33.4	240-270	19.1	7.9	13.9	4.6	
Sardarkrushinagar Dai	ntiwada Agricu	ltural University	y, Jagudan				
Sugandham		15.0	210	23.3	3.1	11.0	2.7
					(Jayas	shree et al. 2	015b)

2. Planting materials

2.1 Seed rhizomes

Turmeric is propagated through vegetative rhizome for commercial production. Rhizome (also denoted as 'clump', 'bulb', 'corms' 'set', 'tuber' in the literature) is of two types viz., mother rhizome and finger rhizome also known as daughter rhizome (developed from mother rhizome). The fingers are primary, secondary or tertiary depending on their position, primary finger constitute a major share in the clump, the secondary and tertiary are less in quantity. Both mother and finger are used for propagation. However, primary fingers are commonly used for planting due to its large availability. In India, mother rhizome are used for planting in Krishna and Guntur districts, and finger alone is used in Cuddapah district of Andhra Pradesh whereas both mother and fingers are used separately in Tamil Nadu . Mother rhizomes are found better than finger rhizomes (Aiyadurai 1966). The highest yield was obtained from whole mother rhizomes followed by the primary rhizomes with 5-6 internodes and the half-cut mother rhizomes. Whole mother rhizomes produced rapid growth and development of plants. The primary, secondary and tertiary rhizomes with 3-4 internodes did not differ from one another in terms of growth and yield. The combined effect of half cut mother rhizome with N:P₂O₅:K₂O at 120-60-120 kg ha⁻¹ produced the highest yield (94.26 t/ha). Dhatt et al. (2008) recorded that mother rhizome and primary fingers were significantly superior than secondary fingers in respect of plant growth characteristics, yield plant⁻¹, size of mother rhizome, primary and secondary fingers production. Although, mother rhizome and primary finger were at par in terms of plant growth, yield and size of secondary fingers, but former was a better planting material in terms of size of mother rhizome and primary finger. It is therefore the growers should use either mother rhizome or primary finger as planting material to raise the turmeric crop for higher yield .

2.1.1 Seed size

Mothers split longitudinally into two halves and fingers are broken into pieces of 5 to 10 cm length weighing approximately 50 to 100 g with one or two buds are used for planting (Aiyadurai 1966). Philip (1983) reported that the highest yields could be obtained from seed rhizome pieces with 2 to 3 eyes, and primary rhizome of 30-40 g with a larger diameter or mother rhizome weighing 25-34 g. Singh et al. (2000) noted that whole mother rhizomes (70-80 g) planted at 50x20 cm gave highest yield in Haryana. Planting of full mother rhizome of 80-100 g resulted in minimum leaf blotch incidence caused by Colletotrichum capsici and maximum rhizome yield (22 t/ha) followed by half mother rhizome of 50-80 g (Archana et al. 2000). It was observed that plants from 30 g, 40 g and 50 g of daughter rhizomes had a significantly larger shoot biomass and higher yield than those from smaller daughter rhizomes in both the greenhouse and field experiments. The shoot biomass and yield are highest in the plants grown directly from mother rhizomes when compared to the plants from daughter rhizomes attached to that of mother rhizomes. This study further indicated that the turmeric seed rhizome should be 30-40 g with a larger diameter, and seed mother rhizome should be free from daughter rhizomes. Randhawa & Mishra (1974) while studying the effect of seed size in turmeric reported that large sized rhizome weighing approximately 100 g gave significantly higher yield (61 q ha⁻¹) than small sized rhizomes (53.3 q ha⁻¹) of 50 g weight.

2.1.2 Seed rate

Seed rate of turmeric generally varies based on type of rhizome and spacing adopted. When mother rhizome was used, rate reported was 1800 kg ha⁻¹ while it was 1200 kg/ha for finger. Different seed rates were suggested by several workers (Rao et al.2006). Seed rate recommended for planting one hectare is 2500 kg (KAU,2011).

2.1.3 Preservation of seed rhizomes

Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of *Stychnos nux-vomica (kanjiram)*. The pits are to be covered with wooden planks with one or two openings for aeration. The rhizomes are to be dipped in quinalphos (0.075%) solution for 20-30 minutes if scale infestations are observed and in mancozeb (0.3%) to avoid storage losses due to fungi.

2.2 Bud transplants

Single bud transplants in turmeric as a technique for accelerated production of quality planting material with reduced cost was reported by Chitra and Jansirani (2014). An experiment was laid out at Tamil Nadu Agricultural University, Coimbatore to standardize the rapid multiplication technique in turmeric with four different treatments. Among the various treatments, the treatment finger rhizome with one bud recorded significantly the highest shoot length (24.96 cm), root length (12.08 cm), vigorous index (2334.84) and crop establishment (88.96 %) when compared to other treatments.

2.2.1 Standardization of potting media for protray budling production of turmeric

A trial was laid out to standardize the potting media for protray budling production of turmeric with eight different treatments. The finger rhizome pieces treated with Carbendazim 2g/l for 10 minutes. The rhizome pieces were then spread over the polythene sheet under the tree shade and covered with the medium. The medium was irrigated with rose-can before covering it with another polythene sheet and kept aside for 4 days. The rhizome pieces with buds were picked out and then placed in protrays containing the medium. Approximately 1.2 kg of medium is required for filling one protray. The rhizome pieces were covered with respective medium, irrigated sufficiently with rosecane and the trays were kept one above the other such that 10 trays in one set under the shade net and covered with a polythene sheet until germination. After 7 days, the protrays with sprouted rhizomes were placed individually inside the shade net. Watering was done at regular intervals and Humic acid (0.5%) was sprayed after the emergence of first leaf. After 10 days of the emergence of first leaf, drenching with 19:19:19 mixture @ 0.2% was done. The seedlings attain the transplantable stage after 30 – 35 days of sowing of rhizomes.



All the treatments exhibited significant difference for the various growth parameters of the seedlings. Among the treatment, the treatment Cocopeat + *Pseudomonas fluorescens* was found to show conspicuous effect on the sprouting percentage (95.27), stem length (25.72 cm), root length (12.62 cm), vigorous index (2463.05) and crop establishment (95.40%). The treatment Cocopeat was found to exhibit least performance for all the parameters except sprouting percentage (84.73) and crop establishment (76.60%).

2.2.2 Standardization of suitable planting season for turmeric transplants

An experiment was laid out to standardize the suitable planting season for turmeric transplants with seven different treatments.

Growth parameters: Among the various treatments, the treatment June 15th planting recorded prominent plant height (116.19 cm) and number of leaves (13.13). However the treatment July month planting registered the highest number of tillers per plant (4.60).

Pest and disease incidence: The field experiments conducted during the 2011-12 season showed the incidence of shoot borer comparatively lower in the planting season June 15^{th} (0.84%) followed by July 15^{th} (1.13%) and August 15^{th} (1.16%). Similar trend was found with respect to incidence of rhizome scale in the planting seasons June 15^{th} (0.54%) and July 15^{th} (0.86%). In the case of rhizome rot, all the treatments with single bud derived plants found to exhibit lesser incidence percentage than the June month planted rhizome derived plants (24.50%) and least incidence was recorded in June 15^{th} planting (4.60%) and July 15^{th} planting (5.25%).

Yield parameters: The treatment June 15^{th} planting recorded the highest fresh rhizome weight per plant (1.176 kg), dry rhizome weight per plant (0.242 kg), fresh rhizome yield per hectare (47.18 t) and dry rhizome yield per hectare (9.70 t).

Economics: The treatment June 15th planting recorded the highest gross returns (Rs. 2,68,800/ ha), net returns (Rs. 1,86,750/ha) and B:C ratio (2.28:1). It was followed by July15th planting.

2.2.3 Studies on the effect of rhizome size and nursery on growth and yield of turmeric

A trial to standardize the size of the planting material and to study the effect of the seedling on growth and yield parameters was laid out with nine different treatments. Among the different treatments, the treatment single node (5 g) planting in portray (1 month) recorded the highest yield (67.94 kg) compared to control primary full length rhizome (25-30 g) planting directly in the field (43.77 kg). Enhanced growth and less rhizome maturation phase were observed in bud transplants (Table 3). Transplants from single bud recorded double the yield in turmeric (Table4).

Growing Phase	Direct planting method	Transplanting method
1. Sprouting phase	20 DAP	Seedlings having 3-4 leaves (1 month old)
2. Vegetative phase		
(i) One month after planting	2-3 leaves/plant	6-7 leaves/plant
(ii) Tillering stage	3 MAP	1½ – 2 MAP
3. Rhizome development phase	Starts 5 MAP	Starts 3 MAP
4. Rhizome maturation phase	7-9 months	6-7 months

 Table 3. Growth comparison of Direct planting vs. single bud transplants in turmeric

Characters	Direct planting method	Transplanting method
Propagation through	Whole Rhizome	Rhizome single bud
Seed rate	1000 kg/ac	300 kg/ac
Cost of planting material	Rs. 12,000	Rs. 3,600
Crop establishment	75 - 80%	95 -100 %
Rhizome development	Starts 5 months after planting	Starts 2 months after planting
Productivity	10 - 12 tons/ac	20 - 22 tons/ac

Table 4. Comparison of direct planting vs. single bud transplants in turmeric

2.3 In vitro micro rhizomes

The induction of microrhizomes in four varieties of turmeric viz. Ranga, Rasmi, Roma and Suroma were reported by Nayak (2000). Microrhizomes were produced from tissue culture derived shoots of four cultivars by transferring them to Murashige and Skoog (MS) liquid medium supplemented with 6-benzyladenine (BA) (1-5 mg/litre), enhanced concentration of sucrose (50-100 g/ litre) and with reduced photoperiod (0-8 h). BA (3 mg/litre), sucrose (60 g/litre) and photoperiod (4 h) was found to be most effective for induction of microrhizome in all four varieties of turmeric. Microrhizomes were formed at the base of the shoots r and the weight varied from 40 to 700 mg. Interactions of different factors such as BA, sucrose and photoperiod had a significant effect in the induction of microrhizome. Concentration of sucrose was most effective in rhizome formation followed by photoperiod and BA in the medium. Microrhizomes were harvested after 120 days of culture. These microrhizomes could be stored in MS media with low concentration of BA (0.01 mg/litre) and in moist sand at room temperature. Microrhizomes were produced in vitro independent of seasonal fluctuation and sprouted with roots and shoots in potted soil during planting seasons which were then transferred to the field. These microrhizomes, since produced in vitro can be used as disease free seed rhizomes. Storage of microrhizome in vitro would facilitate continental and intercontinental germplasm exchange programmes

Efficient procedure for *in vitro* micro rhizome production in turmeric was also reported by Shirgurkar et.al (2001), Islam et.al (2004) and Cousins et.al. (2008). *In vitro* microrhizome and minirhizome production in turmeric cultivar Alleppey supreme and its comparative anatomical and histochemical analysis were reported by Archana et al.(2014). The variety showed highest response in liquid MS medium with 80 gl-1 sucrose in Planton culture vessels. The microrhizome technology developed during the present study can be used for large scale production of planting materials in turmeric within a short period of time without compromising the quality and quantity.

Conclusion

The method of production of quality seed rhizomes in turmeric is the same as that of ginger. The difference exists only in seed rate and nutrient management. The high seed rate and long period of storage of seed rhizomes in hot summer period are the major problems faced in seed production of ginger and turmeric. The microrhizome technology / bud transplant technology together with open precision / high tech precision farming technologies will help to overcome these problems and aid in production of high quality seed rhizomes of ginger and turmeric in large scale.



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Planting material production technology in small cardamom

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Introduction

Cardamom (*Elettaria cardamomum* Maton), the "Queen of Spices" is the true cardamom belonging to the *Zingiberaceae*. The area under cardamom (small) was 69,670 ha with a production of 16,000 MT during the year 2013-14. Till late seventies, India was enjoying a near monopoly position in the world trade of cardamom. But situation since then has changed as the share of India in the world trade has declined. The main competitor is Guatemala. Hence, as the International market for cardamom is increasingly competitive, there is no other go except to increase the production of domestic cardamom and to bring down cost of cultivation. There are mainly three types/ cultivars in cardamom viz., Mysore, Malabar and Vazukka. Generally, Mysore and Vazukka types are cultivated in Kerala and Tamil Nadu, whereas, Malabar type is cultivated in Karnataka.

Cardamom selections

Variety	Parentage	Year of release	Released from Institute	Yield kg/ha (Dry)	Salient Features	Recommended for
Mudigere 1	Clonal selection from Malabar type	1984	Regional Research Station, UAS, Mudigere, Karnataka	300	Erect and compact panicle suitable for high density planting, moderately tole- rant to thrips, hairy cater- pillar and white grubs	Karnataka
Mudigere 2	Clonal selection from Malabar type	1996	Regional Research Station, UAS, Mudigere, Karnataka	476	Early maturing variety, suitable for high density planting	Karnataka
PV 1	A selection from Walayar collection	1991	Cardamom Research Station, KAU, Pampadumpara, Kerala	260	Long, bold capsule, suitable for all cardamom growing tracts of Kerala and Karnataka	Kerala and Karnataka
PV 2	Selection from OP Seedlings of PV-1	2000	Cardamom Research Station, KAU, Pampadumpara, Kerala	982	Long bold capsules, high dry recovery percentage, field tolerant to stem borer and thrips	Kerala

ICRI 1	Selection from Chakkupallam	1992	ICRI (Spices Board), Myladumpara, Kerala	325	Profusely flowering, early maturing type, round and bold capsule	Kerala
ICRI 2	Clonal selection from Germplasm collection	1992	ICRI (Spices Board), Myladumpara, Kerala	375	Performs well under high altitude and irrigated condition	Kerala and TamilNadu
ICRI 3	Selection from Malabar type	1993	ICRI (Spices Board) Sakleshpur, Karnataka	440	Oblong capsule, suitable for hill zone of Karnataka	Kamataka
ICRI 4	Clonal selection from Vadagarapara areaofLower Pulneys	1997	ICRI (Spices Board), Kerala Tadiyankudisai, Tamil Nadu	455	Suitable for low rainfall areas relatively tolerant torhizomerotandcapsuleborer	Kamataka
ICRI 5	Mhc 26 a cross between MCC 260 x MCC 49	2005	ICRI (Spices Board), Myladumpara, Kerala		_	Kerala
IISR Kodagu Suvasini	OP progeny of CL-37		Indian Institute of Spices Research Calicut Kerala	745	Small plant type, suitable for high density planting and low inputs	Kamtaka
IISR Avinash	OP progeny of CCS-1		Indian Institute of Spices Research Calicut Kerala	847	Tolerant to rhizome rot.	Kamataka
IISR Vijetha	Aselection from field resistant plants		Indian Institute of Spices Research, Calicut, Kerala	643	Resistant to Katte	Kamataka
ICRI – 6 (MCC-73)	Selection from the germplasm acc. MCC-73	2005	ICRI (Spices Board), Myladumpara, Kerala	-	-	Kerala

* Yield Kg/ha (Dry)

About 24 clonal selections have been developed by cardamom growers themselves in their respective plantations through constant observations of yield and other important traits, resistant to biotic and abiotic stresses. Njallani Green Gold farmer's selection from local Vazukka from Kerala has high yield potential. It has long panicles, wide adaptability and responds to high inputs.

Large Cardamom (*Amomum subulatum*), is another member of *Zingiberaceae* cultivated in the sub-Himalayan State of Sikkim and Darjeeling District of West Bengal covering an area of about 23,500 ha. The annual production varies from 4500-5000 metric tonnes. It is also cultivated in parts of Uttaranchal and in some other North-eastern States. Nepal & Bhutan are the other countries where large cardamom is cultivated. There are mainly five popular cultivars in large cardamom *viz., Ramsey, Sawney, Golsey, Ramla* and *Varlanga. Seremma* which resembles *Golsey* is gaining importance in lower altitudes. *Bebo* is another cultivar from Arunachal Pradesh.

Several varieties with superior quality traits for high yield, resistant to pests and diseases have been evolved through selection and hybridization process and being widely accepted among the farming community across the cardamom growing regions.

Both cardamom (small) and large cardamom can be propagated by seeds (seedlings) as well as clonal propagation (rhizome) and micro propagation (tissue culture). As cardamom is highly a cross pollinated crop, propagation by seeds result in seedling progeny with mixed character and it will not be true to type. The vegetative propagation can overcome this defect. Vegetative propa-

gation can be resorted both by macro *i.e.*, rhizome (sucker) propagation through clonal multiplication under intensive care and micro propagation by tissue culture. Raising of seedlings by tissue culture has gained an impetus in recent years and has been taken up by commercial organizations in India to mass multiply high yielding selections. In order to raise a cardamom plantation, seedlings or suckers of high yielding varieties are to be used (Korikanthimath, 1995, Ravindran and Madhusoodanan, 2002, Ankegowda, *et al.*, 2012).

One of the most important reasons for low productivity in Cardamom is the use of poor planting materials. However, in recent years elite clonal materials has been adopted for enhancing productivity and production. Scientific nursery management needs careful consideration selection of suitable site for nursery, seed selection, preparation of seeds, viability of seeds, optimum time of sowing, pre-sowing treatments of seeds, seed rate and sowing, mulching, transplanting to secondary nursery, irrigation, provision of pandal, fertilizer application, weeding and regular plant protection measures. Details of raising quality planting materials both by using seeds and vegetative means both in Cardamom (*Elettaria cardamomum* Maton) and large cardamom (*Amomum subutatum* Roxburgh) is presented and discussed in this paper.

SMALL CARDAMOM

In order to get quality seedlings, the nursery has to be managed carefully and scientifically. The most developed system of nursery management involves the germination of seed in prepared beds from which they are transplanted into nursery beds and finally into the field. Two stages of nursery–primary and secondary are involved in raising seedlings.

I. Primary Nursery

1. Nursery Site

It is always advantageous to select the nursery site on gentle slope, having an easy access to a perennial source of water (John 1968; Ponnurangam 1946; Siddaramaiah 1967). The nursery area should be cleared of all existing vegetation, stumps, roots, stones etc. Raised beds are prepared after cultivating the land to a depth of about 30 to 45 cm. Usually the beds of one meter width and convenient length up to 5-6 M raised to a height of about 30 cm are formed for sowing the seeds. A fine layer of humus rich forest soil to a thickness of 2-3 cm is spread over the beds. Soaking the soil in the seed bed to a depth of 15 cm with 1:50 formaldehyde solution is found to be effective in controlling the damping off disease of cardamom seedlings (Anonymous, 1985). Beds are to be covered with moist gunny bags or ploythene sheets for one or two days to allow the fumes to act and the seeds are to be sown one week after treatment.

2. Seed selection

Selection of seed material needs considerable attention while raising seedlings. High yield and bold size of cardamom capsules are associated with superior genetical traits of the plants. It is always desirable to watch the continued performance of selected, individual mother plants, before the final selection. (Cherian, 1979). Seed capsules should be collected from high yielding plants, with well ripened capsules, vigorous, fully matured, well formed compact panicles of plants free from infestation of pest and disease. Number of flowering branches formed on the panicles, number of fruit set and number of seeds per capsule should be given due consideration while selecting the material (Anonymous, 1979 ; John 1968 ; Ponnurangam 1946 ; Siddaramaiah 1967). Apart from these desirable attributes – the mother clump should have more number of tillers (shoots) per plant, leaves with dark green colour, high percentage of fruit set. Colour of capsules should be dark green (Krishna, 1968). On an average one kg of seed capsules contain



900-1000 capsules with 10-15 seeds per capsules. Taking into consideration the percentages of germination, mortality due to diseases etc., on an average one kg of seed capsules are required to get about 5000 plantable seedlings.

3. Preparation of Seeds

Seeds for sowing are collected from fully ripe capsules preferably from 2 to 3 round of harvest in September and is then either washed in water and sown immediately or mixed with wood ash and dried for two to three days in the room temperature. The first method gives best results and is almost universal in most of cardamom estates now. After picking, seed capsules should be immersed in water and gently pressed for ejecting the seeds, which should then be washed well in cold water for removing the mucilaginous coating of the seed (Pattanshetti and Prasad, 1973) stated that after. Immediate sowing of fresh seeds is obviously only possible when seed collection is done on the estate where it is required. If seeds have to be transported to far off any distance, some drying is essential to prevent mould development. Treating seeds with organo-mercurials would ensure better germination.

4. Viability of Seeds

Storing seeds for a longer time result in considerable loss of viability and great delay in germination. The study on viability of seeds was conducted by using seeds of Mysore and Malabar types of cardamom at Cardamom Research Centre, Appangala, with treatments comprising of sowing of seeds immediately after harvest (fresh seeds) and after storing for 30, 60 and 90 days. The maximum percentage of germination was in fresh seeds. i.e., 58.86 and 50.63 in Mysore and Malabar types respectively. The germination was reduced when there was a delay in sowing after storing the seeds for a long time. Storage of seeds results in loss of viability and delay in germination. Germination reduced when there is a delay in sowing. Seeds treated with organo-mercurials and stored in bottles maintain viability up to a period of four months. Germination was highest (71.8 per cent) when sown in September (Pattanshetti and Prasad, 1973; Pattanashetty et al., 1978). Seeds treated with organo mercurials and stored in open bottles maintained vigour up to a period of four months. The germination of treated seeds was considerably reduces when they were stored in air tight bottles. Besides the length and type of storage, the weather conditions that follow the sowing had a profound influence on germination (Pattanshetti, et al., 1978). Study conducted to find out if capsules/ seeds stored in polythene bags for a period of 8 months (till subsequent sowing) could be used for raising seedlings by Krishnamurthy et al., (1989) indicated very low percentage of germination in untreated seeds irrespective of their storage in the form of capsules (10%) or extracted seeds (0.6%). Since, seeds lose their viability quite early, they have to be sown immediately for better germination (Abraham, 1958) from natural capsules.

5. Time of Sowing

The time of sowing cardamom seeds varies according to places. When cardamom seeds were sown at monthly interval from September to January best germination was obtained in September (71.8%) and least *i.e.*, 8.0% January (Pattanshetti and Prasad, 1973). Korikanthimath (1981) started that in case of Malabar type of cardamom commonly cultivated in Karnataka, there was a gradual decline in germination percentage *i.e.*, 56.76,51.07,46.44, 34.14, 32.51 and 29.64 when observed after 60 days of sowing in case of seeds sown on 1st August, 15th August, 30th August, 14th September, 29th September and 14th October, respectively. Cardamom seeds sown during September germinated uniformly, early and satisfactorily. The seedlings from these grew fast and healthy and were ready for transplanting at the end of 10 months. If they were further retained in the nursery beds for the next planting season either by proper thinning or by providing wider

spacing in the secondary nursery beds, they developed rhizome with large number of tillers and this was particularly useful in the initial establishment of plantation (Pattanshetti and Prasad, 1972). It is also seen that the seeds sown early (August-September) will put up sufficient growth and can withstand incidence of leaf spot diseases. Late sowing of seeds beyond October will drastically bring down germination as it would coincide with cold temperature. So, the early sowing is always beneficial for better growth and enhancing tillering of seedlings before taking up transplanting in main field. *ie.*, plantation. In the northern areas, Kodagu, Mysore and North Canara, seeds are usually sown in September and germinate in about a month. In the southern areas, the seeds are rarely put down before November and germination is more irregular and takes considerably longer time. Both air and soil temperature show a marked drop in November and December and low temperature at this time may account for some of the difficulties experienced with seed sown in southern districts. The ideal sowing season is the dry period from November to January in Kerala and Tamil Nadu and September to October in Karnataka (Anonymous, 1970; Anonymous, 1979).

6. Pre Sowing Treatment of Seeds

Cardamom seeds possess a hard seed coat which delays its germination. Various studies have been undertaken on the effect of pre sowing treatment of seeds to overcome the delay in germination. Treatment of freshly extracted seeds with concentrated nitric and hydrolic acids for five minutes significantly improved the germination of cardamom seeds sown during November (Prasad et al., 1974). Treatments with Nitric acid, acetic acid (25%) and hydrolic acid (50%) for 10 minutes each were found to be the best for all treatments with 97.6%, 98.6% and 91.5% germination, respectively (Suryanarayana Redyy, et al., 1973). Studies conducted at Cardamom Research Centre, Appangala during late sowing revealed that out of four acids viz., Acetic acid, Hydrochloric acid, Sulphuric acid and Nitric acid with five concentrations ie., 20%, 40%, 60%, 80% and control (untreated), seeds treated with nitric acid recorded maximum germination (49.23%) at 20% concentration, almost double the germination obtained in untreated control (23.30%). Maximum germination was observed in the lower concentration (20%) of all the acids tried for treating the seeds. In the highest concentration (80%) both in case of sulphuric acid and nitric acid, there was no germination at all. It would be quite beneficial to treat cardamom seeds with acids as mentioned above if sowing of seeds is delayed beyond September for ensuring better germination. Overall effect of acid treatment on seed germination of cardamom is presented here below.

Acid	Modeof treatment	Treatment duration	Germination percentage(%)	Reference
Con. Nitric acid	Soaking	5minutes	9% increase	Kololgi et al., 1973
			Increased germination	Prasad <i>et al.</i> , 1974, Govindaraju and Chandrasekharan, 1982
Conc. Hydrochloric acid	Soaking	5minutes germination	Increased Chendrasekharan, 1982	Prasad et al., 1974; Govindaraju and
25% Nitric acid	Soaking	10 minutes	55% increase (fresh seeds) 25% increase (6-8 months old seeds)	Sulikeri and Kololgi, 1977
25% Acetic acid 25% Hydrochloric acid 25% Nitric acid	Soaking	10 minutes	90 per cent germination	Reddy <i>et al.</i> , 1973 Korikanthimath and Ravindra Mulge, 1998
Acetone	Soaking	10 minutes	Increased germination	Govindaraju and Chandrasekharan, 1982

Effect of acid	treatment	on	seed	germination	of	cardamom
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It is seen from the above table that in general, soaking cardamom seeds in dilute or concentrated acids for 5-10 minutes increases the germination percentage. In addition, soaking seeds with GA_3 and ethrel solutions was found to enhance germination while kinetin did not (Rajashekaran *et al.*, 1992). Korikanthimath and Ravindra Mulge (1998) reported increased germination by treating seeds with GA_3 100ppm and planofix 75 ppm. Effect of mutagen on seed germination of cardamom has also been reported by Mohamed Sayeed and Subba Rao (1982).

7. Effect of temperature on germination

The harvest of cardamom normally commences by middle of August and continues up to end of January. The germination of seeds is high when sown fresh and decreases with time. Germination is maximum when seeds are sown during August-September and least when sown in January. Seeds collected from capsules harvested in winter *i.e.*, December to February may not be used for sowing either immediately because of the prevailing very low temperature or after long storage because of poor viability. Hence, studies were conducted to find out the causes of low germination in winter and the remedies to overcome the same (Krishnamurthy et al., 1989). The cause of low germination were studies by sowing cardamom seeds in January in the geographically distinct locations (coastal area and hill areas). Results indicated that the germination of cardamom seeds was significantly affected by locations. There was a significant positive correlation between minimum temperature V/s maximum temperature (0.975). Apart from other factors, ambient temperature also plays a role in germination. The low temperature also influences germination. The low temperature in the cardamom growing area reduces as well as delays germination it Gurumurthy and Hegde (1987) found that germination is significantly correlated with maximum and minimum temperature prevalent in the area. The cardamom seeds fail to germinate at temperature less than 15°C and greater than 35°C at constant temperature in incubator. Germination of 70.9-73.0% was considered optimum which was achieved at 30°C. The highest percentage germination was observed under ambient temperature for September-October (Siddagangaiah et al., 1993). Studies conducted on influence of ploythene structure and polythene cover (covering the seed bed) on percentage of germination indicated significant difference in germination among polythene structure consisting of spreading of polythene sheet on a frame placed 6 inches above materials (situations) could be attributed to increment in minimum and maximum temperature beneath polythene structure (4.5/ 3.7°C) compared to polythene cover (3.2/ 3.0°C) and control. Hence, it is always advantageous to take up sowing of seeds in early August-September for enhancing germination. Late sowing which would synchronize with winter temperature should be avoided.

8. Seed rate and Sowing

The seed rate commonly adopted is 2-5 g per square meter of germination bed for raising 10 months old seedlings and 10 g for raising 18 months old seedlings (Anonymous 1976; Anonymous 1986). Seeds are either broadcasted or sown in lines, usually not more than 1 cm deep. Rows are spaced 15 cm apart and seeds are sown 1-2 cm apart within row. Deep sowing of seeds should be avoided for better and quick germination. Seed beds are to be dusted with any suitable insecticides to prevent termite attack. Line sowing is always preferable as against broadcasting of seeds where there is a chance for the overcrowding of seedlings after sprouting which lead to heavy mortality when damping off disease appears. After sowing the seeds, beds are covered with a thin layer of fine sand or soil and pressed gently with wooden plank. Beds are watered daily. Germination will commence in about 30 days and may continue for a month or two. The mulch materials are removed soon after the commencement of germination. The young seedlings are to be protected against exposure to sun and rain by providing shade pandals over the germination beds (Anonymous, 2003).

9. Mulching of nursery beds

Use of mulches on the nursery beds has a profound influence on germination (Abraham 1958). The beds covered with paddy straw recorded highest germination (40.82%) when seed were sown in September (Korikanthimath 1981). Treatment of seeds with concentrated nitric acid increased the percentage of germination 60 days after sowing from 8-16% and this further increased to about 60% by the mulch treatment with coconut coir dust, paddy straw or goose berry (*Phyllanthus emblica*) leaves (Mayne, 1951 ; Sulikeri and Kololgi, 1978 ; Korikanthimath, 1983). Among the various mulches, paddy straw is most desirable as it is economical and locally available. Potagrass (*Granotia stricta*) is commonly used in Kerala.

Germination will commence in about 30 days and may continue for a month or two even later. The nursery beds should not be covered with *pandal* till the commencement of germination. Exposure of beds to sun after mulching followed by irrigation would enhance germination due to local build up of increased (higher) temperature. The emphasis placed on leaving the beds exposed to the sun in the early stages suggests that the temperature is probably a vital factor in satisfactory seed germination (Mayne, 1951). The mulch materials are removed soon after the commencement of germination. The young seedlings are to be protected against exposure to sun and rain by providing shade *pandals*.

10. Major pests and diseases in nursery and management

Major diseases observed in the nursery are - leaf spots, damping off/seedling rot and leaf rot.

A. Diseases

a. Primary nursery - leaf spots

Primary nursery leaf spot caused by, *Phyllosticta elettariae* is a destructive disease in nurseries. The disease makes its appearance during the months of February- April with the receipt of premonsoon showers. The disease initially manifests as small dull white round to oval spots, which later turn necrotic and leave a hole (shot hole) in the center of necrotic area. The spots may be surrounded by water soaked area. The disease is more severe in open nurseries exposed to direct sunlight. However, the seedlings develop tolerance as they pickup growth.

The disease can be contained by undertaking the following management measures:

- Sowing of the seeds may be undertaken during August September to ensure sufficient growth of seedlings so that they develop tolerance to the disease.
- Provide adequate shade by providing overhead *pandals* with coir mat/agro- shade nets/ thatched coconut fronds etc.
- Prophylactic spraying with fungicides such as mancozeb (0.2 %) may be resorted on the leaves. First spray is to be given during March-April, depending on the receipt of summer showers and subsequent sprays at fortnightly intervals. Two to three rounds of spraying may be given.
- Clipping and destructing of severely affected leaves after spraying is to be done to arrest further spread to the remaining healthy plants.
- Avoid raising nursery continuously in the same site.



b. Secondary nursery leaf spot

In secondary nurseries, another type of leaf spot incited by *Cercospora zingiberi* is of common occurrence. The disease is characterized with the formation of yellowish to reddish brown coloured rectangular patches on the lamina which run parallel to the veins. In the advanced stages, the lesions assume muddy red colour. Prophylactic spraying with mancozeb (0.2 %) on the foliage effectively prevents the incidence and subsequent spread of the disease.

c. Nursery leaf rot

Normally seedlings of three to four months old are more vulnerable to this disease. The disease, which is of limited occurrence in the nurseries, is caused by *Fusarium* sp. and *Alternaria* sp. The symptoms include formation of water soaked lesions on the leaves which later becomes necrotic patches leading to decay of affected areas. Usually the damage is more pronounced on the leaf tips and distal portions of the foliage. Under favourable conditions, rotting extends to petiole and leaf sheaths also. Avoiding excessive watering in the nurseries prevents initiation and further proliferation of the disease. When the disease is noticed in the nurseries, spray the seedlings with carbendazim (0.2%) twice at 15 days interval after destroying the affected plant parts.

d. Damping off or seedling rot

The disease appears usually in the nurseries during rainy season and accentuated excess soil moisture due to inadequate drainage facilities. The disease is caused by soil-borne fungi such as *Pythium vexans* and *Rhizoctonia solani. Fusarium oxysporum* also causes similar seedling rot, resulting in the wilting and withering of entire seedlings. In the initial stages of disease development, the leaves turn pale with yellowish tips. Gradually, the symptoms spread over the entire leaf lamina, extending to leaf sheath and result in wilting of seedlings. The collar portion decays and the entire seedlings collapse. In mature seedlings, rotting extends from the collar region to the rhizomes resulting in decay and ultimate death of the plant. To contain/ control the disease resort to following operations

- In primary nurseries, practice thin sowing to avoid overcrowding of the seedlings.
- Prevent water stagnation by providing adequate drainage facilities.
- Remove affected seedlings and maintain proper phyto sanitary measures in the nursery.
- When infection is noticed, drench the nursery beds with copper oxychloride (0.2 %).
- Pre-sowing treatment of seeds with antagonistic bio control agents such as *Trichoderma* or *Pseudomonas* protect the seedlings in the early stages of growth. Application of *Trichoderma* at 100 grams per square meter of the bed also helps in reducing the disease spread.

B. Pests

a. Pest Management in nurseries

In nursery stage seedlings are affected by cut worm, shoot borer, root grub, leaf thrips and root knot nematode. Root grubs and root not nematode pose more problem in two season nurseries. To manage whole pest complex the following measures are to be followed at various stages of nursery.

b. Cultural Practices

Raise nurseries away from main plantations to reduce possibilities of infestation and reinfestation from the nearby infested plantations.

Provide sufficient organic manures to encourage better vegetative growth.

- Shift nurseries repeatedly to overcome soil- borne pest problems like root knot nematodes and root grubs.
- Catch and destroy the beetles of root grubs using insect nets especially in two season nurseries.
- Collect the cut worms hiding in the mulch in the affected area and destroy.

c. Chemical control

Insecticides like quinalphos (0.05%), fenthion (0.075%) or dimethoate (0.05%) may be used to tackle the pest problem. The sprays may be undertaken at monthly intervals starting from rapid tillering stage. In the old nursery sites, exposed sandy loam areas and two season nurseries root knot nematode assume severe proportion. Apply one round of carbofuran or phorate at 30-40 g/ m^2 in one season nursery at rapidly tillering stage and apply two rounds of granular insecticides to two season nurseries at three monthly intervals. Application of granular insecticides at three monthly intervals is highly essential to protect the underground and sub-aerial parts in clonal nurseries (Gopakumar and Chandrasekar, 2002)

II. Secondary Nursery

There are two methods of raising seedlings in secondary nursery. They are bed and poly bag nurseries. In Kerala and Tamil Nadu region, the seedlings are transplanted to secondary nursery beds when they are about 6 months old, where raising of seedlings both in primary and secondary nursery are commonly followed. Whereas in Karnataka, the old practice of sowing seeds in the primary nursery and thinning out excess (crowded) seedlings and allowing seedlings to grow right in the same nursery is followed. Where seedlings were not transplanted into fresh beds, there was a considerable complaint of nursery losses from disease. This obviously suggests that overcrowding is an important factor, damaged by nursery leaf spot and damping off disease (Mayne, 1951). The experiment conducted by Korikanthimath (1982) have clearly revealed that following of both primary and secondary nursery practices would be more ideal to get vigorous seedlings attaining a minimum of 4-5 strong tillers within a span of 10 months itself.

1. Preparation of seed beds

Prepare beds as in primary nursery. A layer of powdered cattle manure and wood ash may be spread on the bed and mixed with soil before transplanting.

On an average, 10 secondary beds are required for transplanting the seedlings from one germination bed. A mixture of powdered cow dung and wood ash is spread over the secondary beds before transplanting. Beds for transplanting are prepared in the same way as for primary nursery seed beds although there is frequently the adoption of more compost or pulverized cattle manure.

2. Leaf stage and spacing

The time at which transplanting takes place depends very largely on the time at which seeds are sown. In Karnataka, where seeds are sown during August-September, transplanting takes place in November-January. In Kerala and Tamil Nadu states, the seedlings from primary beds (4-5 leaf

stage) are transplanted to secondary nursery beds during June-July at a spacing of 20 x 20 cm. Studies conducted Cardamom Research Centre, Appangala, Kodagu, Karnataka on the optimum spacing and size (leaf stage) of seedlings for transplanting in secondary nursery revealed that, rate of mortality was found to be maximum when transplanting was done in the 2^{nd} leaf stage (25.4%) as against 5th leaf stage (1.09%). Transplanting seedlings at 5-6th leaf stage is more ideal as the seedlings in the primary nursery would put up strong, sturdy and adequate growth and could withstand transplanting shock. Korikanthimath (1982) reported that the number of tillers produced per seedling was significantly more in wider spacing (11.92) by following 30 x 30 cm spacing followed by 22.5 x 22.5 cm (9.24) and 15.0 x 15.0 cm (7.29) respectively. Rate of mortality was higher when transplanting was done in second leaf stage. It can be minimized by transplanting at four-five leaf stage. However, taking into consideration that vast area and expenditure involved in raising nursery by transplanting seedlings at 5-6 leaf stage at a spacing of 15 x 15 cm may be followed.

3. Fertilizer

The broad uptake ratio worked out for pre potent plants was 9:1:17::N:P:K, respectively. Based on the above observation it is quite evident that cardamom plant requires more of potassium. Nitrogen and phosphorous are needed in comparatively lesser extent (Korikanthimath et al., 2001). A well decomposed compost, cattle manure and fertilizer top jungle soil may be used for application to each nursery bed @ 8-10 kg (2.5 x 1.0 m) both in the primary and secondary nursery. Since considerable amount of nutrients are removed by the seedlings, it will be necessary to apply fertilizers in secondary nursery. It is found that as much as 120 g nitrogen, 20 g phosphoric acid and 300 g potash, 50 g magnesium and 75 g calcium are removed on an average from a bed of 100 seedlings. To promote uniform growth 250 g mixture made of 92 parts of 17:17:17 and 8 parts of Zinc sulphate dissolved in 10 litres for 1000 plants may be sprayed once in 15-20 days starting after one month of transplanting (Anonymous, 1990). Regional Research Station, Mudigere, recommends NPK mixture at the rate of 160 g per bed one month after planting. This is to be increased by 160 g every month until a maximum of 960 g per bed is reached. The proportion of NPK is one part urea, two parts superphosphate and one part murate of potash, (Anonymous, 1979). At Cardamom Research Centre, Appangala, Korikanthimath (1982) observed that application of 45 g N, 30 g P₂O₅ and 60 g K₂O per bed of 2.5 x 1 M size three equal splits at an interval of 45 days would result in better growth and higher number of tillers. The first dose of fertilizer may be applied after 30 days of transplanting in the secondary nursery. Application of Diammonium phosphate (DAP) along with murriate of potash is found to be beneficial for tiller and root production (Anonymous, 1989). Sufficient mulch should be applied after planting as in the case of primary nursery.

4. Erection of *pandal*

Once the seeds germinate which normally under most favourable circumstances is after about a month, the beds must be shaded from the sun. To protect the seedlings from sun, shade has to be provided by erecting a pandal. Overhead *pandal* is preferred to an individual bed *pandal* as it provides uniform filtered sun light and facilitate watering, spraying and other cultural operations. Overhead *pandal* should be erected at least at a height of 2 m for easy movements. Locally available wooden poles bamboo or granite poles may be used for erecting the *pandal*. Normally nursery poles are placed at 3-3.5 m apart. The top of the *pandal* is either covered with network of G.I. wire or with jungle wooden reeper/ rafters. Covering overhead *pandal* with coirmat is most preferable as it allows sufficient filtered sun light which enables adequate growth and production of tillers per plant. Coir mats with half an inch is recommended (Anonymous, 1986). The coirmat may be sprayed with 1% Bodeaux mixture before placing on top of *pandal* to minimize the

damage due to fungal infection. However, locally available covering materials like tree twings (foliage) of Jackate (*Birucaspus longue Roxb*) which will not shed its leaves, knetted coconut fronds and arecanut leaves may be used economically. It is important to avoid dripping from the *pandal* in wet weather as the young plants are tender and easily damaged. Slant pandals are most ideal in cardamom nursery. On the slant *pandals* there is no scope for rain water to accumulate and drop on the leaves of young plants as the rain water flows down the *pandal* and away from the seedlings. This kind of slant *pandals* can be erected both in small (farmer estates) and large commercial nurseries and either for individual beds or for two or three beds together. It is advisable to erect slant *pandals* of 45° angle on the nursery beds to save plants from severe attack of fungal diseases and to obtain healthy cardamom seedlings for planting in estate (Parameshwara *et al.*, 1979). The cover material on *pandal* may be removed immediately after onset of regular monsoon to avoid falling of *pandal* due to over weight on account of absorption of moisture and to allow sunlight during cloudy rainy weather.

5. Irrigation and Drainage

The nursery beds should be irrigated twice a day immediately after planting upto 8-10 days, thereafter once a day upto 30 days. Once the seedlings establish and putforth new growth, watering may be resorted on alternate day till the receipt of monsoon showers. Flood and flash irrigation should be avoided as it may accentuate the problem of damping off and leaf spot diseases. Adequate drainage should be provided to avoid stagnation of water particularly in the low lying areas during monsoon by providing central and lateral drains.

6. Weeding

Hand weeding may be resorted once in 20-25 days to keep the nursery beds free from weeds. The weed growth will be smothered once the seedlings attain sufficient growth.

7. Earthing up

The top soil between the rows of cardamom seedlings would normally get washed out and deposited in the pathways provided between the nursery beds. Scraping of the soil deposited from pathways and application in a thin layer upto collar region may be taken up two months after transplanting seedlings in secondary nursery. Application of the fertile soil collected from jungle along with cattle manure would be much more beneficial. Earthing up may be takenup immediately after split application of fertilizer as mentioned above. This should help in replenishment of fertile soil, strong anchorage enhanced tillering and vigorous growth of seedlings.

8. Rotation and fallow of nursery site

Normally it would be ideal to change or shift the nursery site once in 2-3 years to avoid the buildup of insect/ pests by using the same site repeatedly over a period of time. Where the shifting of nursery site is not possible due to non availability of alternate site, as it normally happens in case of departmental nurseries it would be better to follow the rotation of land with green manure crops like Daincha, Sesbania or Sunhemp and raising of cardamom seedlings. Green manure crops should be ploughed back and incorporated in the soil once in two years and then the cardamom seedlings may be raised. The practice of leaving part of the area fallow after deep digging/ ploughing for a year would help in exposing of insect/ pests to sun and bringing down the inoculums built up in the nursery site during the previous years.

By following the cultural practices regularly, the seedlings would be ready for transplanting in the main field (plantation) after 10 months of sowing the seeds. Raising of seedlings in the primary



nursery and later transplanting them to the secondary nursery is found to be more advantageous as it facilitates better establishment and initiation of adequate number of suckers per plant.

III. Raising of seedlings in paddy fields

The survey conducted in Coorg, Hassan and Chickamagalur district of Karnataka revealed that most of the small and marginal farmers raise cardamom nursery in paddy fields (wet lands) as water is easily and abundantly accessible. Sufficient drainage needs to be provided both in and around the nursery to avoid water stagnation during monsoon. Beds are separated by deep channels into which naturally available water is run. This ensures moisture supply but as soils are frequently heavy, there is some risk of excessive moisture in the soil (Mayne, 1951). These areas which normally possess sandy loam soils facilitate better root development and adequate growth of seedlings.

IV. Dry nursery

Dry nursery is followed in plot system of cardamom cultivation. This is popularly known as "*Malai* Cultivation" of cardamom in Kodagu district of Karnataka. The protection offered by the forest belt is also congenial it is possible to raise cardamom nursery in small plots without erecting any overhead *pandal* and watering. As no watering involved the nursery is known as "Dry Nursery". The nursery operations are very limited. The maintenance of dry nursery is very cheap as there is no need for watering or overhead pandal. The leaf litter is heaped up and seeds of cardamom are broadcasted after the first or second showers of summer rain in March or April (Mayne, 1951). The seeds are raked into the soil and the surface is covered with leaf mould and thin layer of leaves. The branches of shade trees are cut to regulate shade. The hand weeding is carried out after the germination. Before the end of monsoon, jungle soil is applied as a thin layer and the beds are adequately mulched with leaf litter. The seedlings withstand the drought while growing. Seedling are planted in the field after attaining sufficient growth as is the case with other conventional and common methods of raising seedlings.

V. Poly bag nursery

Transplanting seedlings at 4-5 leaf stage from primary nursery to the poly bag nursery is more suitable (Ankegowda, 2008). Black polythene bags of 20 x 20 cm size and thickness of 100 gauge provided with 3-4 holes at the bottom can be used for raising cardamom seedlings. Bags may be filled with nursery (pot) mixture in the ratio of 3:1:1 of jungle top soil, farm yard manure and sand. The bags are arranged in rows of convenient length and breadth for easy management. At later stage in between the bags adequate space may be provided for better tillering. The advantage of raising seedlings in polythene bags are – seedlings of uniform growth and tillering can be obtained, nursery period can be reduced to five to six months after transplanting seedlings in the main field. Cardamom plants from secondary nursery or poly bags can be transplanted to the main field during last week of May after receipt of pre-monsoon showers or the first week of June soon after commencement of south west monsoon.

9. Age of Seedlings for Field Planting

Generally comparative success of establishment in the estate (plantation) and the raising the seedlings should be given due consideration while recommending one season (10 months old) or two season (18-22 months) old seedlings. One year old seedlings can profitability be planted in estates, when vigorous seedlings are raised in nurseries (Kasi and Iyengar, 1961). However, it is generally observed felt that 10 months old seedlings may be suited for new planting with a well developed rhizome perform well in Karnataka would be more suitable for gap filling which can withstand the competition. Seedlings of 18-22 months old are usually preferred for planting in Kerala, Tamil Nadu region where the Mysore and Vazhukka which are robust in growth are cultivated.

VI. Vegetative Propagation

The vegetative propagation method is simple, reliable and facilitates easy multiplication of selected clump or type. Plants raised from rhizome come to bearing earlier than the seedlings raised from seeds. Vegetative propagation is advantageous in areas where 'Katte' disease is not a problem. Variability in cardamom being very high a study to evaluate the yield and the cropping behavior of cardamom in the field trials over a population of 764 plants obtained from 78 selections was conducted during 1962-64 (Krishnamurthy, et al., 1989). As it was found that nearly 36 per cent of the plants in a plantation only bear heavy yield it was possible to step up production of cardamom by stocking plantation with high yielders and by roguing out medium and poor yielders. The high degree of variability in yield high percentage of plants of poor yielders in the seedling population necessitates selection of clone for getting uniform and increased yield in cardamom. In this background the vegetative propagation assumes a greater significance in multiplication (generation) of high yielding plant material for planting on a larger areas. The vegetative propagation can be resorted to both by macro *i.e.,*, rhizome propagation through rapid clonal multiplication with intensive care and micro propagation by tissue culture. Though cardamom can be propagated both vegetative (micropropagation and clonal) and through seeds, large scale propagation of cardamom was mostly through seeds during earlier years. Since production of heterogenous progeny is an inherent problem, an attempt was made on selection of elite clones, evaluation both in clonal nursery and main field. A simple and reliable rapid clonal multiplication technique was developed.

A. Clonal (Macro/Rhizome/Sucker) Propatation

Vegetative propagation can be resorted by macro propagation i.e.; using rhizomes for propagation under intensive care in the field and micro propagation by tissue culture which deals with meristem and callus under asceptic conditions. Mass multiplication of high yielding cardamom plants (micro propagation) through tissue culture, has been commercialized by several firms. However, the cost of these plants is high and not within the reach of small and marginal growers who constitute nearly 70 per cent of the cardamom farming community. Moreover cardamom is highly location specific. In view of these practical problems, development of a rapid clonal multiplication technique is felt most necessary. Suckers from elite clones can be used for establishing plantations capable of high productivity. Suckers should not be used in areas where katte and other virus diseases (such as Kokke kandu and Niligiir necrosis) are common.

a. Rapid of clonal propagation in cardamom

High yielding varieties/selections are generally multiplied in isolated clonal nurseries. Virus free high yielding plants are selected and subcloned for further multiplication. For rapid multiplication following timely agro techniques has to be followed

1. High yielding plants free from pest and diseases, with characters like bold capsules and retentivity of green colour are to be selected from plantations and part of the clump has to be uprooted for clonal multiplication leaving the mother clump in its original place to induce subsequent suckers for further use.



- 2. The minimum planting unit consists of one grown up sucker (rhizome) and a growing young shoot.
- 3. Trenches having width and depth of 45 cm and convenient length have to be opened filled with jungle soil, compost and topsoil.
- 4. The rhizomes (planting unit) are placed at a spacing of 1.8 m x 0.6 m in trenches, thus accommodating 9259 plants per hectare of clonal nursery area.
- 5. Pandal protection, regular watering (once in a week during November to May) and chemical manure @ 48:48:96 g. NPK per plant in two splits have to be applied.
- 6. On an average 32 42 suckers will be produced after 12 months of planting per one planting unit. Taking the barely minimum of 50% of these suckers/clump one can get 16-21 planting units (one grown up sucker along with a growing young shoot *i.e.*, sucker) from one mother-planting unit after 12 months.
- 7. In an area of 1-hectare clonal nursery 1,48,144 to 1,94,439 planting units can be produced after 12 months.
- 8. Clones thus produced should be free from virus, rhizome rot and root knot nematodes.

(Korikanthimath, 1999 a).

b. Multiplication technique

Rapid clonal multiplication of elite cardamom clones consisted of selection of elite clones, multiplication in trench method of planting with high density (1.8 m x 1.6 m), monitoring of mother clumps from plantation, adoption of precision farming practices *viz.*, selection of suitable site, land preparation, planting the trenches, providing over head shade by locally available shade tree twigs which do not shed leaves, timely plant protection, adoption of appropriate timely cultural operations, uprooting of clumps at the end of 10 months and separating each planting unit (containing the grown up sucker along with a growing young shoot) for further planting in the field for large scale cultivation with genetically elite planting material and economic analysis.

The rate of multiplication of planting material *i.e.*, rhizome containing a grown up sucker along with a growing shoot, was 1:20 (as against 1:9 in the plantation where suckers are normally used for gap filling, under overhead shade trees) within a short span of 10 months as 9,260 planting units were obtained from 463 mother clonal units in an area of 0.05 ha. The pseudostem with swollen base along with its food storage organ *i.e.*, rhizome serves as a new planting unit under macro propagation. This technique is simple, reliable and economically feasible technique for production of quality planting material. It can be easily adopted by farmers right on their own plantations as most of the estates are still inaccessible and spread over in far flung interior ever green forests (Korikanthimath, 1995; Korikanthimath, 1997). At the end of 20 months, a total of 14,816 planting units (each planting unit consisting of a grown up sucker along with a growing young shoot) were produced from an area of 0.05 ha, starting from 463 mother planting units accommodated in the clonal nursery. The rate of multiplication of planting material was 1:32 at the end of 20 months besides resulting in early bearing and contributing to substantial yield. A remarkable yield of 90.29 kg dry cardamom per 0.05 ha was obtained within a short span of 20 months in the high density planting (1.80 x 0.6 m) in clonal nursery. This worked out to be 183.14 g dry cardamom per plant besides generating 32 planting units per mother rhizome.
B. Micro Propagation (Tissue Culture)

Although cardamom is one, of the important plantation crops no work reported on Tissue Culture upto 1980. Only one report on callus induction and organ differentiation from seedlings (Srinivasa Rao *et al.*, 1982) was brought out in 1982 but this did not contain details on transfer of plants to field. Tissue Culture work in cardamom was initiated and technique perfected at ICAR-Central Plantation Crops Research Institute, Kasargod and ICAR-Indian Institute of Spices Research, Calicut, Kerala and Cardamom Research Centre, Appangala, Madikeri, Karnataka. Multiplication of virus resistant and high yielding plants at a faster rate can be achieved by Tissue Culture than can be done by the conventionally used methods.

Three types of explants are found to be economical for culture. They are tender vegetative buds, tender inflorescence and floral raceme. Detailed protocol for multiplication of cardamom by using vegetative buds, immature panicles and floral recemes has been standardized. Quite a number of private Bio technology laboratories in India have taken up the micro propagation of cardamom by resorting to tissue culture with high yielding lines/ selections.Extremely efficient methods for in vitro clonal propagation of cardamom are available (Nadagauda et al., 1983; Priyadarsan and Zachariah, 1986; Vatsy et al., 1987; Regunath and Gopalakrishnan, 1991). Kumar *et al.*, (1985) reported the successful conversion of immature floral buds to vegetative buds and subsequently to plantlets.

a. Plant Regeneration from callus cultures

Plant regeneration from callus cultures of cardamom was reported (Rao *et al.*, 1982, Priyadarsan and Zachariah 1986, Nirmal Babu *et al.*, 1997). Variability could be noticed among the somaclones for the morphological characters in the culture vessels itself. A few somaclones tolerant to 'Katte Virus' were identified (Peter *et al.*, 2002).

b. Raising Tissue Culture Seedlings before planting in the field

On a commercial scale the hardened rooted tissue culture plantlets of 4-5 leaf stage with a well developed root system from Tissue Culture Laboratories are supplied to growers in egg trays or in individual plastic cubicles (pots). On an average 5-6 thousand such seedlings can be transported in a Jeep. After transporting to the site of planting *i.e.*, estates, these plantlets are further transferred to polythene bags (perforated) of 20 x 20 cm containing nursery pot mixture of jungle top fertile soil, sand and cattle manure in 1:1:1 proportion or directly transplanted in the raised bed nursery at 21 x 21 cm apart for better establishment and inducing of suckers (tillers). It would take about 6-9 months to get these seedlings ready for planting in the main field.

Large Cardamom

Propagation of large cardamom is done through seeds, rhizomes (sucker multiplication) and tissue culture techniques. Cultivars suitable for specific areas, altitudes, agro climatic conditions and mother plant/clump of known performance are selected for collection of seed, rhizome and vegetative bud.

A. Propagation through seeds

Healthy plantations free from viral disease with high yield are selected for seed capsules. Spikes are harvested at maturity and seed capsules collected from the lowest two circles in the spike. After dehusking, the seeds are washed well with water to remove mucilage covering of seeds, mixed with wood ash and dried under shade. The dried seeds are treated with 25 % nitric acid for 10 min for early and higher percentage of germination (Gupta, 1989). The acid treated seeds are



washed thoroughly in running water to remove the acid residue and are surface dried under shade. The seeds are sown immediately after acid treatment. Once the seedlings in the primary seed bed reach 3-4 leaf stage (in February/March) if the seeds are sown in September /October or April/May if the seeds are sown in (February/March) they are transplanted either to poly bags or into secondary nursery beds in February/March or April/May respectively (Gupta, 1989). Raising of primary nursery and secondary nursery /poly bag nursery are similar to small cardamom.

B. Propagation through suckers

1. Selection of planting material

High yielding disease free plantations are to be selected. The plantation should have high yield record *i.e.*, more than 800 kg/ha for at least three consecutive years. One mature tiller with two immature tillers or vegetative buds is used as planting unit.

2. Nursery site selection

The nursery should be about 500 meters away from the main plantation to avoid occurrence of pests and diseases. The irrigation facility should be available in the nursery. It should be easily accessible by road. Sloppy land is not suitable for nursery establishment.

3. Preparation of trenches

The trenches should be of 45 cm width and 30 cm depth with convenient length and may be made across the slopes of the field. Top soil (15 cm depth) to be kept separately from the trench in the upside. Below side (15cm depth) soil to be forked thoroughly. Dried leaves to be applied as layer in the trench first. Then the trench to be filled by top soil mixed with cow dung compost. Spacing of 30 cm is required in between two trenches. The planting units to be planted at a spacing of 45 cm in proper staking (Gudade *et al.*, 2013).

4. Pre treatment with bio- agents

Sikkim being an organic state, only eco friendly and non chemical measures should be adopted. Suckers may be treated by dipping in 5% solution of *Trichoderma* sp. */Pseudomonas fluorescens* and *Bacillus subtilis* for 30 minutes before planting in trenches as a prophylactic measure.

5. Time of planting

Planting can be done during last week of May to June. It should be done as early as possible so that maximum number of planting units could be generated for the subsequent season.

6. Maintenance

Thick mulching with dry leaf / grass may be applied at the base of plant and watering may be done during November to March depending on the soil moisture condition. Well decomposed cattle manure may be applied. The plot may be maintained with 50% shade under shade trees or using agro shade net. The disease and pest incidence to be looked from time to time. Disease affected plants to be uprooted and to be destroyed outside the sucker nursery. Spraying and drenching with 5% solution of *Trichoderma* sp./ *Pseudomonas fluorescens* and *Bacillus subtilis* in sucker nursery may be carried out once in three months starting from May-June, August- September, December-January. With proper management, a minimum of 5 planting units could be obtained from a single plant. Monitor the nursery once in a month and ensure water drainage. Weeding may be done, if necessary (Battarai *et al.*, 2013).

C. Micro propagation

Large cardamom can be multiplied on a large scale through micropropagation. Protocols for micro propagation were developed at Indian Institute of Spices Research (Sajina et al., 1997 and Nirmal Babu et al., 1997) Auxiliary buds of 0.5-2cm lengths from promising, virus disease free mother plants are used as explants. The explants were thoroughly washed in clean running water and then in a detergent solution and treated in 0.15 per cent HgCl₂ for 2 min and then passed through absolute alcohol for 30 sec. These are cultured using the modified MS Medium, solidified with agar and with different adjuvant. Nirmal Babu et al., (1997) and Sajina et al., (1997) accomplished both multiplication of shoots and rooting in the same medium, in MS basal+BAP (1mg/l) and IBA (0.5mg/l) with 3% sucrose and gelled with 0.7 percent agar at pH 5.8 and 12 h photoperiod at a light intensity of 2500 lux. This combination produced 8-12 shoots per culture and roots per shoots. Sushen Pradhan et al., (2014) reported that the shoot tip as explants of Ramsay responded well and it was found to be the best explants for the production of disease free planting materials. They tried 52 different hormone concentrations using MS medium. The shooting and the rooting of the explants were better and faster with more number of healthy shoots, leaves and proper growth regulator on different concentration. The best medium was modified MS medium fortified with BAP 3 mg/l +NAA 0.5 mg/l and sucrose 40g and for the formation of both multiple shoots and roots and successfully 100 % acclimatised plantlets were transferred into fields.

Conclusion

There is not much of area expansion both in cardamom(small) and large cardamom, in fact the area under cardamom has come down from 1,00,000 ha. to 73,000 ha. in the recent years due to disturbing natural evergreen forest eco system and the traditional cardamom area being replaced with other high value crops like pepper mix cropped with coffee, etc. in South India. Hence, it is imperative to enhance productivity by using quality planting material (QPM) and bring down cost of production of cardamoms so as to remain competitive in the International market besides meeting the growing demand in India itself. One of the reasons for low productivity in cardamoms is the propagation through seeds. The inherent drawback of this method is the production of heterogeneous progeny which is genetically not uniform due to natural cross pollination. Cardamom can be propagated both vegetatively by macro-clonal or rhizome multiplication, micro propagation (tissue culture) and through seeds. Large scale propagation of cardamom was mostly through seeds during earlier years. Over three decades of research, it is amply proved that it is possible to step up productivity and production by stocking the plantation with high yielders through clonal propagation.

Clonal multiplication ensures genetically uniform planting material true to the parent. Vegetative propagation can be resorted by macro propagation i.e. using rhizomes of elite clones with not only high yield but also resistant/ tolerant to biotic and abiotic stress, under intensive care in the field (clonal nursery) and micro propagation by tissue culture which deals with meristem and callus under asceptic conditions. Mass multiplication of high yielding cardamom plants (micro propagation) through tissue culture, has been commercialized by several firms. However, the cost of these plants is high and not within the reach of small and marginal growers who constitute merely 70 per cent of cardamom farming community. Moreover cardamom is highly location specific. In view of these practical problems, development of a Rapid Clonal Multiplication Technique is felt most necessary to select the high yielders in the farmers plantations/ estates itself to generate the quality plant material for further expansion of the area and also replanting with genetically superior line.



Scientific and systematic nursery practices both in primary and secondary would ensure healthy and vigorous cardamom seedlings. In case of large cardamom, raising of primary nursery and secondary nursery/ poly bag nursery are similar to small cardamom. Both cardamom and large cardamom can be multiplied on a large scale through micro propagation (tissue culture) by using elite clonal materials. A large number of cardamom farmers in Kerala have taken up cultivation of cardamom by clonal propagation of superior selections in almost over 90% of the plantations with a record yield of 2500 kg (dry/ha). The rapid clonal multiplication is thus most reliable, cost effective and can be easily followed by farmers right in their cardamom plantations. The efforts made by several cardamom growers in making their own selections of elite lines and multiplying them for further planting on a large scale is most commendable.

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Protected cultivation for production of quality planting material in spices

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Introduction

Spices are the pride crops of India. These crops bear high value, and also possess huge export potential. The present productivity levels can be enhanced many fold by providing quality planting material of improved high yielding varieties of vegetatively or seed sown crops. But production of quality and healthy planting material is a major challenge under changing climate scenario. Open field production of planting material of these crops or nursery raising is highly affected by viruses, disease or pests which reduces the quality of planting material or seeds. In this modern era of hi-tech farming, protected cultivation technologies are available that can assist in producing disease free healthy quality planting material for strengthening the seed chain for enhancing the production potential of spices in the country. The major factors which deteriorate the quality of planting material are biotic and abiotic stresses, hence for their effective management various protected technologies are highly relevant and efficient which can be used by the growers or nursery houses. A brief description of the models and practices of protected cultivation are mentioned below for production of quality planting material in spices.

Protected cultivation for production of quality planting material

Biotic stresses are mainly caused by pathogenic microbes or insect/pests. In spices soil and air borne diseases and pests are of high significance. Production of disease free planting material is very crucial aspect for enhancing national production and productivity. In spices crop like black pepper, cardamom, ginger, turmeric and tree spices nursery raising is required to develop seedlings for large scale plantation, hence production of disease and virus free planting material is very much essential. For production of disease/virus free planting material protected cultivation technology can be very effective mainly for management of soil borne problems and virus infestation. Nursery raising under protected structures can also help in management of insect/pest incidence on young seedlings. Soil borne problems can be better managed by use of disease free soils or sterilized soilless media and also by minimizing the pathogen inoculums load in the soil of nursery beds. These strategies can be implemented effectively under protected conditons. Soil solarisation using transparent polythene sheets during hot summer months reduces the pathogenic load in the soil; hence for traditional nursery raising practices on raised or flat beds soil solarisation can be used. In crop nurseries wherein plug tray raised seedlings can be transplanted better, artificial disease free sterilized soilless media like coco-peat etc can be effectively used. These nurseries are generally laid in open field under humid conditions, which provides open

space and climate for the pests to infest the crop and also to multiply. Hence, insect proof net covered double door model of nursery houses can be used for raising healthy seedlings, in these structures cover of insect proof net will not allow entry of virus vector insects like whitefly, aphid, thrips, mealy bugs etc., therefore a control over the viral disease is also possible. Soil solarisation is also an effective tool for control of coriander stem gall, which an important seed is borne disease of coriander effecting both yield and quality of seed. Plastic mulching is also effective in reducing the humidity status in the crop canopy which in turn reduces the chances of air born disease infestation.

Spice Crop	Disease	Causal organism	
Black Pepper	Basal wilt	Scleotium rolfsii	
	Stunting disease	Virus (Vector: aphids and mealy bugs)	
Cardamom	Damping off (Rhizome rot)	Pythium vexans, Rhizoctonia solani	
	Viral disease	Cadamom mosaic virus (Vector: aphids)	
Ginger	Bacterial wilt	Pseudomonas solanacearum	
	Rhizome rot	Fusarium spp., Pythium spp., Rosellinia spp	
Turmeric	Rhizome rot	Pythium graminicolum	
Cumin	Alternaria blight	Alternaria burnsii	
Coriander	Stem gall	Protomyces macrosporus	
Fennel	Ramularia Blight	Ramularia foeniculi Sibilla	

Table 1. Major disease in important spices which affects seedling or seed quality

Protected cultivation against abiotic stresses for production of quality planting material:

Abiotic stress like temperature fluctuations, untimely rains, hailstorms etc., causes significant damage to the planting material and also to the seeds. Spices are cultivated in the humid, subhumid and dry conditions of the country depending upon the crop. In the sourthern peninsula of India covering western costal regions, the rainfall average is high, hence it creates unmanageable situation for management of the nursery of spice crops. In these conditions naturally ventilated green houses or poly houses having high level of natural ventilation covered with plastic can provide rain proof shelters for the seedlings. Site selection of nursery is also important, the site should not be low lying to avoid water stagnation. In sub-humid and dry regions of northern and western India problem of untimely winter rains, frost and hailstorms is commonly observed. Hence for safe guarding the crops from these abiotic factors insect net covered or plastic covered walk in tunnels, use of anti-hail nets can be very effective. Frost can be effectively managed by raising vertical plastic walls of 1-2 m height perpendicular to the direction of wind. These barriers block the cold breeze and helps in reducing the chances of frost damage in the early hours in crops like cumin, coriander, ajwain, anise etc. Nowadays unwoven film sheets are also available, these sheets can also be used instead of plastic sheets. The protected structures not only provide shelter for the crop against temperature, rains but it also limits pest incidence to an extent, in cross pollinated crops like coriander, ajwain, celery, dill etc., the protected structures should not be packed to block entry of honeybees as this will drastically reduce the pollination percentage and in-turn seed yield.



Recent advances in Protected Cultivation in Seed Spices

Seed spices are crops mainly cultivated in the western arid and semi arid regions of the country. These crops faces tremendous pressure of weeds in the initial growths phase. In the recent years, studies have shown that crops like coriander, fennel, dill, celery and anise can be raised easily by seedling propagated under plug trays. These seedling of 50-60 days in age can be transplanted over raised beds equipped with drip fertigation and plastic mulch. Celery crop is generally grown in the northern plains, in the western semi arid conditions its adaptability is poor, because of which the plants doest yield high, but a single intervention of plug tray nursery raising has made the crop to yield high under semi arid conditions of Rajasthan. These interventions of nursery raising in seed spice crops are innovative and will help in increasing the per unit productivity level of per unit area as the time taken by these crops for initial establishment is high, therefore, a nursery plant of 50-60 days in age can help in taking long duration kharif crops like cotton, maize etc in these regions.

Seed spice crops are mostly cross pollinated in nature, the maintenance of genetic purity of seed material is also critical and crucial in progressing seed chain. The nucleus and breeder seed production programmes can be taken up in protected structures irrespective of the isolation distance, as honeybees are the main pollinating agents in these crops. Hence, protected structures like insect proof net house or naturally ventilated greenhouses can be used in large scale for maintenance and production of quality mother seed of improved varieties of seed spices.

Conclusion

Protected cultivation technology is highly relevant in production of quality planting material/seed of spice crops. In the era of climate change were unpredictable situation arises due to temperature fluctuations, heavy rains, hailstorms, frost etc, these protected cultivation technologies are having potential scope for its implementation in spice crops for producing a healthy crop. Disease and pests are of high concern, soil borne disease and virus are major problems in nurseries, and hence use of soilless media for plug tray nursery raising, soil solariazation and plastic & insect net covered nursery houses can help in producing disease free healthy seedling of spice crops. Insect net covers also control movement of insect vectors which in-turn help in managing viral problems in spices. Abiotic stresses effect can also be managed in spice crops, moreover protected structures also provide valuable technology for producing seeds of cross pollinated crops like coriander, fennel, dill, ajwain etc irrespective of the isolation distance. These protected technologies are very useful and innovative, the application on spice crops depends upon the need and circumstances, and therefore an understanding of its proper application is very much crucial before implementation. The relevance of protected cultivation in spices for production of quality planting material is very high, with the popularity of protected cultivation in the country and research interventions in the coming times more effective technological packages can be delivered.

Planting material production technologies in garlic (Allium sativum)

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Introduction

Garlic (Allium sativum L.) is one of the most important bulb crop grown and consumed as spice or a condiment through out the India. It is rich in proteins, phosphorus, potash, calcium, magnesium and carbohydrates. Ascorbic acid content is very high in green garlic (Purohit, 2001). Garlic is a native of western Asia and Mediterranean countries. This has been in cultivation for centuries. The families of Italian and Spanish descents in the United States uses garlic in almost every dish. The genus Allium is a large and diverse one containing over 1,250 species. Its close relatives include elephant garlic, chives, onion, leek and shallot. Currently, the interest in garlic is highly increasing due to nutritional and pharmaceutical value, anti microbial, antibiotic and medicinal values including high blood pressure and cholesterol, atherosclerosis and cancer of human disease. Garlic used in various ways in all curries, fried, boiled, baked, soup making and in pickles. Garlic dehydrated in the form of powder and flakes for use as spice. Garlic is export-oriented crop to earning valuable foreign exchange for the country. . The National scenario of the garlic production has shown considerable development in the past decades, particularly after extensive research and development work taken up by National Horticultural Research and Development Foundation (NHRDF). Though, there is increase in area, production, productivity as also storage and export of garlic, there is further need to increase the production and reduce the post harvest losses to meet out the increasing domestic and export demand.

Area and production

Garlic is grown worldwide in 14.22 lakh hectares, with a total production of 237.70 lakh tonnes and productivity of 16.71 tonnes /ha during the year 2011 as per FAO. China is the world leader in area (8.27 lakh ha) as well as in production (191.56 lakh tonnes), followed by India (2.00 lakh ha and 10.58 lakh tonnes) (Gupta *et al*, 2014). The area, production and productivity of garlic has considerably increased from 0.42 lakh ha., 1.32 lakh tonnes and 3.18 tonnes/ha during 1977 to 2.44 lakh ha (480.95 % increase), production 12.91 lakh tonnes (878.03 % increase) and productivity 5.29 t/ha (66.35 % increase) in the year 2014-15. The above achievements are certainly because of the adoption of high-yielding and improved varieties and apply innovative technologies by farmers disseminated by the NHRDF, Govt. of India/State Govt., State Agricultural Universities and ICAR institutes. The details of the current available area, production and share are given below.



Consumption pattern of garlic in India

NHRDF, Nashik has done on extensive sample survey covering 12 states with sample of about 6975 rural (52 districts) and 5330 urban (53 districts) families and noted highest per capita consumption of garlic in Gujarat 5.28 g/person/day followed by Punjab 4.85 g/person/day, Himachal Pradesh 4.78 g/person/day, Haryana 4.63 g/person/day and lowest consumption noted in Tamil Nadu 2.75 g/person/day, Uttar Pradesh 3.17 g/person/day, Delhi 3.22 g/person/day and Rajasthan 3.61 g/person/day, as against the national average of 3.88 g/person/day (Gupta, *et al.* 2015).

Taxonomy and botany

Garlic is a diploid species (2n=2x=16) in the subgenus *Allium* of the Alliaceae (formerly in the Liliaceae, and then the Amaryllidaceae). The edible underground stem is the composite bulb made of numerous smaller bulbs called cloves. The other cultivated plants in this subgenus are leek, usually tetraploid, and elephant garlic, usually hexaploid (2n=2x=48) (both *A. ampeloprasum* L.). Garlic (hard-neck type) produce inflorescences having topsets with/without flowers and usually no seed, except in few recently discovered fertile garlic clones. Elephant garlic produces a large leek like inflorescence but, seed produced are sterile and it rarely forms topsets (bulbils) in the inflorescence. If the plant of elephant garlic does not flower, the bulb consists of a single, large clove, termed as 'round'. Elephant garlic and garlic form a bulb, but leek does not. Elephant garlic is related to leek (*A. ampeloprasum* L.), but forms cloves resembling those of garlic, although appearance and flavor predominantly resemble leek (Fritsch and Friesen 2002). Elephant garlic bulbs consist of 2 to 6 large cloves and 2-10 corms (bulblets) while garlic bulbs usually have more cloves of a relatively consistent size, especially for bolting types. Garlic reproduces almost exclusively by means of underground cloves or vegetative bulbils (topsets) in the inflorescence and is mostly sterile. Variation in plant type, bulb size, bulb weight, colour, coat layer, leaf

length and width, growth habit, stress resistance, number of leaves, ability to flower, adaptation to different environmental conditions has been reported in garlic (Senula and Keller, 2000 and Volk and Stern, 2009) and this has been attributed to its apomictic nature which leads to the existence of extensive somatic mutations (Ata, 2005), chromosomal aberrations and genome plasticity. Public sector breeding has led to the release of approximately 20-25 varieties but the productivity is still low as compared to other countries

Status of improved garlic varieties

Though there are more than 40 improved varieties of garlic developed by different Universities and Institutes all being produced and made available to farmers on commercial scale. However, many varieties though is higher yielding and have better storage qualities are not popular in view of non availability of adequate quantity of seed. In garlic, the improved varieties are Agrifound white, Yamuna Safed, Yamuna Safed-2, Yamuna Safed-5 in smaller clove types and Yamuna Safed-3, Yamuna Safed-4, Yamuna Safed-8 in bigger clove type which could be grown in plains. Agrifound Parvati and Agrifound Parvati-2 is the only bigger clove variety in long day type mainly grown in northern hills. The seeds of all these varieties are being produced and distributed by NHRDF only on quite large scale and being popularized in different potential areas. There are so many other varieties like Godavari, Sweta, Bhima omkar & Purple, HG-1 & 2, GG-3 & 4, LC-1 etc. developed by different institute and SAU's, but the seeds of these varieties are not available to grower being produced on commercial scale at present. There is need to develop bigger clove varieties of garlic to meet the requirement of export market, for which NHRDF has developed bigger clove variety Agrifound Parvati-2 (G-408) and Agrifound Parvati (G-313) which is commercialized in H.P. and Northern Hills, For plain area new variety released Yamuna safed-8 (G-384) for Zone-II and Yamuna safed-5 (G-189) for Zone-III, IV and VI.

The low productivity of garlic in India is mainly because of inherent low yield potential of short day types as compared to long day type garlic varieties grown in temperate regions. Besides, climatic factors, weather vagaries like heavy and continuous rainfall, drought etc, inadequate market support, non-availability of genuine planting material of garlic varieties released by various agricultural universities and ICAR institutions is equally important and responsible for low productivity. As per NHRDF estimates during year 2014-15 in garlic annually we have required about 1.32 lakh tonnes garlic seed material of improved varieties, but presently total production of garlic seed of improved varieties is about 1000 tonnes which is not adequate. In garlic there is high percentage of splitted and undersize bulbs which lead to more unmarketable share. In the interest of overall development of these commodities, a systematic programme for production of quality seed and planting material needs to taken up by involving progressive farmers, research organizations and development departments. It is, now high time to have organized production and distribution of quality planting material of improved garlic varieties and increase production of this crop for meeting the domestic and export requirements. In case of garlic, it is only NHRDF, which is producing seed material of developed improved and notified varieties. The total production of garlic seed material of improved varieties produced by NHRDF is around 1000 tonnes annually which is only about 1% of the total requirement. Rest of the seed material is being produced by farmers and private traders themselves without follow the seed production standard. The various garlic varieties developed by different organization is given in Table 1.



Organizations	Varieties	Colour
National Horticultural Research and Developed Foundation, Nashik	Agrifound White Yamuna Safed Yamuna Safed-2 Yamuna Safed-3 Yamuna Safed-4 Yamuna Safed-5 Yamuna Safed-8 Yamuna Safed-9 Agrifound Parvati Agrifound Parvati-2	White White White Creamy white White White White Purple Purple White White
Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra	Godavari Sweta GG 4 Phule Baswant	Purple White White White
Chaudhary Charan Singh Haryana Agricultural University, Hissar, Haryana	HG-1 HG-2	White White
Punjab Agricultural University Ludhiana Punjab	LCG-1	White
Vivekanand Parvatiya Krishi Anusandhan Shala, Almora, Uttarakhand	VL Garlic 1 VL Garlic 2 VL-Garlic 7	White White Purple white
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	Ooty 1	Dull white
Directorate of Onion and Garlic Research Rajgurunagar, Pune, Maharashtra	Bhima Omkar Bhima Purple	White Purple
Junagarh Agricultural University, Junagarh,Gujrat	GAUG-1 GAUG-10 GG-2	White White White
Govind Balabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand	Pant Lohit	White
Central Institute of Temperate Horticulture, Srinagar, Jammu and Kashmir	CITH-G-1 CITH-G-2	White Purple Purple

Table 1. Garlic varieties developed by different organization

Requirement of Garlic Seed bulb for country

In garlic there is no authenticated data on actual requirement of quality seed material are available. Based on the present estimates on area, the seed requirements have been worked out as under Table 2 (Dubey & Gupta, 2014).

S. No.	Class	Breeder Seed (Stage I & II)	Foundation Seed	Truthfully/Certified
1.	Bigger cloved short day variety (20%)	306.60	3066.00	30660.00
2.	Bigger cloved long day (3%)	45.99	459.90	4599.00
3.	Smaller cloved short day (77%)	843.15	8431.50	84315.00
	Total	1195.74	11957.40	119574.00

Table 2. Different class of Garlic Seed Bulb (tonnes)

Note: Multiplication ratio taken as 1:10 and seed rate 0.50 tones/ha for small cloved and 0.70 tones/ha for bigger clove varieties.

Production technique of planting materials

The seed production in garlic is now well organized with the efforts taken by Department of Agriculture, Cooperation and Farmers Welfares, Ministry of Agriculture and Farmers Welfares, Govt. of India under Central Sector Scheme of Mission for Integrated Development of Horticulture. NHRDF is the major agency producing the quality seed in organized sector. In garlic, it is only NHRDF, which is producing Breeder, Foundation and certified seed material of its different varieties for maintain the seed bulb chain of notified varieties . NHRDF has developed total 9 varieties of garlic for different agro climatic zones, which are commonly available to the farmers for the cultivation. The different improved production techniques as follows:

1. Climate

Garlic is frost hardy plant requiring cool and moist period during growth and relatively dry period during maturity of bulb. There are two types of varieties one suitable for long day conditions i.e. around 30° N latitude and the other under short day conditions. The yield potential, however, depends upon the extent of vegetative growth made before bulbing commences. The critical day length for bulbing is 12 hours along with the day length, temperature also affects bulbing. An exposure of document cloves or young plants to temperature of around 20° C or lower depending upon the varieties for 1 - 2 months hastens subsequent bulbing. During growing season these cloves develop green tops, which appear as lateral shoots to the false stem, as the plants mature the loss of a few outré sheaths exposes the outermost cloves so that the bulbs appear rough. Higher temperature prevailed during bulb development may affect physiological maturity of cloves thereby causing softening soon after harvest which causes heavy economical loss.

2. Soil

Garlic can be grown on variety of soil, which should have deep friable better on fertile, well drained loamy soil. The land having very light or heavy clay soil should be avoided; such soils do not give good yield of quality seed bulb. The pH of soil, between 6 to 7 is suitable for good crop. Alkaline and saline soils are not suitable for garlic cultivation. The acidic soil favours bigger bulbs, cloves and early maturity.

3. Propagation

The garlic is propagated by single and having cloves diameter is 8-10 mm since give increased yield of better quality bulbs. Tissue culture technique has also been developed to produce healthy garlic bulbs. Garlic being narrow spaced crop, requires too many labourers for planting and other operations .In Lahaul and Spiti district of Himachal Pradesh bulb are first sown in nursery and



after 6 weeks they are transplanted in main field at proper spacing. In foreign countries kidney bean planter is used for planting of garlic to minimize the cost of cultivation.

4. Method of planting

The garlic planters have also been developed in India and are used in some areas of Madhya Pradesh, Gujarat, Punjab, Haryana, Rajasthan etc. but the performance is not satisfactory and thus need to be improved. The garlic clove separators are also available for separation of cloves for planting where labour for clove separation can be reduced considerably. Following are different methods of planting of garlic:

- i. Dibbling: Fields are divided into small plots convenient for irrigation. Cloves are dibbed 5-7 cm deep keeping their growing ends upwards.
- ii. Furrow: Furrows are prepared to appropriate spacing with hand hoe. In these furrows cloves are dropped by hand as desired spacing and then covered lightly with loose soil.
- iii. Broadcasting: Cloves are scattered evenly in well leveled field / seed bed by hand, then covered by harrowing and the field is divided in to small plots for irrigation.
- iv. Seed drills: The seed drills for garlic sowing have been developed In Gujarat, Punjab and MP but performance is not yet seen satisfactory and improvements are required.

The common method is dibbling for furrow planting by hand. The clove dipping in 1% Sodium or Potassium Orthophosphate and then in 0.1% Carbendazim gives better results in respect to growth, production and quality of garlic bulbs.

5. Farm mechanization

Traditionally farmers are sowing garlic by manual method with the help of labour which is a very costly method and also by seed drill in few cases where the area is more. In both the cases the spacing seed rate are not maintained as per recommendation which lead to low yield and increase cost of production. Therefore, it is a very much essential to development machines and tools. Though the garlic planters, tractor driven automatic (17-34) seed cum fertilizers drill double hopper with rotor set and accessories have been developed by M/S. Mausam Agro Private Limited, Rajkot, Gujarat in India and are used in some areas of Madhya Pradesh, Gujarat, Punjab, Haryana, Rajasthan etc. but the performance is not satisfactory and thus need to be improved. The garlic clove separators developed by M/s. Shree Kishan Industries, Atkot Road, Jadsan, Rajkot, Gujarat which saves on labour for breaking of garlic bulbs for separation of cloves for planting. The works for refinement of these two machines are needed.

6. Time of planting

The time of planting differ from region to region and varieties to varieties .However, it is planted from August to Oct. in M.P, Maharashtra, Karnataka and A.P; September to November in Northern plains of India; in Gujarat planting is done during the October to November. Proper season for planting in hills is March-April. It can also be planted during September-October. In West Bengal and Odisha, October-November is best time of planting of garlic. For production in late *Kharif*, the planting on 15th August in flat bed is recommended. Agrifound White (G-41), variety has been recommended in late *Kharif* under Nashik, Maharashtra and Karnal, Haryana conditions. The planting is done in Sept. –Oct. and higher yield was recorded when crop was planted from 25th Sept. to 25th Oct. in Haryana state. Planting of Yamuna Safed-3, 5 and 8 using 8-10 mm clove size from 5th Oct. to 10th Oct gave better bulb size, yield and quality of in Haryana state.

7. Requirement of planting material

Outer side of the bulbs cloves of 8-10 mm diameter gave increased yield. Long slender cloves present in the centre should not be used for planting as such cloves. Depending on size of clove and variety about 500-600 kg cloves of 8-10 mm diameter are require for 1 ha area, considering the planting of 9 - 10 lakh cloves per hectare. Compact and non bolted bulbs of bigger size give early maturity and high yields. In hill grown garlic the clove size is bigger and thus can be used with higher seed rate upto 1000 kg/ha.

8. Land preparation

The field is ploughed to fine tilth by giving four to five ploughing with sufficient interval between two ploughing. The ploughing should be done by tractor drawn implements or *deshi* plough. The ploughing should be shallow as most of the roots penetrate to a depth of not more than 8-10 cm. the planking should be done for proper levelling. The width of plots should be such that intercultural operations are possible to be taken up by sitting on bunds. The length of the bund should be according to the level of the land. If length of beds is more and the land is not levelled there is water logging at one point and no water at another point, this affects production and quality adversely. When green manuring is taken the field should be thoroughly prepared after decomposition of green manure crop. For planting with drip irrigation / micro irrigation long raised bed with 27 inches width is prepared.

9. Manures and fertilizers

The requirement of nitrogen and other fertilizers differ from soil to soil, it is better to get the soil tested and then apply fertilizers as per recommendations. It has been recommended to apply 20 t/ ha FYM at the time of field preparation and mix well in the soil at the time of last ploughing. The 100 kg N, 50 kg P and 50 kg K per ha apply through chemical fertilizers under normal condition, however, 150 kg N and planting at 10 cm x 7.5 cm has given best result in Karnal conditions. 60 kg each of N and P and 120 kg K per ha has been recommended under West Bengal conditions. 90 kg each of N and P per ha has been recommended for higher yield under Uttar Pradesh conditions.. Half of N and full dose of P and K should be applied as basal dose and rest N in two splits i.e. at 30 and 45 days after transplanting. It has been reported that highest amount of P, K, Ca and Mg in the plants are at 50-60 days after planting. It is therefore, suggested to apply fertilizer before this stage. K deficiency in garlic causes poor root development. Micronutrients are effective in increasing the yield. Application of a mixture of NPK in the ratio 75 kg:85 kg: 55 kg plus 5 kg each of boron, zinc and molybdenum per ha produced maximum amount of allyl propyl disulphide. The studies showed that application of MnSO₄ at 0.1%, boric acid at 0.02%, $CuSO_4$ at 0.02%, $ZnSO_4$ at 0.02% stimulate dry matter accumulation in the cloves and use of borax up to 10 kg/ha increased bulb size and yield. Zinc sulphate @ 20 kg/ha as soil application with other fertilizers gave better yield performance. At Nasik, the garlic variety Agrifound White grown under drip irrigation with application of NPK @ 100:50:50 kg/ha, S @ 20 kg/ha as basal dose, spray of NPK (19:19:19), water soluble fertilizers @ 1% at 15, 30 and 45 days after planting and 1% spray of Nitrogen and Potash (13:0:45) at 60, 75 and 90 days after planting gave higher bulb yield and maximum returns. At Karnal, the planting of garlic variety Yamuna Safed-4 between 15th to 20th October and spraying of Nitrogen and Potash (13:0:45) @ 1% at 30, 45 and 60 days after planting and further spray of NPK @ 1% (19:19:19) at 60, 75 and 90 days after planting gave higher gross as well as marketable yield. The spray of GA, @ 25 ppm in garlic variety Yamuna Safed-3 at 45 and 60 days after planting at Karnal increased the gross yield by 20-32% as well as marketable yield by 116.91%. (Gupta et al., 2015).

10. Spacing

The planting distance of garlic differs from area to area and variety to variety. Planting of 8 to 10 mm sized cloves in flat bed at 15 cm x 10 cm spacing has also been recommended for north India whereas 12.5 x 7.5 cm spacing has been recommended under central and southern India for optimum yield. Wider spacing of cloves increases uptake of nitrogen and water by individual plants which increases premature sprouting and rubberification of garlic. Garlic can be taken as solo crop and also as inter crop in sugarcane, orchards, plantation crops, vegetable crops, etc.

11. Irrigation

The irrigation is garlic required at 8-10 days interval during vegetative growth and 10-15 days during maturation. Flood irrigation is given after planting. The optimum soil moisture for emergence is 80-100% of field capacity. There should be no scarcity of moisture in the growing season otherwise bulb development is affected. It has been recommended to irrigate garlic at 60 mm CPE (cumulative pan evaporation) for good crop in Haryana state. Garlic is shallow rooted crop with most of roots limited to the upper 5 cm of soil. The soil ateach irrigation should be kept wet to this level. As the crop reaches at maturity immediately stop irrigation to allow field to dry out first. Continued irrigation as the crop matures causes the roots and bulb scales to rot. Excessive water supply results in sprouting, and rubberification problems are seen severe in the garlic fields which are more frequently irrigated than the normal. Successful garlic crop with increased yield and better quality can be taken up using drip irrigation on micro sprinkler irrigation by planting on raised beds. Ahmed et al. (2007) reported that irrigation at 3 days intervals resulted in significantly more no. of leaves per plant, plant height at maturity, bulb yield, bulb weight, number of cloves per bulb and clove weight as compared to irrigation at 5, 7 and 9 days intervals. Studies on the efficacy of the micro-sprinkler irrigation revealed that bulb yield of garlic increased by 38% (Pawar et al., 1998). Among the irrigation methods evaluated, drip irrigation at 100% PE recorded the highest marketable bulb yield in garlic with 30-40% water saving in comparison to surface irrigation (Sankar et al., 2008).

12 Intercultural operation

Since garlic is a closely planted crop, manual weeding is tedious, expensive and often damages the plants. For good yields of quality garlic seed bulb, necessary to keep fields free from weeds by timely weeding and hoeing. First weeding is done after one month planting and 2nd weeding is done after one month of 1st weeding. Hoeing the crop and earthing up just before the formation of bulbs (about two and half months from sowing) loosens the soil and helps in the setting of bigger well filled bulbs. The crop should not be weeded out at a later stage because this may damage the stem and impair the keeping quality. As reported above, manual weeding is not only expensive, sometimes when there is labour scarcity it becomes difficult to arrange weeding which ultimately results in poor bulb development and yield. The studies carried on weed management showed that the critical period of crop v/s weed competition in garlic is 15 to 60 days after planting depending on the competing weed species and their densities (Qasem, 1996). Pendimethalin, Oxyfluorfen, Metolachlor and Trifluralin are found effective in weed management in garlic (Kumar et al., 2013). The Pendimethalin @ 3.5 lit or Oxyflurofen @ 0.25 kg a i per ha + one handweeding at 45 days after planting showed good control on the weeds under Karnal and Nasik conditions. It is further reported that the post emergence application of Quizolofop Ethyl 5% EC weedicide with Oxyfluorofen is also found effective for weed control (Gupta et al., 2015).

13. Roughing

Roughing will be done at the time of inspections .The off type and other plant other than particular varieties will be take out from the field for maintain the purity of quality of seed bulb.

14. Plant protection

The diseases caused by abiotic and biotic factors are causing economic yield losses as well as quality. Garlic suffers from various insect, pest and diseases in the standing crop from the planting, vegetative stage till harvesting and spoilage caused by pathogenic microorganisms during storage as well as transit. The diseases caused by fungi, bacteria, virus and nematodes viz., purple blotch (*Alternaria porri*), stemphylium blight (*Stemphylium vesicarium*), rust (*Puccinia porri*), powdery mildew (*Lavellula taurica*), white rot (*Sclerotium rolfssi*), black mold (*Aspergillus niger*), blue mold (*Penicllium* sp.), bulb canker (*Embellisia allii*), mosaic, iris yellow spot virus (Tospovirus), bacteria rot (*Erwinia* sp.) and bloat nematode (*Ditylenchus dipsaci*). The very less incidence of rust, powdery mildew, blue mold, bulb canker, bacterial rot, bloat nematode and bulb mite (*Rhizoglyphus robini*) were found in garlic. Thrips (*Thrips tabaci*) is one of the major insect causing economic loss in garlic.

The diseases and thrips insect can be managed by integrated approach following the application of antagonistic fungal bioagents like *Trichoderma viride*, or *Pseudomonas fluorescens* @ 5kg/ha gave promising result to control the white rot of garlic. Purple blotch and stemphylium blight are the major foliar disease of garlic control by mancozeb @ 0.25% or propineb @ 0.2%, chlorothalonil @ 0.2% or azoxystrobin @ 0.1% and tebuconazole @ 0.1% spray started after 30 DAP and subsequently at 15 days intervals. Mosaic and IYSV can be managed by rouging of diseased plants was the possible measures to control the disease and removal of volunteer plants of previous season crop helps in reducing the inoculums in the field as well as chemical control of the insect thrips by spraying of insecticides such as deltamethrin @ 0.1% or cypermethrin @ 0.1% or spinosad @ 0.1% or fipronil @ 0.15% and azadirachtin @ 0.4% at 10-15 days intervals. Preharvest spray of carbendazim @ 0.1% and streptocycline @ 200 ppm effectively control the black mold disease in the storage.

15. Harvesting and yield

The crop is considered ready for harvesting when the tops turn yellowish or brownish colour and show signs of drying up and bend over. The bulbs mature in about 4-5 months after planting, depending upon cultivar and season/soil etc. Garlic variety Yamuna Safed-3 is early maturing cultivar. Harvesting at 100% neck fall gave minimum storage losses and field curing for 3-5 days by windrow method was found to be beneficial. This enables development of bulbs with tightly attached cloves for prolonged storage. Early harvesting results in poor storage quality bulbs whereas delayed harvesting results in splitting and sprouting of bulbs. In India harvesting is done manually by hand digger or in some area where soil is loose the plants are pulled along with the tops by hand. The quality seed bulb yields of vary between 100-150 q/ha depending upon the variety and the regions where crop are grown.

16. Economic of seed production:

The knowledge about cost of production is very necessary as garlic seed bulb. In view of follow up of improved agro techniques and inputs, the cost of cultivation of garlic has increased considerably. Farmers will be take due care in harvesting maximum with optimum level of inputs including labour. On the basis of economic survey conducted during the cost of production of garlic seed bulb has been estimated between Rs. 1560 to Rs. 2262 per q depending upon the variety, labour wages, input cost and.



17. Post harvest management

Many operations are performed in getting mature good quality seed bulb from the field losses take place during these operations which are to the extent of 15-50% depending on the variety, practices differ from place to place and losses may increase if proper post-harvest management and storage practices are not followed. The operations which are to be managed well to minimize losses in storage and handling are curing, sorting and grading, packaging, transportation and storage. The post-harvest management practices which need to be followed for maximum recovery.

18. Drying and curing

These two operations are essential in post-harvest management of garlic. Drying is done to remove excess moisture from the outer skin and neck with a view to reduce storage rot. Curing is additional process of drying to remove the excess moisture and to allow the colour development and help the bulbs to become compact and go into dormant stage. It is done for about a week in the field for drying. The method and period of curing vary depending on weather at the time of harvesting. Bulbs are covered along with the tops of each other to avoid damage to the bulbs from sun. These also are cured for 7-10 days in shade either with tops or after cutting the tops by leaving 2.5 cm above the bulbs and removing the roots. Harvesting at 100% neck fall and curing by windrow method has been recommended and the curing in field till foliage turns yellow should be done. Artificial curing can be done by passing hot air at 27-35°C through the curing room. It takes about 48 hrs for complete curing process if humidity is between 60-75%. Curing of garlic bundles with bulbs covered by soil in compact layers or shed curing by keeping garlic bundles with foliage in standing condition in compact layer help proper curing of garlic. The NHRDF has also designed one curing chamber for garlic where curing at desired level can be attained by circulating hot air through garlic bulbs kept in crates in racks.

19. Sorting and grading

Garlic bulbs after curing are run over a grader or graded manually before they go into storage for further seed production programme. The thick neck, splited, injured, diseased or bulbs with hollow cloves are sorted out. It is very much necessary to practice sorting and grading for maintain the quality seed bulb . For storage also it is necessary to practice sorting and grading to minimize loss on account of driage and decay.

20. Storage

Thoroughly cured garlic seed bulbs keep fairly with dried leaves can be stored by hanging in well ventilated rooms. The same has been recommended for storage to minimize loss. In Jamnagar area of Gujarat and also some pockets of Indore and Mandsaur in Madhya Pradesh as also in Mainpuri and Etawah district in Uttar Pradesh bulbs are stored for 6-8 months. The storage of garlic with dried foliage in bundles tightly heaped in ventilated godowns is done at DOGR and also by farmers in Nashik and Pune area which given lower storage losses (Bhonde *et al.*, 2012). Cold storage of garlic is possible at 0-2°C temperature and 60-70% relative humidity. The storage loss of 12.5% was recorded for garlic stored at 1.5°C and RH 75% compared to 42.4% losses in ambient temperature. Ghawade *et al.* (2011) reported that total storage loss in garlic was significantly lower in the bulbs stored by hanging method than the bulbs kept in polythene, netted and hessian bags. Not much work on storage have been done in our country however, the ventilated three tier godown constructed by NHRDF are found quite suitable for garlic storage in bags by pilling up to 5 bags with adequate space between left for aeration and movements for 25 MT capacities wherein losses after six months were significantly reduced. This type of storage is adopted by all states Govt. under various central sector schemes.

Minimum seed certification standards for garlic (Trivedi & Gunasekaran, 2013):

- I Application and Amplification of General Seed Certification Standards:
 - a) The general seed certification standards are basic and together with the following specific standards constitute the standards for certification of garlic seed.
 - b) The general standards are amplified as follows to apply specifically to garlic.
 - c) All certified classes shall be produced from the cloves obtained from the bulbs whose source and identity may be assured and approved by the Certification Agency.

II. Land Requirements:

Land to be used for seed production of garlic shall be free of volunteer plants.

III. Field Inspection: Minimum of two inspections shall be made as follows.

- i. The first inspection shall be made when plants are large enough to verify isolation, off types including and other relevant factors.
- ii. The second inspection shall be made when leaves begin to fall and before lifting of bulbs to verify isolation, off types and other relevant factors.

IV. Field Standards

A. General requirements

i) **Isolation:** The seed fields of garlic shall be isolated from the contaminants shown in column 1 of the Table below by the distance specified in columns 2 and 3 of the said Table.

	Contaminants	Minimum distance (meters)	
		Foundation	Certified
	Field of other varieties	5	5
	Field of the same variety not conforming to varietal purity requirements for certification	5	5
B.	Specific requirements		
	Factor	Maximum permitted limits (%)*	
		Foundation	Certified
	* Off- type	0.10	0.20

*Maximum permitted at final inspection; Note: All off type plants should be rouged out along with bulbs

V. Seed (Planting Stakes) Standards

- a) The average diameter of each bulb shall not be less than 2.5 cm or 25 gm in weight
- b) The seed material shall be reasonably clean, healthy and firm and shall conform to the varietal characteristics of the variety. The bulbs not conforming to varietal characteristics shall not exceed 0.1% and 0.20% (by number) for foundation and certified seed classes respectively.



Future thrust

Although reasonable progress has been made so far in the garlic research, but still many important problem have to be tackled. The future priorities are: -

- a) Use of advanced crop improvement techniques of asexually propagated crops for the development of high yielding varieties.
- b) Development of bigger cloved garlic varieties, which can be grown under short winter season for export.
- c) Development of early maturing varieties.
- d) Resistance breeding against biotic and abiotic factors.
- e) Standardization of improved package of practices particularly for new varieties.
- f) Development of high TSS varieties suitable for processing.
- g) Mechanization and cropping system in garlic cultivation.
- h) Development of garlic varieties for late kharif season.
- i) Post harvest technology is to be strengthened with special thrust on storage, packaging and transport.
- j) Rapid multiplication technology including heat inactivation of virus infection and in vivo preservation of garlic material.
- k) Seed technology research.
- 1) Transfer of Technology for better adoption.
- m)Integrated disease and pest management.

Conclusion

The productivity of garlic is very low due to low yield potential of the available garlic varieties and non-availability of virus-free planting material. Way-forward is to combine conventional and Biotechnological approaches to improve garlic were first limited to regeneration from different explants of garlic to increase the production which was followed by standardization of somatic embryogenesis. Varieties with high yield, good storability and carrying tolerance/resistance to major pests and diseases need to be developed. Garlic being a cross pollinated crop is highly heterozygous i.e. it has better seedlings survival and plant vigour. Hence, modern breeding should aim at seed propagated (F_1 hybrids), thus eliminating the main ailments of clonal propagation, including carryover of pests from one generation to another, low propagation rate, voluminous storage of bulbs, rotting and sprouting, and spatial position of the transplanted cloves. The use of true seeds will save the costs of vegetative propagation and spare the need for virus elimination. Many constraints in achieving high level production and productivity of long day garlic seed bulb in India, research is underway to resolve the current issues and assure India's better position in domestic and international market. The research work on long day varieties taken by institutes to develop big clove and bulb, if results of research are systematically interpreted and applied in

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garlic breeding, multiplication, production and storage the long day garlic can become highly remunerative to farmers of north Himalayan agro-climatic region of the country.

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Planting material production technology in saffron (Crocus sativus L.)

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Introduction

Saffron (*Crocus sativus*L.) is an autumn flowering high value, low volume spice crop that grows throughout Mediterranean Europe and Western Asia between 10° West and 80° East longitudes and 30 to 50° North latitudes (Salwee and Nehvi, 2013a). J&K state of India has a unique distinction of producing saffron due to its temperate climate that favours chilling requirement of crop required for vernalization. Moderate autumn temperatures accompanied with sub zero temperatures during winter and low summer precipitation makes saffron farming system a success and ensures livelihood security to about 17000 farm families from 27 villages of Pampore the heritage site of saffron. State at present is producing 15 M.T of quality saffron a unique of its kind among saffron producing countries of world over 3715 hectares giving an exchequer of Rs 225 crores to all those involved in saffron farming system directly or indirectly.

Saffron with subhysteranthous behavior is a perennial herbaceous plant attaining a height of 25 to 40 cm (Salwee and Nehvi, 2013a). Corm, foliar structure and floral organs constitute main parts of saffron plants (Nehvi et al., 2010). Plant undergoes different cycles of plant development starting from August with regeneration followed by flowering in October. Recapituation stage is responsible for plant propagation and lasts from November to April and is the most critical period of plant development. Structural variation in corm and corm attributes in Kashmir saffron starts from Ist fortnight of September with initiation of sprouts in apicular, sub-apicular and auxillary regions after surviving the period of summer dormancy (May to August) and is completed around 25th of November with emergence of cataphylls above soil surface by around 25th of October followed by development of contractile roots in November after flowering is over (Salwee and Nehvi, 2014a).Corm weight is directly correlated to number of sprouts. Corms weighing > 8 g exhibit activation from all regions compared to smaller size corms that exhibit activation from apicular and sub-apicular regions (Salwee and Nehvi, 2014d). Daughter corms are developed from the activated meristematic regions and derive their food material from the mother corm. At the end of recapituation stage mother corm is reduced to a disc like structure at the base of daughter corm.

Triploid nature of saffron with basic chromosome number 8 restricts seed formation due to irregular meiosis resulting in sterile pollen grains. Genetic phenomina thus favours vegetative propagation in saffron (Salwee etal.,2016a,b).Temperate conditions of Kashmir forces irregular activation of meristematic regions leading to low proliferation ratio of 1:4 as sprouts from lateral meristematic regions being week have poor proliferation capacity.

Saffron fields had become senile due to abundance of saffron corm rot and availability of quality planting material was a big question. To revive the industry Ministry of Agriculture Govt of India in collaboration with Agriculture production Department J&K launched National Saffron Mission in 2010. To meet the National demand of 100 M.T the Policy makers are contemplating to introduce saffron in non traditional areas of J&K. Potential area of about 12000 ha have been identified by SKUAST-K researchers for horizontal expansion. Expansion would require about 60,000 M.T of quality planting material. Therefore strategies need to be developed for making the quality planting material available to the farmers(Salwee and Nehvi,2013b).

Approaches for production of planting material

In saffron (*Crocus sativus* L.) corm is designated as planting material. For production of 60,000 M.T of quality corms three pronged approach needs to be followed as technologies and protocols are available with SKUAST-K as given below.



Approach-1

Adoption of nursery management for vegetative propagation of natural populations

Under National Saffron Mission 3715 ha of saffron area is to be rejuvenated under SKUAST-K technologies and at present 2000 ha have already been rejuvenated. Rejuvenation over the targeted area of 3715 ha is expected to yield about 37150 M.T corms with proportion of quality corms(>8 g) to the tune of 22290 M.T and undersized corms to the extent of 14860 M.T. Out of 2290 M.T of quality corms available from the rejuvenated area only 7430 M.T can be spared for nontraditional areas as the remaining quantity of 14860 M.T shall be utilized by the farmers for replanting in the same area of 3715 ha. The undersized corm (14860 M.T) shall be planted in private sector nurseries with a planting geometry of 20x10 cm at a density of 5 lac corms/ha .Integrated Management Module with application of inorganic fertilizers viz;N:P₂O₅:K₂O @90:60:50kg/ha in combination with vermicompost @5q/ha and well rotten FYM @ 10 M.T/ha. After 3 years the registered nurseries are expected to yield 42450 M.T with proportion of quality corms to the tune of 25440 M.T and undersized corms to the tune of 170101 M.T. Approach will facilitate production of 32870 M.T that can be utilized for horizontal expansion over an area of 8214 ha. Second cycle of nursery corm production shall meet out the requirement of 60,000 M.T as shown below.



Approach 2

Adoption of tissue culture approach for mass multiplication of elite lines

For mass multiplication of corms of high yielding varieties tissue culture offers better opportunity. Lack of high yielding varieties in saffron is a big impediment for productivity. Restriction of conventional breeding approaches due to sterile pollen hinders varietal development. However scientific efforts of utilizing mutation breeding approach has helped in development of a genetic stock of about 4400 lines. Screening of these lines at morphological and biochemical front has helped in identification of 13 extraordinary lines that awaits mass multiplication using tissue culture route (Salwee and Nehvi, 2014c).

Tissue culture protocol a unique of its kind available with SKUAST-K ensures very high proliferation ratio after using whole saffron corm as an explants. Followed by culturing and subculturing of sterile explants on growth medium supplemented with cytokinins, auxins and growth retardant to promote sprouting, shooting, multiple shooting and corm development (Salwee *et al.*, 2013; Salwee and Nehvi, 2013c; Salwee and Nehvi, 2014b). Tissue culture will favour development of initial transplants of quality planting material with a proliferation ratio of 1:70 compared to 1:4 achieved under field conditions. Initial tissue culture corms shall be raised under green house conditions for further proliferation.





Approach 3

Adoption of nursery management module for vegetative propagation of initial tissue culture material of elite lines

To increase the proliferation ratio of tissue culture raised corms from 1:70 to 1:280 first cycle tissue culture raised corms are grown under nursery management module. The approach will facilitate quick multiplication of elite lines for their subsequent commercial exploitation by the saffron growers.

Conclusion

Planting material production approaches once followed by saffron growers and agro processors of J&K state will ensure availability of corms for more than 12000 ha. Saffron farming system will increase overall production from 15 M.T to about 79 M.T with increase in exchequer from Rs 225 crores to Rs 1185 crores

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Planting material production in herbal spices

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Introduction

Herbal spices are a group of crops under the broad category of spices. The herbal spices utility and consumption is trending towards gaining momentum in the contemporary world. India stands second position in the export of spices and herbs next to China with 17 % contribution (Eurostat, 2015). Legal food safety requirements, historic trade relations, preference for certain level of processing, and population of Indian ethnic community by the importing countries makes important export relations for the herbal spices. The growth of the herbal spices industry is slow but it will be steady. The best opportunity for the growth of the developing market lays in the value added products from the herbs. The utility of herbal spices are for culinary, cosmetic and pharmaceutical purposes. The Herbal spice crops are Rosemary, Thyme, Celery, Parsley, leeks, chives, horse radish, bay tree, marjoram etc. The herbal spice crops are relatively tolerant plants to water stress and pest attack. It will survive in a wide range of soil types with good drainage facilities. The herbal spices Rosemary, Thyme, Mint are propagated by cuttings, dividing the roots and some of them are through seeds. The availability of quality planting material is a major criterion for promotion of the herbal spices crop. The Nilgiris offers a good potential and scope for the promotion of the herbal spice crops commercially, particularly rosemary, thyme and celery specially for its dry leaves and oil extracted from the fresh leaves.

1. Rosemary (Rosemarinus officinalis L., Family: Lamiaceae)

Tamil Nadu Agricultural University, Horticultural Research Station, Ooty has released an Ooty (RM) - 1 Rosemary variety. It is resistant to whitefly, aphids and leaf blight. It is a selection from the germplasm maintained at the research station. The major constituent present in the leaf is 1, 8 –cineole (20-50%), borneol (20%) and carnisol (2.6%). The commercial propagation is through semi hard wood cuttings. The nursery beds are prepared with vermicompost, biodynamic compost, red earth in equal proportions. Length of 10-15 cm cuttings is planted in the nursery beds and after about 6-8 weeks; the rooted cuttings are pricked and the plants are planted in polybags and maintained for about 25 days. They are transplanted in the main field. The rosemary cuttings are packed up using sphagnum moss by which the usage of plastics can be avoided. The sphagnum moss holds more of moisture and will aide in withstanding the long distance transport of rooted cuttings before planting in the main field. A maximum of 20 - 25 cuttings can be produced from a well grown mother plant in a year. A foliar spray of 3% panchagavya will have a very good effect on the growth of new flushes in the rooted cuttings. The rosemary plants will



respond well to use of organic nutrients. Cow pat pit (CPP), a fermented product of cow dung, egg shell, rock powder is an organic product when applied to the nursery beds, will have a very good effect on enhancing the rooting of the crop.

Rosemary Ooty-1





Rosemary cuttings in sphagnum moss

Rosemary mother plant full grown

2. Thyme (Thymus vulgaris, Family: Labiate)

Horticultural Research Station, Ooty has released a Thyme Ooty - 1 variety which is a selection from the germplasm maintained. Thyme is commercially propagated through cuttings and is easy to root material. The polybag is used for rooting the cuttings which consists of a mixture of vermicompost, biodynamic compost, red earth in equal proportions. 35 numbers of cuttings can be produced from a well grown mother plant in a year. The mother plants should be stopped irrigation before 15 - 20 days for taking cuttings, since a mild stress has to be created to the plants. The cuttings are packed up using the sphagnum moss as done for the rosemary propagation.

3. Celery (Apium graveolens, Apiaceae)

Celery is a well known herbal spice crop used in many for continental preparations. Horticultural Research Station, Ooty has released a Celery Ooty - 1 variety. It is propagated through seeds and the seed rate is 1.25 kg/ha. Celery is basically a slow growing crop. The seeds are very minute and raised beds have to be done for sowing of seeds. Seeds will take 3 weeks to germinate. The bed has to be formed by removing stones, debris, and enriched with vermicompost, biodynamic compost for 3 inches layer. Line sowing method 10 cm spacing should be followed for seeds sowing. The viability of the seeds is for 3 years. Water has to be done gently to avoid splashing of seeds. Mulching has to be done for the protection of seeds during watering. The duration of the crop is 75 days and seeds germinate three weeks after planting. Spacing followed for seed production is 45 x 15 cm. The seed crop is liable for lodging and hence staking should be done. Seeds are borne in primary, secondary and tertiary umbels and seeds mature at different intervals. So, selective and timely harvest should be done. The seeds are harvested when 80 % of the seeds in umbels turn into brown colour and average seed yield is 85 g/plant. Seed yield is 1.40 tonnes/ ha.

The multiplication of seeds and planting material through vegetative propagation plays a poignant role in further spread of the variety or crop for the herbal spices. The assistance made through Mission for Integrated Development of Horticulture programme will certainly aid in the development of herbal spice sector in a commercial way.

4. Mint (Mentha spp.; Family: Lamiaceae)

Mints are the best known herbs in the world over. Plants o f mints species are hardy and perennial and have rhizomes and stolons for propagation. These are formed on maturity of the plant. *Mentha piperata, M. spicata, M. arvensis* are the popularly cultivated species. These species rarely set seeds, and are commercially propagated through division of stolons or rooted cuttings. The crop comes well in a soil with rich in organic matter and humus content and a pH of 6-7; good drainage; water holding capacity. Pepper mint is cultivated for the essential oils and menthol is major constituent in it with 0.5 %. 400 kg of stolons is required for planting one hectare of main field. The best time for separating the stolons from main field is during the month of December and January.

Conclusion

The multiplication of seeds and planting material through vegetative propagation plays a poignant role in further spread of the variety or crop for the herbal spices. The assistance made through Mission for Integrated Development of Horticulture programme will certainly aids in the development of herbal spice sector in a commercial way.



Studies on rapid multiplication technique of black pepper (*Piper nigrum* L.) on bamboo split method, soil mound method and serpentine method at costal district of Karnataka

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Abstract

The experiment was conducted at Zonal Agriculture and Horticulture Research Station, Brahmavara during 2014-2015 to study different propagation methods of black pepper (*Piper nigrum*) (var. Panniyur–4). The experiment was laid out in randomized block design with five treatments and four replications treatment *viz*. T1= Soil mound method (15cm), T2= Bamboo split method (15 cm), T3= Bamboo split method (20 cm), T4= Bamboo split method (25 cm), T₅=Serpentine method (20 cm), The vines in soil mound method exhibited superior performance with respect to length of the vine (1.89 m), number of nodes per vine (15.75), root production per node (3.25), number of braches per vine (1.37) and success percentage (89.75) followed by the T3= Bamboo split method of propagation with respect to the all characters.

Introduction

Black pepper (*Piper nigrum* L. *Piperaceae*) is called the "King of Spices" (Srinivasan, 2007; Mathew *et al.*, 2001). It is one of the most economically important spice crops of the world. Out of 1000 species of pepper, *Piper nigrum* is the most important cultivated species due to its economic value (Bhat *et al.*, 1995). Black pepper can be propagated by seeds, cuttings, layering, and grafting. Seed propagation often results in genetic variation while other methods of black pepper propagation are slow and time consuming (Atal & Banga, 1962). So there is a need to introduce efficient methods for faster propagation of black pepper in order to get more seedling in short duration and for quality planting material (Sivaraman, 1987). In India, black pepper is propagated vegetatively through stem cuttings, it is the easiest and cheapest method for rapid multiplication of black pepper. The Indian Institute of Spices Research (IISR), Calicut, has standardized a rapid multiplication method of black pepper which involves, use of bamboo halves (splits) (Sivaraman 1987). In coastal region of the Karnataka, availability of suitable bamboos is high. Therefore an experiment was conducted to assess the suitable indigenous technique for rapid multiplication of black pepper by using bamboo split method, soil mound method and serpentine method.

Materials and Methods

The experiment was conducted at Zonal Agriculture and Horticulture Research Station, Brahmavara during 2014-2015. Semi-hardwood cuttings of black pepper (var. Panniyur-4) were prepared in 2014 and kept for rooting and served as base material. The rooted cuttings were used for planting on bamboo splits, soil mound and serpentine method. The experiment consisted of five treatments viz. T1=soil mound (15cm spacing); T2 =bamboo splits (15cm spacing); T3=bamboo splits (20cm spacing); T4 bamboo splits (25cm), T5 = serpentine method (20 cm). The experiment was conducted in randomized complete block design in which each treatment was replicated four times. In the treatment, T1(soil mound method) a soil mound of 2.5 m x 0.60 m (45° angle) of 2 m length was prepared using locally available soil. In the upper layer of 5 cm of soil mound, well decomposed cow dung was mixed @ 1 kg/sqm and black pepper cuttings were planted at the base of soil mound at a spacing 15.0 cm (T1), as the vines elongates they were kept in contact with soil by the help of coconut leaflet midrib so that the roots are produced at each node. T2 (bamboo split method) split halves of bamboo (1.5 m) with septa at 30 cm interval were fixed at 45° angle on a strong support fixing the lower portion of the bamboo on the trance at 15 cm spacing and rooted cuttings were planted at the base of each bamboo splits. Bamboo splits at three spacing viz., 15 cm (T2), 20.0 cm (T3) and 25 cm (T4) are placed and as the vines elongates they were tied with the bamboo splits with rope as they can come contact with the soil present in between bamboo septa for producing roots in each node. In the treatment T5 (20 cm serpentine method) the rooted cuttings were planted in the previously made trench with 20 cm spacing. As the cutting produces nodes, poly bags of size 15cm×10cm were kept under each node for producing roots and this process was repeated continuously as the vine elongates. Nursery roofing sheet was used for providing shade in each treatment. In case of T1, T2, T3, T4, when the plant reaches the top of the soil mound and bamboo splits (about 3 months from initial planting), the terminal bud is nipped off and stem is crushed at about three nodes above the base, in order to activate the growth of auxiliary buds. After about 10 days, each plant is cut at the crushed point and taken out of the rooting medium without damaging the root system at each node. Then single node cuttings are taken from the plants and planted in poly bags filled with potting mixture. Care was taken to keep the auxiliary bud above the soil. The poly bags were kept in a cool humid place. In about 3 weeks, the buds started developing and the poly bags were shifted to an open shaded area. No major disease was observed during the tenure of experimentation. The statistical analysis of data to estimate variance and critical difference in Randomized Block Design was done by adopting the standard procedures of Panse and Sukhatme (1985).

Results and Discussion

The mean length of vines after 3 months of planting varied from 1.89 m to 1.19 m. On an average longest vine length (1.89 m) was obtained from T1 (soil mound method with15 cm spacing) while lowest vine length (1.19 m) obtained from serpentine method (T5 with 20 cm spacing). Maximum nodes per vine (15.75) were found from soil mound method (T1 with 15 cm spacing) while lowest number of nodes per vine (6.75) was obtained from serpentine method (T5 with 20 cm spacing). Similarly, the roots produced per node also varied from (3.25 to 1.50) the maximum root productions (3.25) was recorded in soil mound method (T1 with 15 cm spacing) were superior over other methods in present investigation (Table 1). This might be due to more volume of soil available for root growth and the addition of decomposed cow dung on the upper layer of soil mound might help better water retention and aeration unlike in serpentine method (T5). The number of branches varied from (1.37-1.02) in different treatments. The maximum number of branches per vine (1.02) was recorded in T5 (20cm Serpentine Method). These results of the present study are in accordance with the earlier findings of (Khandekar *et al.*, 2004, and



Bhuyan *et al.*,2015) who also found superior vine length, nodes per vine and number of roots per vine from soil mound method. This may be due to the availability of water and nutrients from the mound. Although in bamboo split method (T2) the vine strikes roots in each node but the amount of rooting media was small in bamboo halves and this roots suffered from water stress during the hot period of the day resulted in poor growth. The vines from serpentine method (T5) also suffered from water stress and shortage of nutrients. On the other hand vines from soil mound method (T1) got enough water and surface area which resulted in longer vines. Therefore, this method was very much economical from farmers' point of view.

Treatment	Length	node/	Roots/node (no.)	Branches	Success (%)
	of vine (m)	vine (no.)		/vine (no.)	
T1	1.895	15.750	3.250	1.375	89.750
T2	1.595	11.750	2.250	1.125	87.500
T3	1.665	13.250	2.875	1.250	88.000
T4	1.615	10.000	2.000	1.000	88.750
Т5	1.195	6.750	1.500	1.050	87.000
SEm±	0.03	0.91	0.18	0.154	0.511
CD (P=0.05)	0.09	2.82	0.57	NS	1.57

Table 1. Growth performance of black pepper cuttings on soil mound , bamboo splits with different spacing $% \left(\frac{1}{2} \right) = 0$ and serpentine method of planting

T1=soil mound (15.0 cm spacing); T2= bamboo splits (15 cm spacing); T3= bamboo splits (20 cm spacing); T4= bamboo splits (25 cm spacing); T 5=serpentine method (20 cm spacing)

Conclusion

The soil mound and bamboo split method were superior over serpentine method of propagation with respect to the all characters. The soil mound method is best for rapid multiplication of black pepper (var. Panniyur-4) over other methods tested in year of study. This method should be used to produce more propagule of black pepper to meet the planting material requirement of farmer under Udupi district of Karnataka

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Priming of rooted black pepper vines with non-protein amino acids improves acclimatization during transplantation

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Abstract

The failure in acclimatization of black vines to transplanted field condition is a major issue in black pepper cultivation, especially due to the unprecedented raining pattern in pepper growing areas. Pre-treatment with low concentrations of non-protein amino acids (NPAAs), GABA (ãaminobutyric acid) and BABA (â-aminobutyric acid) increased the osmotic stress tolerance potential of two black pepper varieties, Panniyur 1 (drought-sensitive) and Panniyur 5 (drought tolerant). Among the different concentrations of GABA/BABA tested, the pre-treatment of rooted cuttings of pepper plants with very low concentrations of GABA (2 mM)/ BABA (0.5 mM) (GABA/ BABA-priming) influenced various morpho-physiological and biochemical parameters positively and PEG (poly ethylene glycol 6000; 10 % w/v)-induced osmotic stress tolerance potential was increased in both varieties of black pepper. At these effective concentrations, primed black pepper plants showed enhanced rate of leaf RWC and also a faster reduction of cellular osmotic potential as compared to non-primed plants, induced with osmotic stress, and so the extent of wilting was lesser in them. Although both GABA/BABA showed positive responses in pepper vines while encountering osmotic stress, BABA was found to be more effective and among the varieties, Panniyur 5 showed better performance. This methodology could be an effective solution to enhance the quality of planting material so as to encounter the harsh conditions in the field during transplantation.

Introduction

Black pepper is a rain fed crop of moist tropical regions and in India it is successfully grown in southern regions of the country (Kandiannan *et al.*, 2014). The crop prefers a hot, humid climate and an adequate rainfall of 200-300 cm. Pepper plants are highly sensitive to rainfall distribution, because proper rain fall is necessary for its vegetative as well as reproductive growth (Dastager *et al.*, 2011; Gopakumar, 2011). The moisture deficit due to the unprecedented raining pattern in pepper growing regions affects the establishment of cuttings in the field during transplantation, increasing the mortality rate of transplanted black pepper vines (Thankamani and Asokan, 2004). Likewise, severe drought coupled with humidity, may easily prepone the pathogen infection which is yet another problem in pepper cultivation (Anandaraj and Sarma, 1995). Therefore, the tolerance to soil moisture stress is important for survival of transplanted cuttings of black pepper. The present study focuses towards the understanding of a new method of 'priming' the black



pepper plants with non-protein amino acids, GABA (ã-aminobutyric acid) or BABA (â-aminobutyric acid) for increasing their osmotic stress tolerance potential, with an intension on the further use of this method in field condition.

Though different strategies are developed for increasing abiotic stress tolerance, 'priming' can be adopted as a better technique for improving the tolerance potential of plants towards various abiotic stresses like osmotic stress. Priming is a process by which plants attain a unique physiological state called 'primed' state, after a pre-exposure to a priming agent and which will increase the ability of the plant to withstand a subsequent stress (Goellner and Conrath, 2008; Macarisin *et al.*, 2009). Priming is comparatively simple and cost-effective because it is a part of induced resistance in plants, where pre-treated plants respond more rapidly and or efficiently when they are re-exposed to the stressed condition (Conrath *et al.*, 2006; Jakab *et al.*, 2005; Jisha *et al.* 2013; Jisha and Puthur, 2015). In priming, innate/ inherent ability of plants are further enhanced by priming treatments and so the technique is comparatively more natural and easily adoptable.

Materials and methods

Two black pepper varieties viz., Panniyur 1 (P1) and Panniyur 5 (P5) were selected for the study; P1 is a known drought-susceptible and P5 is a drought-tolerant variety (Thankamani *et al.* 2003; Vijayakumari and Puthur, 2014).

Four sets (40 plants/set) of healthy rooted plantlets (with 6–7 leaves) of both drought-tolerant and sensitive varieties were raised in Hoagland nutrient medium in light transparent bottles (19×11 cm) and kept in a culture room (RH: 60 ± 2 %; temperature: $25 \pm 2^{\circ}$ C; light intensity: 120 µmol m² s⁻¹) and acclimatized for a period of 2 weeks. For treatments, the existing Hoagland medium in bottles was replaced and the plants were supplied with fresh Hoagland medium containing PEG (poly ethylene glycol 6000; 10 % w/v). To impart 'priming' the plants were subjected to a pre treatment with different concentrations of GABA (0.5, 1, 1.5, 2 and 2.5 mM)/ BABA (0.25,0.5, 0.75, 1.0 and 1.25 mM), 24 h prior to 10 % PEG treatment in Hoagland medium. Plants kept in Hoagland nutrient medium without any treatment, served as control in the case of both drought-tolerant and -sensitive varieties. Various analyses were conducted with fully unfolded youngest leaves at intervals of 5 days starting from 0 to 15 days.

Percentage of wilting was assessed according to Engelbrecht and Kursar (2003). For assessing wilting, severely affected plants with strong visible changes in surface structure, angle, colour and burning of leaf tips were counted after visual observation.

Relative water content of the leaves was measured as per the protocol of Weatherley (1950).

Leaf ϕ_s was measured according to Hura *et al.* (2007), using a vapour pressure osmometer (Wescor 5520, USA).

Both RWC and ϕ_s were measured in samples collected between 10 am and 12 pm.

Results and Discussion

Black pepper plants showed visual symptoms of osmotic stress by 10 d of PEG treatment and towards 15 d of stress, leaf RWC reduced significantly and the plants started wilting. Among the varieties, P1 was severely affected by stress; whereas P5 showed signs of tolerance up to 15 d (concentration of PEG above 10 % induced severe stress in both varieties and the plants showed signs of death by 15 d (Table 1).
							RWC (%)			
Days			Panniyur 1	l				Panniyur 5	5	
	Control	PEG 5%	PEG 10%	PEG 15%	PEG 20%	Control	PEG 5%	PEG 10%	PEG 15%	PEG 20%
1	93 ± 2.6	94 ± 2.1	93 ± 1.9	94 ± 2.5	89 ± 2.1	92 ± 2.0	93 ± 2.2	92 ± 2.2	94 ± 2.0	89 ± 2.5
5	92 ± 3.1	93 ± 2.5	83 ± 2.7	83 ± 2.8	78 ± 2.1	92 ± 2.9	92 ± 3.9	87 ± 2.1	81 ± 2.1	77 ± 1.2
10	93 ± 2.1	89 ± 3.1	65 ± 1.7	60 ± 2.6	51 ± 1.8	93 ± 2.3	88 ± 1.6	75 ± 1.8	70 ± 2.9	65 ± 2.5
15	94 ± 2.4	81 ± 2.0	40 ± 1.2	32 ± 1.0	21 ± 1.0	93 ± 1.9	83 ± 1.4	48 ± 2.1	32 ± 1.5	27 ± 1.2
					V	Wilting (%)			
Days			Panniyur 1	l				Panniyur 5	5	
	Control	PEG 5%	PEG 10%	PEG 15%	PEG 20%	Control	PEG 5%	PEG 10%	PEG 15%	PEG 20%
1	0	0	0	0	3 ± 0.01	0	0	0	0	0
5	0	0	11 ± 0.04	6 ± 0.03	23 ± 1.1	0	0	0	3 ± 0.02	17 ± 0.9
10	0	6 ± 0.02	39 ± 2.1	56 ± 2.2	100 ± 5.3	0	3 ± 0.02	26 ± 1.1	45 ± 1.7	87 ± 4.1
15	0	29 ± 1.7	80 ± 4.3	100 ± 4.5	100 ± 4.7	0	23 ± 1.0	71 ± 3.3	94 ± 4.1	100 ± 4.5

Table 1. RWC and percentage of wilting in black pepper varieties subjected to different concentrations of PEG 6000 treatment.

'0' means no wilting was observed.

Black pepper plants pre-treated with the different concentrations of NPAAs, GABA (0.5, 1, 1.5, 2 and 2.5 mM)/ BABA (0.25, 0.5, 0.75, 1.0 and 1.25 mM) and then subjected to PEG 6000 (10%) treatment showed statistically significant reduction in wilting and loss of leaf RWC as compared to the plants treated with PEG (10%) alone (Table 2 and 3; Fig.1 and 2). It was observed that the reduction of osmotic potential was highest at initial days (5 and 10 d) of osmotic stress in pepper plants treated with NPAAs (Fig.3 and 4). Among the different GABA concentrations tested, 2 mM was found to be more efficient in bringing about the reduction of above mentioned parameters in both varieties of black pepper (Table 2; Fig. 1 and 3). Likewise, in treatment BABA, 0.5 mM was found to be more efficient in bringing the reduction of above mentioned parameters in both varieties of black pepper (Table 3; Fig. 2 and 4). Higher concentration of NPAA's treatment was not good enough in showing positive results during the experimental condition.

Table 2. Percentage of wilting on 15 d in black pepper varieties subjected to different concentrations of GABA and PEG 6000 (10%) treatment

Treatments	Wilting (%)	
	Panniyur 1	Panniyur 5
Control	0	0
0 GABA + 10% PEG	80 ± 3.2	72 ± 1.9
0.5 mM GABA + 10% PEG	74 ± 2.2	66 ± 2.9
1.0 mM GABA + 10% PEG	71 ± 2.9	62 ± 2.9
1.5 mM GABA + 10% PEG	64 ± 1.1	49 ± 1.1
2.0 mM GABA + 10% PEG	63 ± 1.9	50 ± 1.9
2.5 mM GABA + 10% PEG	68 ± 1.1	48 ± 2.9



Fig. 1. RWC recorded in plants subjected to different concentrations of GABA (0, 0.5, 1.0, 1.5, 2.0 and 2.5 mM) and PEG 6000 (10%) treatment in P1 and P5 varieties of black pepper.



Fig. 2. RWC recorded in plants subjected to different concentrations of BABA (0, 0.25, 0.50, 1.00 and 1.25 mM) and 10 % PEG (6000) treatment in P1 and P5 varieties of black pepper.

PEG decrease the water potential of the medium and thus induce osmotic stress when plants are cultured in nutrient medium containing PEG (Materecher *et al.*, 1992; Marcinska *et al.*, 2013). The wilting of black pepper plants by 15 d was due to inadequate water absorption from Hoagland medium by the plants. In plants, 'wilting' of leaves is a symptom of cell turgour loss. Therefore, monitoring of 'wilting' is a simple but important phenotypic expression indicating critical plant water status due to drought stress; and scoring of wilting is used extensively by breeders during selection of drought tolerant phenotypes (Engelbrecht *et al.*, 2007; Blum, 2011). On 5 d of imparting stress, wilting was initiated in plants due to PEG treatment which was indicated by droop-

Treatments	Wilting	(%)	
	Panniyur 1	Panniyur 5	
Control	0	0	
0 BABA + 10% PEG	81 ± 2.9	70 ± 3.7	
0.25 mM BABA + 10% PEG	70 ± 3.8	57 ± 2.2	
0.50 mM BABA + 10% PEG	54 ± 1.9	43 ± 1.1	
0.75 mM BABA + 10% PEG	58 ± 2.9	42 ± 2.7	
1.00 mM BABA + 10% PEG	62 ± 3.4	52 ± 3.9	
1.25 mM BABA + 10% PEG	68 ± 2.9	56 ± 2.3	

Table 3. Percentage of wilting on 15 d in black pepper varieties subjected to different concentrations of BABA and PEG 6000 (10%) treatment

ing of vines and loss of leaf turgour. By 10 d of the exposure to stress, wilting was marked by burning of shoot tips as well as hardening and loss of green colour of leaves. Towards the last phase (15 d), >50% wilting occurred in plants, but the plants survived and the severity of PEG-induced osmotic stress in black pepper plants was marked by visual changes in features of leaves such as significant changes in leaf angle (maximum leaf angle), colour (yellowish brown to black) and texture (leathery) and also appearance of necrosis. In black pepper, pre treatment with either of the NPAAs could reduce the wilting of plants considerably and among the NPAAs, the BABA treated plants showed least percentage of wilting on 15 d of osmotic stress. It was found that the wilting response of plants pre-treated with GABA/BABA was concentration dependent and 2 mM GABA/0.5 mM BABA gave better results in the present investigation.



Fig. 3. Leaf osmotic potential (ϕ_s) recorded in plants subjected to different concentrations of GABA (0, 0.5, 1.0, 1.5, 2.0 and 2.5 mM) and PEG 6000 (10%) treatment in P1 and P5 varieties of black pepper.





Fig. 4. Leaf osmotic potential (ϕ_s) recorded in plants subjected to different concentrations of BABA (0, 0.25, 0.50, 1.00 and 1.25 mM) and 10 % PEG (6000) treatment in P1 and P5 varieties of black pepper.

It is therefore inferred from the study that at low doses, pre treatment with NPAAs like GABA/ BABA induced some 'priming effect' in pepper plants, which may be the reason for reduced wilting observed in primed plants of black pepper as compared to non-primed ones. Severe dehydration due to PEG-induced osmotic stress caused 450% loss of RWC in both pepper varieties. Upadhyaha *et al.* (2008) have observed that leaf RWC fell to 41–53%, when tea plants were imposed with drought for 20 days. RWC is used as a good index for assessing drought tolerence, as it is a less variable parameter of cell water status in plants (Ocampo and Robles, 2000). Symptoms of wilting was initiated in black pepper plants when leaf RWC was recorded around 80% and visual symptoms of severe wilting were observed when leaf RWC was recorded between 40-60%. The loss of leaf RWC was considerably lesser in the plants subjected to GABA/BABA treatments (at optimum concentrations), as compared to non-primed plants and the data was in correlation with the results of the percentage of wilting.

Osmotic stress caused lowering of ϕ_s in leaves of pepper varieties and the decreased ϕ_s in leaves is an indication that plant cells accumulated ions, dissolvable substances like sugars and other compatible solutes such as proline, glycine betaine *etc.* for countering the osmotic stress by maintaining relatively higher water content necessary for the functioning of important metabolic processes. In primed condition of black pepper plants, the reduction of ϕ_s as compared to nonprimed plants was highest on 5 d of osmotic stress. The significant reduction of ϕ_s at early days of stress in GABA/BABA-primed plants of black pepper may be due to early adjustment of osmticum and maintenance of proper water status. But, the ϕ_s in primed plants was not as reduced as that observed in non-primed plants on 15 d of osmotic stress, and this implies that, GABA/BABA treatment facilitate the plants to maintain an ideal ϕ_s at an early stage so that plants encounter the osmotic stress more effectively and with lesser interventions on normal metabolic activities.

The results indicated that a prior application of NPAAs at low doses results in 'priming' of pepper plants which equip the plants to encounter osmotic stress faster and stronger than the non-primed plants. The primed responses of GABA/BABA-treated plants included the decrease in 'wilting', increase of leaf RWC, faster reduction of osmotic potential etc. as compared to non-primed plants.

In GABA/BABA-primed state, the pre conditioning of plants results in faster activation of defense related activities which can minimize the wastage of metabolic energy by controlling the overall metabolism during critical states of stress (Jakab *et al.*, 2005; Conrath *et al.* 2006; Jisha and Puthur, 2015; Vijayakumari and Puthur, 2016). Hence the activation of defense responses in GABA/BABA priming can be regarded as cost-effective in perspective of energy utilization during stress in black pepper varieties.

Among the GABA and BABA priming, BABA priming resulted in more increased tolerance towards osmotic stress, in terms of the parameters measured (delayed wilting, high RWC, ϕ_s and MDA content) in black pepper; and this increased action of BABA may due to the stereo-specific action of BABA due to its 3-(â) position of amino group, during the activation of defense-related cell signaling. Amongst the varieties, apparently drought tolerant variety P5, showed comparatively better result in primed condition. It is hypothesized that the innate tolerance capacity is found tobe further enhanced to maximum in plants under 'primed' condition as evident from the comparatively improved characteristics of P5 plants.

Conclusion

The wilting and loss of leaf RWC were highest in P1 variety as compared to the apparently drought tolerant variety P5. The pre treatment with GABA (2 mM)/BABA (0.5 mM) in hydroponically cultured plants induced an enhanced tolerance towards PEG treatment in terms of reduced wilting and lesser decrease in leaf RWC. The pre treatment with NPAAs induces some 'priming' effect in black pepper plants which increased the tolerance of plants towards osmotic stress. In priming, the abiotic stress tolerance potential was also enhanced so that the plants are better able to mitigate the abiotic stresses encountered by them. As a simple and cost-effective technique, the method of priming using NPAAs like GABA and BABA can be adopted in field condition for alleviating the transplantation shock and further acclimatization of black pepper plants transplanted to fields.

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Effect of shade net colour on establishment and growth of black pepper cuttings in nursery

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Abstract

Black pepper is a perennial spice crop which is conventionally propagated vegetatively using runner shoots produced from the base of the plant. The ideal time for raising pepper nursery is February to April. Most of the pepper nurseries are roofed with green shade nets (50 %). Influence of different coloured shade nets in nurseries has been well studied in many crops but information is lacking in pepper. Hence a study was undertaken in pepper nursery at Pepper Research Station, Panniyur during February to July 2015 with green, red and black colour shade nets (50 %). Light intensity and temperature inside the nursery were recorded using Lux meter and Thermometer at 10.30 am, 2 pm and 4 pm. Light intensity was significantly higher under red colour shade net especially during 2 pm the maximum being 13160 lux. Growth with respect to number of well developed leaves and height of the plants was also higher under red shade net. The highest mean plant height of 32.95 cm was observed under red shade net and lowest under black shade net (23.9 cm). The highest mean number of well developed leaves per plant was observed under red shade net (11.5 nos.) followed by 8.3 nos. under black shade net and 7.7 nos. under green shade net. There was no significant difference in percent establishment of cuttings and number of nodes under different colour shade nets. But plant mortality was significantly less under red shade net nursery. The study revealed that colour of the shade net has an effect on growth parameters black pepper cuttings in nursery.

Introduction

Black pepper (*Piper nigrum* L.) belonging to family Piperaceae is a perennial climbing vine grown for its berries which are extensively used as spice and in medicine. Black pepper grows successfully between 20° N and 20° S of equator upto 1500 m above mean sea level. It is a plant of humid tropics requiring 2000-3000 mm of rainfall. The crop tolerates temperature between 10ÚCand 40ÚC. Black pepper can be grown in a wide range of soils with a pH of 4.5-6.5.

Black pepper is the most important spice crop contributing much to our national economy. Production and productivity of the crop has shown a decline over the last many decades due to various reasons like pests and diseases, senile vines in gardens and poor adoption of proper scientific management practices. Nevertheless, farmers are trying to explore new and still unexplored areas in a quest to bring more area under cultivation of black pepper. Increasing price



trend of black pepper over the last few years has been one of the reasons for this trend. As a prelude to increasing and intensifying black pepper cultivation, availability of planting materials in sufficient quality and quantity must be ensured. Black pepper is a perennial spice crop which is conventionally propagated vegetatively using runners produced from the lower 30 cm to 50 cm of the vine. The nursery is usually raised during February to June every year.

Conventionally, black pepper nurseries are covered with green shade nets (50 %) and influence of different colours of shade nets in nurseries on growth of plants has been well studied in many crops. It is well documented that plants react to changes that occur in the spectrum of electromagnetic radiation to which they are exposed through alterations in morphology and physiology (Kasperbauer and Hamilton, 1984). Studies on the influence of different coloured shade nets are not much reported in black pepper. Hence, a study was undertaken in black pepper nursery to understand the effect of different coloured shade nets on growth and survival of nursery plants.

Materials and methods

The study was undertaken at Pepper Research Station, Panniyur, Kannur, Kerala during February to July, 2015. The experiment was designed in CRD with three treatments and twenty replications. The treatments were different colour shade nets (50 %) *viz.*, red, black and green. Green shade net which is conventionally used in nurseries was taken as control. Two node cuttings from runners of variety Panniyur 5 were planted in potting mixture (2 soil: 1 Sand: 1 cow dung) filled in polybags of size 6×5 '' were used. Each bag contained four cuttings and twenty bags were used as replicates. Light intensity was measured using a standard handheld Lux meter (LX 101A, Lutron Electronic Enterprises Co. Ltd). Temperature inside the nursery was measured using a mercury thermometer (Zeal 76 mm) kept inside the nursery at a height of 1.5 m above ground level. Light intensity and temperature were measured at 10.30 am, 2 pm and 4 pm every day. Observations on number of plants rooted and survived (per cent survival), plant height, number of well developed leaves and number of nodes were observed 90 days after planting. Statistical analysis of data was done as per Panse and Sukhatme (1957).

Results and discussion

The study revealed that coloured shade nets have varying effects on growth and survival of black pepper cuttings (Table 1).

Treatments	Rooting(%)	Plant height (cm)	No. of well developed leaves	Number of nodes	Survival(%)
T1 (Green)	86.45 (68.58)	24.75	7.7	5.2	82.75 (65.62)
T2 (Red)	86.75 (68.79)	32.95	11.5	5.55	85.90 (68.09)
T3 (Black)	86.55 (68.59)	23.9	8.3	4.8	84.80 (67.13)
S. Em	-	2.88	1.17	-	0.92
CD (5%)	NS	6.7	3.01	NS	1.82

Table 1. Effect of coloured shade nets on germination, growth and survival of black pepper nursery plants

(Values in parenthesis are angular transformation data)

There was significant difference between treatments with respect to plant height, number of well developed leaves and per cent survival (Fig.1 and 2). The highest mean plant height (32.95 cm)

was observed under red coloured shade net while the least was recorded under black shade net (23.90 cm) on par with green shade net (24.75 cm). Stephens (2007) has also reported maximum height for chilli (*Capsicum annuum* L.) plants grown under red shade net. Highest number of well developed leaves (11.5) was recorded for plants grown under red shade net followed by plants under black (8.30) and green (7.7) shade nets. Anushma *et al.*, (2014) has reported maximum number of leaves per plant in grafts of jamun (*Syzigium cuminii* Skeels) grown under red coloured shade net. Per cent survival was maximum (85.90) under red coloured shade net which was on par with per cent survival under black coloured shade net (84.8). The least per cent survival was recorded for plants grown under green shade net (82.75). Illic *et al.*, (2015) has reported that red shade nets create optimal growing conditions for tomato (*Solanum lycopersicum*).



Fig.1. Effect of coloured shade nets on growth of black pepper plants



Fig. 2. Effect of coloured shade nets on percent survival of black pepper plants

There was significant difference between different coloured shade nets with respect to light intensity during morning, noon and afternoon. The maximum mean light intensity was recorded under red shade net during noon (13160 lux) and the minimum under green shade net (6340.33 lux) which was on par with that of black shade net (6620.33 lux). Light intensity was always higher under red shade net during morning, noon and afternoon hours (Table 2).

Treatments	Morning light intensity (Lux)	Noon light intensity (Lux)	Afternoon light intensity (Lux)
T1 (Green)	3490.33	6340.33	3470.53
T2 (Red)	7010.00	13160.00	7240.63
T3 (Black)	3320.33	6620.33	3470.00
S. Em	331.0	434.4	353.3
CD (5%)	1373.84	1714.4	967.7

Table 2. Light	intensity	under	different	coloured	shade	nets	(Lux)
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There was significant difference between temperature recorded under different coloured shade nets, the highest values being observed under red shade net irrespective of time of observation (Fig. 3). There was no significant difference between temperature under green and black shade nets during morning hours while there was significant difference between temperature (35.73 ^o C) was observed under red shade net during noon.



Fig. 3. Temperature under different coloured shade nets (⁰ C)

Based on correlation studies, it was evident that plant height in nurseries was significantly correlated to light intensity during morning and afternoon hours while number of leaves was correlated to morning temperature. Sasaki and Mori (1981) while working with *Vatica odorata* (Griff.) Symington had observed that seedling growth in height and weight increased linearly with increasing light.

	Plant Height (CM)	No.of Leaves	% survival	Light intensity (Morning)	Light intensity (Noon)	Light intensity (Afternoon)	Temperature (Morning)	Temperature (Noon)	Temperature (Afternoon)
Plant height	1.0000								
No. of leaves	0.9731	1.0000							
% survival	0.7101	0.8533	1.0000						
Light intensity (Morning)	0.9990*	0.9823	0.7406	1.0000					
Light intensity (Noon)	0.9926	0.9938	0.7902	0.9970*	1.0000				
Light intensity (Afternoon)	0.9964*	0.9891	0.7673	0.9992*	0.9993*	1.0000			
Temperature (Morning)	0.9783	0.9997*	0.8406	0.9865	0.9962*	0.9924	1.0000		
Temperature (Noon)	0.9790	0.9058	0.5519	0.9691	0.9472	0.9582	0.9156	1.0000	
Temperature (Afternoon)	0.7755	0.9001	0.9952	0.8027	0.8463	0.8263	0.8895	0.6307	1.0000

Table 4. Correlations for plant characters and survival with light intensity and temperature under coloured shade nets

*Significant at 5% level

The study revealed that the influence of different coloured shade nets on black pepper nursery plants and the prospect for using red coloured shade net on a commercial scale. Stephens (2007) has also found the best overall performance of chilli seedlings when grown under red coloured shade net.

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In vitro propagation in black pepper through seed culture – A case study

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Abstract

Black pepper (*Piper nigrum* L.) populary known as "Black Gold" is one of the important spice crop of Udupi. The hot and humid climate of sub-mountainous tracts of Western Ghats is ideal for its cultivation. In the district, area under pepper increased from 267 ha (2008-09) to 383 ha (2014-15) (Source: Dept. of Horticulture, Udupi). There is dearth for quality planting materials of resistant varieties. Entrepreneurs like Mr. Shyam Prasad and Mrs. Prasanna Prasad started Annapoorna Nursery in a 10 acres land propagating different horticulture plants with black pepper as one of the major crop in Pethri village, Udupi District. Rapid multiplication method and production of grafted black pepper using Piper colubrinum as root stock, was adopted in their nursery for the production of quality planting material. In the year 2009, after successfully completing a short term course on in vitro propagation, they started Annapoorna Plant Tech - Tissue Culture Lab for mass multiplication of Horticulture plants. From their hard efforts and guidance from the Scientists of Indian Institute of Spice Research, Kozhikode and Krishi Vigyan Kendra, Udupi, they were able to successfully regenerate black pepper var. Panniyur-1, through seed culturing. They were able to culture 100 plants from a single seed. Mother blocks of different black Pepper varieties viz., Thevam, Thekkan, Panchami and Pornami were raised under shade houses, to prevent cross pollination and to obtain true to type plants. The availability of quality planting material throughout the season shall be a boon to the black pepper growing farmers of the Udupi District.

Introduction

Black pepper (*Piper nigrum* L.) popularly known as "Black Gold" is one of the important spice crop of coastal region. The hot and humid climate of sub-mountainous tracts of Western ghats is ideal for its cultivation. With the increasing area under pepper in Udupi, there is a dearth for quality planting material of resistant varieties. The black pepper is traditionally propagated from cuttings; seeds tend to produce dioecious progenecies but favourable hermaphrodite cultivars can be vegitatively propagated. Nambiar *et al.*, (1977), Bavappa & Gurusinghe (1978) and Sivaraman (1987) have described methods of vegetative propagation of black pepper for initial multiplication as well as for large scale planting. However, use of runners with 2-6 nodes from 5 to 10 year old vine, for nursery and field plantations can yield only 50 cuttings per plant per year,

limiting the potential to proliferate improved varieties. Black pepper is commonly infected by fungal, bacterial, viral and mycoplasmal pathogens. Internal infections caused by viruses and mycoplasma are difficult to control and are always transferred by vegetative propagation.

In 1998, Mr. Shyam Prasad Bhat and Mrs. Prasanna Prasad Bhat started a small scale nursery -Annapoorna Nursery in 10 acres of land at Pethri village, Udupi District, Karnataka. Initially they started production of economically important horticulture plants *viz.*, Arecanut, Coconut, Pepper, Nutmeg, Cinnamon, Clove, Mango and Sapota, Teak and Sandalwood through various propagation techniques like seeds, air layering, cuttings, budding, grafting etc. At present they have collection of more than 200 varieties of different species of horticulture plants in their scion bank.

With their vast experience in the field of nursery, they realized the demand for quality planting material of black pepper. The increase in price of processed black pepper motivated the farmers of coastal and neighboring districts viz., Chikamagalore, Uttar Kannada, Shivamogga, Coorg and Hassan to go for area expansion of black pepper and also rejuvenation of senile garden. Annapoorna nursery produce annually 1 to 2 lakh of black pepper rooted cuttings and the large scale production of black pepper rooted cuttings is a challenging task in coastal region as they have to address lot of practical problems. Heavy rainfall during the month of June to September (> 3800 mm in 92 rainy days), restricts the production of rooted cuttings as the cuttings initiated for rooting succumbs for foot rot disease due to excess moisture in the media. Cuttings propagated during April to May have poor success rate due to excess heat and lack of moisture retention in the media. During the month of September to February the vines will be bearing and pruning of vines for propagation will affect the yield of the crop. In their nursery they also tried rapid method of propagation techniques - the Serpentine Method, the technology released from Indian Institute of Spice Research, Kozhikode, Kerala, but couldn't able to meet the demand of the planting material of resistant varieties. Hence, to overcome the dearth of quality planting material they came up with an innovative idea of production of black pepper plantlets through in vitro propagation. After completing a short term course on tissue culture at University of Agricultural Sciences, Bangalore, the couple started Annapoorna Plant Tech tissue culture lab in 2009 mainly for the *in vitro* production of banana plants and at present they have the capacity to produce 8 lakh banana plants annually.

Materials and Methods

The mother plants of black pepper were procured from IISR, Kozhikode and were raised in their nursery. The *in vitro* propagation of black pepper was carried out as per the protocol given by Murashige and Skoog (1974), through inoculating matured black pepper seeds, nodes, internodes, leaves and shoot tip as explants. The explants were first washed with running water and then rinsed with 1% Sodium Hypochloride. The explants were then dipped in Polyoxyethylene Sorbitan Monolaurate (Tween 20) for 20 minutes and then washed in Isopropyl Alcohol. The sterilized and washed explants were then treated with 0.1% Mercuric Chloride for 5 minutes and then to remove the traces of Mercuric Chloride, the explants were washed three times with sterilized distilled water. The explants were then inoculated on Murashige and Skoog medium, Linsmaier and Skoog medium (LS) and Woody Plant media (WPM) with different concentrations of BA (1, 2, 3, 4, 5 and 6 mg/L). The same procedure was followed for multiple shoot formation. All culture were grown under 16 hours of light illuminated by 40 W white fluorescent lights and 8 hours dark period in air conditioned growth room. The temperature of culture room was maintained at 25±2°C. Sub culturing was carried out at every 21 days interval. Nodal segments from the proliferated shoots were sub-cultured again for further multiple shoot induction. Regenerated multiple shoots were cut, the individual shoots were placed in half MS medium containing 2 g/L of activated



charcoal and different concentrations of IBA for root induction. Data was recorded after 5 weeks for multiple shoot induction and rooting frequency.

Results and Discussion

In the present study, Mr. Shyam Prasad Bhat and Mrs. Prasanna Prasad Bhat tried for the callogenesis of black pepper vine from seeds, nodes internodes, leaves and shoot tip explants and organogenesis from callus to produce disease free plants of Piper nigrum L. Profuse callusing was observed in the MS media with 5 mg/L BA when compared with WPM and LS media of different concentrations of BA. Among the explants matured seeds showed profuse callus and shooting inoculated in MS media with 5 mg/L BA when compared to nodes, internodes, leaves and shoot tip, where the callusing was slightly less. Although some fungal contamination occurred, the persistence of bacteria was most notable which hampered the establishment of the plantlets. The excised micro shoots obtained from the matured seeds, were cultured on half MS medium supplemented with 0.1 mg NAA and 1.5 mg/L BA which showed profuse shooting. Maximum rooting was observed in the media containing half MS media and 2 g/L Activated charcoal. In vitro techniques for micro propagation of black pepper have already been reported using shoot-tip explants (Nazeem et al., 1992; Philip et al., 1992; Babu et al., 1993; Joseph et al., 1996), Leaf explants (Sujatha et al., 2003), nodes explants (Bhat et al., 1992), root explants (Bhat et al., 1995) and Seeds (Nair and Gupta, 2006). The plantlets regenerated from seedling derived callus and shoot tips had also been reported, but most attempts to regenerate plants from mature vine were unsuccessful.

The rooted plantlets were removed from the medium and transferred to green house for hardening and successfully test planted in the farmer's field. From a single seed of black pepper inoculated they were able to produce 100 rooted pepper plantlets. As they were successful in regeneration of black pepper plantlets by using matured seeds as explants there was less chance of maintaining genetic purity of the regenerants. To maintain genetic purity of the progeny the mother plants were raised in separate shade houses and the seeds were used for *in vitro* propagation.

Conclusion

Through, Annapoorna Plant Tech tissue culture lab they are able to produce 8 lakhs of quality banana plantlets annually. Based on the performance of the *in vitro* propagated black pepper in the field, they have planned to produce 50000 *in vitro* propagated black pepper plantlets in the year 2017. The Annapoorna nursery has been accredited by the National Horticulture Board for the Udupi District. Recognizing their innovative ideas in the field of agriculture and valuable service for the farming community, Ministry of Agriculture, Govt. of India, honoured Mr. Shyam Prasad Bhat with 'Best farmer' in the year 2012, for his agri-entrepreneurship. Mrs. Prasanna Prasad Bhat has been recognized by the ICRISAT, Hyderbad as the best 'Women Farmer'. From their hard work and their enthusiasm to adopt innovative technologies in the field of nursery management and propagation Mr. Shyam Prasad and Mrs. Prasanna Prasad have earned lot of credentials in the society and also have created employment for the rural youths of Udupi district.

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Evaluation of biocontrol agents and fermented organic preparations on growth of rooted cuttings in black pepper nursery

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Abstract

A study was conducted at Pepper Research Station, Panniyur to evaluate the efficacy of biocontrol agents and fermented organic preparations on growth and suppression of *Phytophthora* infection in black pepper. Native isolates of rhizosphere bacteria and fungi were isolated and evaluated under in vitro for their antagonistic activity against Phytophthora capsici, the foot rot pathogen. The promising isolates and fermented organic preparations viz; Fish amino, Egg amino and Jeevamrutha were evaluated in black pepper nursery. Treatment with Potassium phosphonate was kept as chemical check. The plant growth parameters were recorded before and one month after treatment application. Among the different treatments, application of bacterium isolate A1 showed maximum increase in plant height of 49.30% as against control (23.5%). The shoot girth at collar region was maximum in plants treated with Fish amino (29.63%) while in control it was only 6.1%. Plants treated with bacterial antagonist S2 recorded maximum increase in number of leaves (57.89%) whereas the total leaf area was maximum in plants applied with Jeevamrutha (49.98%) followed by bacterium S2 (42.54%). In control the increase in leaf number and leaf area was only 23.81% and 26.12%, respectively. Chlorophyll contents viz., chlorophyll-a, chlorophyll-b and total chlorophyll was maximum in plants treated with Jeevamrutha with 0.32, 0.29 and 0.61 mg gram⁻¹ plant tissue, respectively. In control plants, chlorophyll a, b and total chlorophyll recorded was 0.19, 0.15 and 0.34 mg gram-1 plant tissue, respectively. Phytophthora infection at collar region was not observed in plants treated with Potassium phosphonate and Fish amino. Application of Egg amino and Jeevamrutha also recorded less infection on collar. The study indicated the efficacy of fermented organic fertilizers and bioagents in improving plant growth and also reducing nursery diseases and can be effectively utilized in commercial production of healthy planting materials of black pepper in nurseries. However further studies need to be conducted to elucidate the mode of action in disease control for conclusive results.

Introduction

Black pepper (*Piper nigrum* L.), the 'King of Spices' has been cultivated in India since ancient times and it is the most important spice crop in trade all over the world. Though India has the largest area under black pepper cultivation in the world, the production and productivity is very low when compared to other nations. Various reasons has been attributed for this production decline *viz.*, lack of proper production technology, poor maintenance of gardens, pests and dis-

eases, unavailability of elite planting materials etc. However in the recent years, much efforts are being made to rejuvenate the existing gardens to increase the production. The availability of quality planting material is a major constraint in increasing the area, production and productivity of black pepper. The propagation of black pepper is mainly through rooted cuttings and layers. In nurseries, the plantlets are prone to attack by a number of pests and diseases and the management of these mainly resort to chemical treatments. As spices are one of our main dietary constituents, it becomes more important to find out alternative strategies to chemical control. Nowaday's integration of chemicals and biocontrol agents has been considered as an alternative approach as it reduces the amount of chemicals as well as pollution hazards with minimum interference on the ecosystem (Papavizas and Lumsden, 1980). Many potential biocontrol agents have been identified for managing plant diseases. These agents are also known for their effect on plant growth enhancement (Singh and Singh, 2002). In recent years, application of fermented organic fertilizers has been introduced to modern agriculture for producing safe and good quality agriculture products. With this background an attempt was made to evaluate some native isolates of antagonistic microorganisms and farm made fermented organic preparations on growth of black pepper cuttings in nursery.

Materials and Methods

Isolation and in vitro evaluation of antagonistic microorganisms

Soil samples were collected from the rhizosphere of healthy black pepper vines of the experimental farm at Pepper Research Station, Panniyur. Isolation of native antagonistic bacteria and fungi were done as per standard procedures. *In vitro* screening was done using dual culture technique to identify isolates antagonistic to *Phytophthora capsici*, a major pathogen of black pepper and the best isolates were selected, purified and maintained for further studies.

Preparation of fermented organic plant growth stimulants

Three organic preparations *viz*. Jeevamrutha, Fish amino and Egg amino were chosen and prepared as per the procedures followed by local farmers. For preparing 10 L Jeevamrutha, cow dung (500 g), cow urine (500 ml), powdered green gram (1 g), coconut water (10 ml) and a hand full of fertilizer free fertile top soil were used. All ingredients were mixed well in a plastic container, covered with a gunny bag and kept in shade for seven days. The mixture was stirred three times daily using wooden ladle. After seven days the mixture was strained through a muslin cloth and kept for study.

For fish amino, equal quantity of fish and jaggery were taken, sliced, mixed and kept in closed container for 10 days after which the solution was strained through a muslin cloth and stored. Egg amino was prepared by keeping eggs (5 Nos) dipped in lemon juice (10-15 Nos) and kept for 5 days in closed container. After 5 days required jaggery (250 g) was added, mixed well and kept for five more days, then filtered and stored.

In vivo evaluation of biocontrol agents and fermented preparations under green house condition

The promising antagonists selected under dual culture technique and the fermented preparations were evaluated on three months old rooted cuttings of black pepper for their effect on growth enhancement and disease suppression. The experiment was laid out in completely randomized design with four replications. Talc based formulation of selected bacteria @ 2%, Fish amino and egg amino @ 0.5% and Jeevamrutha at 10 times dilution were prepared and drenched to root zone of pepper cuttings grown in poly bags. After 10 days, a foliar spray was also given. *Tricho-derma* sp. grown in rice bran was applied to root zone @ 5g kg⁻¹ soil. A challenge inoculation



with the pathogen *Phytophthora capsici* was made on the leaves and at the collar region of the cuttings. Application with Potassium phosphonate @ 0.3% was kept as chemical check and plants without any treatment served as control. The plant growth parameters were recorded before and one month after treatment application and percent increase was calculated. Chlorophyll content of the leaves was estimated following standard procedures. Infection on leaves were measured on fourth day of inoculation and percent leaf area infected was calculated. Length of lesion at collar region was recorded for estimating stem infection.

Results and Discussion

Data showed that (Table 1), among the different treatments, application of bacterium isolate A1 showed maximum increase in plant height of 49.30% as against 23.56% in control. Application of Potassium phosphonate resulted in 37.57% increase in plant height. The plants treated with bacterial antagonist S2 individually and in combination with *Trichoderma* sp. also recorded considerable increase in plant height with an increase of 36.65% and 35.65%, respectively. The increase in shoot girth at collar region was maximum in plants treated with Fish amino (29.63%), followed by combined application of bacterium A1+ *Trichoderma* sp. (28.21%) and bacterium S2+ *Trichoderma* sp. (27.71%) while in control the increase was only 6.1%. Individual application of S2 (26.92%) and A1 (21.35%) also recorded increase in shoot girth.

Regarding the total number of leaves, plants treated with bacterial antagonist S2 recorded maximum increase of 57.89% followed by combined application of bacterium S2+ *Trichoderma* sp.

Treatments	Plant Height (%)	Shoot girth (%)	Total no. of	Total leaf area (%)		Chlorophyll cor (mg g ⁻¹ tissue	ntent e)
	Increase	merease	increase	merease	Chl.a	Chl.b	Total chl.
Bacterium A1	49.3	21.35	52.38	27.82	0.30	0.26	0.56
Bacterium S2	36.65	26.92	57.89	42.54	0.25	0.16	0.41
Trichoderma sp.	11.14	12.64 43.75 27.64		27.64	0.30	0.22	0.53
A1+Trichoderma sp.	19.03	28.21	29.41	25.54	0.28	0.22	0.50
S2+Trichoderma sp.	35.65	27.71	52.94	38.65	0.28	0.25	0.52
Fish amino	18.88	29.63	31.58	29.99	0.22	0.13	0.34
Egg amino	7.79	13.25	50.00	32.59	0.27	0.25	0.52
Jeevamrutha	16.19	16.3	44.64	49.98	0.32	0.29	0.61
Potassium phosphonat	te 18.48	21.04	35.29	28.77	0.24	0.21	0.45
Control	23.56	6.1	23.81	26.12	0.19	0.15	0.34

Table 1. Effect of biocontrol agents and fermented organic products on growth of rooted cutting in black pepper nursery

*percent increase in one month period

0.00

4.23

1.06

Tooled culting in black pepper i	luisery		
Treatments	Infected leaf area (%)	Collar infection (cm)	
Bacterium A1	79.54	2.33	
Bacterium S2	74.36	2.88	
Trichoderma sp.	59.93	3.58	
A1+Trichoderma sp.	73.98	2.10	
S2+Trichoderma sp.	69.94	3.28	
Fish amino	23.18	0.00	
Egg amino	87.42	0.43	
Jeevamrutha	53.49	1.10	

Potassium phosphonate

Control

CD (0.05)

Table 2. Effect of biocontrol agents and fermented organic products on *Phytophthora* infection on rooted cutting in black pepper nursery

(52.92%) and A1 (52.38%) as against 23.81% increase in control. In case of total leaf area, application of Jeevamrutha recorded highest increase (49.98%) followed by application of bacterium S2 (42.54%) whereas in control the increase in leaf area recorded was 26.12%.

1.77

94.37

24.1

Chlorophyll contents *viz.*, Chlorophyll a, chlorophyll b and total chlorophyll was maximum with 0.32, 0.29 and 0.61 mg gram⁻¹plant tissue in plants treated with Jeevamrutha. Application of bacterium A1 and S2 individually and in combination with *Trichoderma* sp. and Egg amino also showed higher chlorophyll content than the control plants. In control, chlorophyll a, b and total chlorophyll recorded was 0.19, 0.15 and 0.34 mg gram⁻¹plant tissue, respectively.

The data on the effect of different treatments on *Phytophthora* infection on leaves (Table 2) showed that percent leaf area infected ranged from 1.77 - 94.37% on fourth day of inoculation. The least infection of 1.77% was recorded in plants treated with Potassium phosphonate. However application of Fish amino reduced leaf infection considerably to 23.18%. In control plants 94.37% leaf area was infected on the day of observation. In case of infection on collar region, all treatments considerably reduced the disease when compared to control. *Phytophthora* infection at collar region was not observed in plants treated with Potassium phosphonate and Fish amino. Application of Egg amino and Jeevamrutha also recorded less infection on collar.

Several workers have reported the efficacy of biocontrol agents in enhancing plant growth in addition to their ability in reducing plant diseases. The results of the present study are in agreement with Manoranjitham *et al.* (2000) and Anith and Manomohandas (2001). Plant growth regulators like gibberllins, cytokinins and indole acetic acid (IAA) induced by the strains might have contributed for better plant growth and development (Dubeikovsky *et al.*, 1993).

Various organic preparations for plant growth and disease suppression have been suggested by local farmers. But very few scientific evidences are obtained in this regard. In the present study, Jeevamrutha was found very effective on plant growth especially on healthy leaf production and



in reducing pathogenic infection. Sadanshu et.al. (2009) reported that Jeevamrutha is considered to be a panacea for the prosperity of agriculture. The effect of Fish amino and Egg amino on plant growth improvement and disease suppression was suggested by Muhammed (2010). The high calcium content of the product might have involved in strengthening the cell walls thereby preventing pathogen invasion.

Conclusion

The study indicated that the efficacy of fermented organic fertilizers and bioagents in improving plant growth and also in reducing nursery diseases and can be effectively utilized in commercial production of healthy planting materials in black pepper nurseries. However further studies need to be conducted to elucidate the mode of action in disease control for conclusive results.

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Novel method of runner vine production for black pepper in protected structures

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Abstract

In black pepper, propagation is done using runners produced from the base of field grown, 10-15 year old, robust and high yielding vines. The major constraint in establishing black pepper nurseries for large scale production of rooted cuttings from these runners is the limited availability of sufficient number of runners. With a view to augment the production of planting materials in black pepper by exploiting the potential of the polyhouse, a nursery was established during 2012-13 period at College of Agriculture, Padanakkad. Using the stock plants of seven high yielding varieties of black pepper planted in growbags, a new method of trailing the runners on rope tied vertically up in the polyhouse was tried for obtaining sufficient quantity of runner vines every year. The vines recorded fast growth under polyhouse conditions yielding three harvests per year during the initial period itself. The method is found to be a promising one with minimum recurring cost as the material required for trailing the runners is easily available, of low cost and the management of plants in the polyhouse is effective in enhancing the growth rate. The average number of two noded cuttings per plant per harvest during second year is 23 nos. The cuttings kept for rooting under polyhouse condition showed 80-85 percent survival and were further multiplied by serpentine layering. The comparison of rate of production of runners from different varieties under the polyhouse condition based on average number of runners and average length of runner showed that there is significant difference between the varieties. The highest number of runners was produced by Panniyur 4 (2.97) and Panniyur 7 (2.77). The average length of runner was significantly higher in Panniyur 1 during both years under study (367.08 cm) and Panniyur 5 during second year (363.86 cm).

Introduction

Black pepper, also known as "king of spices" is one among the expensive spice crop cultivated in India and many other tropical countries. It holds a prime position among other commodities in the spice trade market. For increasing the black pepper production, extensive new planting and replanting of senile and unproductive vines with high yielding varieties is essential. Thus there is a great demand for production of high quality planting material within the shortest time.

Different propagation methods are followed in black pepper for large scale multiplication. Vegetative mode of propagation using runners produced from the base of field grown, 10-15 year old, robust and high yielding vines is mostly adopted. The major constraint in establishing black pepper nurseries for large scale production of rooted cuttings from these runners is the limited availability of sufficient number of runners. In order to overcome this difficulty, rapid propagation method was developed wherein, rooted cuttings raised in polybags were planted at the base of bamboo splits (1.2-1.5m), filled with rooting medium and allowed to grow (Sivaraman, 1987). However, this method has limitations because of severe attack of termites on bamboos in some areas and the difficulty in maintenance, replacement and availability of suitable bamboos (Khandekar *et al.*, 2004). Another modification of this method is to use PVC pipe splits in which partitions like bamboo nodes are made, which is costly and inconvenient. Hence this was further modified by trailing runners on simple wooden sticks kept in a slanting position and later these runners were cut and used to make rooted cuttings. However this method was not successful in Padanakkad condition, as the soil is sandy and there is high incidence of root grubs.

With the popularization of protected cultivation, polyhouses with controlled conditions for plant growth and fertigation methods offer greater possibilities in nursery also. With a view to augment the production of planting materials in black pepper by exploiting the potential of the polyhouse, a nursery was established during 2012-13 period at College of Agriculture, Padanakkad with financial support from Directorate of Arecanut and spices Development under Mission for Integrated Development of Horticulture (MIDH).

Under the project, high yielding varieties of black pepper were planted in grow bags and were kept in polyhouse. Cuttings from these plants are rooted by conventional and serpentine layering methods. Using these mother vines, a new method of trailing the runners on rope was tried for obtaining sufficient quantity of runner vines every year. The results of the observations recorded for two years to assess the performance of these vines under poly house condition are presented.

Materials and Methods

Under the project, a nursery was established for black pepper propagation, consisting of a polyhouse (tropical model with natural ventilation) of area 224sq.m and a poly-cum-shade house (Quonset type) of area 448sq.m). As there were no mother vines available for collection of runner vines at College of Agriculture, Padanakkad, initial stock material of seven high yielding black pepper varieties (Table 1) were collected from Pepper Research Station, Panniyur during 2012. These were further multiplied by serpentine method in the poly-cum-shade house.

Rooted plants were transplanted into grow bags (24 x 24 x 40 cm) containing potting mixture made of soil, sand, cowdung and cocopith in equal quantity. Seventy five plants of each variety were kept in polyhouse with drip, fertigation and fogger facilities. As the vines grow, these were trailed on coir ropes tied vertically up. After each harvest of runners, the potting mixture was fortified with 100g urea, 80g muriate of potash and 50 g magnesium sulphate. Observations were recorded on number of runners obtained and average length of a runner per grow bag during each harvest. The data were subjected to analysis of variance. Varietal comparison was done using Duncan's Multiple Range Test (DMRT) and year wise comparison was done using equal variance t- test, since the variances for each year is homogenous.

Results and Discussion

The vines recorded fast growth under polyhouse condition yielding three harvests per year during the initial period itself. Presently the vines are ready for harvest after every three months, indicating a possibility of getting four harvests per year from third year onwards. The total cuttings obtained for each variety per year, the observations on number of runners obtained and average length of a runner per grow bag per year for each variety is provided in Table 1. The method is found to be a promising one with minimum recurring cost as the material required for trailing the runners is easily available, of low cost and the management of plants in the polyhouse is effective in enhancing the growth rate. The production of runners during first year was lower as the plants were just establishing. During second year, the total number of two noded cuttings was almost double that of first year. The significant increase in number of cuttings obtained was mainly due to the significant difference in the average length of the runners during second year.

The average number of two noded cuttings per plant per harvest during 2015 is 23nos. In rapid multiplication technique, the number of single noded cuttings reported is 10/plant/harvest (http://iisr.agropedias.iitk.ac.in). The cuttings kept for rooting under polyhouse condition showed 80-85 percent survival and since these are two noded cuttings, the growth and establishment were also fast. These are further multiplied by serpentimne layering under the poly-cum-green house.

The comparison of rate of production of runners from different varieties under the polyhouse condition based on average number of runners and average length of runner showed that there is significant difference between the varieties (Table 1). The highest number of runners was produced by Panniyur 7 in 2014 (2.77) while in 2015 it was by Panniyur 4 (2.97), while it was least in Panniyur 5 in 2014 (2.03) and Panniyur 6 in 2015 (1.89) which are on par. During first year, the average length of runner was significantly higher in Panniyur 1 (288.89 cm) while it was least in Panniyur 7 (187.11 cm). During second year also Panniyur 1 showed maximum length which was on par with Panniyur 5. The remaining varieties also picked up growth, all the five varieties showing values on par.

Name of Variety	No. of plants	Total No. noded cu obtained runners	of two ttings from / year	No. of run bag [*]	nners/grow *	Averag len runner (c	gth of m)*
		2014	2015	2014	2015	2014	2015
Panniyur1	71	3196	4600	2.22 bc	2.52 ^b	288.89 ^a	367.08 ^a
Panniyur2	71	2910	4450	2.33 bc	2.52 ^b	246.48 bc	312.37 ^b
Panniyur3	67	2726	4800	2.45 ba	2.69 ba	286.11 ª	315.61 ^b
Panniyur4	68	2254	5100	2.31 bc	2.97 ^a	281.94 ª	321.34 ^b
Panniyur5	75	2130	5200	2.03°	2.09 °	232.37 °	363.86 ^a
Panniyur6	66	2282	4600	2.55 ba	1.89 °	270.39 ab	330.78 ^b
Panniyur7	65	1662	4650	2.77 ^a	2.54 ^b	$187.11^{\ d}$	334.95 ^b
TOTAL	483	17160	33400	-	-	-	-
Overall mean -	35.53	69.15	2.38 2.4	5 256	5.18 335.40		
p-value (5%level)(be	etween va	rieties)	0.0051 <0	.0001	< 0.0001	<0.	0001

Table 1. Growth parameters of runner vines of black pepper produced by vertical trailing on rope under polyhouse condition

p-value (5% level)(between 2 years) 0.1349 0.0004

* Means with the same letter within a year are not significantly different



Conclusion

The results reveal that the method of growing black pepper plants in grow bags by trailing the stem on ropes for getting sufficient quantity of runner vines for propagation in commercial nurseries can be used effectively for large scale production of rooted cuttings in Kerala. The method yields on an average 23 nos of two noded cuttings per plant per harvest which show 80-85 percent survival. These cuttings were further multiplied by serpentine method. The growth rate of the vines is higher in the polyhouse condition with Panniyur1 and Panniyur5 being the most suitable for the purpose. The present study also reports for the first time, a novel method for large scale multiplication of black pepper in polyhouse conditions.

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Effect of growth regulators and media on rooting of black pepper (*Piper nigrum* L.) cuttings

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Abstract

An investigation on effect of media and growth regulators on rooting of black pepper (*Piper nigrum* L.) cuttings was conducted during 2012-13 at College of Horticulture, Mudigere. The study pointed out that, among the different growth regulator formulations tried, IBA 1000 ppm helped in better induction of rooting by over 70 per cent followed by IBA 500 ppm and NAA 250 ppm which recorded 66.67 and 63.33 per cent as against 43.33 per cent in the control. Among the different rooting media tried, black pepper cuttings which were pre-treated with IBA 1000 ppm and planted in the media containing soil +sand + FYM + vermicompost (1:1:1:1) recorded highest rooting percentage i.e. 80 per cent which is on par with soil + sand + FYM + vermicompost in 2:1:1:1 proportion (76.67 %) and soil + sand + FYM + coir dust in 1:1:1:1 proportion (76.67 %). The study revealed that black pepper plants could be multiplied easily by pretreatment of cuttings with IBA 1000 ppm and growing in the media comprising soil + sand + FYM + vermicompost (1:1:1:1 v/v) in polyhouse conditions. As an alternative, the medium comprising of coir dust can also be used in the places where, vermicompost is scarce and costly.

Introduction

Black pepper (*Piper nigrum* L.) popularly known as "King of spices", is the oldest and most important spice crop grown in India. Black pepper can be propagated through seeds and vegetative methods. Owing to its heterozygous nature, seedlings do not breed true to type and known to have long pre-bearing period. Hence, vegetative propagation through cuttings is commercially adopted. Availability of adequate quantity of quality planting material for large scale multiplication is one of the major constraints in increasing the productivity of pepper in India. The recent developments like, use of growth regulators, media, greenhouse or mist technology, rapid multiplication techniques are found helpful in solving this problem to a greater extent. Plant growth regulators and media, play a vital role in improving the rooting in black pepper cuttings. Growth regulators such as auxins increase the percentage of success and number of roots in black pepper cuttings, improving the vigour, thus reducing the mortality rate of plants in the field. There is an immense need to increase the area under pepper plantation to meet the domestic as well as export market. Hence, the present investigation was carried out to study the influence of Growth regulators and media on rooting of black pepper cuttings.



Materials and Methods

The present investigations were carried out in naturally ventilated polyhouse at College of Horticulture, Mudigere. The healthy cuttings of Panniyur 1variety were procured, semi hard wood cuttings of pencil thickness (0.8-1.0 cm diameter) were selected and cuttings of 10 cm length with 2 nodes were prepared by giving a slant cut at the bottom. Potting mixture consists of jungle soil, sand and FYM in the ratio of 2:1:1 was filled into 20×12 cm sized perforated polythene bag of 200 micron thickness. Before planting the cuttings, media was drenched with Copper oxy chloride (0.3 %) as a prophylactic measures against fungal diseases.

The experiment was laid out in the naturally ventilated polyhouse with completely randomized design. For the growth regulator study there were eleven treatments including control in which growth regulators like IBA, IAA and NAA formulations were used at different concentrations. Each treatment was replicated thrice, with 100 cuttings per replication. The planted cuttings were allowed to rooting for 75 days. Five cuttings per treatment per replication were carefully removed from the polybags and dipped in water to remove the soil adhering to roots to record the observations on roots *viz.*, days taken for root initiation, percentage of rooted cuttings and number of roots per cutting.

For experiment to know the effect of media on rooting of black pepper cuttings, different proportions of rooting media consisting of sand, soil, FYM and saw dust or coir dust or coffee pulp compost or vermicompost were prepared in accordance with the treatments and were filled in polythene bags and placed in the naturally ventilated poly house. Simple completely randomized design was adopted for the experiment. There were thirteen treatments of different rooting media used singly or in combination. Each of the treatment consisted of 100 cuttings replicated thrice. The growth regulator formulations viz., IBA, 1000 ppm which had shown the highest success in rooting in the earlier experiment was used as a standard pre-treatment to all cuttings. The observations on stem, leaves and root characters were recorded.

Results and Discussion

The data (Table 1) clearly indicated the favourable and significant influence of growth regulators on all shoot parameters as compared to control. IBA was superior to NAA. The combination of IBA and NAA at different concentrations was not so effective in respect of shoot parameters studied.

Early sprouting (17.40 days) and highest percentage (82.67) of sprouting was recorded in the treatment IBA 1000 ppm. This might be due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of growth regulators (Chandramouli, 2001). With regard to number of leaves, cuttings treated with IBA at 1000 ppm and 500 ppm performed better (4.2 and 3.6 leaves per cutting, respectively) over other treatments. Cuttings treated with IBA at 1000 ppm have recorded the maximum shoot length when compared to other treatments. Similar findings were also reported by Kempe gowda *et al.* (2006) in long pepper and attributed it to the auxins activated shoot growth which might have resulted in elongation of stems through cell division accounting in higher number of leaves and shoot length.

Earliest (35.47 days) and maximum rooting (70 %) were observed when the cuttings were treated with IBA 1000 ppm, which differed significantly from rest of the treatments. An early sprouting and higher shoot parameters at initial stages might have brought early and better rooting. Duhamel (1998) reported that hormone like substances were formed in developing bud, which transfer through phloem to the base of the cuttings, where these stimulate rooting. Further, stored food materials with the aid of growth regulators might have hastened the rooting (Haissing and Davis,

Table 1. Effect of growth regulators	s on sprouti	ng and ro	oting of	Black pepp	er cutting	S				
Treatments	Days to sprout	Number of leaves 75 DAP	Length of new shoot (cm) 75 DAP	Percentage of sprouting (%) 75 DAP	Days taken to root initiation	Rooting (%)	No. of primary roots	Root length (cm)	Fresh weight of roots (g)	Dry Weight of roots (g)
T ₁ -Control	24.47	2.20	6.17	49.00	44.27	43.33	1.78	10.93	1.30	0.49
T_2 -IBA 500 ppm	19.27	3.60	9.10	73.00	38.67	66.67	6.11	17.09	2.34	0.91
T ₃ -IBA 1000ppm	17.40	4.20	10.40	82.67	35.47	70.00	7.28	18.18	2.71	1.02
T4-IBA 1500ppm	19.93	3.13	8.42	71.33	40.00	56.67	5.11	15.15	2.03	0.77
T5-NAA 250ppm	19.60	3.47	8.96	73.67	38.80	63.33	5.67	16.93	2.32	0.89
T6-NAA 500ppm	19.80	3.20	8.53	69.00	39.60	60.00	5.11	16.41	2.27	0.85
T7-NAA 1000 ppm	20.60	2.80	7.97	62.67	40.27	43.33	3.33	14.55	1.67	0.68
T8-IAA 1000 ppm	19.80	3.27	8.70	71.00	38.93	60.00	5.44	16.76	2.29	0.87
T9-NAA+IBA 250 ppm	20.13	3.07	8.16	70.67	40.67	53.33	4.89	15.32	1.99	0.76
T10-NAA+IBA500ppm	20.60	2.87	8.14	65.33	41.07	50.00	4.00	14.85	1.80	0.76
T11-NAA+IBA1000ppm	21.87	2.40	7.39	53.00	42.67	43.33	1.89	12.27	1.41	0.54
DAP = Days After Planting										

Table 2. Effect of media on sprouting	g and root	ing of Bla	ack peppe	er cuttings						
Treatments	Days to sprout	Number of leaves 75 DAP	Length of new shoot (cm) 75 DAP	Sprouting (%) 75 DAP	Days taken to root initiation	Rooting (%)	No. of primary roots	Root length (cm)	Fresh weight of roots (g)	Dry Weight of roots (g)
T ₁ -SOIL:SAND:FYM (2:1:1)	18.07	4.20	10.42	76.00	39.13	63.33	7.60	17.78	2.64	0.99
T ₂ -SOIL:SAND:FYM:SD (1:1:1:1)	17.07	5.60	15.21	79.33	34.80	73.33	8.73	22.77	3.44	1.34
T ₃ -SOIL:SAND:FYM:SD (2:1:1:1)	17.43	5.37	14.52	78.67	35.27	70.00	8.37	22.05	3.20	1.21
T ₄ -SOIL:SAND:FYM:SD (3:1:1:1)	17.80	5.10	12.64	76.67	38.80	66.67	7.97	19.37	3.01	1.14
T ₅ -SOIL:SAND:FYM:CD (1:1:1:1)	16.53	5.90	17.71	81.67	35.87	76.67	9.73	26.79	4.33	1.65
T ₆ -SOIL:SAND:FYM:CD (2:1:1:1)	16.87	5.70	16.99	81.00	36.13	73.33	9.53	24.17	4.07	1.50
T ₇ -SOIL:SAND:FYM:CD (3:1:1:1)	17.33	5.43	15.77	79.67	37.87	70.00	9.10	21.47	3.83	1.37
T ₈ -SOIL:SAND:FYM:CC (1:1:1:1)	17.53	5.23	13.32	78.00	37.00	70.00	8.33	20.16	3.38	1.28
T ₉ -SOIL:SAND:FYM:CC (2:1:1:1)	17.67	5.07	12.97	77.33	37.60	66.67	8.20	19.49	3.16	1.14
T ₁₀ -SOIL:SAND:FYM:CC (3:1:1:1)	17.87	4.68	12.12	76.33	38.13	66.67	8.00	18.57	2.76	1.02
T ₁₁ -SOIL:SAND:FYM:VC (1:1:1:1)	15.93	6.7	20.26	85.33	33.07	80.00	7.07	24.27	5.08	1.96
T ₁₂ -SOIL:SAND:FYM:VC (2:1:1:1)	16.20	6.23	18.00	82.33	33.47	76.67	10.13	23.23	4.52	1.77
T ₁₃ -SOIL:SAND:FYM:VC (3:1:1:1)	16.93	5.70	16.03	80.67	34.13	73.33	9.33	22.17	4.17	1.62

1984). Cuttings treated with IBA (1000 ppm) recorded the maximum number of roots (7.28) and length of the root (18.18 cm). The growth regulator treatments increased the fresh and dry weight of induced roots. The maximum fresh and dry weight of roots (2.71 and 1.02 g, respectively) was observed in IBA 1000 ppm followed by IBA at 500 ppm. A similar increase in rooting percentage of Indian lavender stem cuttings applied with growth regulators (IBA and NAA) has also been reported by earlier workers (Somappa, 1979 and Swetha, 2005). In general, IBA 1000 ppm and IBA 500 ppm have been found to induce significant rooting in black pepper cuttings. The basis for this may be enhanced hydrolysis of nutrient reserves (mainly starch) by auxin treatments. According to Nanda *et al.* (1968) enhanced hydrolysis activity in the presence of exogenously applied hormones was responsible for the increased rooting in auxin treated cuttings. The cuttings which received IBA at 1000 ppm excelled over all the other treatments in all the root characters followed by IBA 500 ppm.

Among the various rooting media studied in the present investigation, there were significant differences in shoot characters among the different rooting media (Table 2). In addition to growth regulators the better rooting can be attributed to the favourable conditions prevailing in poly houses like high temperature (30-35° C) and high relative humidity (85-90 %) and is responsible for reduced transpiration and respiration rate associated with higher photosynthetic activity which promoted better rooting in cuttings (Hartmann and Kester, 1986).

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Quality planting material production for black pepper (*Piper nigrum* L.) under nursery conditions

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Abstract

An experiment was conducted at PRS, Panniyur during 2010-11 to study the feasibility of using different fungicides, biocontrol agents and hormones for the production of quantity planting material of black pepper under nursery conditions. The fungicidal treatments had minimum incidence of disease when compared to other treatments. The biocontrol agents (*Pseudomonas* and *Trichoderma*) increased the rooting and shooting of black pepper cuttings and also reduced the mortality rate. The cuttings treated with tender coconut water had better germination but incidence of the disease was very high.

Introduction

Black pepper (*Piper nigrum* L.), the king of spices is a traditional historic spice crop which has been under cultivation since ancient times in India. India was the leading producer of pepper in world followed by Malaysia, Vietnam etc, but presently the hierarchy has changed due to several factors. There are several constraints associated with decline in productivity of black pepper viz. lack of good quality planting materials and the dreaded foot rot disease. Production of pre-rooted cutting in polyethylene bags is the surest way of producing quality planting material throughout India. Root proliferation has been enhanced by the application of growth regulators such as IBA (Pillai et al., 1982, Suparman and Zaubin, 1988). The two node cuttings of runner shoots proved better for black pepper multiplication with the treatment of IBA (1000 ppm). Ecological hazards of chemical based management strategies have prompted farmers to shift their focus to ecofriendly practices. In the context of organic cultivation, application of rhizobacteria and biocontrol agents are gaining much importance. These rhizosphere organisms not only protect the plant from diseases but also impart growth and vigour to plants. Application of rhizobacteria and Trichoderma harzianum is reported to enhance growth of black pepper plants in the nursery (Anandaraj and Sarma, 2003). Fortification of potting mixture with Trichoderma and application of mycorrhiza at the time of planting helps to produce good quality rooted cuttings. In this context an investigation

was carried out to study the effect hormones, fungicides and biocontrol agents in inducing early germination, rooting and growth of black pepper in comparison with the traditional technique.

Materials and Methods

An experiment was conducted at PRS, Panniyur during 2010-11 to study the feasibility of using different fungicides, biocontrol agents and hormones for the production of quantity planting material. The experiment was laid out in CRD with 5 replications and 7 treatments *viz*. T1 - Carbendazim (0.1 %); T2 - Potassium phosphonate (0.3 %); T3 - *Pseudomonas* (250g/750ml water); T4 – *Trichoderma*; T5 – Mycorrhiza; T6 - IBA (1000ppm); T7 - Tender coconut water.

The potting mixture was prepared using garden soil, sand, and farm yard manure in 1:1:1 proportion and used for filling polythene bags of size $20 \times 15\,$ cm. Two nodded cuttings were dipped in respective treatments fungicides (Carbendazim, Potassium phosphonate) for 2 min, *Pseudomonas* slurry for 20 min, IBA at 1000 ppm for 45 sec and tender coconut water for 20 min. One kg of *Trichoderma* formulation mixed with 10 kg potting mixture and was filled in polybags. The application of mycorrhiza was done by placing 25g of AMF infected sorghum roots in pits before planting of cuttings.

The cuttings were planted in prepared polybags and kept under shade after mulching with mango leaves. Irrigation was done at regular intervals and mulch was removed after twenty-one days. Spraying of fungicides and biocontrol agents were done at regular intervals. Observation on germination percentage, time taken for germination, disease incidence (%), no. of leaves, shoot length, root length and no. of roots were recorded. The data obtained were statistically analyzed using the procedure of Panse and Sukhatme (1985).

Results and Discussion

The maximum germination was observed in carbendazim (92%) treated cuttings, followed by potassium phosphonate (89%), mycorrhiza (88%), *Pseudomonas* (67%), *Trichoderma* (54%) and IBA (55%) (Table 1). The conventional treatment of dipping in tender coconut water resulted in comparatively lesser germination. The disease incidence of different treatments ranged between 0-56%. The fungicidal treatments had minimum incidence of disease when compared to other treatments. The cuttings treated with carbendazim were free from disease and had no disease incidence. The treatments T3, T4 and T5 were on par. The cuttings treated with tender coconut water had better germination but incidence of the disease was very high.

Treatments	% germination	Disease incidence (%)	
T1	92	0.0 (0.95)	
Т2	89	8 .0 (11.19)	
Т3	67	32.0 (34.17)	
Τ4	54	32.0 (34.17)	
Т5	88	32.0 (34.17)	
Т6	55	40 .0 (41.00)	
T7 (Control)	52	56 .0 (48.69)	
		CD (0.01)- 17.084	
		CD (0.5)- 12.663	

Table 1. Effect of different treatments on the g	germination and disease incidence rooted	cuttings.
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(values in parantheses are arc sin transformed values)



The time taken for germination ranged from 26.6-35 days. The fungicidal dip of cuttings resulted in minimum period of 26.6 days for germination. The biocontrol agents treated cuttings took more time for germination when compared to fungicidal applications. Even though the conventional method of treating pepper cuttings with tender coconut water took more time for germination, the application of biocontrol agents were better.

The number of leaves in germinated cuttings indicated that treatment with *Pseudomonas* resulted in more no. of leaves than the other treatments (Table 2, Fig1 and 2). The result is in accordance with finding of Thankamani *et al.* (2005). The shoot length was comparatively higher in *Pseudomonas* treated cuttings (24.1 cm) followed by *Trichoderma* treated cuttings (14.78 cm). All the other treatments were on par and lowest shoot length was noticed in carbendazim treated cuttings. The root length was significantly higher in *Pseudomonas* treated cuttings (16.4 cm) with 11 roots followed by *Trichoderma* treatment (11.36 cm) with 7 numbers of roots. Lowest root length was observed in tender coconut water and carbendazim treated cuttings. Use of *Trichoderma* and vermicompost enriched coirpith in seedling stage prevents infection during main field planting



Fig 1. Effect of different treatments on biometric characters Fig 2. Rooting and shooting pattern in different treatments

Treatment	Time taken for germination	No. of leaves	Shoot length (cm)	Root length (cm)	No. of roots
T1	26.6ª	2.31	8.48	10.66	5.0
T2	29.6	2.33	9.23	10.08	8.0
Т3	30.8	4.07 ^a	24.01ª	16.4ª	11.2ª
T4	34.6	2.78	14.78	11.36	7.6
Т5	33.8	2.45	13.24	9.28	5.8
Т6	34.2	1.76	10.76	10.68	7.0
T7 (Control)	35.0	1.60	9.00	8.14	4.8
CD (0.05)	3.93	1.29	6.64	3.49	1.74

Table 2. Effect of different treatments on vegetative characters of rooted cuttings

(Prasath *et al.*, 2014). Shanthi *et al.* (2003) reported higher plant height, root length and root biomass in banana due to *P. fluorescens* application. Increased shoot length, root length with and more number of root no. in *Pseudomonas* treatment was in accordance with findings of Thankamani et *al* (2005). Glick (1995) reported increased plant nutrient uptake and hormones IAA, GA production by rhizobacteria which helped in plant growth. Increased feeder root production resulting in increased absorptive area on rhizobacteria treated plants. Production of ethylene is inhibited by aminocyclopropane carboxylic acid deaminase leading to rapid elongation of roots due to production of ammonia (Kloepper, 2003).

The use of fungicides not only enhance the germination of cuttings but also reduced the disease incidence. Application of hormones though recommended for rooting of pepper cuttings the survival rate is comparatively low. The biocontrol agents and fungicides increased the rooting and shooting of black pepper cuttings and reduced the mortality rate. The application of *Pseudomonas fluorescens* slurry can be made use of in producing good quality pepper cuttings.

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Effect of propagation method on successful growth performance of pepper plants

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Abstract

The propagation of rooted pepper plants and grafted pepper plants were produced by using orthotropic and plagiotropic branch of Paniyur-1 pepper plants, during the period 2012 to 2015 at Agricultural and Horticultural Research Station, Ullal. The one batch of cuttings of orthotropic and plagiotropic branches were rooted in $4' \times 6'$ poly bags and another batch of cuttings of orthotropic and plagiotropic branches were grafted on the *Piper colubrinum* root stock for the study under 50% shade house condition. The results showed that 64% of rooted pepper plants and 86% of grafted pepper plants were successfully produced from orthotropic branches. A success of 35% of rooted cuttings and 95% of grafted plants were recorded from plagiotropic branches. The percentage of success was more in grafted plants as compared to direct rooting. The growth performance and development of grafted plants.

Introduction

Pepper (*Pepper nigrum*) is one of important commercial spice of India which is a major producer, consumer and exporter of black pepper in the world. It is a crop of tropical and sub-tropical regions and requires tropical and sub-tropical climate condition. Black pepper is native to south India and is extensively cultivated there and elsewhere on tropical regions and is a flowering vine in the family Piperaceae, cultivated for its fruits which is usually dried and used as a spice and seasoning. It has been found in vast altitudinal regions and showed great adaptability to a wide range of environmental conditions (Howard, 1973). Dried ground pepper has been used since antiquity for both its flavor and has a medicine. Black pepper is reputed in the ethno medicine of many countries for its multi – dimensional medicinal properties (Scott *et al.*, 2008). The pepper is one of the most common spice on European cuisine and its descendants. The fruit known as a pepper corn when dried, dark red when fully mature and contains single seed.

Bush pepper is a miniature pepper plant in the shape of a bush grown as a potted plant with decorative and economic value, raised from lateral branches (Plagiotropic branch) of yielding vines using a rooting hormone. Bush pepper needs no standards for trailing or climbers for harvesting, anybody can care the plant and pluck the spikes as one wishes. Keeping 3-4 pots in the sit out or Veranda of the house especially in urban/flat dwellers help them to taste field fresh spices. Though the crop is traditionally harvested from vines grown on support trees, researchers at the Indian Institute of Spices Research (IISR), Calicut, Kerala have demonstrated the production of green pepper from bushes grown in pots and in the fields. Black pepper can propagated by seeds, cutting, layering, and grafting. Seed propagation often result in genetic variation while other methods of black pepper propagation are slow and time consuming (Atal & Banga, 1962).

So, there is a need to introduce efficient methods for faster propagation of black pepper. In different countries of world viz. India, Sri Lanka black pepper plants are multiplied rapidly in order to get more seedling in short duration and for quality planting material (Sivaraman, 1987).

Considering this in the view, the present investigation on performance of rooted and grafted pepper from orthotropic and plagiotropic branches of paniyur -1 tried on experimental as well as commercial scale production. The batches of experiments were carried out in 50% shade net house and propagated pepper plants are planted in cashew orchard of Agricultural & Horticultural Research Station Ullal with recommended dose of fertilizer.

Materials and Methods

The rooted and grafted pepper plants are prepared by using orthotropic and plagiotropic branches of pepper variety Paniyur-1 for 3 years. The 10 years old of 10 Paniyur-1 plants were selected for the study. The orthotropic branches of 100 cutting were planted in 4'X 6' PF bags and kept in 50% shade house for rooting and sprouting. Another set of 100 cutting were grafted above on the *Pepper colubrinum*, as root stock plant and kept in the shade house for rooting and sprouting. All the leaves of orthotropic cuttings were removed and dipped in 0.2 per cent copper oxychloride solution for 20-30 minutes before planting.

In the some way plagiotropic branches of 100 cutting were planted in 4'X6'. PE bags and kept in 50% shade house for rooting and sprouting. Another set of 100 cutting of plagiotropic branches were grafted above on the *Pepper colubrium*, as root stock plant and kept in shade house for sprouting. All the leaves of plagiotropic branches cuttings were removed except flag leaf and dipped in 0.2 per cent copper oxychloride solution for 20-30 minutes before planting.

For commercial multiplication each 3000 plants of rooted and grafted plants were produced. The observations like, No. of cutting planted, No. of cutting grafted, % rootting and grafting success, and % saleable plants are produced were noted.

Field experiment was conducted for two years at Agricultural and Horticultural Research Station Ullal, University of Agricultural and Horticultural Sciences, Shivamogga; Karnataka from 2012 to 2015 to study the performance of rooted and grafted pepper plants. The Research Station, located in a cashew growing belt, has mainly typical laterite soils of the West Coast with patches of red sandy loam. The terrain is mostly undulating with a gradient of 4 to 15 percent. Except in some patches, the soils are very shallow and poor in nutrient status. The soil is low to medium in fertility with adequate quantity of Copper, Iron and Manganese. The soil is acidic in nature with a pH range of 5.4 to 5.8. The crop response to manuring and irrigation is very good in this type of soil.

Experiment was laid out in Randomized block design with ten replications. The observation like yield (kg), plant height (cm), stem girth (cm), canopy spread (ft), leaf area (cmsq) and vegetative shoot were noted from 2012 to2015. The experimental data of each observation on cashew plants were subjected to ANOVA separately in RCBD. The level of significance used in "F" and "t" test was P=0.05. Critical difference value were calculated wherever 'F' tests were significant (Panse and Sukhatme, 1985).

Results and Discussion

The growth performance of propagated plants of orthotropic and plagiotropic branch of pepper studied at Agricultural and Horticultural Research Station, Ullal showed in the Table-1 & 2. It is revealed from the tables that rooted pepper plants maintained more or less uneven plant height, uniform canopy spread and more No. of branches are noted compared to grafted bush pepper



Table 1. The yield and plant growth performance of rooted bush pepper plants

Note: * Significant, ** Non-significant

Treatments	Plant height (cm)	Plant girth (cm)	Branch girth (cm)	Leaf area (cm ²)	Canopy (cm)	No. of vegetative branch (No)	Yield intercrops (gms)
1	41.17	1.99	1.67	195.00	3.40	16	460
2	47.27	2.10	1.67	188.00	3.40	18	460
3	46.33	2.10	1.00	197.00	4.13	19	420
4	48.00	1.93	1.67	182.67	4.33	17	460
5	50.67	1.87	1.33	196.33	4.68	15	450
6	51.00	2.03	1.33	209.33	4.60	16	480
7	49.67	2.07	1.00	190.00	4.90	18	490
8	47.67	1.93	1.67	202.67	4.80	20	500
9	49.00	1.93	1.00	204.33	3.73	16	480
10	50.33	2.07	1.00	203.33	4.03	18	490
S. Em	0.36	0.03	0.26	3.75	1.18	2.11	7.42
CV	1.35	2.97	34.16	3.30	4.86	6.11	10.10
F Test	*	*	* *	*	*	*	*
CD@ 5%	1.06	0.10	0.77	3.75	3.44	6.22	21.42

Table 2 The yield and plant growth performance of grafted bush pepper plants

Note: * Significant, ** Non-significant
plants shown significant difference. The uniform yield and plant height is noted in grafted bush plants. But more yield noted in rooted pepper plants of plagiotropic branches. The more yield in rooted bush pepper plants may be due to more number of fruiting branches in the plants. The uniform plant height and yield in grafted bush plants may be due to effect of grafting method on the yield and development of fruiting branches. The Table -5 showed that in both orthotropic and plagiotropic branches of cutting rooted and sprouted in poly bags showed less success compared grafted method both in large scale and experimental level. This may be due to more effective union of pepper scion on root stock, hence the good successful.

The plant growth performances of plants produced from orthotropic branches showed in Table - 3 and 4. It is revealed from the table that plant growth slow in grafted plants and significantly faster growth observed in rooted plants. The canopy spread and vegetative branch are more in rooted pepper compared to grafted pepper.

The numbers of branches were also varied in different treatments. The result of the present study corroborates with the findings of the Khandekar *et al.*, 2004 who also found superior vine length, nodes per vine and number of roots per vine from soil mound method.

Conclusion

Table 3 . The plant growth performance of grafted paniyur -1 pepper plant produced from orthotropic branches.

Treatments	Plant height (cm)	Plant girth (cm)	Branch girth (cm)	Leaf area (cm ²)	Canopy (cm)	No. of vegetative branch (No)	Yield (gms)
1	158.33	1.67	1.00	81.33	8.00	06	
2	153.33	1.83	1.33	91.33	8.27	07	
3	157.33	1.93	1.00	89.67	8.60	06	
4	149.67	1.97	1.00	84.67	7.97	08	
5	152.67	1.87	1.33	91.00	7.93	08	
6	142.00	1.83	1.00	90.33	8.53	06	
7	145.00	2.03	1.00	92.33	8.50	08	
8	151.00	2.00	1.00	86.67	8.40	07	
9	151.67	1.93	1.00	95.33	7.83	08	
10	151.00	1.63	1.33	95.33	8.20	09	
S. Em	3.93	0.15	0.09	2.67	0.15	0.18	
CV	9.91	13.89	14.43	5.15	3.17	3.44	
F Test	*	* *	*	*	*	*	
CD@ 5%	8.55	0.44	0.25	7.80	0.44	0.58	

Note: * Significant, ** Non-significant



Treatments	Plant height (cm)	Plant girth (cm)	Branch (cm)	Leaf area (cm ²)	Canopy (cm)	No. of vegetative branch (No)	Yield (gms)
1	126.00	1.83	4.33	128.33	37.33	10	
2	140.00	1.57	4.33	143.33	37.00	09	
3	131.67	2.00	4.00	161.00	40.00	11	
4	205.00	1.80	5.33	161.33	34.67	09	
5	189.33	1.90	5.00	180.00	35.00	08	
6	200.00	1.87	6.67	136.67	36.67	07	
7	226.67	2.03	4.00	138.00	37.00	09	
8	175.00	1.97	4.67	167.67	39.33	10	
9	193.00	1.93	4.00	173.33	40.33	10	
10	182.67	2.00	7.67	176.67	40.67	12	
S. Em	4.62	0.09	0.52	11.88	1.69	0.22	
CV	4.52	8.33	17.84	13.14	7.73	3.86	
F Test	*	* *	*	*	* *	* *	
CD@ 5%	13.48	0.27	1.51	34.68	4.93	0.62	

Table 4. The plant growth performance of rooted panniyur – 1 pepper plant produced from orthotropic branches.

Note: * Significant, ** Non-significant

Table:5 Effect of propagation method on successful growth performance of pepper plants.

		Total propaga	ated cutting	Successfu	lplants	% Successful		
Branches	Propagation method	Experiment	Commercial	Experiment (No.)	Commercial (No)	Experiment (%)	Commercial (%)	
Orthotropic	Rooted	100	75000	64	4875	64	64.10	
	Grafted	100	3000	86	2585	86	86.16	
Plagiotropic	Rooted	100	3000	35	1056	35%	35.20	
	Grafted	100	3000	95%	2868	95%	95.26	

The Propagation study of Panniyur-1pepper showed that successful 64% of rooted pepper plants and 86% of grafted pepper plants were produced in rooted and grafted pepper cutting of orthotropic vine. The Propagation study of plagiotropic branch of paniyur-1 pepper showed that, successful 35% of rooted pepper plants and 95% of grafted pepper plants were produced. The percent successful more observed in grafting method compared to rooting method of propagation. The growth performance and development of **rooted** plants of orthotropic vine cuttings and plagio-tropic branches showed significantly higher compared to **grafted** plants after the propagation.

The growth performance of all the pepper planted are better in cashew orchard is a sustainable crops in the field of horticulture, which found to have more performance in yield under coastal zone of Karnataka.

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Clone multiplication of different cultivars of large cardamom (Amomum subulatum Roxb.)

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Abstract

Large cardamom (Amomum subulatum Roxb.), a member of the family, Zingiberaceae is the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal. Survey has been conducted in East, West, North and South Sikkim during 2014-15 and recorded distinct characters of six cultivars of large cardamom viz. Ramsey, Ramla, Sawney, Golsey, Varlangey and Seremna. Ramsey, Varlangey and Ramla are suited for high altitudes (>1515 MSL), Sawney is suited for mid (975 - 1515 m MSL) altitude and cultivars Golsey and Seremna are suited for low (< 975 m MSL) altitude areas. All cultivars have maroon tillers except in Golsey with green tillers. Scremna have drooping leaves and Golsey with narrow and crect leaves. Varlangey, Sawney and Golsey produces bold capsules and Seremna produces medium round capsules. The rich genetic diversity available in large cardamom could be effectively put to use by introducing appropriate varieties suitable to specific location in the NE region. The decline in productivity of large cardamom is due to the absence of high yielding varieties, lack of sufficient genetically superior plant material for different agro-climatic conditions. The clonal multiplication experiment Indian Cardamom Research Institute (ICRI) farm at North Sikkim showed that the large cardamom cultivar Seremna produced more no. of tillers (1:13) followed by Sawney (1:11) and Varlangey (1:10.5) in twelve months. Golsey produced least tillers/plant (6.2). On an average the multiplication ratio was 1:9.7. It is advisable to grow location specific cultivars for particular area in order to obtain good growth and high productivity. Quality planting material is one of the most critical issues that farmers were facing. Its helps in increasing the production and productivity. There is lot of demand for good quality planting material from within and neighboring states like Arunachal Pradesh Manipur, Meghalaya, Mizoram and Nagaland.

Introduction

Large cardamom (*Amomum subulatum* Roxb.), a member of the family, Zingiberaceae is the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal covering an area of about 26,060 ha with an annual production of 4000 to 5500 metric tons (Anon 2013). It is also cultivated in some other North Eastern Hill states like Arunachal Pradesh, Nagaland, Mizoram, Manipur, Meghalaya, Assam and parts of Uttarakhand. (Singh, 1978; John and Mathew, 1979; Gupta, 1983, Subba, 1984; Gupta and John, 1987). Nepal and Bhutan are the other two Himalayan countries where large cardamom is cultivated. Sikkim is the largest producer of large cardamom and constitute lion share of Indian and world market. The

large cardamom plant is a perennial herb with subterranean rhizomes with leafy shoots. It is a shade loving plant (Sciophyte) and requires 50 percent shade for growth and development. Propagation of large cardamom is done through seeds and suckers. The crop is entomophilious and being cross pollinated by bumble bees and has natural hybridization diversity within the species. Planting through suckers ensures true to the parents with a high productivity if they are collected from high yielding, disease free plants. The sucker nursery helps to generate large amount of planting materials for the ensuing planting season.

There are mainly six cultivars of large cardamom *viz.*, Ramsey, Ramla, Sawney, Golsey, Varlangey and Seremna. Cultivars suited for high altitudes (>1515 MSL) are Ramsey, Varlangey and Ramla. Sawney is suited for mid (975 – 1515 m MSL) altitudes and cultivars Golsey and Seremna are suited for low (< 975 m MSL) altitude areas (Gyatso *et al.*, 1980). This crop thrives well from 6°C to 25°C with well distributed annual rainfall of 200-350 cm. It is well adapted to the hilly forest ecosystem where the fertility status is high due to natural nutrient recycling

There is tremendous potential to increase the area, production and productivity in other NE states. In Sikkim, total area under large cardamom was 15500 ha with production of 3681 tonnes and productivity of 235 kg/ha (Anonymous 2011). The decline in productivity of large cardamom is due to the absence of high yielding varieties, lack of sufficient genetically superior plant material for different agro-climatic conditions. Therefore it is highly essential to identify the genotypes suitable in different agro-climatic situations and to replace the local unproductive large cardamom by using elite planting materials

Establishment of sucker nurseries could address one of the most critical issues that farmers are facing. There is a lot of demand for good quality planting material from within the state and neighboring states like Arunachal Pradesh Manipur, Meghalaya, Mizoram and Nagaland. Hence the experiment was aimed at two objectives, to conduct survey in East, West, North and South Sikkim to study the distinct characters of different cultivars of large cardamom and to find out the sucker multiplication rate in different cultivars.

Materials and Methods

Survey was conducted in East, West, North and South Sikkim during 2014-15 and recorded distinct characters of six cultivars of large cardamom *viz.*, Ramsey, Ramla, Sawney, Golsey, Varlangey and Seremna. Collected suckers of each cultivars (100 each) were evaluated for the clonal multiplication. Clone multiplication experiment was conducted at the experimental farm of the ICRI at Kabi, North Sikkim (27°24'21.79"N, 88°37'12.23" E) at an elevation of 1590 m MSL during 2014-15.

Preparation of trenches: Terraces with good drainage in a slope area near the main cardamom plantation was selected for establishing sucker nursery. Trenches of 45 cm width and 30 cm depth with convenient length was prepared at a distance 1.5 ft. Top soil (15 cm) was removed and kept separately from the trench and the sub soil below was forked thoroughly. Dried leaves were applied as layer in the trench and was filled by top soil mixed with cow dung compost.

Collection and preparation of planting units: Mother plants were selected during previous year before harvest and tagged which were highly productive and free from viral and fungal diseases. Suckers from these mother plants were collected during last week of May, old rhizome portions and damaged roots were pruned off and planting unit consisting of a matured tiller with one or two new tillers or vegetative buds were selected. Sikkim being an organic state, only eco friendly and non chemical measures was adopted. Suckers was treated by dipping in 3% solution of *Pseudomonas fluorescens* for 30 minutes before planting in trenches as a prophylactic measure.



Planting: The sucker units were planted at a distance of 1.5 ft with bulbous portion of the rhizome above the soil. Support was given to the planting units by necessary stakings (Fig 3, 4). Mulching was done all along the plant base in order to keep up the soil moisture.

Maintenance: Thick mulching with dry leaf / grass was applied at the base of plant and watering was done during November to March depending on the soil moisture condition. Well decomposed cattle manure may be applied. The plot was maintained with 50% shade under shade trees. To check the infections of *Colletotrichum* blight and leaf streak, phytosanitation was carried out by removing the infected leaves and tillers. Spraying and drenching with 3% solution of *Pseudomonas fluorescens* in sucker nursery was carried out once in three months starting from May-June, August-September, December-January. Incidence of thrips, lace wing bug and mites are noticed and the infected leaves and pseudo stems were collected and burnt. Hand weeding was done once in three months.

Results and Discussion

Six cultivars Ramsey, Ramla, Sawney, Golsey, Varlangey and Seremna showing location specificity and variability has been observed in the morphological characters, flower characters and capsule characters (Table 1,2).

Ramsey

Characters	Ramsey	Ramla	Sawney	Varlangey	Seremna	Dzongu Golsey
Suitability	High altitude	Mediumto High altitudes	Mediumto High altitudes	Mediumto High altitudes	Low altitude High altitudes	Low altitude High altitudes
Plant type/Morphology	Robustgrowth	Robustgrowth	Robustgrowth	Robustgrowth	Lessrobust	Lessrobust
Plant height (M)	1.5 - 2	1.5 - 2	1.5 - 2	2 - 2.5	1.5 - 2	1-1.5
Tiller colour	Maroon	Maroon	Maroon	Maroon / Greenish tiller with maroon spots	Green	Green
Leaf shape	Narrow	Broad and long	Broad and ovate	Narrow leaves with wavy margins	Drooping leaves	Narrow and erect
Flower blooming period	May 2 nd fortnight	May	May 2 nd fortnight	May-June	March-April	March
Spikes/tiller	2	2	2	3-4	2-3	2
Capsules / spike	15-20	15-20	15-25	20-30	10-20	7-10
Capsule Size	Small	Medium	Bold	Bold	Med.round	Bold
(LXB) cm	2 x 1.8	2.1x2	2.5 x 2	3 x 2.7	2.1 x 2	2.7 x 2.6
Seeds / capsule	25 - 40	30 - 40	35 - 50	50-70	65 - 70	50 - 70
Month of Harvest	OctNov.	OctNov.	Sept-Oct.	Nov-Dec.	SeptOct.	AugSept.

Table 1. Distinct characters of different cultivars of Large cardamom

Pest and disease Susceptible to viral diseaseSusceptible to viral disease(i)Susceptible to viral diseases(ii)Sus.to Alternaria ria & Cylindrocladium leaf spot(i)Susceptible to viral dis.(ii)Sus.to Alternaria leaf spotSus.to Alternaria leaf spot Tolerant to chirkey & susceptible to foorkey

Note: Ramla appears to be a natural hybrid between Golsey and Ramsey

Name of the	Length	Length of	Labe	ellum	Antl	ner
cultivar	a corolla (cm)	style (cm)	Length (cm)	Breadth (cm)	Length (cm)	Breadth (cm)
Varlangey	2.4	5.1	4.2	1.2	1.0	0.4
Sawney	2.5	4.9	3.2	1.2	1.0	0.3
Ramla	3.0	5.0	4.2	1.5	1.1	0.35
Ramsey	2.4	5.2	4.1	1.5	1.2	0.3
Seremna	2.6	5.3	4.0	1.5	1.0	0.35
Golsey	2.5	5.1	4.1	1.4	1.0	0.3

Table 2. Flower characters of different cultivars

The name Ramsey was derived from two Bhutia words – 'Ram' meaning mother and 'sey' for gold (yellow). This cultivar is well suited for higher altitudes, on steep slopes. The tillers colour is maroonish green to maroon. Second half of May is the peak flowering season. Capsules are small, the average being 2.0 cm in length with 1.8 cm diameter, with 15-20 capsules in a spike, each containing 25-40 seeds. The harvest is during October-November.

Ramla

The plants are tall and vigorous like Ramsey and have capsule characters like Dzongu Golsey; the colour of tiller is maroon like Ramsey and Sawney. The leaves of Ramla are very broad compared to all other cultivars. Cultivation is restricted to a few mid-high altitude plantations in north Sikkim.

Varlangey

This cultivar grows medium and high altitude areas in South Regu (East Sikkim) and at high altitudes at Gortak (Kalimpong sub-division in Darjeeling district of West Bengal). Its yield performance is exceptionally high at higher altitude areas i.e. 1500 m and above. It is a robust type and total tillers may range from 60 to 80 in a clump of 4-5 years age. Colour of tillers is like that in Ramsey i.e. maroonish-green to maroon towards collar zone; girth of tillers is more than that of Ramsey. Each productive tiller on an average produces almost three spikes with an average of 25 capsules/ spike. Size of capsules is bigger and bold with 65-70 seeds. Harvest begins in the last week of October.

Sawney

This cultivar got the name from Sawan in Nepali, corresponds to August by which month this becomes ready for harvest at low and mid altitudes. This cultivar is widely adaptable, especially suited for mid and high altitudes i.e. around 975-1500 m. It is robust in nature and consists of 40-80 tillers in each clump of 4-5 years of age. Colour of tillers maroon. Average length and diameter of a spike is 6 cm and 11 cm respectively. Harvest begins in September-October and may extend up to November in high-altitude areas.



Golsey (Dzongu Golsey)

The name has derived from Hindi and Bhutia words; 'Gol' means round and 'sey' means gold. This cultivar is suitable to low altitude areas below 975 m especially in Dzongu area in North Sikkim. Plants are not robust like other cultivars, and consist of 20-50 straight tillers with erect leaves. Unlike other cultivar, tillers are green in colour. Capsules are big and bold, and contain about 60-62 seeds. This cultivar becomes ready for harvest in August-September

Seremna

This cultivar is grown in a small pocket at Hee-Gaon in West Sikkim at low altitude and is known for its high yield potential. Plant features are almost similar to Dzongu Golsey but the leaves are mostly dropping, hence named as Sharmney. Total tillers range from 30 to 60 and is not robust in nature. On an average 2-3 spikes emerge from each productive tiller with an average of 15 capsules per spike, each having 65-70 seeds. This cultivar is having narrow adaptability as it is not performing well in other low altitude areas.

Gyatso *et al.* (1980), Biswas *et al.* (1986), Karibasappa *et al.* (1987), Rao *et al.* (1993) studied the different morphological and yield contributing characters of different cultivars of cardamom. The rich genetic diversity available in large cardamom could be effectively put to use by introducing appropriate varieties suitable to specific location in the N-E region. Further, these gene pool are being used by Indian Cardamom Research Institute, Regional research Station, Spices Board Tadong to develop high yielding, disease and drought tolerant lines for the benefit of the farming community of North Eastern Region of India.

Quality planting material is one of the most critical issues that farmers were facing. Its helps in increase the production and productivity. There is lot of demand for good quality planting material from the farmers of this country. In the clone multiplication experiment, Seremna produced more no. of tillers (1:13) followed by Sawney (1:11) and Varlangey (1:10.5) in twelve months. Golsey produced least tillers/plant (6.2). On an average the multiplication ratio was 1:9.7 (Table 3, Fig. 2, 3, 4 & 5). From this experiment we can conclude that multiplication rate varies with the cultivars and multiplication rate is comparatively less in Golsey which is suitable for low altitude. It is advisable to grow location specific cultivars for particular location in order to obtain good growth and high productivity.

Cultivar	No. of	No. of	Multiplication	Plant	No. of	Le	af	Stem
	planted	shoots produced	rate	(cm)	leaves	Length(cm)	Breadth(cm)	(cm)
Varlangey	100	1050	1:10.5	110	12	46	8.5	4.5
Sawney	100	1100	1:11	96	9	46	7.5	4.2
Ramla	100	800	1:8	78	10	38	9.5	4.5
Ramsey	100	840	1:8.4	92	9	43	7.0	4.0
Seremna	100	1400	1:13	98	10	50	9.5	4.5
Golsey	100	620	1:6.2	70	9	40	8.0	4.0
Mean	100	968.3	1:9.7	90.6	9.8	43.8	8.3	4.3

Table 3. Sucker multiplication rate in different cultivars in one year and morphological characters





Fig 1. Terraces on a sloppy land

Fig 2. Large cardamom, mother plant



Fig 3. One mature tiller with two small tillers used for planting

Fig 4. Trench planting of large cardamom

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Conclusion

The area, production and productivity under large cardamom have declined over the years. Non availability of location specific high yielding, disease free planting materials is one of the reasons for that. To overcome these problems establishment of large cardamom sucker nursery with suitable cultivar is an urgent need to increase the area under its cultivation and the production and productivity of large cardamom. The rich genetic diversity available in large cardamom could be effectively put to use by introducing appropriate cultivars suitable to specific location in the N-E region



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Bio priming seed material to enhance yield in offseason green ginger (*Zingiber officinale* Rosc.) cultivation

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Abstract

In Kerala, ginger is generally cultivated as a rainfed crop, planted during April - May and harvested during December – January. The demand for green ginger in Kerala is more during the state festival season 'Ónam' in August - September. By growing ginger as an irrigated crop during January – February to August –September, the green ginger can be made available during this high demand time, which will naturally fetch good market price. The seed rate is 1500 kg /ha, and usually 20 g rhizome bits are used for planting. Single sprout bud of 3-5 g rhizomes can also be used as ideal planting material (Prasanth et. al., 2014), which reduces the cost of seed material and makes the planting material available in sufficient quantity, as it gives multiples of plants resulted. An experiment was laid out in Krishi Vigyan Kendra-Thrissur in completely randomized beds prepared in the inter spaces of coconut gardens. The conventional seed rhizome bits of 20 g and plantlets produced by planting rhizome bits of 3-5 g planted in portrays were compared. The seeds of both were treated with different biocontrol agents like Trichoderma viride, Arbuscular Micorrhizal Fungi and its combinations. The trials were also conducted in selected farmers' fields, planted in beds as well as in growbags. The percentage establishment in field was more for bioprimed seed materials. The treatment with a combination of Trichoderma viride and Arbuscular Micorrhizal Fungi gave the maximum yield both in conventional rhizome bits (40% increase in yield over control) and transplants (78% increase in yield over control). The plant height and number of tillers were also more in treated planting materials. Thus, it was inferred that growing ginger in offseason in partial shade under irrigated conditions, green ginger can be made available during the time of its peak demand for domestic consumption. If transplant technology is adopted, more number of planting material can be made available at lower price as well. Off season green ginger production will also ensure year round availability of planting material, which can cater to the seed requirement of small holders too.

Introduction

Ginger (*Zingiber officinale Rosc.*) is an important spice crop of Kerala, which is also largely consumed as green ginger in households as an additive in many recipes. It has many medicinal properties and used widely in home remedies. In Kerala, ginger is generally cultivated as a rain fed crop planted during April –May and harvested during December – January. The demand for green ginger in Kerala is more during the festival season 'Ónam', in August -September. By growing ginger as an irrigated crop during January – February to August –September, the green ginger can be made available during "Onam" season, which will fetch a good market price too.

Generally yield will be low when it is grown in these offseason as an irrigated crop. The recommended seed rate is 1500 kg/ha. Usually 20 g rhizome bits are used for planting. But single sprout bud of 3-5 g rhizomes can also be used as ideal planting materials (Prasanth *et. al.*, 2014). This will reduce the cost of seed material and make the planting material available in sufficient quantity. The present study was laid out in the farm of Krishi Vigyan Kendra, Thrissur with an objective to increase the yield of green ginger when grown in off season and also to reduce the quantity of planting material requirement.

Materials and Methods

The experiment was laid out in Krishi Vigyan Kendra, Thrissur in a completely randomized design with beds taken in the inter space of coconut garden. The seed materials were planted in the raised beds of 1.2 m^2 area during second week of January. The beds were mulched with green leaves and irrigated daily up to the commencement of rainfall. The plants were harvested during second week of August. The seed material of variety 'Varada' was used for the study. The planting materials used were seed rhizome bits of 20g. Transplants were prepared by planting small rhizome bits of 3-5g in protrays forty five days in advance. Hence, the seedlings were 10-15 cm in height at the time of planting in the main field.

For seed treatment, viable seed rhizome bits of 20g as well as 3-5g were steeped in a slurry of biocontrol agent *Trichoderma viride* at the rate of 4g per litre of water for one kilogram of seed material. They were then air dried for 24 hours at normal temperature (Khatso *et. al.*, 2013) and used for planting in the main field in the case of conventional rhizome bits. But the small rhizome bits were planted in the protrays for seedling production. For treatment with Arbuscular Mycorhizal Fungi (AMF), the commercial formulation of Kerala Agricultural University was used at the rate of 5g per plant as suggested by Samanhudi *et al* (2013) and applied at the time of planting seed material rhizome bits. But the microbial preparation was applied in the cavities of protrays in which the small rhizome bits were intended to plant. Observations on plant height, number of tillers, fresh rhizome yield and yield per plot were recorded at the time of harvest.

Results and Discussion

The data presented in the Table.1 shows that the highest yield was recorded when the seed material rhizome bits were treated with biocontrol agent *T. viride* and planted in AMF enriched rhizospere. This treatment recorded the highest yield of 4.1 kg/plot. The same treatment gave the highest number of tillers and plant height though not significant. Lalfakawma *et al* (2014) also reported that increased in plant height, number of tillers and fresh rhizome yield on treatment with *Trichoderma viride*. Earlier to that, the effect of seed treatment on yield of green ginger was also reported by Khatso *et. al.*,(2013). Samanhudi (2013) also reported higher yield and biometric parameter in Mycorrhizal application.

Similar trend was also observed when the planting materials used were transplants (Table. 2). Combined treatment with *Trichderma viride* and AMF had an influence in increasing yield of green ginger.

Biopriming the seed material before planting enhances the production (Rafi and Dawar 2015). As shown in Table. 3, the bioprimed seed enhances the yield. Maximum increase was noticed when a combination of *Trichoderma viride* and AMF were given. However, yield from rhizome bits and transplants were statistically on par as evident from the t- test applied (t- 0.783). The effect was more when the planting material used were small bits adopting transplanting technology

Treatment	Plant height(cm)	No of tillers	Yield per plant (g)	Fresh weight of rhizome per plot (kg)
Trichoderma viride	83.2	8.2	180.0	3.5
Arbuscular Micorrhizal Fun	gi 85.2	8.2	204.0	3.9
<i>Trichoderma viride</i> and Arbuscular Micorrhizal Fun	gi 88.4	9.2	209.0	4.1
Without any treatment	74.0	9.0	148.0	2.9
CD (1.0 %)	NS	NS	41.11	

Table 1. Effect of biopriming on biometric characters and yield of green ginger grown using rhizome bits as planting material

Table 2. Effect of biopriming on biometric characters and yield of green ginger grown using transplants as planting material

Treatment	Plant height(cm)	No of tillers	Yield per plant (g)	Fresh weight of rhizome per plot (kg)
Trichoderma viride	86.2	6.8	167.0	3.3
Arbuscular Micorrhizal Fun	gi 71.4	7.2	153.0	2.9
<i>Trichoderma viride</i> and Arbuscular Micorrhizal Fun	gi 85.0	9.2	214.0	4.0
Without any treatment	77.2	6.4	124.0	2.4
CD (1.0 %)	8.203	1.642	54.303	

Table 3.	Effect	of	biopriming	on	yield	of	fresh	rhizomes	grown	in	raised	beds	using	different
planting	materia	ls												

Treatments	Rhizome bits	% increase over control	Transplants	% increase over control
Trichoderma viride	3.50	20.29	3.28	39.15
Arbuscular Micorrhizal Fungi	3.98	36.56	2.99	26.84
<i>Trichoderma viride</i> and Arbuscular Micorrhizal Fungi	4.10	40.5	4.03	78.22
Without any treatment	2.91	-	2.35	-



(78.22% increase over control). By using transplants, cost of planting material can be reduced and also more number of materials can be made available where there is a dearth of planting material (Prasath *et al*, 2014).

Conclusion

The study showed that green ginger can be produced in off season also under partial shade of coconut plantation as an irrigated crop and it can ensure availability of green ginger when the demand is high. It can also be inferred that whenever transplant technology is used for planting material production, the seed material has to be treated with biocontrol agents to enhance the yield. If transplant technology is adopted, more number of planting materials can be made available at lower cost. Another implication of the results is that off season green ginger production will also ensure year round availability of planting material, which can cater to the seed requirements of small holders, who grow ginger as one of the intercrop in coconut garden, mainly for home consumption.

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Effect of organic treatments in plug tray production of

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turmeric planting material

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Abstract

Among the different spices grown in the Andaman and Nicobar Islands, turmeric is one of the important spices that is widely grown in plantation based cropping system. Organic cultivation is of major concern in the Island. There is enormous scope for organic spices production in the Island. As part of DASD funded programme front line demonstration trials on organic ginger and turmeric cultivation are done in famers' fields. The planting of transplants instead of seed rhizomes is of recent practice and the technology has been standardized using plug trays. This technology will be of high utility in the Island to save the planting material and for healthy planting material production. Keeping this in view, we have initiated an experiment to standardize the organic treatment for planting material production in the turmeric variety Co-2. The rhizome bits weighing 5 g each with single node were placed in layers of coir pith bed under shade condition for 7 days. After 7 days the 90 percent of the rhizome bits were sprouted and were planted in the plugtrays in which the media contained different organic manures like FYM, coir pith, vermicompost in combination with biocontrol agents. The foliar sprays were also done with different organic formulations like panchgavya, jeevamrutham and humic acid at 5 days intervals on 15th day (panchagavya 1%), 20th day (Jeevamrutham 1%) and 25th day (Humic acid 1%) in all the treatments. Among the different organic media, the combination of Cocopeat, FYM, vernicompost in the ratio of 1:1:1 along with trichoderma and VAM treatment recorded early sprouting (7.3 days) and maximum plant height (25.8 cm) combined with the foliar spray treatment of panchgavya, jeevamrutham and humic acid. The turmeric transplants were ready for planting in the main field after 30 days in this particular treatment. For organic cultivation of turmeric the use of media with organic manures and organic formulation will ensure the vigorous and chemical free quality planting material. Further the quantity of seed rhizomes are very much reduced which in turn reduce the production cost.

Introduction

Turmeric (*Curcuma longa*) is an important spice belonging to the family Zingiberaceae. The commercial part is rhizome or underground stem. Turmeric is one of the most important and ancient spices of India. There is a very good commercial value for the byproducts like spice oils, oleoresins and curcumin. The colouring principle curcumin is the main component of this plant

and is responsible for the anti-inflammatory properties (Sigrist et al., 2011). The crop is cultivated in central and southern states of the country mostly in Andhra Pradesh, Orissa, Tamil Nadu, Maharashtra, Kerala, Bihar and Assam. In Andaman and Nicobar Islands, among the different spices grown, turmeric is one of the important spice which is getting popular recently and the farmers of the island cultivate turmeric as a successful intercrop in coconut or arecanut based planting system. Organic cultivation of spices is of major concern in the Island as the use of fertilizers and plant protection chemicals are very less when compared to the other mainland Indian states. The use of chemical fertilizer, herbicide and pesticide for increasing yield and controlling weeds and pests can contaminate the water, air and food, decrease soil fertility, inhibit growth of soil microorganisms and hazard to human health. Beside these, utilization of organic manure in agriculture is recommended for retaining productivity of problem soils, reducing the usages of chemical fertilizer, improving economy in agriculture and minimizing environmental problems (Kamal and Yousuf, 2012). Organic farming assumes significance globally towards sustainable production and quality upgradation of turmeric (Sadanandan et. al., 1998). The use of organic manures right from the planting material production will help the farmers for organic certification of their produce as there will not be any residual effect of chemicals. The planting of transplants instead of seed rhizomes is of recent practice and the technology has been standardized using plug trays by Tamil Nadu Agricultural University, Coimbatore. This technology will be of high utility in the island to save the planting material and to produce healthy and disease free planting material. Keeping this in view, an experiment was conducted to standardize the organic treatment for plug tray production of turmeric transplants.

Materials and methods

The present experiment was conducted at the experimental farm of Central Island Agricultural Research Institute (CIARI), Port Blair during the year 2015 and the turmeric variety used for the experiment is Co-2. Healthy and disease free turmeric rhizomes were selected for the experiment. The mother rhizomes were cut into small bits with at least one node and weighing 5 g each. A pit was made under the tree shade. The rhizome bits were spread in layers of coir pith in the pit and kept for 7 days. The coir pith beds were watered once or twice a day depending on the weather condition to maintain sufficient moisture in the bed. After 7 days the rhizome bits were separated from the coir pith bed and the sprouted bits were transferred to plugtrays. Nine different treatment combinations were imposed as the media for growth of rhizome bits. The different media combinations are T1- Cocopeat + Trichoderma viride + Pseudomonas flourescens, T2- Cocopeat+VAM+ Trichoderma viride + Pseudomonas flourescens, T3- Cocopeat +vermicompost+ VAM+ Trichoderma viride + Pseudomonas flourescens, T4 - Soil+ FYM+VAM+ Trichoderma viride + Pseudomonas flourescens, T5-cocopeat+ FYM+ VAM+ Trichoderma viride + Pseudomonas flourescens, T6 - Cocopeat+ FYM+vermicompost+VAM, T7 -soil alone, T8- cocopeat alone and T9- vermicompost alone. In all the nine treatments organic foliar spray was done at 5 days intervals on 15th day (panchagavya 1%), 20th day (Jeevamrutham 1%) and 25th day (Humic acid 1%) after planting the rhizome bits in the plugtray. The experiment was laid out in completely randomized block design with three replications. After planting the rhizome bits in portrays in different media combinations, the plug trays were placed under shade net. Watering was done twice a day with rose can to maintain sufficient moisture. Observations on sprouting percentage were recorded on 7th day and 14th day after planting the rhizome bits in plugtrays. The other growth observations like plant height and number of leaves were recorded on 25th day after planting in the plugtray. The data obtained for different treatment combinations were statistically analyzed (Gomez and Gomez, 1984).

Treatments	Sprouting at weekly	Percent at vintervals	Plant Height (cm)	No. of leaves (Nos)
	7 Days (%)	14 Days (%)	after 25 days	after 25 days
T_1	29.33	84.00	22.60	3.33
T_2	46.66	88.00	26.76	3.66
T ₃	54.66	86.66	25.96	4.33
T_4	70.66	92.00	27.60	4.00
T_5	62.66	88.00	20.66	3.33
T_6	76.00	98.66	30.96	5.66
T_7	40.00	80.00	20.03	2.66
T ₈	54.66	89.33	23.33	3.33
T_9	57.33	82.66	21.60	3.33
S.E.D	1.69	2.15	0.73	0.36
C.D (0.05)	2.40	3.04	1.04	0.52
C.V %	5.09	6.45	2.21	1.09

Table 1. Effect of organic treatments on sprouting percentage and growth parameters of turmeric rhizome bits

T1- Cocopeat + *Trichoderma viride* + *Pseudomonas flourescens* + Foliar spray*, T2-Cocopeat+VAM+ *Trichoderma viride* + *Pseudomonas flourescens* + Foliar spray*, T3- Cocopeat +vermicompost+ VAM+ *Trichoderma viride* + *Pseudomonas flourescens* + Foliar spray*, T4 – Soil+ FYM+VAM+ *Trichoderma viride* + *Pseudomonas flourescens* + Foliar spray*, T5-cocopeat+ FYM+ VAM+ *Trichoderma viride* + *Pseudomonas flourescens* + Foliar spray*, T6 – Cocopeat+ FYM+vermicompost+VAM + Foliar spray*, T7 –soil alone + Foliar spray*, T8- cocopeat alone + Foliar spray* and T9- vermicompost alone + Foliar spray*. Foliar spray* - Organic foliar spray was done at 3 times at 5 days intervals on 15th day (panchagavya 1%), 20th day (Jeevamrutham 1%) and 25th day (Humic acid 1%)

Results and discussion

The rhizome bits embedded in the coir pith bed were removed after seven days and it was observed that about 90 per cent of buds were sprouted. The sprouted rhizome bits were planted in nine different treatment combinations and observations on sprouting percentage, plant height and the number of leaves were recorded and were statistically significant (Table 1). The sprouting percentage recorded at 7th day and 14th day after planting the rhizome bits in the plugtrays with different treatment combinations revealed that the sprouting percentage was maximum in the treatment T6 (cocopeat+ FYM+ vermicompost+ VAM+ organic foliar spray) both on 7th day (76%) and 14th day (98.66%) after transplanting. This treatment consists of the organic manures like cocopeat, FYM and vermicompost which enhances the sprouting percentage because of the porous nature of the media, retention of optimum moisture and good aeration in the root zone.



This organic growing media combination supply ample quantities of nutrients to plants which in turn enhanced the sprouting percentage.

The growth observations like plant height (30.96 cm) and number of leaves (5.6) were also maximum in the treatment T6 when compared to the other treatment combinations. This might be due to the cumulative effect of all organic media such as FYM, vermicompost, coircompost and VAM along with organic foliar spray due to the good water holding capacity, high porosity, increased surface area that provides many microsites for microbial activity and strong retention of nutrients. Previous studies reported that organic manure improved soil productivity and fertility, which improved yield and quality of turmeric (Hossain and Ishimine, 2007; Velmurugan *et al*, 2007; Mohapatra and Das, 2009 and Dinesh *et al*, 2010)

Conclusion

It is concluded that the media combination of cocopeat+ FYM+ vermicompost+ VAM+ organic foliar spray have significantly influence the sprouting percentage and growth parameters of the turmeric transplants in the plug tray method. Therefore, the combination of organic manure is crucial for nutrient exhaustive crops like turmeric for commercial cultivation.

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Effect of seed rhizome cuttings on growth and yield of turmeric

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Abstract

Turmeric is propagated by different types of rhizomes *viz*, mother, primary and finger rhizomes. The effect of size of seed rhizomes on growth and yield of turmeric was evaluated. The mother rhizome as well as fingers were cut to different sizes and planted directly in to the field as well as plantlets were prepared in protrays and transplanted after one month. The significantly highest leaf area, height of plant, maximum number of leaves per tiller and highest number of tillers were recorded by the turmeric planted using mother rhizomes which was on par with mother rhizomes cuttings (10 -15 g) directly planted in the field. The significantly maximum weight of mother rhizome (73.53gm/plant), maximum number of primary rhizomes per plant (2.80), maximum weight of primary rhizomes (111.97 gm/plant), maximum number and weight of fingers per plant (16.20 and 568.62 gm/plant, respectively) and highest fresh as well as dry yield of rhizomes was recorded in the same treatment (360.81 qha⁻¹ and 75.96 qha⁻¹, respectively) which was at par with mother rhizome pieces directly planted in the field (318.39 qha⁻¹ and 65.65 qha⁻¹, respectively). Hence, the planting of Mother rhizome pieces (10-15 g) directly in the field will save 50% seed rhizomes without affecting the yield.

Introduction

Turmeric (*Curcuma longa* L) is one of the most important spice cash crop of India. It is cultivated throughout the India around 2.32 lakh ha area with annual production 11.90 lakh tonnes (Anonymous, 2015). It is sacred, auspicious multi purpose spice valued for its food and colouring agent required by pharmaceutical, confectionary and cosmetic industry. Modern biomedical research also attests the medical value of turmeric in a variety of ailments. The major constituent present in turmeric is curcumin 0.3 -5.4 per cent (Leung, 1980) depending on the variety and climatic situations. The demand for the varieties having high curcumin content is increasing day by day. But the avability of quality planting material is the major limiting factor in turmeric cultivation.

Traditionally turmeric is propagated by a small portion of the rhizomes known as seed rhizome or seed sets. (Ravindran *et al.* 2007). The seed rhizomes are mainly three types *viz.*, mother rhizomes, side or primary rhizomes and secondary rhizomes and fingers. The yield of turmeric was



maximum in the plants grown directly form mother rhizomes among the different types of rhizomes. The planting material used affects the growth and yield of turmeric. Therefore, selecting the right size of planting material is the most critical factor in the turmeric cultivation (Padmadevi *et al.*, 2012). Large sized seed rhizomes of ginger give significantly higher yield than planting of small pieces (Nybe and Raj, 2004). Hossain *et al.* (2005) found high yield of turmeric from using 30-40 gm seed rhizomes compared to 10 and 20 g seed rhizomes.

Even though planting large size seed rhizomes yields more, the seed requirement is too large about 2.5 tonnes ha⁻¹. The cutting of seed rhizomes into pieces as well as preparation of plantlets in protray helps to reduce the seed rate of turmeric. Hence, the present experiment was conducted to study the effect of seed rhizome size as well as its splitting on growth and yield of turmeric with major objective of reduction in the quantity of seed.

Material and methods

The field experiment was conducted to study effect of seed rhizome bits on growth and yield of turmeric in vertisol at Agricultural Research Station Kasbe Digraj, Dist. Sangli (Maharashtra) during 2014-2015. The experiment was laid out in randomized block design with three replications and a spacing of 37.5 x 30 cm. All the cultural practices were followed as per the recommended package of practices. The treatment comprises Single node bits (5 g) directly planted in field (T_1), Two node cuttings (10 g) directly planted in field (T_2), Mother rhizome cuttings (10-15 g) directly planted in the field (T_3), Single node cutting (5 g) planted in pro tray (T_4), Two node cutting (10 g) planted in pro tray (T_5), Mother rhizome cuttings (10-15 g) planted in pro ray (T_6), Secondary rhizomes/fingers (15-20 g) planted directly in the field (T_7), primary rhizomes (25-30 g) directly planted in the field (T_8) and Mother rhizomes (35-40 g) directly planted in the field (T_9). The single node and two node bits were prepared from fingers. The plantlets prepared in protray by using planting mixture (Coco peat, farm yard manure and soil 1:1:1 proportion) were transplanted in the field after one month of its planting in pro tray. The observations of growth and yield attributes were recorded. The data were analyzed as per the method suggested by Panse and Sukhatme (1985).

Results and discussion

The effect of seed rhizome cuttings on growth and yield attributing characters of turmeric are presented in Table 1.

Growth attributing characters

In the present study the growth attributing characters like leaf area, height of plant, number of tillers per plant and number of leaves per tiller were studied. The significantly highest leaf area (582.50 cm²) was recorded in turmeric planted by using mother rhizomes which was followed by mother rhizome cuttings directly planted in the field (439.71 cm²). The maximum height of plant (128.93 cm) 150 days after planting was recorded in the treatment where turmeric is planted using mother rhizomes which was at par with mother rhizome cuttings directly planted in the field (120.27 cm). The maximum number of leaves per tiller was recorded in the treatment turmeric planted using mother rhizomes (13.27) which was on par with mother rhizome cuttings directly planted in the field (12.00). The highest number of tillers per plant was recorded in the treatment turmeric planted using mother rhizomes (3.40) on par with mother rhizome cuttings directly planted in the field (3.33).

This might be due to the mother rhizomes contain more reserved food material which is utilized by the plant for initial establishment and vigorous growth. The more is the rhizome size maxi-

Treatments	Leafarea (cm²)	Heightof plant(cm)	No. of Leaves/ tiller	No. of tillers/ plant	Wt.of mother thizone/ plant(gm)	No.of primary rhizomes/ plant(gm)	Wt.of primary rhizomes/ plant(gm)	No. of Secondary thizomes/plant	Wt. of fingers/ plant (gm)	Projectedfresh yield(qha ⁻¹)	Projected dry yield (qha ⁻¹)
$\mathbf{T}_{_{1}}$	211.36	82.00	9.07	1.40	32.60	1.00	44.47	10.73	301.61	155.57	31.43
${ m T}_{_2}$	292.26	00.66	10.93	2.20	60.43	1.60	57.07	11.87	380.92	264.36	54.51
$\mathrm{T}_{_3}$	439.71	120.27	12.00	3.33	68.73	2.80	93.03	14.87	507.62	318.39	65.65
${ m T}_{_4}$	174.68	66.73	8.60	1.00	25.87	0.73	26.87	9.60	240.96	124.63	25.18
T_5	235.31	75.07	9.27	1.20	39.73	0.73	29.13	11.13	312.85	201.17	41.48
$\mathbf{T}_{_{6}}$	287.55	89.67	9.47	1.67	43.23	1.20	48.07	11.87	345.32	235.89	49.66
${f T}_7$	287.58	94.13	9.93	2.20	56.53	1.60	65.13	12.47	362.78	261.70	52.87
${ m T_{_8}}$	377.88	109.07	11.07	2.60	64.60	1.87	80.47	13.80	415.38	291.35	61.34
T_{9}	582.50	128.93	13.27	3.40	73.53	2.73	111.97	16.20	568.62	360.81	75.96
SE <u>+</u>	13.60	5.10	0.60	0.22	3.15	0.17	5.91	0.75	22.04	18.71	3.87
CD (5%)40.77	15.30	1.79	0.66	9.43	0.52	17.73	2.24	66.07	56.10	11.60

Table 1. Effect of rhizome size and cuttings on growth and yield attributing characters of turmeric

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mum is the growth attributes. But the turmeric plantlets prepared in pro tray after transplanting recorded slow growth as it contains less stored food material in the rhizome cuttings. Padmadevi *et al.* (2012) reported that larger seed rhizomes contain larger amount of reserves that enhanced seedling growth which ultimately result in to taller plant. These results are in conformity with the observations recorded in tropical soda apple (Akanda *et al.*, 1996) and spring wheat (Stougaard and Xue, 2004). They reported that larger seed produce longer coleoptiles and had higher reserves which improves seedling establishment.

Yield attributing characters

The significantly higher weight of mother rhizome (73.53gm/plant) was recorded in mother rhizomes followed by mother rhizome cuttings (68.73 gm/plant) and by primary rhizomes (64.60 gm/plant) directly planted in the field. Maximum number of primary rhizomes per plant (2.80) was observed in mother rhizome cuttings directly planted in the field at par with mother rhizomes (2.73). The significantly higher weight of primary rhizomes (111.97 gm/plant) was recorded in mother rhizomes planting followed by mother rhizome cuttings directly planted in the field (93.03 gm/plant). The maximum number and weight of fingers per plant (16.20 and 568.62 gm/plant, respectively) was observed in mother rhizomes at par with mother rhizome cuttings directly planted in the field (14.87 and 507.62 gm/plant, respectively). The highest fresh as well as dry yield of rhizomes was also recorded by mother rhizomes (360.81 qha⁻¹ and 75.96 qha⁻¹, respectively) on par with mother rhizome cuttings directly planted in the field (318.39 qha⁻¹ and 65.65 qha⁻¹, respectively).

The vigorous initial growth of the plant yielded more due to better establishment of the plants. The maximum leaf area, number of leaves and tillers trap maximum sunlight resulting into increased photosynthesis and yield maximum shoot biomass as compared to the transplanted plantlets. Hossain *et. al* (2005) reported that maximum will be the yield of turmeric because of larger shoot biomass production. The similar results were observed by Sarker *et. al* (2001) in rice.

Conclusion

Planting Mother rhizome cut pieces (10-15 g) with one or two active buds directly in the field will save 50 % seed rhizomes without affecting yield of the turmeric. The growing of the plantlets in protray yielded less due to its initial slow growth after transplanting. But it needs further investigation to provide a solution for obtaining maximum yield form the transplants as it requires less seed.

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Effect of seed rhizome weight and spacing on quality seed production of turmeric at Terai Zone of West Bengal

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Abstract

Turmeric (*Curcuma longa* L.) is an asexually propagated rhizomatous spice crop with high yield potential at Terai zone of West Bengal. Availability of the quality planting material of high yielding varieties suitable for the agro-climatic region is an impediment for increasing the area under this crop. An experiment was conducted to study the effect of seed rhizome weight and spacing on quality production of seed turmeric at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar West Bengal during the year 2009-10 and 2010-11. Mean performance revealed significant variation in different growth and yield characters with respect to seed rhizome weight, spacing and their interaction. Fresh yield of rhizomes increased with increasing seed rhizome weight. However, the fresh yield of 32.00 t/ha was produced with the 50 g (W_3) seed rhizome weight which was statistically at par with 35 g (W_2) seed rhizome. Significantly the highest fresh rhizome yield was recorded in 20 cm × 15 cm spacing. Considering the interaction effect, the highest quantative and qualitative fresh rhizome yield of 35.43 t/ha was recorded in treatment combination of 35 g seed rhizome planted at a spacing of 20 cm X 15 cm (W_2S_2) and that may be recommended for both seed and crop production of turmeric.

Introduction

Turmeric (Curcuma longa L.) is a rhizomatous, asexually propagated important spice crop and native to India. It belongs to the family Zingiberaceae. India is a leading producer, consumer and exporter of turmeric in the world and earned a foreign exchange of 2000 million \$ (Anonymous. 2012). It is used as spice, dye, drug and cosmetic in addition to its use in the auspicious religious occasions. Apart from the above use, it has tremendous use in pharmaceutical and colouring industries. Turmeric inhibits the development of cataracts, breast cancer, colon cancer, and lymphoma (Devi and Sangamithra, 2011). Apart from its spice and medicinal value it is also used in the preparation of different cosmetic items. In India it is cultivated in an area of 1.95 lakh ha with a production of 9.99 lakh tonnes. In West Bengal, it is cultivated in 15.8 thousand ha with a production of 42 thousand tonnes. Productivity of turmeric in West Bengal is quite low (2.66 t/ha) compared to national average (5.11 t/ha). The low productivity and less acreage in West Bengal may be due to the use of low yielding cultivars, non availability of the quality planting material and poor management practice. Availability of the quality planting material of high yielding varieties suitable for the agro-climatic region is important for increasing the productivity. Seed rhizome of turmeric must be matured, bold in size with good stored food. Turmeric is commercially propagated through a small portion of rhizomes bits known as seed rhizome and it gives economic yield. The type of planting material used affects the growth and yield

of the crops as the cost of planting material amounts to 50% of crop production (Pujari *et al.* 2015). Selection of right size of planting material (length, weight and number of growing buds per seed) is a very critical factor in the commercial cultivation of turmeric. On the other hand, optimum plant density of a crop varies considerably depending upon climatic conditions of the growing area and growing condition of the crop. Plant spacing is an important factor for higher production and gives equal opportunity to the plants for their survival and best use of inputs (Kumar and Gill, 2010). However, the information on the effect of different rhizome weight and plant spacing for the production of turmeric seed rhizomes are scanty in the terai zone of West Bengal. Considering these, an experiment was conducted to study the effect of seed rhizome weight and spacing on quality production of seed turmeric.

Materials and methods

An experiment was conducted to study the effect of seed rhizome weight and spacing on quality production of seed turmeric at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar West Bengal during the year 2009-10 and 2010-11. The experimental soil was sandy clay loam having pH 5.89, 0.93% organic carbon, 135.65 kg/ha available nitrogen, 48.56 kg/ha available phosphorus and 65.39 kg/ha potash. The climatic condition of this region is sub-tropical humid in nature. The experiment was laid out in Factorial Randomized Block Design with four replications studying three levels of seed rhizome weight [$20g(W_1)$, $35g(W_2)$ and $50g(W_3)$] and three levels of spacing [15 cm \times 15 cm (S₂), 20 cm \times 15 cm (S₂) and 30 \times 15 cm (S₂)]. Raised beds of $3.00 \text{ m} \times 1.20 \text{ m}$ size and 15 cm height were prepared, rhizomes of the variety Suranjana was planted during the first week of April 2009 and 2010, respectively. Full dose of farm yard manure @ 15 t/ha was applied at the time of land preparation. Inorganic fertilizers were applied at the dose of N: P₂O₅: K₂O @ 80: 80: 120 kg/ha. Irrespective of treatment, full dose of P₂O₅ and 1/3 dose of N was applied as basal, rest 2/3rd N and K₂O were applied in two equal splits at 45 and 90 days after planting. Observations on different morphological and yield attributing characters were recorded from ten randomly selected plants from each plots. Harvesting was carried out when the leaves begin to change colour from green to yellow. Rhizome yield per hectare was calculated on the plot weight basis. For determination of dry recovery percentage the harvested turmeric rhizome was washed and dried properly till a constant weight was obtained. Curcumin content of dry turmeric rhizome was estimated (Sadasivam and Manickam, 1996). Statistical analysis of the data was done as per method suggested by Gomez and Gomez (1984).

Results and discussion

Perusal of the data presented in Table 1, Table 2, Table 3 and Table 4 revealed that there was a significant variation in different growth and yield characters of turmeric with respect to seed rhizome weight, spacing and their interaction. Plant height and number of leaves per plant (Table 1) increased with increasing seed rhizome weight. Significantly tallest plant (108.78 cm) was recorded in 50 g seed rhizome weight (W_3). Highest number of leaves per plant (12.00) was recorded with 50 g seed rhizome weight (W_3) which was statistically at par with 35 g (W_2) seed rhizome weight (11.06). Significantly lowest plant height and number of leaves per plant (83.33 cm, 7.61, respectively) was recorded with 20 g seed rhizome weight (W_1). Higher plant height and number of leaves per plant increased per plant was recorded with higher seed rhizome weight due to higher reserve food materials which help to increase the vigour of the plant. Plant height and number of leaves per plant increased with increasing the plant spacing from 15 × 15 (S_1) cm to 30 × 15 (S_3) cm. Higher plant height (104.00 cm) was also recorded in the plant spacing of 30 cm × 15 (S_3) cm and was lowest (87.55 cm) in 15 × 15 cm (S_1) spacing.

Weight of mother rhizome, primary rhizome, secondary rhizome and individual clump increased with increasing seed rhizome size from 20 g to 50 g and plant spacing from 15×15 cm to 30×15 cm

	P	Plant height (cm)			Number of leaves/plant					
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled				
Seed Rhizome Weight										
W_1	81.44	85.22	83.33	7.33	7.89	7.61				
W_2	97.67	99.00	98.33	11.00	11.11	11.06				
W3	108.78	114.00	111.39	11.56	12.45	12.00				
SEm ±	3.67	4.24	3.75	0.62	0.56	0.51				
CD (P=0.05)	10.71	12.37	10.56	1.81	1.64	1.91				
Spacing										
S ₁	87.55	92.89	90.22	9.00	9.44	9.22				
S ₂	96.34	99.78	98.06	9.89	10.33	10.11				
S ₃	104.00	105.55	104.78	11.00	11.67	11.34				
SEm ±	3.71	4.02	3.66	0.67	0.69	0.65				
CD (P=0.05)	10.84	11.75	10.32	N.S.	N.S.	N.S.				
Interactions										
W_1S_1	75.33	80.67	78.00	6.67	7.33	7.00				
W_1S_2	82.67	85.67	84.17	7.33	7.67	7.50				
W_1S_3	86.33	89.33	87.83	8.00	8.67	8.34				
W_2S_1	87.00	92.67	89.84	9.67	9.33	9.50				
W_2S_2	95.67	99.33	97.50	11.00	11.33	11.17				
W_2S_3	110.33	105.00	107.67	12.33	12.67	12.50				
$W_{3}S_{1}$	100.33	105.33	102.83	10.67	11.67	11.17				
W_3S_2	110.67	114.33	112.50	11.33	12.00	11.67				
W ₃ S ₃	115.33	122.33	118.83	12.67	13.67	13.17				
SEm ±	5.21	4.65	4.42	0.96	0.87	075				
CD (P=0.05)	15.21	13.58	12.46	N.S.	N.S.	N.S.				

Table 1. Effect of seed rhizome weight and spacing on plant height and leaf number of turmeric

N.S. – Non Significant; $W_1 = 20g$ seed rhizome weight, $W_2 = 35g$ seed rhizome weight and $W_3 = 50g$ seed rhizome weight; $S_1 = 15$ cm X 15 cm spacing, $S_2 = 20$ cm X 15 cm spacing and $W_3 = 30$ X 15 cm spacing

	Mother	rhizome weight/cl	Primary rhizome weight/clump (g)			
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Seed Rhizome	Weight					
\mathbf{W}_{1}	42.55	43.25	42.90	75.42	86.31	80.87
W ₂	52.08	51.64	51.86	95.57	98.11	96.84
W3	59.95	60.48	60.21	99.23	106.50	102.87
SEm ±	1.75	1.64	1.58	3.65	2.93	3.16
CD (P=0.05)	5.10	4.78	4.45	10.66	8.56	8.92
Spacing						
\mathbf{S}_{1}	45.50	45.86	45.68	62.76	70.85	66.81
S ₂	53.09	53.15	53.12	90.08	97.79	93.93
S ₃	55.99	56.36	48.15	117.38	122.28	119.83
SEm ±	1.87	1.65	1.58	3.57	2.99	3.14
CD (P=0.05)	5.46	4.83	4,46	10.43	8.74	8.85
Interactions						
W_1S_1	38.63	34.79	36.71	41.43	57.30	49.37
W_1S_2	43.42	46.81	45.12	81.80	85.64	83.72
W_1S_3	45.59	48.15	41.15	103.04	116.00	109.52
W_2S_1	42.51	45.71	44.11	66.39	72.36	69.38
W_2S_2	56.89	50.23	53.56	94.50	108.17	101.34
W_2S_3	56.85	58.98	57.92	125.82	113.80	119.81
W_3S_1	55.37	57.07	56.22	80.47	82.90	81.69
W_3S_2	58.96	62.41	60.69	93.94	99.55	96.75
W ₃ S ₃	65.52	61.95	63.74	123.28	137.05	130.17
SEm ±	4.72	4.05	3.86	5.78	5.45	5.43
CD (P=0.05)	13.78	11.83	10.89	16.88	15.92	15.31

Table 2. Effect of seed rhizome weight and spacing on mother rhizome weight and primary rhizome weight of turmeric

 $W_1 = 20$ g seed rhizome weight, $W_2 = 35$ g seed rhizome weight and $W_3 = 50$ g seed rhizome weight; $S_1 = 15$ cm X 15 cm spacing, $S_2 = 20$ cm X 15 cm spacing and $W_3 = 30$ X 15 cm spacing.

	Seconda	Secondary rhizome weight/Clump (g)			Individual clump weight (g)			
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled		
Seed Rhizome	Weight							
\mathbf{W}_{1}	10.56	10.75	10.66	134.38	140.31	137.34		
W ₂	15.19	16.59	15.89	162.84	166.34	164.59		
W3	15.53	15.93	15.73	174.71	182.91	178.81		
SEm ±	1.06	0.99	0.98	6.36	5.65	5.02		
CD (P=0.05)	3.11	2.90	2.76	18.63	16.55	14.66		
Spacing								
S ₁	10.62	10.47	10.55	124.73	127.18	125.96		
S ₂	12.68	13.53	13.10	155.85	164.46	160.16		
S ₃	17.98	19.27	18.63	191.35	197.91	194.63		
SEm ±	0.92	0.81	0.87	6.27	5.25	4.92		
CD (P=0.05)	2.70	2.37	2.45	18.37	15.38	13.87		
Interactions								
W_1S_1	8.73	7.25	7.99	106.32	99.34	102.83		
W_1S_2	10.47	11.38	10.93	135.69	143.83	139.76		
W_1S_3	12.49	13.61	13.05	161.12	177.76	169.44		
W_2S_1	10.53	11.78	11.16	119.43	129.85	124.64		
W_2S_2	14.15	16.23	15.19	165.54	174.63	170.09		
W_2S_3	20.89	21.75	21.32	203.56	194.53	199.05		
$W_{3}S_{1}$	12.61	12.38	12.50	148.45	152.35	150.40		
W_3S_2	13.42	12.97	13.20	166.32	174.93	170.63		
W ₃ S ₃	20.56	22.45	21.51	209.36	221.45	215.41		
SEm ±	1.26	1.18	1.09	7.24	6.82	6.55		
CD (P=0.05)	N.S.	N.S.	N.S.	21.25	20.01	18.60		

Table 3. Effect of seed rhizome weight and spacing on secondary rhizome weight and clump weight of turmeric

N.S. – Non Significant; $W_1 = 20g$ seed rhizome weight, $W_2 = 35g$ seed rhizome weight and $W_3 = 50g$ seed rhizome weight; $S_1 = 15$ cm X 15 cm spacing, $S_2 = 20$ cm X 15 cm spacing and $W_3 = 30$ X 15 cm spacing

	Fresh rhizome yield (t/ha)			Curcumin content (%)			
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	
Seed Rhizome	Weight						
\mathbf{W}_{1}	25.36	25.26	25.31	5.18	5.23	5.21	
W ₂	28.29	28.88	28.58	5.22	5.26	5.24	
W3	32.22	31.78	32.00	5.27	5.28	5.28	
SEm ±	0.52	0.68	0.43	0.04	0.03	0.03	
CD (P=0.05)	1.52	1.97	1.21	N.S.	N.S.	N.S.	
Spacing							
S ₁	28.27	28.47	28.37	5.18	5.22	5.20	
S ₂	32.69	32.27	32.48	5.23	5.24	5.24	
S ₃	27.49	27.94	27.72	5.26	5.30	5.28	
SEm ±	0.54	0.67	0.43	0.03	0.03	0.02	
<u>CD</u> (P=0.05)	1.58	1.95	1.21	N.S.	N.S.	N.S.	
Interactions							
W_1S_1	24.82	24.22	24.52	5.15	5.18	5.17	
W_1S_2	28.12	27.61	27.86	5.17	5.23	5.20	
W_1S_3	23.16	23.94	23.55	5.21	5.27	5.24	
W_2S_1	28.56	29.21	28.88	5.17	5.22	5.20	
W_2S_2	35.50	35.36	35.43	5.24	5.25	5.25	
W_2S_3	29.59	29.31	29.45	5.26	5.3	5.28	
W_3S_1	31.73	31.69	31.71	5.21	5.27	5.24	
$W_{3}S_{2}$	34.45	33.85	34.15	5.29	5.23	5.26	
W ₃ S ₃	29.72	30.57	30.14	5.30	5.33	5.32	
SEm ±	0.91	1.17	0.74	0.05	0.05	0.05	
CD (P=0.05)	2.65	3.42	2.10	N.S.	N.S.	N.S.	

Table 4. Effect of seed rhizome weight and spacing on fresh rhizome yield and curcumin content

N.S. – Non Significant; $W_1 = 20g$ seed rhizome weight, $W_2 = 35g$ seed rhizome weight and $W_3 = 50g$ seed rhizome weight; $S_1 = 15$ cm X 15 cm spacing, $S_2 = 20$ cm X 15 cm spacing and $W_3 = 30$ X 15 cm spacing

(Table-3 and Table-4). Considering the interaction effect, it was evident that the highest mother rhizome weight (63.74 g) was recorded in 50 g seed rhizome weight along with 30 × 15 cm spacing (W_3S_3). Significantly highest primary rhizome weight (137.05 g) was recorded in 50 g seed rhizome with 30 cm × 15 cm spacing (W_3S_3). Significantly the highest individual clump weight (178.81 g) was also recorded with seed rhizome of 50 g (W_3) and was lowest (137.34 g) with 20 g seed rhizome (W_1) of turmeric. Significantly highest clump weight (194.63 g) was recorded in widest spacing of 30 cm × 15 cm spacing (S_3) and lowest (125.96 g) in closest spacing of 15 cm × 15 cm (S_1). The interaction effect revealed that, highest individual clump weight (215.41) was recorded in the combination of 50 g seed size and 30 cm × 15 cm spacing (W_3S_3) which was statistically at par with 35 g seed size with a spacing of 30 cm × 15 cm (199.05 g).

Fresh yield of seed turmeric rhizome increased with increasing seed rhizome weight. However, the fresh yield of turmeric seed rhizome of 32.00 t/ha was recorded in the 50 g seed rhizome treatment at par with 35 g seed rhizome. Significantly highest fresh rhizome yield was recorded in 20 cm \times 15 cm spacing. The highest fresh rhizome yield of 35.43 t/ha was recorded in seed rhizome size of 35 g with a spacing of 20 cm \times 15 cm at par with the treatment 50 g seed rhizome with a spacing of 20 cm \times 15 cm (34.15 t/ha). In this experiment most of the parameters showed better performance in the higher seed weight and widest spacing. A similar finding was also recorded by Philip (1985). This might be due to the heavier seed rhizome helped for better initial as well as subsequent growth of the plant. On the other hand, widest spacing minimized the competition among the plants (Randhawa and Mishra, 1974). But widest spacing accommodates less number of plants in per unit area and ultimately reduced the fresh yield as a result seed rhizome size of 35 g along with a spacing of 20 cm \times 15 cm recorded the highest rhizome yield. With respect to curcumin content, there was no significant difference with respect to seed rhizome size, plant spacing and their interaction.

Conclusion

Considering the quantative and qualitative fresh turmeric seed rhizome yield of 35.43 t/ha recorded in treatment combination of 35 g seed rhizome planted at a spacing of 20 cm \times 15 cm, this may be recommended for both seed and crop production of turmeric in Terai zone of West Bengal.

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Assessment of weight loss in stored ginger (*Zingiber officinale* Rosc.) under different storage materials

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Abstract

Studies were carried out at Experimental Farm of ICAR- Indian Institute of Spices Research, Peruvannamuzhi, Kozhikode to find out the influence of green leaves and inert storage materials on physiological weight loss of seed ginger rhizomes stored in wooden storage units kept in semipermanent shed. The storage unit with a capacity of 100 kg has wooden base of size $1 \times 1 \times 0.1$ m, above which side walls made of welded mild steel mesh is provided to a height of 30 cm in 27 different storage units. Ginger rhizomes treated with fungicide Mancozeb (0.3%) were kept in the storage unit and stored with green leaves such as *Glycosmis pentaphylla*, *Strychnos nuxvomica* and inert materials such as sawdust, sand and granite powder. Pre-treated rhizomes alone and untreated rhizomes served as control. Maximum percentage of bold healthy rhizomes with less moisture loss was obtained when rhizomes were stored with granite powder and sawdust (76.4%) and was on par with sand (74.2%). Influence of various storage materials on germination percentage of ginger rhizome showed that all the treatments except control was effective in maintaining the germinability (100%) of seed rhizomes. Studies on microbial infestation of stored rhizomes indicated that, storing ginger with *Strichnos nuxvomica* leaves showed pest/pathogen free seed rhizomes.

Introduction

Ginger (*Zingiber officinale* Roscoe.) is an economically valued spice crop used as vegetable and medicine. Owing to its warm pungent taste and pleasant odour, it is used widely as a flavouring agent in numerous food preparations, beverages, baked foods, confectionary, breads, soups, pickles and many popular soft drinks in common. Ginger is propagated vegetatively by the seed rhizomes and among inputs, seed materials alone accounts for about 40 % of total cost of production. The storage period of the seed rhizome for 3-4 months from harvest to next planting season is faced with many problems such as rotting, shrinking, sprouting and rooting resulting in huge losses. In order to avoid spoilage and to obtain good germination, proper storage of seed rhizome is essential. The ambient conditions during storage period is 22-25° C make the growing buds fat and strong and temperature higher than 28°C in the long run make the buds thin and weak. If the storage humidity is too low, rhizome will wrinkle and sprouting speed and bud quality get affected (Xizhen *et al.* 2005). Spreading layers of *Glycosmis pentaphylla* (Paannal) leaves along with ginger rhizome is one of the methods practiced for reducing storage loss (Nybe & Miniraj 2005). Zero energy cool chamber (ZECC), is found ideal for storing fresh ginger. The loss in

weight of rhizome was only 23% after storing for four months in this chamber, while the ginger stored in open condition was shrunken in four months (Kumar *et al.* 2006). In Malabar area, cleaned rhizomes are smeared with a paste of cow dung and paannal leaves before storing to prevent scales and rotting. Beena et al. (1997) reported a seed storage practice consisting of seed treatment with Mancozeb (0.3%) and Malathion (0.1%) for 30 minutes, air drying and storing in pits lined with sand in thatched sheds or rooms where the temperature do not exceed 28°C. In another method, seed rhizomes are stored in pits in layers along with well drained sand/saw dust (Kumar *et al.* 2006). For storing large quantities of ginger rhizomes, neither pit nor zero energy cool chambers is sufficient. Hence 27 storage units with each having a capacity of 100 kg, with wooden base of size 1 x 1 x 0.1m, above which side walls made of welded mild steel mesh provided to a height of 30 cm were made for a total capacity of 2.7 tons.

Storing ginger rhizomes with *Glycosmis pentaphylla* is being practiced by several farmers in Kerala but moisture loss is high. Storing ginger with sand and sawdust is recommended (Kumar *et al* 2006) but the availability is scarce AS sand is very expensive. Keeping this in view an experiment was planned to find out the influence of green leaves and inert storage materials on physiological weight loss of ginger stored in wooden storage units kept in semi-permanent shed.

Materials and Methods

The experiment was conducted at experimental farm of ICAR- Indian Institute of Spices Research, Peruvannamuzhi Kozhikode from 2009 - 2011. The experimental site is located at 11° 34' N and 75° 49' E with an attitude of 60 m above MSL. The experimental site has a typical tropical humid climate with bimodal monsoon rains, with an annual rainfall of 4500 mm per year. The mean maximum temperature varied from 25-37°C and the minimum temperature from 17.5-31°C during the experimental period. Average rainfall during February, March, April, May, June, July, August and September were 0, 22.4, 14.58, 28.46, 33.86, 68.50, 20.26, 28.11 mm, respectively.

Twenty seven storage units made up of wood and mild steel mesh with a total capacity of 2.7 tons was used in the experiment. Capacity of single box is 100 kg. For this experiment ginger rhizome weighing 50 kg was used to fill the each storage unit. Each inert material and green leaves were spread to a thickness of 2 cm in a box over which ginger rhizomes were spread to a thickness of 2 cm in a box over which ginger rhizomes were spread to a thickness of 25 cm and again covered with the storage materials. A space of 10 cm from the top of the box was left for ventilation and the ginger rhizomes were stored for a period of four months with different treatments. Care has been taken to reduce the temperature inside the shed below 28°C by providing shade below the roofing. Healthy, uniform sized rhizomes of ginger variety Varada were used for the study. Rhizomes were treated with fungicide Mancozeb (0.3%), dried in shade and stored with different storing materials. The experiment was designed in CRD with seven treatments and three replications. Treatments are storing treated rhizomes with T1- *Glycosmis pentaphylla*, T2- *Strychnos nuxvomica*, T3- Sawdust, T4 – Sand, T5 - Granite powder, T6 - Fungicide treated rhizomes alone, T7 - Untreated rhizomes alone (Control).

The weight of healthy, shrinked and infected rhizomes was recorded after 120 days of storage in each storage unit and expressed in percentage. The moisture loss in weight was found out by deducting weight of healthy, shrinked and infected rhizomes from total quantity used for storage. Rhizome samples stored under various storing materials were analysed for the microbial association both by microscopic observation of surface growth and by culturing in different media. After the storage period of 4 months, healthy rhizomes were planted in beds of 3 m × 1m size at a spacing of 25×25 cm to study the effect of storage method on sprouting. Observations on sprouting were taken per bed and expressed as percentage. The data recorded were statistically analyzed (Panse & Sukhatme,1985).

Results and Discussion

The effect of various storing materials on percentage recovery of healthy ginger rhizomes is presented (Table 1). There were significant difference between treatments; data indicated that maximum percentages of healthy rhizomes were obtained when stored in granite powder (76.62) on par with sawdust and sand. Lowest percentage recovery of healthy rhizomes was recorded by control (58.69).

Table 1.	Effect o	of inert	and	green	leaves	on	percentage	recovery	of	healthy	rhizomes,	loss	of
moisture	and ger	minatio	n										

Treatment	Healthy rhizomes (%)	Shrinked rhizomes (%)	Infected (%)	Moisture loss (%)	Germination (%)
Glycosmis pentaphylla	61.50	11.15	17.00	10.17	100
Strichnos nuxvomica	58.33	11.03	16.50	14.17	100
Sawdust	71.17	8.3	13.67	8.00	100
Sand	70.83	8.8	15.83	7.00	100
Granite powder	74.30	9.0	13.67	5.50	100
Fungicide treated alone	55.80	12.90	16.83	12.0	100
Untreated alone	50.67	15.00	20.67	15.0	68.5
CD 5%	12.50	4.43	NS	4.33	NS

There was significant difference in the quantities of shrinked rhizomes with different storing materials used. Lowest percentage of shrinked rhizome was noticed with sawdust on par with sand, granite powder, *Glycosmis pentaphylla* leaves and, *Strychons nuxvomica* leaves storing. Highest percentage of shrinked rhizome was recorded in control.

Treatments in which inert materials and green leaves were used had less shrinkage and disease incidence, especially in the case of granite powder, sawdust and sand. Weight of healthy rhizomes was high under these treatments which show the significance of storage material to keep the surrounding at low temperature and then by reducing the moisture loss from rhizomes. For minimizing water loss from produce stored, the capacity of air to take up additional moisture from the immediate surroundings should be lowered and hence the storing material is used to reduce moisture gradient between the produce stored and its immediate surroundings. Principal aim of using storing material is to control shrinkage and prevent the undesirable physiological changes like transpiration, respiration and disease incidence. This could be achieved primarily by controlling the post-harvest environment such as maintenance of low temperature and high humidity (Khurdiya, 1995). Granite powder is a bad conductor of heat and provides better insulation. Percentage pore space of granite powder (48%) is high compared to sand (43%) which might have helped for better air circulation to keep the surroundings in cool condition to prevent moisture loss (Thankamani, 2011). As a result better recovery of healthy rhizomes was observed in the experiment.

Recovery of healthy rhizomes was also higher when rhizomes were stored with sawdust and sand. Maya and John (2000) observed less moisture loss in the case of Sapota stored with saw-



dust. Sand is the recommended storing material for ginger (Kumar *et al.* 2006). Storing rhizomes with dry sand was found to be the most effective method to reduce physiological loss of weight in ginger (Chandrappa *et al.* 1997). This result agreed with the findings of Oti *et al.* (1988) in ginger.

Influence of various storage materials on rhizome infection was not significant. However maximum occurrence was observed in untreated rhizomes. Lowest percentage of infected rhizomes was noticed when ginger rhizomes stored with *Strichnos nuxvomica*, sand, sawdust, granite powder as storing material. Saw dust as amendment reduced rhizome rot incidence in ginger.

Micro organisms associated with stored rhizomes during the study period are shown in Table 2. In most cases *Fusarium* sp. was observed on the cut surface of the rhizomes. On rhizomes stored with *Glycosmis pentaphylla*, *Aspergillus* sp. was found to be on the surface and *Rhizoctonia* growth was obtained while culturing. Ginger stored with *Strichnos nuxvomica* showed no surface growth or any other growth in the culture medium. Ginger stored with sand also had no fungal growth but mites were found on the rhizomes and bacterial growth was obtained on culturing. Ginger stored with sawdust and chemical treated rhizomes without any lining material had only *Fusarium* growth. In granite powder *Fusarium* was found on the cut surface with bacterial growth in the media. Ginger stored without any treatment had saprophytic nematodes along with *Pythium* and *Fusarium* in culture.

The result on moisture loss from rhizomes stored revealed that maximum percentage moisture loss was from control (15.0) on par with *Strichnos nuxvomica* leaves and treated rhizomes. Percentage of moisture loss was significantly lower when rhizomes were stored using granite powder on par with sand and sawdust. Among the green leaves as storage materials, maximum percentage moisture loss was observed in the case on *Strichnos nuxvomica* followed by *Glycosmis pentaphylla*. The increased moisture loss from rhizomes kept without any inert and green leaves may be attributed to higher rate of evapo-transpiration and other physiological process like respiration prevailed under this method. Temperature and water activity are the two most important physiological parameters which control the rate of decay of commodities in storage (Khurdiya 1995). Very low humidity in the storage space caused physical deterioration which occurs as evaporation loss and affects the texture of stored commodities resulting in shrinking and wilting.

Treatment	Microscopy/ surface growth	Potato Dextrose Agar	Nutrient Agar	Cassaminoacid Peptone Agar
Glycosmis pentaphylla	Aspergillus sp.	Rhizoctonia sp.	Nil	Nil
Strichnos nuxvomica	Nil	Nil	Nil	Nil
Saw dust	<i>Fusarium</i> sp. (cut surface)	Nil	Nil	Nil
Sand	Mites	Nil	Bacteria	Nil
Granite powder	Fusarium sp.	Bacterial growth	Bacteria	Nil
Fungicides Treated rhizomes alone	Fusarium sp.	Nil	Nil	Nil
Untreated rhizomes	Nematodes (Saprophytes)	Pythium, Fusarium	Bacteria	Nil

Table 2. Micro organisms associated with rhizomes of ginger under storage

Storage of ginger in pits without any lining material was not suggested due to rotting and decay losses (Dey *et al.* 1996).

Influence of various filling materials on germination percentage of ginger rhizome showed that 100% germination was seen in all the treatments where filling material was used. Germination percentage was lowest in the case of control (70.00) though it was not significant.

Conclusion

Recovery of healthy rhizomes was higher in storing ginger with inert materials and green leaves. Germination of the ginger rhizomes were higher when granite powder as filling material on par with sawdust and sand which are generally used for storing. Granite powder may be used as storing material for ginger in places where availability of sand and sawdust is scarce.

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Effect of cytokinins and auxin on shoot proliferation of cotyledonary nodes derived from axenic seedling of tamarind (*Tamarindus indica* L.)

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Abstract

An experiment was conducted in the plant tissue culture laboratory of the Department of Horticulture, University of Agricultural Sciences, Dharwad to standardize concentrations of cytokinins and auxin on shoot proliferation of cotyledonary nodes derived from axenic seedling of tamarind. From the present investigation it was clear that among the various combinations of growth regulators, BAP 0.5 mg/l + NAA 0.1 mg/l was the best combination for shoot proliferation of cotyledonary nodes derived form axenic seedling of tamarind.

Introduction

Tamarind (*Tamarindus indica* L.) is one of the arid fruits crops grown widely in the tropical and sub-tropical regions of the Indian sub-continent particularly in central and south India. Tamarind is popularly known as 'Indian date'. It is a multipurpose tree having high medicinal, industrial and nutritional values in addition to its main use as food, fodder and timber.

Micropropagation provides a rapid, reliable system for the production of large number of genetically uniform plantlets. It offers a method to increase valuable genotypes rapidly and expedite the release of improved varieties. In addition, micropropagation ensures mass production of elite clones from hybrid or specific parental line. It makes the propagules which have good health status and possessing desirable characters available through out the year.

Micropropagation of tree species offers a rapid means of producing clones, planting stock for afforestation, woody biomass production and conservation of elite and rare germplasm (Bonga and Durzan, 1982; Bajaj, 1986). But woody taxa are generally difficult to regenerate under *in vitro* conditions. Recently, some success has been achieved in few leguminous tree species (Dhawan, 1989), tamarind being one among them. Regeneration of plantlets from shoot tips and cotyledons obtained from seedlings of tamarind have been reported by Kopp and Nataraja (1990) and Jaiwal and Gulati (1991). *In vitro* induction of multiple shoots from axillary buds of tamarind has also been reported (Balkrishnamurthy and Ganga, 1997). However, till date there is no standard protocol available for *in vitro* clonal propagation of this tree. Considering the above facts the present investigation was carriedout to standardize the *in vitro* propagation methodology of tamarind.
Material and Methods

Tamarind seeds were collected from the mature pods of elite tree of DTS-1 situated at Kumbhapur Farm, Main Agricultural Research Station, Dharwad, thoroughly washed with a detergent Tween-20 (0.1%) for 10 minutes and with double distilled water. The seeds were surface sterilized with 0.1 per cent (w/v) aqueous mercuric chloride solution for 15 minutes and soaked in sterile water for 4-5 hours. The seeds were individually cultured on solidified half strength MS medium containing two per cent sucrose and 0.7% agar. The cultures were incubated in dark at $25\pm2^{\circ}$ C. Within 15 days of culture, germination occurred and seedlings of 5-8 days were used as the source of explant. The cotyledonary nodes of size 1.0 - 1.5 cm were used as explants from axenic seedlings.

In order to standardize the concentration and type of cytokinin on shoot proliferation different cytokinins mainly 6-benzylaminopurine (BAP) (@ 0.5, 1.00, 2.00 mg/l) and kinetin (KIN) (@ 1, 2, 3 mg/l) were added to MS media. To study the effect of cytokinins and auxin combinations on shoot proliferation different auxin concentration *viz.*, 1 napthaleneacetic acid (NAA) (@ 0.1, 0.2, 0.4 mg/l) were added to the MS media containing BAP 0.5 mg/l and kinetin 1 mg/l. All the cultures were incubated in air conditioned room at a temperature of $25\pm2^{\circ}$ C, with photoperiodic regime of 16 hr light and eight hour dark cycles. Observations were recorded on per cent shoot induction, mean number of days taken for shoot induction, mean number of shoots per explant and per cent response to multiple shoot induction after four weeks of incubation. The data generated from the experiments were statistically analysed as described by Panse and Sukhatme (1967).

Tr. No.	*BM + Treatments	Per cent shoot induction	Mean number of days taken for shoot induction	Mean number of shoots per explant	Per cent response to multiple shoot induction
T ₁	BAP 0.5 mg/l	85.00 (67.20)	8.50	2.25	100.00 (90.00)
T ₂	BAP 1.0 mg/l	72.25	9.50	2.15	50.00
T ₃	BAP 2.0 mg/l	62.30 (52.14)	11.00	1.65	75.00
T ₄	BAP 3.0 mg/l	55.22	13.25	1.40	50.00
T ₅	KIN 1.0 mg/l	65.20	7.25	1.90	75.00
T ₆	KIN 2.0 mg/l	47.80	9.50	1.75	50.00
T ₇	KIN 3.0 mg/l	43.50	11.50	1.75	50.00
	S.Em± CD at 1%	0.667	0.126 0.528	0.029 0.121	1.49 5.91
1					1

Table 1.	Effect	of	cytokinins	on	shoot	proliferation	of	cotyledonary	nodes	derived	from	axenic
see	dlings	of	tamarind									

* BM – Murashige and Skoog medium

Figures in parenthesis indicate arcsin values



Results and Discussion

In plant tissue culture, cytokinins appear to be necessary for cell divisions. Cytokinins are effective in promoting shoot initiation directly or indirectly. Successful treatment with cytokinins induces the growth of several small shoots from each explant over a period of 4-6 weeks. Some times cytokinins are required for embryogenesis and promotion of direct or indirect adventitious shoot formation. The effect of cytokinins on tissue organ cultures can vary according to the type of cytokinins used, the type of culture, the variety of plant and source of the explant. Hence, the efficacy of different cytokinins such as BAP and kinetin for induction of multiple shoots from cotyledonary node was assessed (Table 1). With these cytokinin treatments it was also observed that multiple shoots were induced directly from the cotyledonary nodes along with some amount of callus in the initial stages of growth. BAP was found to be a best source of cytokinin, since the highest per cent of multiple shoots (100%) along with highest number of shoots (2.25 per explant) were induced after 8 days of inoculation in medium containing 0.5 mg/l BAP. However with higher concentration of BAP, the multiple shoot production was reduced. The treatment involving KIN showed the maximum number of multiple shoot induction (75%) at a concentration of 1.0 mg/l.

These results clearly reveal that BAP is the best source of cytokinin for induction of multiple shoots from cotyledonary nodes in case of tamarind. The results is in confirmity with the findings of previous workers in various species. The optimal level of BAP for shoot bud development

Tr. No.	*BM + Treatments	Per cent shoot induction	Mean number of days taken for shoot induction	Mean number of shoots per explant	Per cent response to multiple shoot induction
T ₁	BAP 0.5 mg/l	85.00	9.00	2.25	100.00
-		(67.21)			(90.00)
Τ,	BAP 0.5 mg/l + NAA.1	86.66	8.00	2.50	100.00
2	mg/l	(68.53)			(90.00)
T ₃	BAP 0.5 mg/l + NAA.2	79.50	13.00	2.00	75.00
5	mg/l	(63.08)			(60.00)
T ₄	BAP 0.5 mg/l + NAA.4	0.00	0.00	0.00	0.00
	mg/l	(0.00)			(0.00)
T ₅	KIN 1.0 mg/l	65.00	7.50	2.00	75.00
5		(53.73)			(60.00)
T ₆	KIN 1.0 mg/l + NAA 0.1	68.66	7.25	2.00	90.00
	mg/l	(55.93)			(71.56)
T ₇	KIN 1.0 mg/l + NAA 0.2	57.50	9.57	0.00	0.00
	mg/l	(49.32)			(0.00)
T ₈	KIN 1.0 mg/l + NAA 0.4	0.00	0.00	0.00	0.00
	mg/l	(0.00)			(0.00)
	S.Em±	0.92	0.08	0.021	1.129
	CD at 1%	3.78	0.33	0.086	4.64
		1			1

Table 2. Effect of cytokinins and auxin on shoot proliferation from cotyledonary node derived from axenic seedlings of tamarind

* BM - Murashige and Skoog medium

Figures in parenthesis indicate arcsin values

from seedling explants of mangosteen (*Garcinia mangostana*) was 5.0 mg/l. However higher concentrations were also effective, but shoot buds were clustered and stunted (Goh *et al.*, 1995). Among the other cytokinins tested, BAP was more effective than KIN with maximum shoot proliferation from nodal explants in jack fruit when used at 0.5 mg/l (Rahman and Blake, 1988). Umer *et al.* (1993) obtained the highest number of shoots from seedling explants of *Chloroxylon swietenia* (Satinwood) on MS medium containing 0.5 mg/l BAP.

After having assessed the type of cytokinins and its concentration for multiple shoot induction, the results were further utilized for other treatment combinations with auxin to know the synergistic effect (Table 2). The highest number of multiple shoots (2.50) and per cent (100%) shoot multiplication in early days (8.00) were recorded in the medium containing BAP 0.5 mg/l + NAA 0.1 mg/l. This may be due to the reason that auxins at lower concentrations show synergistic effect of cytokinin. These findings are in close agreement with those of Splittstoesser and Mohamed Yasseen (1991) who also reported multiple shoot induction in cotyledonary nodes explant in medium containing BA 0.2 mg/l + NAA 0.1 mg/l in case of axenic seedlings of tamarind. However, the other treatments comprising NAA at higher concentration (>0.2 mg/l) resulted in only considerable callus formation. Similar results were obtained by Pierik (1987). From the present investigations it was clear that among the various combinations of growth regulators, BAP 0.5 mg/l + NAA 0.1 mg/l was the best combination for shoot proliferation of cotyledonary nodes derived from axenic seedlings of tamarind.

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Effect of type of planting material on growth and yield of turmeric (*Curcuma longa* L.) under Konkan agroclimatic conditions

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Abstract

Turmeric is one of the important spice crop grown in Maharashtra. Considering the market potential, high repaying capacity, non-perishable nature of produce and advantage of natural climatic conditions etc. turmeric is better option as an intercrop as well as sole crop in the Konkan region. However, the major hurdle for its commercial cultivation is the availability of water during the planting period i. e. Month of May. Use of seedlings of turmeric prepared from the single node finger rhizome in portrays which requires limited space and water for raising the seedlings is one of the options to overcome the situation. Hence, an experiment was conducted to study effect of different planting material viz. mother rhizomes, primary rhizomes and portray seedlings from a single node of finger rhizome on growth and yield of turmeric under Konkan agro-climatic conditions. The experiment was conducted at Department of Horticulture, College of Agriculture, Dapoli with three different treatments and seven replications for successive three years (2013-15) in Randomized Block Design. The treatments were T-1- Mother rhizome as planting material, T2-Primary rhizome as planting material T3- Pro-tray seedlings as planting material.

The pooled data indicated that the plant height (139.56 cm) produced in T_3 - Pro-tray seedlings as planting material was significantly superior over $T_1(117.40 \text{ cm})$ and $T_2(102.10 \text{ cm})$. Number of leaves produced in $T_3(23.10)$ was significantly superior over $T_1(18.01)$ and $T_2(13.55)$. The pooled data regarding number of suckers per hill indicated that $T_3(4.52)$ was significantly superior over $T_1(3.52)$ and $T_2(2.82)$. The pooled data indicated that $T_3(602.23g)$ was significantly superior over $T_1(371.77g)$ and $T_2(255.15g)$ in respect of the weight of fingers per hill i.e. yield per hill. The yield of fingers per plant also followed similar trend. The maximum yield of fingers per hectare was produced in (19.65 t) and was significantly superior over T_2 . The highest B:C ratio (6.01) was observed in T_3 as compared to $T_2(3.81)$ and $T_1(3.68)$.

From present investigation it can be concluded that, to get the maximum yield and returns from turmeric under Konkan agroclimatic conditions, the seedlings raised in pro-trays prepared from buds on finger rhizomes should be used. Similarly, this technique will also help to increase area under turmeric under Konkan region of Maharashtra, as the region is facing acute shortage of water during April – May which is the planting season of turmeric when the crop is raised by using mother rhizomes.

Introduction

Turmeric has tremendous medicinal value and is important export commodity of India (Rao *et al.* 2007). Turmeric is one of the important spice crop grown in Maharashtra. However, the commer-

cial cultivation of turmeric is restricted in western Maharashtra and to some extent in Vidharbha. Konkan region has warm and humid climate with high annual rainfall (June to September) ranging from 3000-4000 mm. This is the crop of 6.5 to 7 month duration. Among different Horticultural crops, mango and cashew are the major one while rice is the major agronomical crop grown in Konkan region. However, under changing climatic conditions the productivity of mango and cashew is declining. Under such situations intercropping is one of the major alternatives to improve the sustainability of such orchards. The soils under mango and cashew orchards are well drained and quite suitable for cultivation of intercrops like turmeric. Considering the market potential, high repaying capacity, non-perishable nature of produce and advantage of natural climatic conditions etc. turmeric is better option as an intercrop as well as sole crop in the Konkan region. However, the major hurdle for its commercial cultivation is the availability of water during the planting period i. e. Month of May. Further, planting of after onset of monsoon adversely affects the sprouting percentage and further crop stand which leads to decline productivity. of seedlings of turmeric prepared from the single node finger rhizome in portrays which requires limited space and water for raising the seedlings is one of the options to overcome the situation. Such seedlings become ready for planting after a period of about 40-45 days (ie. after onset of monsoon). Hence, an experiment was conducted to study effect of different planting material viz. mother rhizomes, primary rhizomes and portray seedlings from a single node of finger rhizome on growth and yield of turmeric under Konkan agro-climatic conditions.

Methodology

The experiments was conducted at Department of Horticulture, College of Agriculture, Dapoli with three different treatments and seven replications for successive three years (2013-15) in Randomized Block Design. The treatments were T_{-1} - Mother rhizomes as planting material, T_{2} -Primary rhizome as planting material T_{3} - Pro-tray seedlings as planting material

The treatment T_1 and T_2 were planted on 15th April where as in case of T_3 buds were excised and were placed in pro-trays for rooting at the same time. The planting of seedlings produced in protray was done in 2nd week of June after onset of monsoon every year of experiment. All the recommended practices were followed in case of all the treatment. The protective irrigation was given during dry spell from June to September. Similarly, the irrigation at an interval of 15 days was given from month of October after withdrawal of rain. Various growth observation viz. height of plant, number of leaves, number of suckers per hill, yield per hill (g) and yield per hectare (t) were recorded.

The statistical analysis was performed as per the Annova suggested by Panse & Sukhatme (1997).

Result and Discussion

In table 1 the observations on growth parameters, revealed that there is significant difference in various types of planting material with respect to plant height, number of leaves as well as number of suckers per hill during all the years of investigation.

The maximum plant height of 137.14cm, 128.71cm and 152.84 was produced during 2013-14, 2014-15 and 2015-16 respectively. Similarly, the pooled data also indicated that the plant height (139.56 cm) produced in T_3 - Pro-tray seedlings as planting material was significantly superior over $T_1(117.40 \text{ cm})$ and T_2 (102.10 cm).

The maximum number of leaves i.e.22.14, 23.0 and 24.15 were produced in T_3 - Pro-tray seedlings as planting material during 2013-14, 2014-15 and 2015-16 respectively and was significantly superior over rest of the treatments i.e. T_2 and T_3 . It is revealed from pooled data that number of leaves produced in $T_3(23.10)$ was significantly superior over $T_1(18.01)$ and $T_2(13.55)$.



Table 2 Effect of type of planting material on number of suckers per hill

S.N.	Treatment	No. of suckers per hill					
		13-14	14-15	15-16	Pooled		
1.	T ₁	3.71	3.00	3.82	3.52		
2.	T ₂	2.86	2.71	2.90	2.82		
3.	T ₃	4.43	4.71	4.42	4.52		
	S.E.	0.22	0.24	0.27	0.25		
	C. D.	0.67	0.75	0.82	0.73		

Table 3- Effect of type of planting material on yield of turmeric

SN	Treatment	Yield per hill (g)				Yield per hectare (t)			
		13-14	14-15	15-16	Pooled	13-14	14-15	15-16	Pooled
1.	T ₁	386.57	394.54	334.21	371.77	13.40	13.73	14.23	13.79
2.	T ₂	280.43	238.75	246.26	255.15	10.21	9.86	10.73	10.27
3.	T ₃	606.57	567.96	632.15	602.23	19.99	18.84	20.12	19.65
	S.E.	9.93	8.72	10.13	9.42	2.97	2.64	2.87	2.56
	C. D.	30.59	26.59	31.20	29.11	9.17	7.88	8.64	7.91

Table 4 : Effect of different planting material on economics of turmeric production

(Pooled data)

S.	Planting	Yield/	Yield/ha	Rate/ton	Gross	Cost of	Net	B:C
No.	material	plant (g)	(t)	(Rs.)	Returns	Productions	Returns	ratio
					(Rs.inlakh)	(Rs.inlakh)	(Rs.inlakh)	
1.	P ₁	371.77	13.79	55000/-	13.66	5.06	8.60	3.68
2.	P_2	255.15	10.27	55000/-	15.12	7.95	7.17	3.81
3.	P ₃	602.23	19.65	55000/-	21.23	10.51	10.73	6.01

The yield of turmeric depends upon the number of sucker produced after planting. The suckers produced in T_3 (4.43 in 2013-14, 4.71 in 2014-15 and 4.42 in 2015-16) were significantly superior over the other two treatments. The pooled data indicated that T_3 (4.52)was significantly superior over T_1 (3.52) and T_2 (2.82).

The yield of fingers per hill recorded in different types of planting material exhibited significant difference. The maximum yield of fingers (606.57 in 2013-14, 567.96 in 2014-15 and 602.23 in 2015-16) were produced in T_3 and was superior over rest of the treatment. The pooled data indicated that $T_3(602.23g)$ was significantly superior over $T_1(371.77g)$ and $T_2(255.15g)$ in respect of the weight of fingers per hill i.e. yield per hill. The yield of fingers per plant also followed similar trend. The maximum yield of fingers per hectare was produced in T_3 (19.9 tons during 2013-14, 18.84 tons during 2014-15 and 20.12 tons during 2015-16) during all the years of investigation as well as in pooled analysis (19.65 t) and was significantly superior over control.

As far as economics is concern, the maximum net returns (10.73 lakhs) and B:C ratio (6.01) was obtained in T_3 - Pro-tray seedlings when compared to other planting material i.e. use of mother rhizomes and use of primary rhizomes as planting material.

The production of more number of leaves and more height in T_3 might have contributed in production of more yields in T_3 as compared to T_1 (Mother rhizome) and T_2 (Primary rhizome). The similar results were recorded by Jage Singh *et al.* (2006).

Conclusion

From present investigation it can be concluded that, to get the maximum yield and returns from turmeric under Konkan agroclimatic conditions, the seedlings raised in pro-trays prepared from buds on finger rhizomes should be used. Similarly, this technique will also help to increase area under turmeric under Konkan region of Maharashtra, as the region is facing acute shortage of water during April – May which is the planting season of turmeric when the crop is raised by using mother rhizomes.

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SESSION - II

Advances in production of quality materials in seed propagated spices (Seed spices, chillies, clove allspice, curry leaf)

Planting material production technology in seed propagated perennial spices – Clove, allspice and curry leaf

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Introduction

Inadequate availability of quality planting material is one of the important deterring factors in development of sound horticulture industry including spice industry. It is of special significance especially in perennial spice crops which has a long gestation period and effects are known only in later stages after they start bearing. Planting material is being produced by Government nurseries, the ICAR institutes and SAUs, besides the private nurseries also play important role to meet the requirement of the growers and at present the number of small and medium scale nurseries is over 6300. Yet they all stand to meet about 30-40% demand of planting material. Generally, farmers do not have access to good quality certified disease free planting material of true to type varieties as a result of which production, productivity and quality of the of produce suffers heavily. At present, most of the dependence is on the unregulated private sector nurseries in most of the states which lacks modern infrastructure such as green house, mist chamber, efficient nursery tools and gadgets, implements and machinery. There are several constraints in the existing system of plant propagation. There are several private nurseries operating in the country playing important role in multiplication of planting material of horticulture crops and many of them follow traditional methods and lack adequate infrastructure and sell plant material of unknown pedigree. Of many other constraints, un-availability of standardized root stocks and non- maintenance of healthy stocks of elite varieties are worth mentioning. Since the Government endeavors single-handedly is not able to fulfill the rising demand, a collaborative effort with the private sector assisted with modern infrastructure and advance technologies could only bring significant improvement in this area. To ensure that only quality planting material is supplied to the farmers, it is necessary that the Government standardize the procedures and protocols that need to be followed for raising the planting material, and that a mechanism is set in for accreditation of nurseries and seed certification. Under this situation, guidelines prepared by National Horticulture Board for Recognition of Horticulture Nursery not only provides information for procedure of recognition but also provide technical information for setting up of nursery. It is hoped that this system will fill up the existing gap and go a long way to establish a network.Quarantine procedures and phytosanitary measures are additional means to ensure the health of the planting material. Hence appropriate plant quarantine procedures need to be observed for safeguarding our biosecurity and propagation of healthy planting material. In this paper, advances in Production of Quality Planting Material in Seed Propagated Spices Crops like clove, all spice and curry leaf are discussed.

1. CLOVE

Clove, *Syzygium aromaticum* L. (Syn. *Eugenia caryophyllus*), belongs to family: *Myrtaceae*. The commercial produce is dried unopened flower buds of the evergreen tree, reaching a height of 7 to 15 metres, an important spice noted for its flavour and medicinal values. It is indigenous to

Moluccas Island (Indonesia) and was introduced to India around 1800 A.D. by the East India Company in their spice garden in Courtallam, Tamil Nadu. In India, it is grown in about 2134 ha. producing annually about 922 tonnes, however to meet our requirement we are importing about 10,000 tonnes worth of Rs. 45,000 lakhs. The important clove growing regions in India now are the Nilgiris, Tirunelveli and Kanyakumari districts of Tamil Nadu (765ha), Calicut, Kottayam, Quilon and Trivandrum districts of Kerala (1123ha)and South Kanara district of Karnataka (90ha) besides Andaman has about 196 ha.

Clove is commercially propagated by seeds. Vegetative propagation by cutting (Fernie, 1946), marcoting (Zulkifli,1986) and approach grafting (Rema and Krishnamoorthy, 1994) is not successful even on its own rootstock or on related species also, hence seed propagation is the only reliable method available now. No distinct varieties are recognised in India or elsewhere. The seeds are to be collected from healthy and regular bearing and high yielding trees (Pillai 1972). A branch of 50 cm long, selected from such trees should have more than 10 terminals, 14 clusters, 100 flowers and 1.5 cm long flowers (Bavappa & Reuttimann 1981a). Healthy olivegreen single seeded fruit is more ideal than two seeded fruits (Purseglove *et al.*1981). Such fruits are collected from the ground and sown directly in nursery or soaked in water overnight and the pericarp removed before sowing. Seed viability is short and hence is to be sown immediately after collection. Beds for sowing seeds are of 15 to 20 cm height, one metre width and a convenient length. The beds should be made of loose soils and over which a layer of sand may be spread (about 5-8 cm thick). Seeds are sown at 2 to 3 cm spacing and a depth of about 2cm. The seedbeds have to be protected from direct sunlight.

The germination commences in about 10 to 15 days and may last for about 40 days. In higher elevations, germination is delayed considerably, often requires 60 days. Germination and vigour of seedlings are increased by keeping the seeds between two moist gunnies and sowing during June, with heavy dehusked seeds and by keeping the groove upward. Ten to fifteen days are required for 90 per cent germination (Purseglove*et al.*1981).

Rooting medium in general, consists of soil, sand and farm yard manure in equal proportion (Krishnamoorthy, 1988). Recently, reported that well decomposed coir compost along with vermicompost enriched with bio-fertlisers and bio-control agents like *Trichoderma* and *Psuedomonas* make ideal potting media. Different sizes of polythene bags are used for raising seedlings (Krishnamoorthy, 1988). A fertilizer solution of 1 kg urea, 0.75 kg super phosphate and 0.5 kg muriate of potash dissolved in 100 1 of water when applied at monthly intervals promoted early vigour (Bavappa and Ruettimann, 1981). Age, colour of cotyledon and height of seedlings determine the time of transplanting. Nine to twelve months (Bavappa and Ruetimann 1981; Prasanna Kumari Amma, 1981) to 2 year old seedlings (Krishnamoorthy, 1988) with olive green cotyledons and radicle not blackened after attaining 30-50 cm to 60-80 cm height are suited for main field planting. Seedlings established in coconut husk pots (Prasanna Kumari Amma, 1981) and polybags (Martin *et al.*, 1992) have higher survival in the main field.

Disease and pest management in the nursery site is very essential to produce quality planting material. Clove is usually infected by leaf rot disease caused by the fungus *Cylindrocladium quinquiseptatam*. Dark patches are seen in leaves of mature trees seedlings, which often result in rotting of whole leaves or tips alone causing severe defoliation. This can be controlled by spraying 0.2 percent of carbendazim. Scale insects are known to infest the leaves and tender shoots in the nursery. Spraying 0.05 percent dimethoate can easily control these sucking pests.

Thus, from the above discussion, it is evident that for the production of quality planting material in clove, the following points should be borne in mind:

- 1. The seeds are to be collected from healthy, regular bearing and high yielding trees only.
- 2. Fresh seeds should be used for raising the seedlings.
- 3. Seeds are to be initially raised in beds and when they germinate, they can be picked out and transplanted in big sized poly bags containing well decomposed coir compost along with vermicompost enriched with biofertlisers and biocontrol agents like *Trichoderma* and *Psuedomonas*.
- 4. Two year old seedlings with a height of 30-50 cm to 60-80 cm are suited for main field planting.

2. ALLSPICE

The allspice (*Pimenta dioica* (L.) Morr.) belongs to family: *Myrtaceae*. The product of commerce is the dried immature fruits. It is indigenous to West Indies. Jamaica is the main producer of allspice. Its flavour is said to resemble a blend of cinnamon, clove and nutmeg. It is a small evergreen tree; flowers are white and branch trichotomously in the axils of upper leaves. Flowers are structurally hermaphrodite but functionally dioecious. Stamens are numerous, above 100 in barren trees and 50 in bearing ones. It flowers during March-June and matures in 3 to 4 months after flowering. Fruit is a two seeded berry. Male trees flower earlier. No variety is reported in India but in Jamaica 2 male and 12 female varieties are reported.

The common method of propagation is by seeds. Vegetative propagation by bottle grafting (Shanmugavelu and Rao 1977), budding, approach grafting and top working(Purseglove*et al.*,1981) are also possible. Rema *et al.*, (2008) tried different methods of vegetative propagation namely cuttings, air layering, approach grafting and stooling in allspice and obtained success with a maximum of 64.4, 73.3, 80 and 85% respectively with different propagation methods namely cuttings, air layering, approach grafting and stooling. A combination of IBA and NAA at 2500 ppm prepared in charcoal was effective for allspice rooting. However, they are not commercially practiced and hence, seed propagation is the only means now.

Ripe fruits are collected from high yielding regular bearing trees. The seeds can be stored as ripe berries after collection without extracting seeds up to three weeks. Seeds are extracted after soaking the fruits overnight in water and rubbing them in a sieve and washing with clean water. Drying of seeds is done in shade. Seeds are sown as soon as possible or else germination is reduced (Krishnamoorthy and Rema, 1988). The seeds are sown either in nursery beds, boxes, pots or basins. Beds of 1.2 m width are prepared with light soil incorporated with organic matter or a mixture of sand and coir dust or coir dust alone. Soil solarisation and microbial inoculations such as vesicular arbuscular mycorrhiza (VAM), antagonist like Trichoderma spp. Psuedomonas spp., Bacillus spp. are to be used in the nursery to produce disease free quality planting material. After sowing, nursery beds are mulched to hasten germination. Dried leaves, straw, paper and damp sacks are used as mulch. But viability gets reduced slowly after a period of three weeks and is lost completely after nine weeks. The seeds are sown in raised beds of 15 to 20 cm high, one metre width and convenient length. The beds may be made of loose soil-sand mixture having sand in the top layer. Watering is done using a fine spray. Germination takes place between 9 to 10 days (Purseglove et al., 1981), or sometimes 15 days after sowing (Krishnamoorthy and Rema, 1991). Devadas and Manomohandas, (1988) observed differences in germination by storing seeds for different periods in polythene bags and 70-93 per cent germination was obtained when sown 3 weeks after collection at a temperature of 21.5-30.5°C. The seeds germinate in 15 days and continue up to 40 to 45 days. The seedlings can be transferred to bags three weeks after their emergence above ground level. Seedlings of six months (Shanmugavelu and Rao, 1977) or 9-10 months old having 25-30 cm height are ready for field planting (Purseglove et al., 1981).



To produce disease free planting material, the commonly occurring disease and pest are to be controlled effectively. Leaf rot disease caused by the fungus *Cylindrocladium quinquiseptatum* is a serious disease during rainy months. This can be controlled by giving a prophylactic spraying 1.0 percent of Bordeaux mixture during the end of May. Tea mosquito bug (*Helopeltis antonii*) often affects the young leaves and causes necrotic lesions. This can be controlled by spraying 0.05 percent dimethoate.

Thus, from the above discussion, it is evident that for the production of quality planting material in allspice, the following points should be borne in mind:

- 1. Ripe fruits are collected from high yielding and regular bearing trees.
- 2. Seeds are sown as soon as possible to get higher germination.
- 3. The seeds are sown either in nursery beds, boxes, pots or basins containing light soil incorporated with organic matter or a mixture of sand and coir dust or coir dust alone.
- 4. Three weeks after their emergence above ground level, the seedlings can be transferred to bags.
- 5. Seedlings of 9-10 months old having 25-30 cm height are ideal for field planting.
- 6. In as much as the vegetative propagation has been standardized with more than 80 percent success (approach grafting), it has to be popularized to multiply genetically superior clones in view of their high variability exhibited as it is a cross pollinated crop.

3. CURRY LEAF

Curry leaf (*Murraya koenigii* Spreng. Belongs to Family: *Rutaceae*) plays an important role as a condiment in the culinary preparation of South Indian dishes. A plant of homestead gardens has recently gained importance as a commercial crop and is cultivated in field scale in Coimbatore, Periyar, Madurai, Salem and Trichy districts of Tamil Nadu and in Dharward, Belgaum and Uttara Kannada of Kamataka State. There is no named variety available and farmer prefers local varieties which have pink midrib. University of Agricultural Science, Dharwad has recently released two cultivars viz DWD -1 and DWD - 2 which have an oil content of 5.22 and 4.09% respectively. Both the varieties are having strong aroma.

DWD-1 (Suvasini) is a clonal selection from root suckers and the plant has dark green highly aromatic shining leaves. It is sensitive to low temperature in winter and hence bud burst is poor during winter. The leaves have an oil content of 5.22%. Conventional propagation is by seeds, which germinate under shade. Unfortunately, the seeds retain their viability only for a short period. Clonal propagation by root suckers is another method in the multiplication of elite genotypes. Micropropagation of curry leaf tree using intact seedling was reported by Bhuyan *et al.*, (1997) and by nodal cuttings from mature curry leaf plants cultured in Woody plant basal medium (WPM) was reported by Nirmal Babu *et al.*, (2000). However, propagation by seed is solely practiced commercially. No intensive study on seed propagation technique is reported in curry leaf. The main season of availability of curry leaf fruits is July – August. Seeds are to be collected from 8-10 years old trees. Within 3 - 4 days of collection of fruits, the seeds should be pulped and sown in nursery beds or poly bags. One year old seedlings are suitable for planting.

Soil solarisation and microbial inoculations such as vesicular arbuscular mycorrhiza (VAM), antagonist like *Trichoderma* spp. *Psuedomonas* spp., *Bacillus* spp. are to be used in the nursery to produce disease free quality planting material. Besides, to prevent the incidence of leaf spot disease, spraying of carbendazim @ 1 g/lit of water has to be taken up at regular intervals. Further, sporadic incidence of certain pests may often affect the seedlings. If Citrus butterfly's larvae is seen in the nursery, hand picking and destruction of larvae can be done followed by spraying of malathion @ 1 ml/ lit. If sucking pests such as Psyllid bug and scales are noticed, they can be controlled by spraying dimethoate @ 1 ml/lit.

Thus, from the above discussion, it is evident that for the production of quality planting material in curry leaf, the following points should be borne in mind:

- 1. Ripe fruits are collected from healthy trees of 8-10 years old.
- 2. Fresh seeds should be sown in nursery beds or poly bags.
- 3. One year old seedlings are the suitable for planting material.

Conclusion

The foregoing discussion indicates that in these three tree spices, inadequate information is available for the production of quality planting material besides standards for the production of such materials are not available in these crops. Hence, future research and development in these spice crops should aim to generate information to produce quality planting material.

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Planting material production technology in seed spices (cross and self pollinated)

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Introduction

Spices denote all the aromatic or pungent substances of vegetable origin which are commonly used to season the food dishes and to make them tasteful. India has been known as the home of spices and also the world's largest producer, consumer and exporter of spices, which are being cultivated widely in the country over different agro-climatic zones. About 63 plant species, which yield spices, are cultivated in the country. The important among them, which occupy a sizeable area and enter the National and/or International trade, are black pepper, cardamom, ginger, turmeric, chilies, clove and seed spices. Seed spices are generally grown in low rainfall area, need lesser water and low inputs as compared to other crops. These crops are extensively grown in semi arid and arid regions of India during rabi season. Out of the total 20 seed spices grown in the country, nine are prominent. These are coriander, cumin, fennel and fenugreek, whereas ajowain, sowa (dill), nigella (kalongi), celery and aniseed constitute minor group.

India is the largest producer, consumer and exporter of seed spices in the world. Almost all of the seed spices crops are cultivated in India and most of the states in India grow one or more of seed spices, and has got the privilege to be called as the largest seed spices producing country in the world. But the major growing belt spreads from arid to semi-arid regions covering large area in Rajasthan and Gujarat. Rajasthan alone contributes 40-50% of total area as well as production of coriander and cumin, In case of fenugreek and fennel, the state contributes about 80% and 15-20% of total production in the country, respectively.

Seed is the basic unit of crop production and has greater contribution than environment and cultural factors. Availability of quality seeds of improved cultivars of seed spices is considered crucial for realizing productivity and adoption of cultivars in different agro-climatic conditions. The quality of seed alone is known to account for at least 10-15% increase in the productivity (ICAR 1993). However, lack of quality seed continues to be one of the greatest impediments to bridging the vast yield gap. Therefore, to approach the potentially realizable yield of a cultivar, production and distribution of quality seed is essential. The good quality seed should have the following characters:

1. Genetic purity and uniformity and should conform to the standards of the particular cultivar.



- 2. Disease free, viable seeds.
- 3. Free from admixtures of other crop seeds, weeds and inert matter.
- 4. Acceptable uniformity with respect to size, shape and color.

Substantial increase in yield and quality of seed spices depends upon a number of factors viz., inputs like fertilizers, irrigation and plant protection measures and suitable agronomic practices. However, the use of high quality seed thus plays a pivotal role in the seed spices production. Economically, the cost of seed is a very small component of the total cost of production. It is therefore, important to use the seed confirming to the prescribed standards in terms of high genetic purity, physical purity, physiological quality and health quality. Since ages, Indian farmers were mostly dependent on traditional varieties; therefore seed requirements were met through farm saved seeds. The use of traditional varieties coupled with farm saved seeds whose quality is not guaranteed, resulted in drastic reduction in production.

The Seeds Act passed by the Indian parliament in 1966 created a climate, which could make good quality seeds available to the cultivators. Seed Rules under the Act were framed and notified in September 1968 and the Act was implemented in its entirety in October 1969. It is applicable only to notified kinds/varieties of seed and vegetatively propagating materials used for sowing. The Act provides for the formation of an apex advisory body, namely, the Central Seed Committee; the Central Seed Certification Board; establishment of Seed Certification Agencies; and Central and State Seed Testing Laboratories, etc. The Act provides for the provisions for notification of kinds/varieties to be brought under the purview of the Seeds Act; regulation regarding the sale of seed; and the establishment of a suitable seed law enforcement machinery. Under the Act the Central Govt. It is necessary, for carrying into execution, in the state concerned the provisions of the Act or Rules. Seed Certification Agencies function in accordance with The Seeds Act 1966(section 8).

During seed production, strict attention must be given to the maintenance of genetic purity and other qualities of seeds in order to exploit the full dividends sought to be obtained by introduction of new superior crop plant varieties. In other words, seed production must be carried out under standardized and well-organized condition.

Genetic Purity

Genetic purity means plants and seeds confirming to the characteristics of the variety as described by the breeder. Over the years, this purity is lessened in a variety due to reasons like mutations, mechanical mixture etc. One basic aim is to produce seed which is genetically pure to the set standards. Hence, it is essential to control the factors which will deteriorate genetic purity.

1. Genetic Principles of seed production

1. Deterioration of varieties:

Genetic purity (Trueness to type) of a variety can deteriorate due to several factor during production cycles. The important factors of apparent and real deterioration of varieties) are as follows:

a. Developmental variation: When the seed crops are grown in difficult environment, under different soil and fertility conditions, or different climate conditions, or under different photoperiods, or at different elevation for several consecutive generations, the develop-



mental variation may arise some times as differential growth response. To minimize the opportunity for such shifts to occur in varieties it is advisable to grow them in their areas of adaptation and growing seasons.

- b. Mechanical mixtures: This is the most important source of variety deterioration during seed production. Mechanical mixtures may often take place at the time of sowing, if more than one variety is sown with same seed drill; through volunteer plants of the same crop in the seed field; or through different varieties grown in adjacent fields. Often the seed produce of all the varieties are kept on same threshing floor, resulting in considerable varietal mixture. To avoid this sort mechanical contamination it would be necessary to rogue the seed fields, and practice the utmost care during the seed production, harvesting, threshing and further handling
- c. Mutations: This is not a serious factor of varietal deterioration. In the majority of the cases it is difficult to identify or detect minor mutation.
- d. Natural crossing: In sexually propagated crops, natural crossing is another most important source of varietal deterioration due to introgression to genes from unrelated stocks which can only be solved by prevention

Natural crossing occurs due to following three reasons

- i. Natural crossing with undesirable types .
- ii. Natural crossing with diseased plants.

iii.Natural crossing with off- type plants.

Natural crossing occurs due to following factors

- i. The breeding system of species
- ii. Isolation systems
- iii. Varietal mass
- iv. Pollinating agent
- e. Minor genetic variations: Minor genetic variations may exist even in the varieties appearing phenotypically uniform and homogeneous at the time of their release. During later production cycle some of this variation may be lost because of selective elimination by the environment. To overcome these yields trials are suggested.
- f. Selective influence of diseases: The selective influence of diseases in varietal deterioration is also of considerable importance. New crop varieties often become susceptible to new races of diseases often caused by obligate parasites and are out of seed programmes. Similarly the vegetatively propagated stocks deteriorate fast if infected by viral, fungal and bacterial diseases. During seed production it is, therefore, very important to produce disease free seeds/stocks.
- g. Techniques of plant breeders: In certain instances, serious instabilities may occur in varieties due to cytogenetically irregularities not properly assessed in the new varieties prior to their release. Other factors, such as break down in male sterility, certain environmental conditions, and other heritable variations may considerably lower the genetic purity.

2. Maintenance of Genetic Purity During seed Production:

The various steps suggested to maintain varietal purity are as follows.

- i. Use of approved seed only in seed multiplication.
- ii. Inspection and approval of fields prior to planting.
- iii. Field inspection and approval of growing crops at critical stages for verification of genetic purity, detection of mixtures, weeds, and for freedom from noxious weeds and seed borne diseases etc.
- iv. Sampling and sealing of cleaned lots
- v. Growing of samples of potentially approved stocks for comparison with authentic stocks.
- 3. The various steps suggested for maintaining genetic purity are as follows:
 - i. Providing adequate isolation to prevent contamination by natural crossing or mechanical mixtures
 - ii. Rouging of seed fields prior to the stage at which they could contaminate the seed crop.
 - iii. Periodic testing of varieties for genetic purity.
 - iv. Avoiding genetic shifts by growing crops in areas in their adaptation only.
 - v. Certification of seed crops to maintain genetic purity and quality of seed.
 - vi. Adopting the generation system.
 - vii. Grow out tests.

Strategies for seed improvement

i. Exploitation of Hybrid Vigour

It is the best approach for varietal increase in production of crops.

ii. Description of Notified Varieties

The implementation of plant variety protection would necessarily require detailed characterization of all varieties. The variety registration would have on DUS criteria. Efforts are being made to characterize all the crop varieties under seed production chain.

iii. Enhancement of Seed Replacement Rates

The socio-economic status of the farmer does not permit to purchase quality seeds. Therefore the seed replacement rate is very low. The realistic indents and production of breeder seed of different crop varieties by maintaining quality can enhance SRR. Seed Replacement Rate is the rate at which the farmers replace the seeds instead of using their own seeds

iv. Enhancement of Seed Multiplication Ratio

SMR is nothing but the number of seeds to be produced from a single seed when it is sown and harvested, which can be altered by adoption of proper seed and crop management techniques.



Post harvest handling of seed crop

1. Harvesting and threshing

Harvesting is one of the most important factors affecting quality of the produce. It varies from crop to crop. The crop of coriander matures in 90 to 135 days. Cumin is harvested in about 100-110 days. Fennel takes 170-175 days to mature. In fenugreek, the harvest time is judged when the colour of leaves and pods turn yellow in about 130-140 days. Timely harvest is very important so that there is no loss of seed due to shattering. Harvesting in the early hours of the day is preferable. It is also important to note that in small size spices such as coriander, cumin and ajwain, harvesting should be done by cutting using sickle to overcomes the problem of contamination. After proper drying of harvested material, the seeds are separated by light beating with sticks or rubbing the plants between the pieces of lint free gunny bags or tarpolin pieces followed by winnowing or with the help of mechanical threshers.

However, to achieve required quality standards, precautions have to be taken from the initial stage of raising of crop. The important points which should be considered are:

- i. FYM and poultry manures are finely powdered and mixed thoroughly with the soil. The lumps of the dung of FYM left on the surface of the soil may contaminate the seeds in cumin and coriander.
- ii. Use seed of notified/improved varieties only.
- iii. Recommended crop management practices should be followed to raise a good and healthy crop.
- iv. Don't use any insecticide/fungicide immediately before harvesting.
- v. Seed of harvested material should be separated on pacca and well cleaned threshing yard or tarpaulin. Direct contact with the ground soil be avoided to avoid contamination of stone, dirt etc.
- vi. While cutting the plants, leave the weed plants. Special care should be taken against Zeeri (*Plantgo pumila*) in case of cumin.
- vii. Weed plants should not be harvested along with the spices crops.
- viii. The seed material should be well dried to a moisture level of 10-11 per cent before it is further cleaned and graded.
- ix. Any contaminated or diseased material should not be mixed with good quality material.
- x. While drying the seed, animals or birds should not be allowed to enter the drying yard.
- xi. While winnowing care should be taken to completely remove the chaffy and inert material. Grading of the produce may also be done simultaneously.
- xii. The graded material after proper drying may be stored in dry and cool place after packing in well cleaned gunny bags or other suitable container.
- xiii. The gunny bags should be kept in store which should be neat, clean, dry and cool which is also well ventilated.
- xiv. The material should be stored ensuring protection from dampness.

2. Drying and grading

Direct exposure of the seed to sunlight may affect its quality therefore if necessary seed may be dried under diffused sunlight in a shed with opening on all sides. Artificial drying is done by blowing dry air at 70-85°F but never exceeding 110°F. Grading is done with various types of grader. The quality of seed of seed spices also depends upon the practices adopted in processing, packaging, storing and transportation. The produce may be graded in different grades. Various machines are used for special function which are as under:

1.	Spiral separator	To separate round seeds and flat seeds
2.	Magnet drum/pulley	To separate iron particles
3.	Magnet seed separator/ electrostatic seed separator	To separate identical weed seed from product
4.	Electronic colour sorters	To separate discoloured seed to enhance value of final product.
5.	Gravity separator/ destoner	To separate undesirable material on the basis of gravity.

No colouring material should be used to improve the appearance of the product as chemical and artificial colours are highly objectionable by the importing countries.

3. Seed treatment

Seed treatment with the fungicides and insecticides to arrest the carry over of pathogens and insects with the seed or their fresh entry in to it.

4. Packaging, labelling and sealing

It is necessary to use right type of containers with (seed moisture content at proper level) labelling and sealing in the prescribed manner.

5. Movement and storage

Precautions should be taken to avoid seed deterioration while in transit and or in storage. Ideal storage for long term is dry and cool condition. Ideal condition can be maintained if the sum of RH and Temperature does not exceed 100. The seeds are store in long-term storage in cool dry room. Storage precautions should be followed to maintain the quality of the produce.

Seed quality control factors

1. Seed moisture

The seed moisture affects seed storability. Seeds with low moisture store longer and remain free from insect pests.

2. Germination per cent

Seeds are sown to provide next generation crops. Germination percentage thus, indicates the potential of seeds for developing and establishing into seedlings in the nursery bed (open or polythene) or in the main field. This attribute is given as germination per cent. The combination of pure seed percent and germination per cent is called as Pure Live Seed (PLS) having better viability.



3. Vigour

It indicates the ability of seed to emerge in varying environments or micro-climate of fields where it is grown. It is generally believed, but not always true, that high germination percentage is associated with high seed vigour.

4. Storage life

Seed moisture content is the most important factor influencing loss of viability during storage. Most of the spices seeds which are costly are packed in suitable moisture vapour proof attractive containers and are not or least affected in storage or in transit but the seeds of some large sized seeds e.g. garden pea, beans etc. are packed in porous containers, hence the seed moisture content fluctuates with the change in relative humidity of the atmosphere.

5. Seed health

Spices seed should be free from seed borne diseases and insects infestation. Insect infestation normally destroys the embryos thus making the seeds unfit for sowing. Similarly most of the virus and bacterial diseases are seed borne. They not only contaminate the crop but also help in spreading the disease fast. Hence, seeds must be free from pest and disease and treated with pesticide/ fungicide to prevent contamination and spread.

6. Mechanism of control

The generally accepted system of seed certification involves inspections, sample testing, also enforcement of minimum standards which constitute the mechanism of quality control in seed.

Classes of seed:

The seeds which seeds companies sell in the market and our farmers grow are commonly "certified seeds". The certification of seeds is a legally sanctioned system for quality control of seeds that are used to cultivate crops. The certified seeds are grown under stringent production requirements and they have improved traits such as better yield, pest resistance, drought tolerance, herbicide tolerance etc. The certified seeds are outcome of few years of research and development to get these improved traits. This R&D is done on their parent plants. On this basis, there are four different categories viz. Nucleus Seeds, Breeder's Seeds, Foundation Seeds and finally certified seeds. The Offspring of breeder seeds is foundation seeds to certified seeds. Further, each of the breeders, foundation and certified seeds are certified and labelled with a different colour tag as per Section 5 of the Seeds Act, 1966. Thus, they are also called as Labelled Seed. The Breeder seeds have golden yellow tag, Foundation seeds have white tag and certified seeds have green tag.

Nucleus Seed

The process of development of certified seeds begins from its distant parent called Nucleus Seed. The nucleus seed is a genetically pure seed without any impurity. They are obtained from a handful of healthy plants growing in a plot and then grown strictly in isolation. All physical observations such as plant size, growth features, colour and shape of various parts, days taken in maturity etc. are taken into account and recorded. This stage is the most important phase in the seed development because any erroneous selection of the nuclear seed plants would adversely affect the further generations. Once these plants are selected; their seeds are obtained and threshed separately. These seeds are properly packed and regrown to get the breeder seeds.

Breeder Seeds

A breeder's seed is an offspring of nucleus seed. A breeder is a person (qualified plant breeder) or organization who raises plant primary for breeding purpose. While nucleus seed is genetically pure. The seeds from off springs with best and desired quality are selected and certified as Breeder seeds. Such seeds are protected by legal rights called as Breeder's rights. The Breeder seed is further multiplied into the foundation and certified seeds. In our country, Breeder seeds are produced by Indian Council of Agricultural Research, National Seeds Corporation, States Farms Corporation and Agricultural Universities in India.

Foundation Seeds

Offspring's of the Breeder seed which can be clearly traced to Breeder seed are called Foundation Seeds. They are further breaded to give rise to certified seeds. The production of the foundation seeds must be acceptable to a certification agency. The national Seeds Corporation, State farms Corporation of India (SFCI) have the responsibility to produce foundation seeds which suit to demand of national varieties. The State Seed Corporations produce the foundation seeds to suit to local demands.

Certified Seeds

This is the last stage, which actually reaches to a farmer. Certified seed is the progeny of foundation seed and must meet the standards of seed certification prescribed in the Indian Minimum Seeds Certification Standards, 1988. A person or company who grows and distributes the certified seeds in accordance with the procedure and specifications of the certification agency is called Certified Seed Producer.

Breeder Seed Production in Seed Spices

Seed is one of the most vital and critical inputs for increasing agricultural production. After release of a variety, its seeds have to be multiplied in sufficient quantity which takes 3-4 generations before it reaches to the farmers for commercial use. During multiplication cycles, care has to be taken so that the variety does not degenerate but maintains its original characteristics.

For achieving this goal the seed production programme becomes an exhaustive task requiring high technical skills, financial investments and proper methodology and care. It is expected that the nucleus/ breeder seed should be of high purity, because the genetic purity in subsequent generation will largely depend upon the quality of nucleus/breeder seed. Hence, the nucleus and breeder seed are the back-bone of the seed programme.

In view of this, nucleus/breeder seed production in the country is coordinated through All India Coordinated Research Project on Spices at different SAUs as per indent under the supervision of qualified breeders.

The genetic purity (referred to as purity) of breeder seed stock of a pure-line variety (as in case of fenugreek) refers to the condition that all seeds have the same homozygous genotypes and there is no seed to seed difference in the stock. While in the case of cross pollinated crops *viz*. cumin, coriander and fennel, where the varieties are genetically improved "Populations", this refers to the condition that genotype of seed stock is such that the plants of the crop produced by this lot will clearly conform to the characteristics of the variety and no plant will fall away from the limits of the varietal characteristics. Obviously in case of cross pollinated crops emphasis is given on the genetic constitution of the population rather than on the individual plant. In such crops the method of seed production should ensure that genetic structure of the improved variety is truly reproduced. To achieve this safely some guiding principles for each crop are given here.



A. Procedure of Breeder seed production in seed spices

Self Pollinated Crops –Fenugreek :

First season

- 1. Select the field suitable for fenugreek cultivation and required isolation.
- 2. Sow the source seed/ nucleus seed giving adequate between row and between plant spacing, so that individual plants can be easily accessed.
- 3. Follow agronomic and plant protection practices properly. At maturity select a number of individual plants, thresh them separately and keep in different seed packets. The number of plants selected depends purely on the required seed.

Second season

- 1. Steps 1 to 3 same as for season I.
- 2. Sow individual plant-progenies in breeder seed block.
- 3. Inspect the individual progenies from the beginning of the crop, and discard any progeny or progenies which show variation, not matching with the variety.
- 4. Ensure that only the lines which truly match the variety are allowed to mature. Harvest them together, thresh and clean the seeds. Before harvesting individual plants are again taken from the selected progenies to repeat the cycle.
- 5. Take all precautions in harvesting, threshing and cleaning the seeds so that seed quality is maintained. The seed so produced is the breeder seed which may be used as a source of foundation seed.

Cross Pollinated Crops-Cumin, coriander and fennel:

First season

In principle the same steps are followed in these crops also as in fenugreek excepting the number of plants selected for next season's sowing of individual plant progenies. Here at least 1000 plants should be selected, so that even after rejection of lines sufficient number is left for intermating so that inbreeding chances are avoided and true population structure is reproduced.

Second season

- 1. Steps 1 to 3 are the same as in fenugreek. Of course, the requirement of isolation distances is different for different crops (see field and seed standards).
- 2. Sow individual plant progenies in the breeder seed block having adequate isolation and as far as possible a square shape.
- 3. Inspect the individual progenies from the beginning at regular intervals, identify the lines throwing segregants and remove them from the field. Efforts should be made to identify such lines before flowering so that off types are not allowed to contribute pollens. Harvest the selected lines together-after at least 1000 individual plants have been taken for next season's sowing of breeder seed block.
- 4. Care must be exercised in threshing and cleaning the seed so that their quality conforms to the seed standards.



5. Breeder seed so produced may be used for raising foundation seed crop.

B. Procedure of Foundation and Certified seed production:

Foundation and certified seed crops are raised following approved agronomic and plant protection techniques. All care is taken to ensure that field and seed standards conform to the ones approved for the crop. Obviously timely rouging of off-types, control of diseases and pests, careful harvesting (cumin crop must be harvested only by cutting the plants), threshing cleaning and storage of seed be practices.

Seed Certification

Seed certification is a legally sanctioned system to maintain quality of seeds during seed production, post-harvest operation and distribution of seeds. It includes field inspection, seed quality tests and pre and post control check. Agencies (State Governments or Autonomous Bodies), which are notified under Section 8 of the Seeds Act are authorized for certification of seeds. Anybody willing to come forward to produce certified seed can produce certified seed.

In India the field evaluation of the seed crop and its certification started with the establishment of National Seeds Corporation in 1963. A legal status was given to seed certification with the enactment of first Indian Seed Act in the year 1966 and formulation of Seed Rules in 1968. The Seed Act of 1966 provided the required impetus for the establishment of official Seed Certification Agencies by the States. Maharashtra was the first State to establish an official Seed Certifications Agency during 1970 as a part of the Department of Agriculture, whereas Karnataka was the first State to establish the Seed Certification Agency as an autonomous body during 1974.

At present State Seeds Corporations, National Seeds Corporation, State Farm Corporation of India, State Departments of Agriculture, Private Companies, Cooperatives and individual farmers are producing certified seed. Producing high quality seeds of the seed spices varieties that are notified by the Central and State Governments and make them available to the farmers is the prime aim of the Seed Certification authority

Seed of only those varieties which are notified U/S 5 of the Seeds Act, 1966 shall be eligible for certification. Seeds which are certified by the Seed Certification Agency are called certified seeds, which passes through both the field and seed standards as specified by the certification body. Seed standards are specified and uniform throughout the country, whereas the seed certification procedures and fee vary from one State to another State.

Seed certification consists of the following control measures:

- 1. It is an administrative check on the origin of propagating material for the purpose of trueness to purity (genetic purity).
- 2. Field inspection: At the time of growing a crop for seed production purpose, the data should be obtained on trueness to varietals purity, isolation of seed crop to prevent crops- pollination, mechanical admixtures and diseases dissemination, objectionable weeds and admixtures.
- 3. Supervision on agricultural operations i.e. intercultural operations, harvesting, storage, transport and processing etc. with a view to preserving the identity and quality of the lots.

- 4. Sample inspection: For quality and to maintain genetic purity, a lab test of representative samples drawn by the S.C.A. for determining, % of germination, moisture content, weed seed content, admixture and purity.
- 5. Bulk inspection: For checking homogeneity of the bulk as compared with the sample inspected.
- 6. Control Plot Testing: Samples drawn both from the source seed and the final seed produced can be grown in the field along with standard samples of the variety in question. By comparison, it can be determined whether the varietal purity and health of the produced seed are equal to results based on inspection.

The purpose of seed certification is to maintain and make available high quality seed and propagating materials of notified plant varieties.

Phases of Seed Certification

Seed certification has five phases:

- 1. Verification of seed source.
- 2. Inspection of seed crop in the field.
- 3. Supervision at post-harvest stages including processing and packing.
- 4. Seed sampling and analysis.
- 5. Grant of certificate, certification tag, tables and sealing.

Concepts of Seed Certification

The AOSCA (Association of Official Seed Certifying Agencies) have given some fundamental concepts of seed certification & these are:

- 1. Pedigree of all certified crops must be essential.
- 2. The integrity of certified seed growers must be recognized.
- 3. Field inspection must be made by through qualified field inspectors.
- 4. Verification trials to establish and maintain satisfactory pedigree of seed stock.
- 5. For keeping proper records to establish and maintain satisfactory pedigree of seed stock.
- 6. Standard should be maintained for purity and germination.
- 7. The principles of sealing seeds to protect both grower and purchase must be approved.

Procedure of Seed Certification

The process of seed certification is initiated by an application by the seed grower for certifying the seed produced by him. These applications are made on a prescribed proforma available from the concerned SSCA, and provide details about the location of farm, area of the seed plot, crop variety and the class of seed proposed to be produced, isolation etc. generally, the application is made well in advance of sowing of the seed crop, but in some cases it may be submitted even after the sowing. The SSCA scrutinizes such applications and on being satisfied, carries out field

inspections and seed tests to ascertain the suitability of seed crops/seed lots for certification. If a seed crop/seed lot satisfies the prescribed purity and quality requirements, SSCA issues suitable tags of certification for affixing them to the seed bags under certification.

The decisions regarding the suitability of seeds for certification are based on the following inspections/operations:

- 1. Field inspections
- 2. Inspection during seed processing, and
- 3. Seed tests (generally conducted on processed seed)

Minimum Seed Certification Standards

In a seed quality control programme through seed certification, the minimum seed certification standards, in fact, are the minimum standard conditions which must be met. The minimum seed certification standards thus are the standards required for the certification of seeds by the certification agencies.

The certification standards in force in India are called the 'Indian Minimum Seed Certification Standards'. These were published by the Central Seed Certification Board. As a general principle, these standards have been kept at the level, which demand scrupulous attention of the certified seed growers but at the same time practical enough that these can be met also. The minimum seed certification standards can be broadly grouped into two groups.

- A. General Seed Certification Standards
- B. Specific Crop Standards

The two combined sets of standards constitute the minimum seed certification standards for seed certification.

A. General Seed Certification Standards

The general seed certification standard aims at outlining the general requirements for the production of genetically pure good quality seed. These standards prescribed the procedure for certified seed production so that maximum genetic purity and good quality of the seed this ensured.

B. Specific Crop Standards

Specific crop standard consists of Field Standards and Seed Standards Field standards consist of:

- 1. The minimum preceding crop requirements have been specified to minimize genetic contamination from the disease, volunteer plants.
- 2. The minimum isolation requirement has been specified to minimize seed born disease contamination.
- 3. The number of feed inflection and specified stage of crop have been described to ensure verification of genetic purity and other quality factors.

Seed Standard consists of:

- 1. The minimum percentage of pure seeds and maximum permissible limits for inert matter, other crop seeds have been prescribed.
- 2. The maximum permissible limits for objectionable weeds, seeds infected by seed borne diseases have been prescribed to ensure goods seed health.
- 3. The maximum permissible limits for moisture content have been prescribed for the safe storage of seeds.

Crop and Seed Standard for Seed Spices

I. Application and Amplification of General Seed certification standard.

The General seed Certification Standards are basic and together with the following specific standards constitute the standards for certification of the seeds of open pollinated varieties/composites in case of cumin, coriander and fennel and pure lines in case of fenugreek.

II. Land requirements

Land to be used for seed production should be free from volunteer plants and in case of cumin; crop rotation of three years is required.

III. Field Inspection

Cross Pollinated Crops-Cumin, Coriander and Fennel:

Open pollinated varieties and composites

A minimum of three inspections shall be made as follows:

- 1. The first inspection shall be made before flowering preferably within 45 days of planting to determine isolation, volunteer plants off types and other relevant factors.
- 2. The second inspection shall be made during 50% flowering to check the isolation, offtypes and other relevant factors.
- 3. The third inspection shall be made at maturity and prior to harvesting to verify the true nature of plant and other relevant factors.

Self Pollinated Crops-Fenugreek:

- A minimum of two inspections shall be made, first before flowering and the second at the flowering and fruit stage.
- IV. Field Standards

A. General Requirements

ISOLATION

Seed fields shall be isolated from the contaminants shown in column 1 of the Table below by the distance specified columns 2 and 3 of the said Table.

Contaminants	Minimum distance (Meter)							
	Cun	nin	Coriander		Fennel		Fenug	reek
	Foundation	Certified	Foundation	Certified	Foundation	Certified	Foundation	Certified
Field of other varieties	800*	400**	200	100	200	100	10	5
Field of same variety not conforming to varietal purity	800*	400**	200	100	200	100	10	5
Specific requirements								
Offtype plants	0.10%	0.50%	0.1%	0.5%	0.10%	0.50%	0.10%	0.20%
Objectionable weed plants	0.05%	0.10%	None	None	None	0.05%	0.010%	0.020%

* = originally it was 100 m, ** = originally it was 50 m

Objectionable weeds

Fenugreek: Melilotus spp. (Senji)

Cumin: Plantago pumila (Zeeri)

Fennel: Cuscuta species (Dodder)

Coriander: Lathyrus

V. Seed Standards

B. Specific requirements

Cumin:

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Factor	Standards for each class			
	Foundation	Certified		
Pure seed (minimum)	97.0%	97.0%		
Inert matter (maximum)	3.0%	3.0%		
Other crop seed (maximum)	10/kg	20/kg		
Weed seeds (maximum)	10/kg	20/kg		
Objectionable weed seeds (maximum)	5/kg	10/kg		
Germination (minimum)	65%	65%		
Moisture (maximum)	10%	10%		
For vapour proof container (maximum)	8%	8%		

Coriander:

Factor	Standard for each class			
	Foundation	Certified		
Pure seed (minimum)	97.0%	97.0%		
Inert matter (maximum)	3.0%	3.0%		
Other crop seed (maximum)	10/kg	20/kg		
Objectionable weed seeds (maximum)	None	None		
Germination (minimum)	65%	65%		
Moisture (maximum)	10%	10%		
For vapour proof container (maximum)	8%	8%		



Fennel:

Factor	Standard for each class			
	Foundation	Certified		
Pure seed (minimum)	97.0%	97.0%		
Inert matter (maximum)	3.0%	3.0%		
Other crop seeds (maximum)	10/kg	20/kg		
Weed seeds (maximum)	10/kg	20/kg		
Objectionable weed seeds (maximum)	5/kg	10/kg		
Germination (minimum)	65%	65%		
Moisture (maximum)	10%	10%		
For vapour proof container (maximum)	8%	8%		

Fenugreek:

Factor	Standard for	each class
	Foundation	Certified
Pure seed (minimum)	98.0%	97.0%
Inert matter (maximum)	2.0%	3.0%
Other crop seed (maximum)	10/kg	20/kg
Total weed seeds (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	2/kg	5/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Germination including hard seeds (minimum)	70%	70%
Moisture (maximum)	8.0%	8.0%
For vapour proof container (maximum)	6.0%	6.0%

Planting material production technology in chilli (Capsicum annuum L.)

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Introduction

Chilli or hot pepper (*Capsicum annuum* L.; 2n=24) is the most valuable commercial spice-cumvegetable crop grown in India and belongs to the family Solanaceae. Chilli is rich in vitamins A, C, E & P. It is indispensable in Indian cuisine for its pungency, colour and flavour. Capsaicin is responsible for pungency and has good medicinal value. *Capsanthin* is the most important pigment of chilli, used as a natural food color. Chillies and its processed products are used very effectively in Indian medicine. In India, chillies (dry-red and fresh-green fruits) were cultivated on 801,500 ha with a total production of 1.3 million MT of dry fruits and 6800 MT of fresh fruits. Average yield of dry chilli harvest was around 1.6t/ ha compared to those of 8.5t/ ha for green chilli (FAOSTAT, 2012). In India, the states of Andhra Pradesh, Karnataka, Maharashtra, Odhisa and Tamil Nadu account for more than 75% of the area and total production of chilli. India stands first in chilli cultivation covering 45 per cent of chilli growing areas of the world. There is a tremendous demand for Indian chillies in the international market that provides a wide scope to increase the export and earn good amount of foreign exchange. Chilli continued to maintain the lead in the spice export basket, accounting for 347,000 tonnes in quantity and Rs. 13,517 crore in value. Chilli market types prevalent in India can broadly be grouped into (i) fresh market (green, red, multi-color whole fruits), (ii) fresh processing (sauce, paste, canning, pickling), (iii) dried spice (whole fruits and powder), and (iv) industrial extracts (paprika oleoresin, *capsaicinoids* and carotenoids).

The genus *Capsicum* consists of approximately 22 wild species, of which five species, *viz., annuum, baccatum, chinense, frutescens* and *pubescens* are cultivated. Among the domesticated species, *C. annuum* and *C. frutescens* are most commonly cultivated species and most of the chillies grown in India belong to these species. In *C. annuum* species, chilli and bell pepper (Simla Mirch/ Bangalore Mirch) are the two broad categories, widely distributed in all South Asian countries. Other types, *viz.*, pickle or stuff type chilli in eastern U.P., squash type in Dharwad district of Karnataka and tomato chilli in Warangal district of Andhra Pradesh are also popular. Chilli crop is introduced to India 500 years back and due to the long history of cultivation, out-crossing nature and popularity of the crop, large genetic diversity including local landraces have evolved. Therefore, India is considered as secondary centre of diversity for the chilli. In hot chilli, great range of variability for several morphological attributes occur throughout India, particularly in South Peninsular Region, North Eastern Region, in foot hills of Himalaya and Gangetic plains. In Sri Lanka and Maldives also high genetic diversity is available in most of its cultivated areas.



Commercially local types (including landraces), open-pollinated improved varieties and hybrid cultivars are being grown in the country. Fifty per cent chilli growing area is under local varieties, 25% of area is under improved OP varieties and the remaining 25% area in under chilli F_1 hybrids.

Hybrid seed is the seed of an F_1 generation sold for commercial production of the crop. Despite of high seed cost, there is increasing demand for hybrids because of high yield, adaptability, uniformity and resistance to biotic and abiotic stresses. Moreover, hybrid/ heterosis breeding is comparatively easy to vegetable breeders as it is easy to incorporate resistant genes for biotic and abiotic stresses and also horticultural traits in F_1 hybrid and also the right of the bred variety is protected in terms of parental lines. Hot peppers express considerable amount of heterosis (20-50%) for yield, hence are amenable for exploitation of hybrid vigour as F_1 hybrids.

Floral Biology

The typical *Capsicum* flower is pentamerous, hermaphroditic and hypogynous. The corolla is rotate in most species with 5-7 petals, which are 10-20 mm long. The diameter of a *C. annuum* flower is 10-15 mm across. The flower colour is dependent on the species, but most *Capsicum* species have whitish flowers. Flowers are usually solitary at the axils of the branches for *C. annuum*, however, some accessions have clusters of flowers at the nodes. The cluster type is associated with the fasciculated gene, which causes multiple flowers/ fruits to form at a node. *C. annuum* start flowering with a single flower at the first branching node; there can be exceptions where two flowers can be found at some nodes. Then a flower forms at each additional node, a geometric progression. Gradually, more than 100 flowers develop on one plant. The rate of fruit set is negatively correlated to the number of fruits developing on the plants. Fruits from early flowers are usually larger and have greater red colour and pungency content at maturity. Chilli is considered to be a day neutral and warm season crop. Fruits do not set when mean temperatures are below 16°C or above 32°C as it reduces pollen viability. However, flowers drop when night temperatures are above 28-30°C. Fruit normally reaches the mature green stage 35-50 days after the flower is pollinated.

Pollination Mechanisms

Chilli pepper flowers are complete, that is they have a calyx, corolla, and male and female sex organs. Most species of pepper are self-compatible. Self-incompatibility has been reported in *C. cardenasii* and in some accessions of *C. pubescens* (Yaqub and Smith, 1971). Mating among siblings is required to produce viable seed within these accessions. Peppers exhibit no inbreeding depression. All species are protogynous and can cross- pollinate. The stigma position is varied depending on the cultivar and growing environment, as slightly below, level with the anthers or exerted beyond, in which case the chances for cross-pollination are greater. Studies have shown that cross-pollination can range from 2-90%. Therefore, pepper breeders and seed producers must use caution to prevent uncontrolled cross-pollination (Bosland, 1993).

Seed production of local/ open pollinated varieties of chilli the odd plants are rogued, according to the criteria listed as per the cultivar description and roguing stages. As cross pollination reported in chilli is high due to stigma exertion, for breeders' seed production 500m isolation distance is recommended and if not possible the selected plants for seed collection needs to be covered by 40-mesh nylon net to avoid pollen contamination.

In order to make controlled hybridizations, a plant breeder must transfer the pollen from the anther of one plant to the stigma of another. To prevent self-pollination, unopened flower buds are chosen. Using alcohol-sterilized forceps, the petals are carefully removed to expose the repro-

ductive organs. The flower is then emasculated by removing all anthers. The stigma is then examined for any pollen 'contamination' before making the controlled cross. Pollen is transferred from the open flower of the male, or pollen donor, using a small paintbrush, bee stick or by direct contact with the anthers. The pollen is placed on to the stigma of the emasculated female plant. The cross is labeled and, after the fruit ripens, the seed is collected.

Roguing stages and main characters to be observed

- 1. Before flowering: check the desirable characters typical of the cultivar, including growth habit, vigour, foliage, pigmentation and leaf morphology
- 2. Early flowering and first mature fruit: check characters as for stage 1, in addition pay particular attention to presence of any seed-borne diseases
- 3. First fruit at market maturity: check characters as for stages 1 and 2, also check fruit colour and morphology

Why F₁ hybrids in chillies?

- Earliness
- High productivity
- High fruit weight
- High dry recovery

Hybrid development:

Peppers grown from hybrid seed are highly uniform and usually higher yielding. Initially area under chilli F_1 hybrids was very low (2%), probably due to small flower size and low seed yield per an act of pollination. However, in the past 10 years the male sterile systems have been exploited in F_1 hybrid seed production and the percent share of hybrid varieties increased to 25 to 30%. As the extent of cross pollination is high, to maintain purity of the parental lines a minimum of 400-500 m isolation distance or covering with nylon net is must.

Methods for the development of F_1 hybrids in chilli :

- Production of inbred lines
- Testing of combining ability
- Improvement of inbred/ parental lines
- Hybrid seed production
 - Emasculation & pollination
 - Use of male sterility

Cost-effective F_1 seed production using CMS line:

Several systems to produce hybrid seed are possible, including the use of genetic male sterile plants and cytoplasmic male sterile plants. Unfortunately, the production of today's chilli hybrids commonly relies on making crosses between the two parents by hand: a very labour intensive and expensive process.



Advantages of using male sterile system in hybrid seed production of chilli:

- i) Cost effective reducing 50% of labour as there is no need for emasculation and tying/ tagging individual fruit after crossing, provided the seed production is inside the net
- ii) Female parent being male sterile, no chances of getting selfed seeds as mixtures
- iii) Protection of female parent, as without maintainer (B) line the female parent cannot be maintained

i) Genetic Male Sterility:

Genetic Male Sterility is used to develop F_1 hybrid seeds in chilli. The sterile plants are used as the female parent of a hybrid cross. The male sterile characteristic is often inherited as a single recessive gene, *ms*. The use of genetic male sterility is limited in hybrid seed production due to the inefficiency of producing and maintaining a population of male sterile plants. In order to produce more male sterile plants one must cross a fertile plant heterozygous for the male sterile trait to the male sterile plant, and then only half the progeny from this cross will be male sterile.

Most of the previously reported GMS lines were in the sweet (bell) pepper. However, genetic male sterility is often inherited as a single recessive gene, ms. Through incorporation of male sterile gene, ms male sterility has also been accomplished in the hot pepper (chilli) types and are being utilized to produce hybrid seeds. More than a dozen monogenic recessive male sterile lines have been identified either in natural population or induced through mutagenesis (Shifriss and Frankel 1969; Pochard, 1970; Daskaloff, 1971; Shifriss and Rylski, 1972; Shifriss, 1973; Hirose and Fujimi, 1980; Deshpande et al., 1983; Milkova and Daskaloff, 1984; Prakash et al., 1987; Meshram et al., 1992; Patel et al., 1998). But, very little information is available on the allelism of these male sterile alleles. The induced male sterile allele in France (ms-509; Pochard, 1970; renamed ms-10 by Daskaloff and Poulos, 1994) was found allelic to msk allele isolated spontaneously in Korea by Woong Yu (1985). The ms-2 line identified by Shifriss and Rylski (1972) was found non-allelic to *ms-1* isolated by Shifriss and Frankel (1969). In general, genetic male sterility systems for hybrid seed production in sweet/ bell pepper have not been used to any significant level owing to the production of a high percentage of non-hybrid seed and because of the labourintensive nature of the system (Daskaloff and Mihailov, 1988). However, GMS has been utilized commercially in chilli (hot pepper) and muskmelon (Shifriss, 1997).

The *ms-509* line (bell pepper type) of Dr Porchard was introduced in India at Punjab Agricultural University (PAU) and recessive male sterility was introgressed in three chilli genotypes, *viz.*, *ms12*, *ms13* and *ms41* (Singh and Kaur, 1986). All the reported *ms* alleles were highly stable, hence promising for hybrid seed production. The *ms12* has been utilized to develop first commercial male sterile based chilli hybrid CH1 by PAU, Ludhiana (public sector) and later CH3. However, the male fertile and male sterile lines can be differentiated only at the flowering stage on the basis of yellowish or light purple anthers (male fertile) *vs.* dark purple anthers (male sterile). Male sterile line *ms-3* introduced from Hungary is maintained at Asian Vegetable Research and Development Centre (AVRDC), Taiwan.

Although there are reports on tight linkage of *ms* gene with phenotypic marker traits (Murthy and Lakshmi, 1979; Meshram and Narkhede, 1982; Pathak *et al.*, 1983), it has not been exploited in chilli for early identification of male sterile plants. However, three morphological markers *viz.*, taller plant height, erect plant growth habit and dark purple anthers are associated with the male sterile plants with *ms12*. A scheme has been proposed to identify and remove majority of male fertile plants from hybrid seed production field at early growth stage based on shorter plant height and intermediate growth habit (male fertile) followed by identification and removal of the remain-

ing male fertile plants on the basis of light purple anthers at later stage. Meiotic analyses of male fertile and male sterile plants revealed that ms12 was a spontaneous male sterile line, in which microspores degenerated immediately after formation of the tetrads (Dash *et al.*, 2001).

Cytoplasmic Male sterility:

Cytoplasmic male sterility (CMS) is another means by which hybrids may be produced. Cytoplasmic male sterility has been widely exploited for hybrid seed production of a number of agronomic and horticultural crops (Havey, 2007) including hot pepper (Kumar et al., 2007). CMS can arise spontaneously in breeding lines, following mutagenesis, as a result of wide crosses, or the interspecific exchange of nuclear and cytoplasmic genomes (Schnable and Wise, 1998). If dominant restorer allele (located in nuclear genome) for pollen fertility of a cytoplasmic male sterile line is identified, it is commonly known as cytoplasmic-genic male sterility (CMS). Hence male sterility in CMS is expressed under the presence of sterile mt-genome located in cytoplasm (Scytoplasm) and recessive allele of restorer (maintainer allele; r) located in the nuclear genome, resulting from an interaction of nuclear and cytoplasmic factors. The advantage of a CMS system is that a population of sterile plants can be generated in which all the offspring are sterile. CMS is most commonly utilized male sterility to produce commercial hybrid seeds, and is three line hybrid breeding involving A line (male sterile; S-rr), B line (maintainer; N-rr) and C or R line (restorer; S or N-RR). Peterson (1958) described a cytoplasmic male sterile system isolated from an Indian accession, USDA PI 164835, but this system was unstable and resulted in fertile pollen under cool conditions. Studies using Peterson's CMS material indicate that additional factors affect pollen sterility and stability (Novak et al., 1971; Shifriss and Frankel, 1971; Shifriss and Guri, 1979). It has been observed that at low temperature, meiotic breakdown is either completely stopped or delayed, resulting in pollen fertility (Shifriss, 1997).

Through inter-specific cross Shifriss and Frankel (1971) were able to isolate sterile cytoplasm from C. annuum, but it was found identical to the Peterson cytoplasm. Cytoplasmic male sterile plants were also obtained by few others (Csillery, 1989; Woong Yu, 1990) within the backcross progenies of C. frutescens X C. annuum. This sterile cytoplasm of C. frutescens was also found identical to the Peterson cytoplasm in respect to sterility and fertility restoration potentials, when crossed with Peterson's maintainer and restorer lines (Shifriss, 1997). Hence three independent sources of cytoplasm (two from annuum and one from frutescens) isolated so far in Capsicum are identical. Several reports suggest that restorer allele(s) (R) is more frequently distributed in hot pepper lines, while occurrence of maintainer allele(s) (r) is more common in sweet and long fruited lines (Novak et al., 1971; Peterson, 1958; Woong Yu, 1985). Woong Yu (1985), in a study of 270 pepper lines found 152 to be stable B-lines, *i.e.*, maintainer (N)msms, 66 to be restorer lines (N)MsMs, and the remaining 50 lines were defined as unstable, leading to segregating progeny following crossing with Peterson's male sterile plants. In addition, the pattern of segregation demonstrated large deviations from year to year. These unstable lines might be heterozygous to the sterility modifier genes and their progeny reacted to yearly or seasonal variation. Eventually, selfing and selection in this material yielded both stable maintainer and fertility restorer ones.

In chilli, now stable cytoplasmic-nuclear male sterile lines (*cms*) lines are available, which can be utilized as female parent in the hybrid seed production. Since male part (constricted anthers with little pollen) is sterile, use of such line precludes huge cost on manual emasculation. Thus, utilizing *cms* line, the production cost of hybrid seeds can be drastically reduced. The *cms* line (also called A line) is maintained by making crosses on it using pollen from maitainer line (also called B line). Through such crossing, 100% male sterile seeds are obtained, unlike *gms* line. Several seed companies in South Korea have started utilizing CMS system (Shifriss, 1997). Work is also

under progress at AVRDC to develop stable CMS system in chilli, to facilitate development of CMS derived hybrids. One of the stable A and B line pairs has been introduced from AVRDC by IIVR and used in the development of high yielding hybrid *viz.*, CCH2. In India, at IIHR four stable *CMS* (MS1, MS2, MS3 and MS4) lines along with their corresponding maintainer lines were developed (Reddy *et al.*, 2002), of which MS3 is resistant to powdery mildew. Using MS1 and MS3, three promising high yielding hybrids *viz.*, Arka Meghana, Arka Sweta and Arka Harita were developed at ICAR-IIHR.

Development of cms line: The cms line (A line) is developed by backcrossing of a selected maintainer line (B line) on to an already available A line for six to seven generations. This generates a pair of A and B line in the new genetic background. Restorer allele (Rf) is either introgressed into identified male parent (restorer breeding) or male parent is directly used for hybrid seed production on cms, if restorer (Rf) gene in homozygous state is already available in male parent (most of the chilli and sweet pepper genotypes possess Rf and rf genes, respectively). Similarly, if maintainer (rf) gene is not available in the line, which is to be developed as A line, then maintainer breeding would be required to transfer recessive gene (rf) in the desirable line.

Number of hybrid fruits: The number of crossed fruits per plant should be kept as many as possible (50-70).

Removal of non-crossed fruits: After completion of hybridization programme, all the non-crossed (untagged) fruits developing/ developed through NCP on female plants are removed, which facilitates vigorous development of crossed fruits and seeds. In case of cms/ gms based hybrid seed production, this practice is not required, as all the fruits developed on the male sterile plants will be crossed fruits, provided recommended isolation distance is maintained.

Harvesting of crossed fruits: Fruits of chilli mature at 35-50 days after pollination. The mature index is red ripe fruit. Before harvesting of crossed fruits, open pollinated (non-hybrid) fruits are removed in order to eliminate chance contamination in hybrid fruits. Hence it should be secured that only tagged fruits are harvested. In case of cms or gms based hybrid seed production, all the fruits developed on cms or gms plants will be crossed fruits, provided recommended isolation distance is maintained.

Extraction of seeds and packaging: The harvested ripe fruits are dried and seeds are separated by maceration (commercial scale) or by longitudinal bifurcating (experimental scale) of the fruits. After extraction, seeds should be dried up to 8% moisture level. Before packing in appropriate moisture proof packing material, seeds should be cleaned on density gradient seed cleaner.

Seed Yield: 300-350 kg/ ha — 30-35 kg/ 10 guntas — 10-15 g/ plant

List of some chilli varieties/ hybrids developed by public institutes through selection and hybridization utilizing genetic resources in India:

Breeding method adopted	Varieties released
Pure line selection	G1, G2, G3, G4 (Bhagyalakshmi), X 235, NP46A, K1, Co1, Co 2, Musalwadi, CA 960 (Sindhur), Patna Red, Pusa Red, Kalyanpur Red, Kalyanpur Selection 1, Kalyanpur Yellow, Pant C1, Pant C2, Arka Abhir, LCA 334
Pedigree method	G5 (Andhra Jyoti), Pusa Jwala, Pusa Sada Bahar, X 235 (Bhaskar), K2, Pant C1, Punjab Lal, Jawahar 218, Azad, Arka Lohit (Sel 1), Arka Suphal
F ₁ hybrids	CH 1, CH 3, Arka Sweta, Arka Meghana, Arka Harita, Arka Khyati

Some of these varieties are quite familiar to the farmers but their cultivation is largely confined to the areas around the research station. Apart from these varieties, there are many local varieties under cultivation in different states; some of them are listed below:

List of local varieties/ landraces that are under cultivation in different states:

Andhra Pradesh	Nallapada, Gollapada, Ellichipur local, Yellow Nellore, Moti Mirchi, Short Warangal, Lanka, Shirla, Sankeswar, Gati			
Karnataka	Byadagi Kaddi, Byadagi Dabbi, Sankeswar, Chinchooli, Arikere, Gouribidanur, Mysore, Selam, Kollegal			
Maharashtra	Sankeswar, Tarapuri, Shiragaon, Gaorani, Surhodi, Lavangi, Dabbi,			
Tamil Nadu	Theni, Petai, Rasagulla of Ramnad, Pattukotai, Sattur, Sammba and Tanjore Kodai-Millaghai			
Madhya Pradesh	Malkapure Gaaurani, Ellichapur, Kakni, Batki, Nulchati			
Bihar	Pattanaya, Mota and Longia			
Uttar Pradesh	Desi, Ramnagar, Lakshmipur			
Punjab	Rakhi Pata, Chokapal, Lambhal, Assam and Gura			
Orissa	Dakini, Bhala, Suryamukhi			
Himachal Pradesh	Sanuri, Samane			
Assam	Bijuri, Suryamukhi, Jayantha, Puri			

List of chilli cultivars recommended for national release in India (1975-2014) through AICRP (VC)

Cultivar type (developed by)		Name (recommended zone/s)
Open pollinated	:	G-4 or Bhagyalakshmi, G-5 or Andra Jyothi (I, IV, V, VI, VII, VIII), K-2 (IV, VI), J-218 (I, IV, V, VI, VII), Bhaskar or X-235 (IV, V, VI, VIII), Muslawadi (V), Arka Lohit/Sel-1 (V, VII, VIII), LCA206-B (V, VI, VII, VIII), Phule C-5(VII), AKC-86-39 (VII), BC-14-2 (V, VI), RHRC-Cluster Erect (VII), PMR57/88-K (VII), LCA-334 (III, IV, V, VII), ASC-2000-02 (VII), KA-2 or Kashi Anmol (IV), LCA-353 (IV, V, VII),BC-25 (V, VI, VII), PC-7 (V), HS-HP-154 (VIII), IVPBC-535 or Kashi Sinduri-Paprika (VIII), PC-56 (I, IV, V, VII, VIII), VR-338 (II), ACS-06-2 (VIII)
F_1 hybrids (10 by private and 5 by public sector)	:	HOE-888 (IV, VIII), ARCH-236 (IV), Sungrow-86-235 (IV, VIII), ARCH-228 (IV, V, VI), Arka Meghana or MSH-172 (IV, V, VI & VIII), Arka Sweta or MSH-149 (IV, VI, VIII), CCH-2 or Kashi Surkh (II, IV, V, VI), KCH-3 (IV), CCH-3 or Kashi Early (IV, V, VIII), BSS-453 (II), NCH-587 (IV, VII), VNR-332 or Rani (IV, VIII), HH-41786 (VII), BSS-378 (VII), VNR-Vidya (IV)



Zones: I = Humid western Himalayan region, II =Humid Bengal-Assam basin, III = Humid eastern Himalyan and bay islands, IV = Sub-humid Satlej Ganga Alluvial plains, V = Sub-humid eastern and south eastern plains, VI = Arid western plains, VII = Semiarid plateau and central highlands, VIII = Humid, semi-arid Western Ghats and Karnataka plateau

Apart from public institutes, many private seed industries are extensively marketing different chilli varieties/ hybrids. Some of the popularly grown private chilli hybrids in major chilli growing areas are:

S. No.	Name of chilli hybrid	Source
1.	Wonder Hot/ Ravindra	Seminis
2.	Delhi Hot	Seminis
3.	Indam 5	IAHS
4.	Indam 10	IAHS
5.	BSS 378	Bejo Sheetal
6.	BSS 275	Bejo Sheetal
7.	NS 1101	Namdhari seeds
8.	NS 1701	Namdhari seeds
9.	Sitara	Syngenta
10.	Roshni	Syngenta
11.	НРН 232	Syngenta
12.	Tejeswini	MAHYCO seeds
13.	Devanur Delux	Nunhems seeds
14.	Sankranti	Nunhems seeds
15.	Soldier	Nunhems seeds
16.	ARCH 82	Ankur seeds
17.	ARCH 228	Ankur seeds

Conclusion

Large number of improved chilli varieties and F_1 hybrids are available for cultivation in the country. Further there is a strong need to develop varieties/ F1 hybrids resistant to emerging disease and pests. Diversification of male sterile lines and incorporation of resistant genes is required. Further healthy seed production is very important. Possibility of utilization of rootstocks having resistance to major soil borne diseases needs to be explored. Rootstock breeding to combine the resistant genes of all major soil borne pathogens needs to be emphasized. Male sterility systems in F_1 hybrid seed production of chilli is being exploited by both public and private institutions in the country. Scientific seedling production of chilli F_1 hybrids for commercial crop production is also in practice. Knowledge on selection of variety to be grown as per the season, market demand and having tolerance to local biotic and abiotic stress tolerance is required. Procuring good quality
seed and/ or seedlings is very important. Adoption of good agricultural practices is recommended for good quality crop production.

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Quality seedling production in chilli

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Introduction

Production of good quality chilli seedlings is very essential for getting higher yield and quality produce. In most of the advanced countries vegetable seedling production is taken up by specialized companies or as a specialized activity. In India, vegetable seedling production system is gradually changing from open field nurseries to protected seedling tray productions in some of the intensive vegetables growing areas and seedling production as a specialized practice is fast catching up.

In the past, the farmers themselves used to produce the seedlings required for transplanting at lower cost, as most of varieties were open pollinated types. Now a days many progressive farmers and entrepreneurs are taking up quality seedling production using seedling trays as a commercial activity mostly for F_1 hybrids as the cost of seeds is quite high. Besides chilli on limited scale, seedling production of tomato, capsicum, cauliflower, brinjal and cabbage F_1 hybrids are being followed on large scale using seedling trays and protective structure such as insect proof net houses. The advantages are, it provides adequate space for each seedling to grow, Improved germination and saving of expensive seeds, Reduces seedling mortality or damping off because of sterilized/pasteurized cocopeat growing media, Uniform, healthy growth and early readiness of seedlings, Ease in handling and cheaper transportation, Better root development and less damage while transplanting, Good field establishment and improved uniform crop stand, Protection from viral disease contamination during nursery stage.

Protected structure

The seedling traves are commonly kept under nylon net house or poly house. Net house is found to be cost effective and feasible structure to grow vegetable seedlings, which can be followed in low rainfall area or during rain free period. Net house is commonly built using granite stone pillars. Stone pillars of 10' x 6'' x 4'' are generally used. These stone pillars are spaced at 5m x 5m and grouted to a depth of 2 feet using cement concrete. The stone pillars all along the periphery of the net house should be tied to a peg stone using guy wire. The height of the structure should be 8 feet. On top of each stone pillar, used rubber tube is tied so that sharp edges of the pillars do not damage the nylon mesh and shade net. Wire grid is provided at the top of the structure as support for the nylon mesh. Normally farmers cover the sides with 40 mesh UV stabilized nylon insect proof net and the top with 50% UV stabilized HDPE shade net. It is advised to cover the top also with 40 mesh UV stabilized nylon insect proof net. During summer and hot sunny days 35% UV stabilized HDPE shade net is spread on the top of the net house to maintain ambient temperatures suitable for seedling growth. Provision should be made to pull polythene sheet over the pro-trays in the event of rainfall by way of making low tunnel structure. For preparing low tunnel structure, 3/4" HDPE pipes or bamboo stick and 400-gauge polyethyl-



ene sheet can be used. The approximate cost for building stone pillar net house will be around Rs.250 per square meter depending on the locality.

Seedling trays

Seedling trays are also called as pro-trays (propagation tray) or flats, plug trays or jiffy trays. The most commonly used are 98-celled trays for crops like chilli, tomato, capsicum, cabbage, cauli-flower, yellow wax, brinjal and gourds. The dimensions of the trays generally are 56 cm in length and 28 cm in breadth and cavity depth of 4 cm. These trays are made of polypropylene and are re-usable. Life of the tray depends on the handling the seedling trays. Seedling trays have been designed in such a way that each seedling gets appropriate quantity of growing media and the right amount of moisture as the trays have pre punched holes to each cavity for proper drainage of excess water and also right spacing.

Growing media

Soilless mixtures are commonly used for commercial seedling production. Sterilized commercial growing media is better as the incidence of seedling diseases is less or nil and it contain right amount of moisture in it. The most common growing media used is coco peat, a by-product of coconut coir industry. It has high water holding capacity, light in weight and porous in nature. It should be well decomposed, sterilized and supplemented with major nutrient sources before using. Basically coconut fibre powder is low in nutrients and high in lignin content. Thus it need to be properly decomposed by adding major and micronutrients and microorganisms. Other growing media which can be used are cocopeat: vermicompost, vermicompost: sand in equal proportions.

Arka Fermented Cocopeat

IIHR has developed a protocol for the preparation of cocopeat from raw cocopeat by using the microbial consortium cultures. It is a fermentation process where complex molecules are broken into into simpler products. In this process a fungal consortium is used to breakdown tannins and phenols present in raw coirpith. The end product (cocopeat) is finally enriched with beneficial microbes. The benefit from this process are: reduced production cost by nearly 50 % over the existing product. Dispenses with washing of the raw coir pith, hence environmentally friendly. Can be done at the nursery itself. Dispenses the need for pasteurization of the growth media

Characteristics of good seedlings

Stocky, Green, Pest-free, Well-developed root system, Tolerates environmental stress when transplanted, Maintains good growth and optimum yield.

Condition for elongation of seedlings

High night temperature, Shortage of sunlight, High nitrogen in soil and High moisture in night.

Seed rate: About 200g seeds are required to raise 30,000 seedlings required to plant 1ha area.

Method of seedling raising

- 1. Fill the seedling trays with appropriate growing medium.
- 2. Make a small depression (0.5 cm) in the center of the cell, it can be created by stacking about 10 trays one over other and pressing the trays together. Alternatively Dibbling machine developed by IIHR ,Bengaluru can also be used to save time and labour.



- 3. Sow one seed per cell and cover with thin layer of medium.
- 4. No irrigation is required before or after sowing if coco peat is sufficiently moist.
- 5. Keep 8-10 trays one over the other and cover the entire stack of tray with black polyethylene sheet. This ensures failry uniform temperature and moisture for facilitating good germination. No irrigation is required till seeds germinate. Care must be taken for unstacking the trays when the seedling is just emerging, otherwise seedlings will get etiolated.
- 6. Seeds start emerging after about 6-10 days of sowing depending on season crops sown. Shift the trays to net house/polyhouse and spread over the bed covered with polyethylene sheet.
- 7. The trays are then irrigated lightly, daily depending upon the prevailing weather conditions by using a fine sprinkling rose can or hose pipe fitted with rose head.
- 8. The trays are also drenched with fungicides (COC or Copper hydroxide @ 2.0g/l) as a precautionary measure against seedling mortality.
- 9. The media may need supplementation of nutrients for good growth of seedlings. Spray 0.3 per cent (3 g/litre) of water soluble solid fertilizer (19 all with trace elements) twice (12 and 20 days after sowing).
- 10. Protect the trays from rain by covering with polyethylene sheets in the form of low tunnel.
- 11. Harden the seedlings by withholding irrigation and reducing the shade before transplanting
- 12. Spray systemic insecticides like Imidacloprid (0.2 ml/litre) 7-10 days after germination and before transplanting, for managing the vectors.
- 13. The seedlings will be ready in about 35-42 days for transplanting into the main field.



Hybrid seed production technology -The role of private sector in chilli production in India

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Introduction

Chilli, *Capsicum annuum*. L occupies an important place in human culture since pre history. India stands first in area (8.5 lakh ha.) covering 45% of world chilli area with a production of 16 lakh Mt.Nearly 80-85% of production is consumed domestically. Only 15-20% is exported in whole form amounting to 2.88 lakh Mt valuing 2500 crore of export earnings. In India, It takes a share of 40% of export volume and 22% of share in value. Chilli is number one dollar earning spice crop of India. The value additions- spice oils and oleoresins take (all spices together) a small volume in export-9500 metric tons amounting to 1500 crores export earnings. The rediscovery of medicinal health values by advances in medical sciences have identified chilli as one of the purest and most effective natural stimulating botanical in herbal medicines. *Capsicum* exerts potent physiological and pharmacological effects without side effects on human health. *Capsicum* has emerged as a most potent immune fortifier, antioxidant and infection fighter. No surprise looking at the values and demand for chilli in International market, it could be renamed as King of spices and condiments.

The value addition proposition looks very attractive in the context of chilli crop for trade and commerce. But the problems in production as well as in supply chain are also huge and need to be addressed. The productivity, yields of the crop varieties have drastically come down and are no attractive and economically viable for cultivation when compared to other crops. To inmore crease the yield levels indiscriminate usage of pesticide, fungicides, high dosage fertilizers have created more problems for industries and export market. Indiscriminate use of Plant Protection measures have increased pesticides load on crop leading to rejections of consignments in export market. The residual pesticides have ill effects on human health. The increase in demand for the spice crop chilli has further boosted the increased use of plant protection chemicals which has a great impact on quality parameters and human health. Chillies and paprika, being highly cross pollinated crop (Tanksley, 1984, Gaddagimath -1998 b.), the local varieties and land races are highly genetically contaminated and have lost their unique spice quality features. This has become a great concern in value addition industries and spice markets. The crop did not receive timely scientific attention and remained as orphan during its peak genetic destruction. Neither Horticulture Science nor Agriculture Science or Spices and Condiment Division took serious scientific care and efforts to promote this crop in the earlier period of 80's - 90's unlike reported and recorded in other crops like cotton, groundnut, soya bean, maize, sorghum etc. Today all responsible institutions and organizations speak about this crop. Unfortunately chilli crop is not a mandatory crop of Spice Board, Govt. of India, though this crop earns more receipts from exports and hence has become a limiting factor for Spice's Board to fund for chilli crop research. It needs a policy change. It is time that all stake holders of this crop come on a common platform and take technical and policy decisions for the growth and promotion of chilli crop to make India as evergreen leader in Global Market.

The value of India Food Industry is more than 5000 Billion INR reported by Agriculture and Industry Survey 2003-04. Much of it comes from processed or instant or ready to eat / serve packed food segments .This growth is expected to be an outcome of socio economic changes, different value perceptions and rapid transformation taking place in Indian society. Fast paced life, increasing numbers of working women, dual income nuclear families, larger disposable incomes, demand for safe, good quality nutritious food are the factors influencing growth of food industry. Chilli as a spice and condiment has a major role in these industries in domestic market. Export market is still very attractive.

Market Needs

There is a huge demand for supply of quality raw material to the consumer market, to value addition industries and export markets. The prime needs of these market are-

(1) Consistency (2) Uniformity (3) Production and supply in volume (4) Timely supply (5) Competitive price (6) Low pesticide load on crop produce and now (7) Organic crop (8) Paprika and (8) De stemmed chilli - a new demand very much heard in market.

These have become the major challenges and threats to the future of chilli spice industry in India. The most popular Indian high quality chilli variety, more driven by value addition industry especially for colour oleoresin and mild chillies with high flavor for domestic market is the "Byadagi Dabbi and Byadagi Kaddi" variety. Today this chilli variety has lost its genetic identity and is a highly genetically corrupted and polluted breed. At least 30-40 kinds of varieties/ variants are noticed in every acre of this crop in traditional area of its cultivation. There is no consistency in the crop quality in this breed. Every load or batch of material arriving to process line is of different quality. It goes difficult to work out logistics of value addition in this crop with this situation. Secondly the arrivals are also not consistent and sure. As the production and supply is very poor, there is a huge competition in prices in domestic market and industries which is not a good sign for the growth. Because of its low yields of 50 to 100 kg per acre in rain fed area that too with fruit borer and antracnose infected white fruits of 50-70%, cultivation of local Byadagi chilli is no more an economically feasible proposition to farmers. As a result farmers are opting for alternative crops like cotton, groundnut soybean *etc*. This is affecting the future of oleoresin industries and is indirect threat to all value addition industries banking on this crop variety in the country.

The ground realities in the production area and competition in the market have threatened the value addition industries and the huge investment on infrastructure and HRD are at high stake. There are instances where Indian oleoresin units are established in China for the reason of competitive price, availability of voluminous material and timely delivery to process line. Few companies are also importing paprika chilli from Europe and African countries to keep their units in operation though it is not viable. These situations need to be seriously reviewed by all stake holders in chilli crop and market. Long term plans and strategies should be structured to strengthen chilli production machinery by providing good productive seed material for the respective region.



The Scientific Solution

All the time in the county, for low production and low productivity situations and to bring stability in market, hybrid seed research and hybrid seed production technology has found out solution to the problems. Chilli crop being highly cross pollinated, harnessing of exploitable heterosis is the only simple solution to stabilize production and supply of quality raw material in volume and in time to market (Gaddagimath ,1992,1998,Temburnal and Rao, 2012, Gaddagimath 2015). The development of conventionally bred F1 hybrids for various market needs will give solace to the major problems of market and would promote export and value addition activities in the country.

Hybrid Seed Production

Chilli being a highly cross pollinated crop significant high level of exploitable heterosis is reported. Hybrids are highly productive and respond very well to hitech management practices and always assure a uniform quality produce to the market. Many a times hybrids are not viable for want of economically viable seed production technique. Simplicity in seed production techniques, high fruit set per plant, high seed recovery per fruit and economically viable large scale seed production technique decides the future of any hybrids in any crop plant. Involvement of male sterile lines in hybrid seed production programs take care of several such factors which ultimately decides the cost of hybrid seeds. Length of pollen viability, stigmatic receptivity, system of pollination, number of fruits per plant, seeds per fruit/ cross, under different systems of pollination are the main factors which influence the increase in total hybrid seed yield per unit area and unit time (Gaddagimath,1998 a &b Temburnael and Rao, 2012).

Success in commercial hybrid seed production depends more on simplicity of technology and economic feasibility of system. The technology should satisfy the following-

- > Planting systems.
- > Simple method of pollination
- > Period of pollination
- > Simple means of identifying male sterile lines
- > Maintenance of genetic purity in seed production plot.

All these systems and techniques should increase seed yield per unit area, unit time, unit labour and unit rupee spent in the activity. Commercial feasibility depends on these factors. Chilli is highly cross pollinated crop and 92 % of cross pollination is reported (Gaddagimath, 1988 a,Tanksley, 1984). A minimum of 250 meters of isolation distance is recommended (Gaddagimath 1998 a) to maintain purity and to avoid contamination by wind. Today most of the seed production programs are carried out in net houses and 50 meters isolation is recommended as a safety measure in seed production. Planting system in practice is usually 2:1 or 3:1 female to male row planting (Gaddagimath 1988b). Open pollinated hybrid seed production systems are under trial and economic feasibility is being worked out. In seed production involving male sterile lines, simple way of identifying sterile lines is important. In addition to this, genetic purity of male lines and restorer parents should be verified before the plot is allowed for crossing for hybrid seed production. Distinct genetic and phenotypic features need to be established to ensure genetic purity of both the parents before allowing crossing program.

Effective pollination is made between 8.30 am to 12.30 noon. Pollination could be continued till 3.00 pm. Highest stigmatic receptivity is found between 10.00 am to11.00 am (Gaddagimath,

1988a) .Open pollinated hybrids and hand pollinated hybrids are in practice. In most cases hand pollination is in practice which results in higher fruit set per plant (Meshram and Mukewar, 1985, Gaddagimath, 1998b). Anthers are collected before dehiscence and are placed in petridishes and are exposed to light heat for anther bursting. Viable pollen grains are collected in pollination rings and female flowers are hand pollinated. No significant difference is found in seed set per flowers in open pollinated and hand pollinated systems but fruit set per plant varies significantly (Gaddagimath, 1998a). Number of crossed Seeds per fruit varies from 60-130 seeds depending on the female parent size and fruit characters. Seeds are manually separated from fruits or by water washing technique by mild crushers.

There are three methods of producing F1 hybrids in chilli which are in practice.

- 1. Hand emasculation based hybrids -Two line hybrids. EMS hybrids
- 2. Genetic male sterility based F1 hybrids. GMS hybrids
- 3. Cytoplasmic genetic male sterility based F1 hybrids -Three line hybrids. CMS hybrids.

Hand emasculation technique is still in practice where male sterile lines are not available. However, this technique is more expensive and risky as it may lead to genetic mixing (selfed female) and recovery of hybrid seeds is less compared to use of sterile lines. Hand emasculated hybrid seeds are more expensive as it involves more labour and success rate is less. It is more a skilled job, an art, a technique and is time consuming. GMS- genetic male sterility is another way of use of sterile plants but is laborious and 50-70% of the fertile plants in female lines need to be uprooted manually or with the help of marker genes. The most competitive, safe, cost effective, less risky is CGMS lines (Gaddagimath, 1992, Shifriss, 1997). It was first reported in stable status with full proof system and technology by Gaddagimath (1992, 1998 a&b). Stable maintainers and high GCA restorers are developed in hot chillies and Paprika's at Sarpan Agri Horticultural Research Centre, Dharwad, Karnataka, India and are in use since 1996-97. A, B and R lines in all major 32 morphological global segments and groups are developed at Sarpan for commercial use. All F1 hybrids released at Sarpan are based on CGMS technology. Even Capsicum F1 hybrids under medium to small fruit segments are developed and released for the market (Gaddagimath, 2015-16). More than 300 variants with potential features and high GCA combiners are established (Gaddagimath, 2015-16). A, B and R improvement programs are regular ongoing programs carried out for future market needs. Diverse materials have been built for various market needs-domestic and international. High colour paprika F1 hybrids - Sarpan- 45, 90, 92 Super, 95,102, and 487 carrying all major features of Byadagi local variety are developed and released(Table-1) for commercial cultivation. It took 25 years to develop F1 hybrids matching all the features of Byadgi paprika. These hybrids are extra early in maturity nearly-30-40 days compared to local variety. These features have made them more drought tolerant and perform superior even in low rain fall situations of 300-400 mm in these regions. Apart from these, they have high level of tolerance to major pests and diseases, respond very well to good agronomic practices. A unique F1 hybrid Sarpan Dandicut with semi deciduous fruit features is developed and released very recently. The uniqueness of this breed is, fruits are harvested on plant without stalk. That means the stalk remains on plant and ripe fruit or semi dried fruits are harvested. Seeds never come out of fruits as there is perfect locking of plasanta tissue with the pericarp. Sarpan has developed 42 F1 hybrids using CGMS technology and released for market for commercial use.

Chilli Seed Research

The seed research carried out in the country off late can provide most promising F1 hybrids in various value added segments suitable for processing and also for various domestic ethnic appli-

cations. The main objectives of seed research programs were focused on following areas of market interests.

- 1. Natural organic colour for oleoresin industry.
- 2. Spice and condiment qualities.
- 3. High capsaicin for pharmaceutical needs.
- 4. Pickling or Achar chillies and chillies for chutney
- 5. Chilli paste and purees.
- 6. Whole fruit canning and disced /sliced chillies.
- 7. Chillies for Niche market garnishing, vinegar, sauces, grilled chillies, ornamental chillies.
- 8. Disease, pests, drought resistant hybrids.
- 9. On plant de-stemmed or destalked chillies

Natural colour/organic colour available in chilli is capsainthin and capsorbin caroteinoid derivatives. They have very high value in food, meat, confectionaries, pharmaceutical and cosmetic industries in the global markets. High colour chillies/paprika are required in large volumes for oleoresin industries. The locally grown Byadgi chilli in Northern Karnataka known for its high colour, unique flavor is extensively in use by the industry. This local variety has lost its quality parameters, has become highly susceptible to sucking pests, viruses and yields very low-50 to 150 Kg per acre. It is no more a viable proposition for cultivation by the farmers. Farmers are looking for alternative crops like maize, cotton, soya bean, ground nut in place of chilli. Area has drastically reduced from 1.2 lakh to 70-80 thousand hectares.

New F1 hybrids at par with and superior to Byadagi local variety in quality parameters are researched at Sarpan Agri Horticultural Research Centre, Dharwad, Karnataka over a period of 28 years of dedicated research. This has brought in high hope of chilli cultivation in the region. All unique parameters- high colour, high wrinkles, acidic flavor, low seed content, high storage life for colour with added features of earliness, high level of tolerance to major pests and diseases the Murda complex are incorporated in to these F1 hybrids to full fill industrial needs (Table-1).

S. No	Hybrid	Colour ASTA	Total Colour units	Oleoresin % wt	Pungency% / SHU
1	Sarpan - 92 Super	308.5	11,08,800	13.48	0.02 / 3800
2	Sarpan - 487	502	16,06,400	10.66	0.04 / 6200
3	Sarpan- 102	292.8	9,38,000	13.51	0.06 / 9400
4	Sarpan Dandicut -2	155.7	4,98,240	8.99	0.66 / 1,04,900
5	Sarpan - 369.	274.4	8,78,720	7.4	0.18 / 29300
6	Sarpan -92	263.3	8,42,560	9.37	0.03 / 4,300
7	Sarpan -92 Delux	316.1	10,11,520	9.46	0.19 / 30,300

Table-1.High colour and high capsaicin hybrids released for the need of value addition industries.

QC Lab reports Spices Board Cochin Abstract.

These F1 hybrids are developed by using CGMS three line hybrid breeding technique (A,B and R lines). They are uniform in their performance, high yielding and are released for commercial cultivation(Gaddagimath,2015). Large area is under cultivation in 2015-16. Under rain fed cropping and transplanted conditions they yield 500-750 kg of uniform sized, high colour dry fruits, while under drilled sown condition they yield to 1000 to 1200 kg per acre. Irrigated yields are realized to the extent of 1800 to 2000 kg under GMP. The uniqueness of these hybrids is they are early by 30-40 days to local variety over riding drought situations. They flower and bear fruits by 50-60 days assuring minimum yields of 300-400 kg of uniform fruits even under low rain fall of 300-400 mm. and higher yields of 900-1200 kg in well distributed rain fall situations 800 to 900 mm. The performance is tested in all these regions over years and locations. These hybrids are consistently performing well and are widely accepted by farmers and also by consumer market. Second important feature is, they are highly tolerant to sucking pests and fruit rot disease. Extent of damage recorded is 4-5 % in sever conditions of fruit rot disease. Seed content is also very low of 20-25% ensuring its colour retention even on storage. They are highly wrinkled fruits and carry unique flavor, aroma and are acidic in taste. They are like Indian paprika matching unique features of European paprika. These hybrids match in all quality parameters of local Byadgi variety and acceptance in consumer market is very high. They are also tested for various value additions, colour oleoresins and are found highly suitable.

With the advances in technology of extraction of colour and capsaicin in the process line, the oleoresin industries are more efficient and cost effective in partitioning of these value added components-colour and capsaicin. Oleoresin industrial needs of chillies are also changing to high colour and high capsaicin breeds so that both value added products could be separated in one go from the same raw material. In economic terms, this is more attractive and feasible looking at the rise in chilli production cost and competition in the market. F1 hybrids of high colour and high capsaicin are also evolved and released commercially for diverse applications of the material.

Spice powder industries do have huge requirement of raw material of high colour and medium to high pungent chilli for domestic and export needs. They also are finding difficulty of getting uniform produce of quality for their process line to assure quality and consistency of processed product to consumer market. Many of the industries plan for blending two or more varieties of different capsaicin and colour to develop product of one consistency and a brand in the market. This is becoming very difficult because of non availability of genuine raw material in market in volume. These industries need to bank on hybrids of uniform colour, flavor, capsaicin and other related qualities as identified by them for their brand to ensure uniform product to the market.

Sarpan Dandicut

Chilli fruit stalks are removed invariably before they are carried to process line for various value addition process *viz.*, spice powder, paste and puree, chutneys, for culinary need, garnishing, for oleoresin extraction *etc.* Fruit stalks add contamination to the value addition process and also spoils the quality of processed product. Huge fruit stalk more than 50000 Metric tons appear every year in APMC yard, industrial yards and city dust bins as garbage due to the event of destemming or destalking. This act requires huge labour force, time- labour days and monies in crores and above all the labour availability is a great concern. De-stemming of chillies by women labour in APMC industrial yards under filthy environment dust is a health hazard leading to lung, heart and allergy diseases and problems. To overcome these problems developing an "On plant destalked chilli" is the simple solution, found out by evolving a F1 hybrid chilli at Sarpan Agri Horticultural Research Centre, Dharwad, Karnataka. The fruits are harvested in red ripe stage or semi dried fruit or even at dried fruit stage without stalk. The stalk remains on the plant. Stalk can

go as an organic matter in soil along with plant instead of entering as garbage in market. Such hybrids will boost morality and high value addition to the chilli market. Sarpan Hybrid Seeds Company Ltd., Dharwad, Karnataka is the first to introduce this concept and release a F1 hybrid "Sarpan Dandicut" using A,B and R three line hybrid program (Gaddagimath 2015 and 2016). These hybrids are grouped under Sanam type (Guntur) morphological group, high in pungency and equally high in colour. There is huge demand for de-stemmed chillies in the market-East and West. Today de-stemming / de-stalking is manually done to meet out market demand. This new hybrid, where in de-stemming / de-stalking is done on plant at red ripe or semi dry fruit stage or even at dry fruit stage will solve all the problems of manual de-stemming in market yard. It is eco friendly and has a solution to labour health, labour saving device, reduces filth and debris in APMC yard and industrial premises, reduces wastage during de stemming process, reduces contamination brought in by stalk, easy for handling in process line and has excellent post harvest management parameters for the market. De-stemming is a laborious time consuming task. This concept hybrid is a great contribution in post harvest management of chilli for export markets and value addition industries. Sarpan Dandicut F1 hybrid is high yielding with a potential yield of 25-35 quintals of dry red chillies per acre in irrigated condition and 8-10 quintals under rainfed cropping.

High colour and medium pungent, medium colour and medium pungent and, high colour and high pungent F1 hybrids for spice powder market with unique flavor and shelf life are also developed at Sarpan Agri Horticultural Research Centre, Dharwad (Table-2). Market needs of wide applications and domestic, ethnic and regional needs are met by continuous research by the companies. Special needs-sweet and colour chillies for fresh markets, niche market needs for whole fruit canning and dicing, paste and purees, pickling, garnishing, ornamental and medicinal needs are being addressed by research in the country. Resistance to major pests and diseases is incorporated in hybrids without say as without these features hybrids are not accepted in market .They would remain as USP to the companies and trade in the market

S. No	Hybrid No.	Colour ASTA	Total Colour units	Oleoresin % wt	Pungency% / SHU
1	Sarpan-212	186	5,95,200	18.04	0.67 / 1,07,300
2	Sarpan242	192	6,14,400	18.50	1.24 / 1,98,400
3	Sarpan 246	189	6,04,800	17.06	0.74 / 1,18,400
4	Sarpan KT- 68	178.4	5,70,880	10.58	0.80 / 1,28,600
5	Sarpan Dandicut	155.7	4,98,240	8.99	0.66 / 1,04,900
6	SarpanNag-10.	121.2	3,87,840	19.24	2.33 / 3,72,100
7	Sarpan Bhoot Nag	409133.0	4,25,600	15.17	1.36 / 2,18,200
8	Sarpan Bhoot Nag-	41599.9	3,19,680	12.30	1.85 / 2,96,700

 Table-2
 Sarpan Chilli Hybrids (medium to high colour and high capsaicin F1 hybrids)

Note: Quality analysed without seed content at Spices Board QC lab Cochin.

Indian Paprika

Paprika is the most popular mild to zero pungent chilli with high organic natural colour. Fruits are broad shoulder with unique acidic flavor and aroma, flat thick skinned suitable for colour oleoresin extraction. First India paprika 'Sarpan SB-106', a hand emasculated hybrid was released from Sarpan in 1993-94. Indian Paprika are highly wrinkled; the character market and consumer prefers. They have similar flavor and aroma of European types, very mild in pungency of 1000 to 3000SHU heat units. Skin is thick, opaque with high density of colour. Byadgi Dabbi chilli resembles them to a greater extent. Further research at Sarpan in these segments resulted in another paprika 'Sarpan -487' (Table-1) with high colour of 502 ASTA. Many promising F1 hybrids with A,B and R lines were developed and released to market viz, Sarpan -102, 92 Super, Sarpan -45, Sarpan 90, Sarpan -95 and many more are in the pipe line. These hybrids have very low seed content of 18-25% which is the character of paprika and have high shelf life colour retention on storage .They are highly suitable for cultivation in rainfed as well as under irrigated conditions. The unique features of these hybrids are, they are extra early, drought tolerant, highly tolerant to sucking pests and diseases. Sarpan -102, 92Super and 487 are being cultivated in Antur-Bentur and Kundagol region of North Karnataka. Since these F1 hybrids have broad genetic base have better adaptability and can be tried else were in rainfed as well as irrigated regions. In Bellary region during 2016, Sarpan -92 Super has performed extremely well and expected to cover a good area in years to come in these regions. These are also tried in Bhadrachalam and in Guntur in Andra Pradesh. Response for these breeds is good. However, the farmers preference in these regions is more towards Sanam type of chillies viz., Sarpan Redbull, Sarpan Dandicut -2, Sarpan-Krishna and Godavari. These new F1 hybrids in Paprika segment in the country would revolutionize paprika cultivation in the years to come. It needs some collective and sincere efforts of all stake holders to promote cultivation of paprika in the country.

Bird eye chilli and high capsaicin hybrids

This is sporadically cultivated for niche market product in India and also in global market. There is huge demand being heard in the market for fresh and in dried form. The one cultivated in Costal belt is *Capsicum frutescens*, relative species of annuum. The yields are very low. It is not commercially cultivable because of its growth habit and poor adaptability. An effort is made in this kind of chilli at Sarpan that resulted in evolving Sarpan –Nag-10 and 20 for the commercial market which are being exported in fresh form as well as in dry farm. New CGMS based F1 hybrids are also evolved and would be released to market soon by Sarpan. Efforts are also made on Bhoot Jolakai to develop F1 hybrid with very high heat values and commercially adaptable features. High colour, high capsaicin containing F1 hybrids are in cultivation (Table-2). It is practically not feasible to evolve F1 hybrids with high capsaicin of 4 to 5 lakh plus SHU for commercial cultivation as it goes difficult to handle high volume of raw material by labours with high heat values for commercial markets needs.

Sweet Chilli

A chilli a day keeps you hail and healthy slogan is true with all its medicinal values established in recent years. Dr Szent Gyorgyi Hungarian Scientist was awarded the Nobel Prize in 1937 for isolating Vitamin –C from paprika fruits and showed that they are one of the richest sources of vitamin. Chilli is a whole medicinal botanical, widely accepted in global market. Because of the heat - the capsaicin, many age groups-children and old age *i.e.* 50 plus, people still do not prefer chilli. To meet the needs of such people and to provide high medicinal values to common man, the concept of Sweet chilli was first developed and the first sweet chilli '*Sarpan Madhu*' – means honey was released for commercial cultivation by Sarpan in 1996. Today Sarpan has 28 variants

in sweet segment on CGMS based technique in various forms, shapes and colour to attract specially children. The idea was children should eat chillies like chocolates so that the beneficial medicinal values can go along with it to take care of their health needs. Sarpan has released *Sarpan Lal, Sarpan Madhu, Sarpan Haldi* and *Sarpan Kesar* for the market. Many more new versions are likely be released soon on CGMS based hybrid technology to cater to the niche market needs.

Regional needs

There is huge demand for regional needs for several ethnic values and regional food preparations which cannot be ruled out. The culture and traditional food taste and food preparations need to be protected and promoted with high values. There is huge potentiality in Indian Food Industry (Agriculture & Industry Survey, 2003). Without chilli / paprika the industry cannot grow. Chilli is an indispensable spice in Indian cuisine. It is our responsibility to cater these niche market needs to promote domestic industry and also for export markets. In this context several F1 hybrids are developed with CGMS lines *viz.*, Nag chillies, Mundu F1, Sarpan Reshampatta, Sarpan Gondal 9 and 27, Sarpan 280 Harti, Sarpan Kanthari F1 retaining all quality features and ethnic values in these breeds .

Huge demands are also for Mexican jalapeno, Haberanos, Italian Lombardi, Periperi *etc.* and the list goes on. Importing of seeds has failed for their poor adaptability and they are prone to pests and diseases. Hybrids developed at Sarpan with well defined buyer specifications and broad genetic base performed extremely well and were also accepted by export market. Sarpan has a big list for these special kinds which are under small size market today. In years to come, it is expected that the needs will grow to good size for the Indian grower base for export promotion.

Training programmes

Our (Sarpan) long association over the last 32 years with Byadgi chilli growers in the Northern Karnataka has helped us in identifying the most potential, consistent, highly adoptable chilli growing belts for cultivation of high quality paprika chilli for export promotion from this region. Kundagol and Anthur-Bentur-Annigeri are the two regions identified as the most potential regions with good soil and weather factors to produce very high quality chilli paprika for export needs. In this context we at Sarpan have made all efforts in educating the farming community to use high quality F 1 hybrids along with USDA recommended Green label pesticides and fungicides for PPM to minimise pesticidal load on crop for export markets. Use of Organic pesticides along with use of Green label products are brought to the awareness of farmers through training programmes exclusively made for them from Sarpan.

Consistent efforts were also made over a period of 14 years in dry land regions by Sarpan to educate farmers to use F1 hybrid seeds of high quality, high yield, drought tolerant, extra early and, disease and pest tolerant hybrids, to produce high quality consistent, uniform raw material in large volumes for timely supply to meet the needs of value addition industries in the country. Now farmers are adopting better management practices using F1 hybrid seeds even in rainfed regions in this part of Karnataka. This has shown a ray of big hope to cultivate high quality chilli for export market needs. Involving all stake holders for common need of cultivation of high quality chilli / paprika is the need of the hour to boost further chilli production machinery in these regions.

Wide spectrum of material is researched in the country and at Sarpan to cater to the need of chilli industry to promote exports from India. Seed production technology using cost effective technologies and also CGMS are in use to cater to the quality seed requirements of growers to enhance production of chilli of value for domestic and global markets. It is time that all stake holders need to come on common platform and share their strength and profits to their involvement in promoting chilli / paprika cultivation in country to make India as the evergreen leader in trade and promotion of chilli spice in the global market.

Benefits of Hybrids

Converging multiple quality parameters with good technology in F1 hybrids has brought in big ray of hope for promotion of chilli in the country.

1. F1 Hybrids will provide purity and uniformity in quality parameters for the consumer market.

2. Hybrids will be consistent over seasons, years and locations assuring consistent supply of raw material for the end use.

3. Hybrids will be more productive, economically feasible for cultivation, more remunerative and better adoptable for various agronomic and weather situations.

4. Hybrids will strengthen raw material supply chain and price stability over time.

5. Hybrids with resistance to major pests and diseases would deliver raw material with low pesticide load to the process line.

Conclusion

Consistent, dedicated seed research is carried out in the country over a period of 25 years. Wide spectrum of hybrid varieties is developed at Sarpan Agri Horticultural Research Center to cater to the needs of domestic and export markets. It is the time that all stake holders come on a common platform and share their views and strengths in the interest of cultivation, production and promotion of trade and commerce of chilli with strong scientific base to make India as an evergreen leader in the global market.

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Seed deterioration in seed spices - Causes and understandings

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Introduction

Seed is the most important input for getting higher profits from any crop. Seed being a biological entity is influenced by several factors- both internal and external. The external factors include the environmental factors in which the seed is present like the temperature, relative humidity, lighting conditions to name a few among myriad of external factors. The internal factors include external living matter including the insects, fungal material, bacterial, viruses, physiological composition which includes various types of chemicals that might have formed or accumulated during the growth and development of the seed, not to forget those that are formed during the storage as well as the genetic makeup of the seed itself. When it comes to the factors that may affect the seed, the seed spices are no different all the above factors do affect the seed.

1. Genetic deterioration:

According to Kadam (1942), the major causes of seed deterioration of genetic purity are developmental variations, mechanical mixtures, mutations, natural crossing, minor genetic variations, selected influence of pest and diseases as well as the technique of plant breeder. Some of these factors are manageable while others are not so. By following set of principles, one can manage by minimizing the deterioration caused by developmental variation; influence of pests and diseases, natural out crossing as well as the contamination induced by mechanical mixtures.

1.1 Developmental variations

In seed spices, the flowering and maturity is not synchronous, particularly in coriander and fennel. The main umbels mature first while the later umbels mature in the order of appearance on the plant. Thus at the time of harvest, the seeds of the main umbel are fully formed while the seeds on the young umbels are small and are still immature. Hence, the plants that develop from these late umbels are expected to weak and less competitive in comparison to the plants generating from the fully mature seed of the first umbel. These developmental variations indirectly create competition among the plants at the time of pollination and affect the overall seed quality.

1.2 Mechanical mixtures

Every one is aware of the menace of mechanical mixtures in maintaining the purity in seed lots. Minimum seed standards have therefore been prescribed to tolerate the mechanical mixtures. One of the way impurities induced mechanical mixtures is through proper cleaning of the harvesting



and threshing equipment and the sites as well strict field monitoring at different stages of crop growth for the identification and removal of the offtypes.

The mutations are bound to occur and the spontaneous mutation frequency is roughly about 10^{-7} to 10^{-8} (Koalchuk, Kovalchuk, & Hohn, 2000) although the rates vary among the species (Wolfe, Li, & Sharp, 1987) and among the genes also (Lichtenauer-Kaliqis, *et al.*, 1996). Some genes are more mutable than the others. Most of these mutations are repaired and most of the spontaneous mutations are minor in nature

1.3 Natural Outcrossing

Except in strict cleistogamous crops such as in fenugreek, natural outcrossing is observed although the rates may vary. The outcrossing is therefore the chief cause of genetic deterioration of the varieties, hence a constant problem for the breeders in maintaining the genetic purity in the planting material of any given species. In the crops where the possibility of propagation through vegetation means is possible, the crossing in itself may not be a problem. Seed spices however are propagated through sexual seed only.

Most of the seed spices have either self pollination or cross pollination as a mode of reproduction. Speaking in terms of evolution, both the modes of reproduction- self and cross have their advantages and disadvantages. Short-lived species on the other hand have to establish population in each generation afresh, hence only such genotypes, which are uniform genetically, can quickly reproduce and occupy, and thus self-fertilizers are more adaptive in such situations (Rees and Jones, 1977). While fenugreek exhibits self pollination, coriander, cumin and fennel exhibit various shades of cross pollination. Most of them are also found in small populations with wide distribution. Thus, each and every sub population is important and in such cases each and every plant becomes important as it is supposed to contain import genes/ gene combinations.

The characteristic features of outbreeders (Breese 1989)

- 1. Most of the outbreeders have mechanisms which encourage outbreeding (which also include self- incompatibility); the populations are heterozygous and are heterogeneous.
- 2. The loss of heterozygous balance through inbreeding leads to a decrease in expression of those characters showing directional dominance and epistasis (inbreeding depression).
- 3. Because of the heterozygous and heterogeneous nature, the populations are particularly vulnerable to change in gene and genotype structure through selection.

Care to be taken to maintain the proper genetic structure of a the variety (Breese, 1989)

- 1. Avoid contamination by foreign pollen or seed through proper isolation and seed handling techniques
- 2. Minimize the genetic drift by ensuring sufficient population size and reducing opportunities for natural selections.
- 3. Securing effective random mating through appropriate pollination techniques.

1.4 Clean Seed production in seed spices

1.4.1 Site

For quality of production of seed spices, crop rotation is recommended. This is particularly necessary in case of cumin, so that the inoculum build-up of wilt and root related diseases is lower.



Dehiscence of seed in seed spices is noted. Thus there is a possibility of the germination of seed from the previous generation is a menace in maintaining genetic purity of the seed. Crop rotation helps in countering such problems which are induced due to dehiscence.

1.4.2 Pollination and isolation

The cross pollination is common in seed spices except in fenugreek and to some extent in cumin. Hence, proper isolation distance should be maintained for seed production plots. The general isolation distance in cross pollinated crops should have a minimum isolation distance of 500 m when the crop is to be used for further seed production, otherwise 200 m is usually considered sufficient.

1.4.3 Crop establishment

In general seed spices particularly from the umbelliferous crops germinate slower. It is ideal therefore to raise a seed crop only during the main season and at the optimum planting time. Since the germination is slower, there is high competition to the young plants from the weeds. Thus seed production plots requires weeding operations.

1.4.4 Roguing

The roguing operations for these crops is extremely important. The initial roguing should be made while the crop is still in the vegetative stage, well before the start of anthesis. Satisfactory isolation should be confirmed at this time; confirm that isolation is according to specified requirements of the seed certification agency. A second roguing should be at the start of anthesis, when the flower colour should be checked. At this time flower colour should correspond to the species and appropriate cultivar description.

1.4.5 Harvesting

The optimum stage for harvesting and securing the best potential seed yield is usually within a period of 6 days, otherwise seed is lost through shattering. Hence, the timing of harvesting operations is critical in order to secure the maximum yield. The All India coordinated Spices Project at S K N College of Agriculture, Jobner have prepared well defined guidelines on harvesting procedures as part of GAP and the same should be practiced.

1.4.6 Drying

Rapid seed deterioration occurs if the moisture content has not been reduced to 9% or less prior to up to 6 months' storage. The moisture content should be reduced to less than 7% at the start of longer storage periods. All samples intended for longer term storage should be less than 5% moisture content.

1.4.7 Seed processing

These crops can normally be processed satisfactorily with an air/screen cleaner.

2 Seed Deterioration

Seed deterioration is an important aspect of seed storage. A physiological understanding of the seed deterioration is therefore needed to appreciate appropriate storage methods suggested. Rape-seed mustard seed is an orthodox type, i.e. the seed needs a certain period of dormancy. The general understanding of seed deterioration in orthodox seeds is given below based on Mc Donald (2004).



Seed deterioration is inexorable, and the best that can be done is to control its rate. Many factors contribute to seed deterioration. These include genetics, mechanical damage, relative humidity and temperature of the storage environment, seed moisture content, presence of microflora, seed maturity, etc. Of these, relative humidity and temperature are the two most important. Relative humidity is important because it directly influences the moisture content of seeds in storage as they come to equilibrium with the amount of gaseous water surrounding them. Temperature is important because it (1) determines the amount of moisture the air can hold (higher temperatures holding more water than lower temperatures) and (2) enhances the rate of deteriorative reactions occurring in seeds as temperature increases. These relationships are so important that Harrington (1972) identified the following two thumb rules describing seed deterioration:

Rule 1: Each 1 percent reduction in seed moisture content doubles the life of the seed.

Rule 2: Each 5°C reduction in seed temperature doubles the life of the seed.

First, rule one does not apply above 14 or below 5 percent seed moisture content. Seeds stored at moisture contents above 14 percent begin to exhibit increased respiration, heating, and fungal invasion which destroy seed viability more rapidly than indicated by the moisture content rule. Below 5 percent seed moisture, a breakdown of membrane structure hastens seed deterioration (probably a consequence of reorientation of hydrophyllic membranes due to the loss of the water molecules necessary to retain their structural configuration). For the second rule, for temperatures below 0°C the rule may not apply because many biochemical reactions associated with seed deterioration do not occur and further reductions in temperature have only a moderate effect in extending seed longevity. Finally, it should not be forgotten that these two factors, seed moisture content and temperature, interact with each other.

A general assumption is that seed deterioration occurs uniformly throughout a seed, but a seed is a composite of tissues that differ in their chemistry and proximity to the external environment. Thus, it should not be assumed that seed deterioration occurs uniformly throughout the seed. Perhaps the best example that this does not occur comes from the use of the tetrazolium chloride (TZ) test which causes living tissues in a seed to turn red. The challenge to the seed researcher/ analyst is to decipher how important the living (or dead) tissues are to successful seedling establishment. When studies have been conducted on seeds using controlled natural and artificial aging conditions, differences in the deterioration of seed tissues have been observed. For example, in wheat seeds, deterioration begins with the root tip and progressively moves upward through the radicle, scutellum, and ultimately the leaves and coleoptile.

Our understanding of the events that cause seed deterioration remains incomplete. Mc Donald (1999) identified at least six reasons why it is difficult to critically evaluate seed deterioration studies:

- 1. The physiological processes governing seed deterioration vary. For example, short-term deterioration in the field is likely a different physiological event than long-term deterioration in storage.
- 2. Seed researchers use different methods to study seed deterioration. They can precisely control short-term seed deterioration under high temperature, high relative humidity accelerated aging conditions, but is this process physiologically equivalent to the conditions occurring in natural, long-term storage conditions?
- 3. The rate of seed deterioration is influenced by confounding environmental and biological factors such as growth of storage fungi that create their own biological niche.

- 4. Influence of seed treatment on seed deterioration and, their impact on seed quality must be recognized.
- 5. Most seed deterioration studies examine whole seeds. As emphasized, seed deterioration is not uniform within a seed and any study of seed deterioration should begin with an understanding of where seed deterioration occurs first.
- 6. Most seed deterioration studies report effects on a seed lot, but seed deterioration is an individual event occurring in a population of seeds composing the seed lot. Studies using bulk seeds are inappropriate.

Our quest to better understand orthodox seed deterioration has led to a variety of proposals. These include changes in the following:

- *Enzyme activities:* Most of these studies search for markers of germination such as increases in amylase activity or changes in free radical scavenging enzymes such as superoxide dismutase, catalase, peroxidase, and others.
- *Protein or amino acid content:* The consensus is that overall protein content declines while amino acid content increases with seed aging.
- *Nucleic acids:* A trend of decreased DNA synthesis and increased DNA degradation has been reported. It is widely believed that degradation of DNA would lead to faulty translation and transcription of enzymes necessary for germination.
- *Membrane permeability:* Increased membrane permeability associated with increasing seed deterioration has been consistently observed and is the foundation for the success of the conductivity test as a measure of seed quality.

Each of these general findings represent the result, not the cause, of seed deterioration. As evidence mounts, the leading candidate causing seed deterioration increasingly appears to be free radical production. Free radical production, primarily initiated by oxygen, has been related to the peroxidation of lipids and other essential compounds found in cells. This causes a host of undesirable events including decreased lipid content, reduced respiratory competence, and increased evolution of volatile compounds such as aldehydes.

2.1.1 Free radicals – what are they and why are they important?

All atoms that make up molecules contain orbitals that occupy zero, one, or two electrons. An unpaired electron in an orbital carries more energy than each electron of a pair in an orbital. A molecule that possesses any unpaired electrons is called a free radical. Some free radicals are composed of only two atoms (O2 -) while others can be as large as protein or DNA molecules. Why is the free radical important in biological systems? The energetic "lonely electron" (1) can detach from its host atom or molecule and move to another atom or molecule or (2) can pull another electron (which may not have been lonely) from another atom or molecule. The most common free radical reaction is when one free radical and one non-free radical transfer one electron between them, leaving the free radical as a non-free radical, while the non-free radical is now a free radical. This initiates a chain of similar reactions which cause substantial damage in the interval that the reactions are occurring. Thus, free radicals can react with one another and with non-free radicals to change the structure and function of other atoms and molecules. If these are proteins (enzymes), lipids (membranes), or nucleic acids (DNA), normal biological function is compromised and deterioration increased. The positive association of free radicals with animal aging has recently been reviewed. What still remains uncertain is their role in orthodox seed aging.



Lipid peroxidation begins with the generation of a free radical (an atom or a molecule with an unpaired electron) either by autoxidation or enzymatically by oxidative enzymes such as lipoxygenase present in many seeds. Various forms of free radicals have been observed or detected in living tissue, each with a differing capability for cell damage.

Superoxide anion (O_2) . Superoxide anion is produced by autoxidation of hydroquinones, leukoflavins, and thiols as well as enzymatically by flavoprotein dehydrogenases such as mito-chondrial NADHdehydrogenase.

Hydrogen peroxide (H_2O_2) . Hydrogen peroxide is produced by the spontaneous or enzyme-catalyzed dismutation of O_2 or by two-electron reduction of O_2 . Flavoenzymes such as monoamine oxidase present on the outer mitochondrial membrane of virtually all cells are probably the most important contributors to intracellular generation of H_2O_2 . These enzymes which normally use O_2 as a substrate catalyze two-electron transfer reactions that produce H_2O_2 .

Hydroxyl radicals (OH). Hydroxyl radicals are formed from O_2 and H_2O_2 in the presence of iron which catalyzes the reaction. In cells, iron can be bound to compounds such as adenosine triphosphate (ATP), guanidine triphosphate (GTP), and citrate, thereby forming a more soluble iron-chelate complex. OH is by far the most reactive oxygen radical, and it reacts almost immediately with any molecule at the site where it is generated. The main mechanism of toxicity of H_2O_2 and O_2 may be their ability to combine to form OH.

Singlet oxygen $({}^{1}O_{2})$. During lipid peroxidation, ${}^{1}O_{2}$ can be generated in the termination step:

$$LOO \bullet + LOO \bullet \rightarrow LO + LOH + {}^{1}O_{2}$$

and in the reaction with triplet carboxyls formed during lipid peroxidation:

$$RO^* + O2 LO + {}^{1}O_2$$

Singlet oxygen combines with DNA bases causing genetic damage.

2.1.2 What is the influence of seed moisture content on free radical assault?

Lipid peroxidation occurs in all cells, but in fully imbibed cells, water acts as a buffer between the autoxidatively generated free radicals and the target macromolecules, thereby reducing damage. Thus, as seed moisture content is lowered, autoxidation is more common and is accelerated by high temperatures and increased oxygen concentrations. Lipid autoxidation may be the primary cause of seed deterioration at moisture contents below 6 percent. Above 14 percent moisture content, lipid peroxidation may again be stimulated by the activity of hydrolytic oxidative enzymes such as lipoxygenase, becoming more active with increasing water content. Between 6 and 14 percent moisture content, lipid peroxidation is likely at a minimum because sufficient water is available to serve as a buffer against autoxidatively generated free radical attack, but not enough water is present to activate lipoxygenase-mediated free radical production.

Lipoxygenases may contribute to cell degradation by modifying cell membrane composition. In higher plants, two major pathways involving lipoxygenase activity have been described for the metabolism of fatty acid hydroperoxides (Figure 1). One pathway produces traumatic acid, a compound that may be involved in plant cell wound response and volatile C6-aldehydes and C6-alcohols shown to be correlated with seed deterioration. The other pathway produces jasmonic acid, a molecule that may play a regulatory role in plant cells. Lipoxygenases have been identified and associated with almost every subcellular body in plants, so it is likely that they have



important regulatory roles in development. This may include the deterioration of hydrated seeds through free radical production.

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SESSION - III

Success stories and innovations at farmers level entrepreneurship

Industrial requirement to orient planting material production in spices

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Introduction

In spite of a global economic slow during the year 2014-15, which continues through the current year as well, the growth of the Indian spice industry and its exports have continued its increasing trend both in volume and value. During the FY2014-15, a total of 8,93,920MT of spices and spice products valued Rs.14899.68crore (US\$2432.85 Million) has been exported from the country as against 8,17,250 tons valued Rs.13735.39crore (US\$ 2267.67 Million) in 2013-14 registering an increase of 9% in volume and in value 8% in rupee and 7% in dollar terms. The industry is targeting to attain an export of US\$5 Billion by 2020. However, the industry is facing innumerable challenges for attaining the goal as ever before. Challenges due to globalisation (increased competition from other producing counties, especially from ASEAN); challenges due to new stricter legislations and regulations (which includes apart from the existing ones, newer labelling regulations, too low tolerance on foreign materials including admixture, full traceability on raw materials, stricter agrichemical residue levels etc.); rising costs (due to increasing raw material prices, rapid depreciation of currencies, much more cost on food safety, increasing cost on compliance and business continuity planning (BCP). The consumer on the other hand is demanding low/reasonable pricing, perfectly safe food, full transparency on product and raw materials, good taste, good function (health), good packaging etc. For meeting the consumer expectation, the importer is demanding full traceability, safe products, and reasonable price by cost saving efforts, quick response and punctuality. Thus the Indian spice industry, which starts with the farmer at the upper end of the supply chain to the retailer at the bottom end of the chain, has to align in the same philosophy, dynamic requirement and taste of the final consumer.

In 2-14-15 US was the major importer of spices from India followed by China, Vietnam, Malaysia, the UAE, the UK, Germany, Saudi Arabia, Thailand and Sri Lanka. It is interesting to note that except for USA, EU (UK and Germany) and the Gulf (UAE and Saudi. Arabia), rest of the importing countries are our major competitor for world spice market. Industry faces severe shortage of raw materials of desired quality at competitive prices. Most of the exporting spice industries are importing 35-40% of the requirement of raw materials from other producing countries as there is severe shortage of raw materials of required quality within the country (Table 1). For vz. pepper is imported from Sri Lanka, Vietnam and Indonesia; turmeric from Myanmar, Vietnam and Indonesia; ginger from Nigeria, Myanmar, Ethiopia, Peru, Ghana; nutmeg from Sri Lanka, Indonesia etc.



Table1.Quantity of selected spices showing the Export and Import of spices-2014-15

India is the largest producer, consumer and exporter of spices. While India produces almost whole range of (75 of the 109) spices, countries like Vietnam and Indonesia focus on 5-6 items of spices only. India produces spices in small and medium holdings, other countries produces in large plantations. This make them cost advantageous, hence lower price and more competitive. Monsoon dependant cultivation in India affects both quantity and quality of production. India's historical position as the "spices capital" of the world is visibly under threat.

WSO-AISEF has shortlisted four important spices – pepper, chilly, cumin and turmeric for sustainable spices initiate in the country. It may be noted that these spices are traditional spices of the country and together they contributes 66% quantity and 50% on value of exports out of India (table 2.). There is tremendous scope for increasing the production of these commodities within the country. Controlling quality at source will be critical for India for which the industry will have to directly engage with the farmers to ensure safety and quality of the produce.

Table 2. Quantity and Value of export of the four important spices shortlisted by WSO-AISEF. (2014-15)

	Qty (MT)	% to total.	Value (Rs.Cr)	%to the total
Total Exports of spices from India	893920	100	1489967	100
Export of Chillies	347000	38.82	351710	23.61
Export of Cumin	155500	17.40	183820	12.34
Export of Pepper	21450	2.40	120842	8.11
Export of Turmeric	66675	7.46	74435	5.00
	590625	66.07	730807	49.05

1. Black Pepper

Black pepper is indigenous to Kerala, known better in a historical context as the "Malabar Coast", and its plentiful supply here had for long been kept a secret to the outside world by the seafaring traders insecure about everlasting profits. Of all the "spices of the East", pepper was much in demand in the old world because its origins remained a mystery and the transfer of the produce across the shores an enormous chore.

The country has, of late, been facing a stiff competition from Vietnam in international pepper market. That's not all. India's imports from Vietnam had also surged last year. Vietnam accounts for about 30 per cent of the world's total pepper yield and about 50 per cent of its export volume. The US, the UAE, the Netherlands and India are the leading consumers of Vietnamese pepper.

"Many of the indigenous varieties of pepper vines conducive to our geographical and climatic conditions have disappeared over the decades. The present ones are prone to be easily afflicted by the diseases. So, it is important to make available planting material to the farmers

With the cultivated area shrinking steadily in India, pepper production also fell to 50,000 tons by 2010 from 79,000 ten years ago. In Kerala alone, area under pepper cultivation fell from 172,182 Ha to 85,335 Ha in a single year from 2010-11 and production plummeted to 37989 tons from 45267 tonnes, according to the state's Economic Review. Pepper cultivation is on a never-before decline in Kerala, the land of its origin. Are we witnessing the end of a region's historic role?. An irrevocable tragedy, on the anvil.

The industry feels that if India is to retain its dominant position in global spice trade it is imperative that it is ensured that productivity of major spices like pepper, turmeric, ginger etc is improved drastically. At present ours is one of the lowest with the result that there is a fear of Indian spices not being competitive compared to other producing origins. We have a large domestic market with a large demand for spices and hence it is crucial that our production is sufficient enough to meet this requirement and have a comfortable export surplus. We have already lost our dominant position in pepper and cardamom global export trade and it could happen in other spices as well if we do not take the right measures.

Industry suggests that there is need to develop pepper varieties that are high in piperine and oil content similar if not better than to Sri Lanka otherwise Indian oleoresin processors will continue to import such types of pepper from other origins as they are doing now. Over the years industry assess under field condition that despite scientists and researchers coming up with many new varieties over the past decades, (Panniyur has gone up to 8 and so also karimunda) it is still the older ones that are being favoured by farmers — Panniyur I, karimunda and local cultivars, the most popular varieties being cultivated by farmers. So is there something missing in all the Rand D work that is being done that none of the new varieties seem to be attracting the attention of the farmers for whom these are intended ?

1. Chilli (Red Pepper)

India commands roughly 65 % of the total global market of oleoresin, spice oils etc, but currently on a diminishing trend. China has emerged as the largest paprika producer..China's paprika production has crossed 1.5 lakh tonnes and this volume has enabled it to sell the spice cheaply in the global market. China's paprika chilli extract is about 20% cheaper due to higher productivity of oleoresin and zero pungency compared to Byadagi chilli. Indian oleoresin industry finds it cheaper to import crude Chinese paprika extract, value add through reprocessing and exporting it. Contrary to "Make in India" programme of Government of India, many leading Oleoresin exporters have set up manufacturing units in China to buy and process paprika locally.

India exported 11,475 tonnes of oils and oleoresins valued at Rs 1,911 crore during 2014-15. On the quantity front increase was just 1% compared to the previous financial year. The fact that the growth in export of high-end value added products from the country is on the decline while spices used in the industry for mass consumption like curry powders/masala/ready to cook ingredients are on a fast tract.



In order not to further lose ground, efforts are to be made to improve productivity and also to remove the existing pungency of Byadagi chilli or promote paprika like chilli in suitable areas of the country or develop paprika like varieties suiting to tropical climate. Contaminants, both physical and chemical, adulterants, microbial contaminants and aflotoxins, and others, lack of uniform quality in quantity as desired by the industries are few of the problems at the industrial level.

Chilli market received a further setback this year with the crop in rainfed areas dropping by over 60% to 20,000 tonne due to scanty rainfall. The crop in irrigated regions has not been much affected. "As the productivity of Byadagi chilli has gone down (around 400kg/acre), growers are shifting to hybrid pungent varieties which give better yield, above 2000kg/acre.

2. Turmeric

For over 5,000 years, turmeric has been used throughout India, China and Indonesia as a spice and medicinal agent. But only recently has it started capturing imaginations around the world – as a panacea and a palliative for a wide range of ailments. So much so that it has been granted "Generally Recognised as Safe" (GRAS) status by the USFDA. Although exports are just above the \$100 million mark – not significantly high considering its potential – the focus of international attention is slowly shifting to turmeric and its extracts. Going by the growing interest, turmeric trade is all poised for a quantum leap in terms of number of international takers in the near future. And being the only bulk producer of turmeric (India accounts for about 80% of world turmeric production), India holds a near monopoly over its exports.

Turmeric is widely grown in the southern peninsular region of India. Andhra Pradesh and Tamil Nadu are the two major turmeric producing states contributing nearly 70% to the total produce, followed by Odisha, West Bengal, Maharashtra, Karnataka and Kerala. The Alleppy Finger Turmeric (AFT) grown in Kerala is popular for its rich content of curcumin – around 6 to 6.5%. This type of turmeric finger is usually the preferred variety of turmeric exported to USA. However, availability of true Alleppy turmeric has declined Even good quality seed materials are not available for any large scale cultivation of AFT. On the other hand, Madras Turmeric is widely grown in districts like Salem, Erode, Coimbatore, Dharampuri areas of Tamil Nadu. This variety is usually traded in the Erode market, which is one of the biggest trading centers of turmeric in India. These mustard yellow coloured rhizomes – underground root of thick mass – comprise nearly 3-3.5% of curcumin. The curcumin content of the turmeric is decreasing year after year, which is a concern for the industry,

Similarly, Andhra Pradesh, the biggest turmeric producing state in India, is known for Nizamabad Turmeric grown in Nizamabad, Guntur, Karimnagar and Kadapa districts of the state. This type of turmeric is pale yellow and the curcumin level is not more than 2%. The Middle East is one of the major markets for this variety of turmeric. During the years of cyclonic rains where the crop get damaged, availability of quality seeds becomes a periodic problem of cultivation in that region, for which an effective seed production mechanism may be derived. Another variety Rajapuri Turmeric is largely grown in Maharashtra and is marketed through Sangli and Mumbai trading centers. It is slightly superior to the Madras variety with curcumin content of 3.5-4.0%. This type of turmeric is mostly exported to the Japanese market in polished form. Some of the other well know varieties are Duggirala Turmeric grown in Guntur district of Andhra Pradesh, Dehradun local, Daghi and Lakadong produced in the North East region with high curcumin content,

Surprisingly, the productivity of turmeric in India has been on a decline over the last few years due to a couple of factors. Two major cyclones, coupled with unseasonal rains in Andhra Pradesh and surrounding coastal areas during last couple of years, have lowered the yield of turmeric in

these belts. The possibility of genetic deterioration in quality of the planting materials of the traditional varieties may also be looked into by researchers.

Oleoresins from turmeric are in high demand globally in the present times. This highly processed liquid of turmeric is of brownish dark-yellow appearance and finds usage in pharmaceutical and food industry and a shift away from synthetic colour all over the world. This is the reason for turmeric oleoresins exports witnessing a CAGR of 24% in the last five years. AFT and turmeric with above 5% curcumin is preferred by the Oleoresin industry and this variety is to be promoted for cultivation in suitable agro-ecological zones.

India must enhance its product quality, cleanliness of fingers, etc. 165. India must also improve total productivity to remain in dominant position, so that it continues to supply at most competitive prices. For this, the area under high yielding cultivars needs to be increased by supplying desired quality turmeric seeds and also micro tubers multiplied through tissue culture.

Industry observes that production of high curcumin content turmeric has been declining rapidly. This has led to industry especially oleoresin processors importing Turmeric of 5 % and above from Vietnam and Indonesia in fairly substantial quantities .. Why is it that we are unable to produce the type of Turmeric required by the industry? Despite attempts in the North east and Orissa no significant impact has been seen So we are witnessing a repeat of pepper scenario in turmeric in near future as a global player and it could happen in other spices as well, if we do not take the right measures. Industry is committed for sourcing materials if quality materials are made available but price should be competitive enough to enable exporters compete in the global arena with other origins: otherwise no business will be forthcoming. Remunerative pricing can not be ensured by the industry, but market rate can be ensured. Exporters have had experiences where we were advised that good quantities of high curcumin content turmeric were available but we did not receive any samples for testing despite many requests / reminders and in the case . Past experience of the industry with R&D institutions were not that encouraging, and when the industry did get a sample, the curcumin content was far below 5 %. All this calls for greater cooperation and understanding of industrial requirements. Otherwise industry will continue to struggle sourcing the required quality materials in right quantity.

4. Cumin

For the past 5 years from 2010-11, the export of all spices from India has increased nearly by 117% while that of seed spices as a group has increased by 268% over the same period. During 2014-15, the export of seed spices was 2,41,900 tonnes valued at Rs 2650.46cr. Share of Cumin alone is 58% in volume and 68% in value followed by coriander (17% & 18% respectively), 10% volume for celery and 9% for Fennel. Fenugreek and the rest of the seed spices contribute to the remaining 6% in volume.

Cumin is mainly cultivated in the dry parts of western Rajasthan and Gujarat. Major competing countries for India are Syria, Turkey, China and Iran. With production in Syria and Turkey being affected by war, Indian cumin is of higher demand internationally. NRCSS, Ajmer has already identified that the poor productivity of cumin is largely due to the low adoption of high yielding varieties by farmers and poor seed replacement rate (SRR). In addition, wilt disease infestation during initial growth phase and blight disease during post flowering stage cause heavy damage to the crop. Frost injury and *Alternaria* blight infestation add to farmer's misery. As the major reasons for low productivity of cumin is already identified, a systematic seed replacement approach with suitable high yielding varieties is the only solution for increasing production and productivity in Cumin.



5. Importance of planting materials in crop production.

"What you sow is what you reap" the proverbial truth everyone understands, but miserably ignores when we come to farming. The following questions one need to address for ensuring quality planting material production are

- > Where do farmer get his planting materials?
- > Do we have location specific knowledge of which variety to be grown?. If so why low adoption?
- > Do we have certified mother gardens for sourcing genuine materials for mass planting material production? If so who certifies it?
- > Do we have a system to know authenticity of the variety by the farmer?
- > Do we have any traceability of the planting materials being produced and distributed for its cultivation, like bar coding or other forms of record keeping?
- > Do we have Good Nursery Practices developed and laid out for each spices under commercial cultivation and do we have the level of adoption of the GNP, if recommended?
- > Do the government, nodal agencies like DOASD, SAUs/ICAR or others have programmes to identify and promote cultivation of suitable varieties supplying certified seeds for production of uniform quality produce in any agro-ecological zones and liking with markets/processors/consumers?
- > Many a times, farmers are not able to achieve the level of production they used to achieve 25-50 years back with then practiced local varieties with the present HYV introduced?
- > Do we have a system to promote time tested local varieties that were traditionally cultivated (local suitability is already time-tested) through other agencies like farmer groups, NGOs etc?

Conclusion

The industry is of the opinion that fifty per cent of productivity issues in spices could be addressed, if genuine quality planting materials of the right variety suiting to the agro-ecological zone is made available for the farmers with the right technology. All the varieties distributed for cultivation should be certified and barcoded for authenticity and traceability of varieties distributed for cultivation.

Large scale production of healthy planting materials in Karnataka, Tamil Nadu and North East through grower's participatory approach

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Black pepper is propagated vegetatively through rooted cuttings and also by direct planting of runners and orthotropic shoots. Nursery diseases act as the major constraints in the production of quality rooted cuttings. Another alarming factor is that if cuttings from infected nurseries are planted in the main field, the diseases are also carried to the main field resulting in their wide spread. Poorly managed Nurseries are the main sources of two viral, four fungal, two nematode diseases and also seven insect pests. Often unwitting planting of inferior genetic stock also contribute to the low production. Remunerative prices in the last three years have rejuvenated the interest on the crop. The growers and corporate companies are making all-out efforts to introduce black pepper as profitable crop in the coffee, tea, cardamom, arecanut and coconut plantations. Small mono crop blocks are also being raised in many potential plantation zones. The crop has got great potential to be grown in non traditional areas such Pondicherry, Goa, Maharashtra, Andhra Pradesh, Odisha, West Bengal, North Eastern States, Andaman and Nicobar islands. There is huge demand for new varieties like Thevam, P-5, Virus free P-1, Girimunda, Arka-excel, Malabar-excel, P-8 and some traditional varieties like karimalligesara, vadakkan, kottanadan and karimunda. The success achieved through the active participation of elite growers and large plantations in many potential plantation zones of India is summarized below.

Areas covered

Assam	:	North Bank, Lower assam, centeral Assam, Misa area and Upper assam
West Bengal	:	Doars Area in JalpaiguriDistrist.
Megahalya	:	Small gardens bordering Assam.
Tamil Nadu	:	Gudulur, Pachalur, Tandikudi, Sirumalai, Valparai, Yercad,
Karnataka	:	Kodagu, Hassan, Chikamagaluru, Shivamogga, Dakshina Kannada, Uttara Kannada and BR hills.
Kerala	:	Wayanad

Major Nursery Problems recorded in different areas

Assam: Bulk selection of planting material, Over grown plants, Badna virus infection, Gallmidge and nematode infestation and *Phytophthora* infection.



- Meghalaya: Poor growth, poor genetic stock, Badna virus infection,Gallmidge, nematode infestation and *Phytophthora* infection.
- West Bengal: Bulk selection of planting material, *Phytophthora* infection, Badna and CMV infection.
- Karnataka:Badna virus infection, *Phytophthora* infection, anthracnose (*Colletotrichumg loeosporioides*) infection, false shooting, Gallmidge, nematode infestation, scales, marginal gall thrips, rotting of cuttings due to *Rhizoctonia* infection.
- Tamil Nadu:Badna virus, *Phytophthora* infection, anthracnose infection, false shooting, Gallmidge, nematode infestation, scales, marginal gall thrips, rotting of cuttings due to *Rhizoctonia* infection.
- Kerala(High elevation areas):Badna virus infection, *Phytophthora* infection, anthracnose infection, Gallmidge, nematode infestation and scales.

Holistic steps followed in different nurseries

- 1) Identification of nucleus plantations and selection of location specific virus free high yielders
- 2) Establishing nucleus multiplication units and varietal bank
- 3) Establishment of small poly houses for introduced varieties to eliminate chances of new introduction of pathogens
- 4) Preparation of soil mixture, solarization and fortification of bio agents
- 5) Training to field staff on all aspects of nursery management, importance of timely operations, avoidance of dripping and identification of various pest, disease and abiotic problems and their management
- 6) Random visits and constant monitoring of all operations
- 7) Mandatory implementation of phyto-sanitary and prophylactic measures
- 8) Grading and hardening of rooted cuttings
- 9) Distribution of varieties to different growing conditions
- 10) Organizing field and nursery visits to educate growers and workers on refinements to be followed in next course of action

Suitability of varieties based on actual field observations in different agro climatic zones

- 1) P-1: best yielder in all locations under optimum management conditions not suitable clayey soils, high shade , high rain-fall zones and high elevation(Above 1200m)
- 2) P-5: good yielder in all elevation and different cropping system and performs well even under shaded conditions
- 3) Thevam: best yielder under protective irrigation, suitable in all elevation upto 1500m under various cropping system. Tolerant to wilt and high soil moisture conditions
- 4) Panchami: suitable to high rain, high elevation and shaded plantations. Moderate yielder

even under high elevation and resistant to anthracnose

- 5) Kottanadan and Neelamundi: Moderate yielders in all locations particularly as mixed crops in tea plantations. Performs well even under clayey soils
- 6) Karimalligesara, Kaniakadan andBalehalli selection(Sirsi):Suitable as mixed crops in arecanut plantations
- 7) Karimunda selections (Sreekara, shubakara and P-6): Suitable in all moderate rainfall and shaded areas. Assured high quality black pepper.

Propagation methods adopted

Single and double nodal cuttings, rapid multiplication through split bamboo/PVC pipe method, serpentine layering on polybags and humus bed, vertical multiplication system(column method), compact multiplication system and in-situ rooting of runners(serpentine method)

Area	Varieties	Number of rooted cuttings (lakhs)
Assam, Dores in Jalpaiguri and Meghalaya	P-1, Kottanadan, Aimpriyan, Thevanmundi	3.5
Tamil Nadu	P-1, P-5, Aimpriyan, Chomala and Thevam	1.5
Kerala	P-1, P-5 and Thevanmundi	1.2
Karanataka	P-1, P-5, Chomala, Thevam, Karimundaselections,Vadakkan, Karimalligesara,Jeerakamundi, Neelamundi, Kurimaleai, Panchami, Sreekara,Shubakara, P-6 and Kaniakadan	17.5

Quantity of rooted cuttings produced in 2015 planting season

Way forward:

Production of healthy planting material is the need of the hour and demand for quality planting material is ever increasing. To meet this demand supply has to be accelerated with the co-operation of all crop research and development agencies. Varietal banks are to be established in all potential zones and mass multiplication of location specific varieties should be taken up with active participation of planters and self-help groups. In this process grower level/corporate level/ group level network of certified nurseries are to be established through timely implementation of common guidelines, technical package and timely monitoring of production package, sufficient quantity of quality planting material can be achieved.



Income enhancement through crop diversification and seed production

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Mr. Devrajbhai Amthabhai Patel, resident of village Varsada, Taluka Kankrej, Dist. Banaskantha, Gujarat is holding 25 acres of land. Kankrej is one of the backward Talukas of Banaskantha district. The traditional cropping pattern of Mr. Patel was mustard, cotton, castor and cumin before 2004. In spite of very high potential land he was earning only about Rs. 3.0 lakhs from cultivation of these crops annually due to traditional method of cultivation and use of either local or very old varieties. In order to introduce fennel as a new cash crop and demonstrate the technologies of cumin the field demonstrations of recently released variety Gujarat Fennel -11 with Gujarat Fennel – 2 and Gujarat Cumin – 4 with Gujarat Cumin-2 was conducted in this area under All India Coordinated Research Project on Spices by CRSS, Jagudan in 2004. Very encouraging results obtained in these demonstrations. This has motivated Mr. Patel to replace mustard crop by fennel and also extended the area of cumin. The others farmers of this village and neighbouring village also started sowing fennel and now fennel has become major source of income as well as profit of the farmers. Inspiring from the trainings organized by SSRS, SDAU, Jagudan Mr. Patel started seed productions Gujarat Fennel - 11 and Gujarat Cumin - 4. Last year he produced about 5000 kg of Certified/TF seeds of GC-4 and 2000 kg of GF-11 and distributed among farmers of this area and surrounding belts also. His farm income is increased from Rs. 3.0 to 15.0 lakhs by diversification of the crops and seed production programme. Mr. Patel was awarded as best farmer for crop diversification and seed production by S. D. Agricultural University, Sardarkrushinagar, Gujarat in the year 2011.



Advances in Planting Material Production Technology in Spices

Bush pepper – A profitable venture by an innovative farmer

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It may sound impossible to reap huge income from a small scale agri-enterprise. But the case is true for Mr. Jojo, an enterprising youth who runs a horticultural nursery. He has mastered the art of bush pepper making and became successful in its marketing. Bush pepper is a miniature pepper plant rooted from lateral branches of a pepper vine. Literally the bushy growth habit adapted for cultivation in pots and fullness of spikes all around gives the plant an ornamental attire for onlookers. Nowadays bush pepper peps up every home. It has become a sought after ornamental spice meeting the culinary need and aesthetic sense of most of the urban and semi-urban people. It has the charm of producing green berries throughout the year with less care and hassle free harvesting by virtue of possessing the ability to grow without support. This makes every roof top, veranda, sit out and court yard accessible to the plant.

Mr.Jojo was impressed by the demand for bush pepper plants and the premium price offered by the customers for few of his yielding potted plants displayed in the nursery. The usual method of bush pepper making is by using three noded cuttings of lateral branches and induction of rooting using hormone at controlled conditions. The success in this method was very low fluctuating from 10 to 40 per cent only. The saying 'practice makes a man perfect' is true regarding the propagation skills of Jojo. He has perfected many propagation techniques in fruit plants like rambutan and spices like nutmeg.

Jojo with a penchant for care of plants has learned the scientific principles of plant propagation from Krishi Vigyan Kendra of Indian Institute of Spices Research, Kozhikode. He was the young farmer award winner of Kerala government and National award winner among youth from Indian Agricultural Research Institute, New Delhi for his outstanding horticultural nursery and integrated farming activities. Usually the side shoots of pepper plants in pots are not taken for bush pepper production, for the fear of reduced growth. Jojo started his trials on the plants in pots and arrived at a new production technique of bush pepper that can produce bush pepper in tandem from yielding plants in pots.

The new technique of Jojo is simple and results in quick production of bush pepper without affecting the parent plant in the pot. The method simply induces rooting below the nodes of a branch by keeping the node in close contact with soil-FYM mixture taken in a polybag, kept on the surface of potted mother plant with sufficient branches and spikes. The branch is held in good contact with soil by using an inverted 'V' shaped support of fresh coconut midrib. Watering is done twice daily. After about 40 days, the roots emerge from the nodes. The new bush pepper plants in the polybag can be removed from mother plants after three weeks and can be marketed at attractive prices.

He has identified a superior clone of the most popular cultivar, Karimunda from his garden. The cultivar has high spiking intensity with frequent bearing of two spikes per node of the lateral. The



speciality of the clone and its performance are the reasons for queuing up of public in his nursery for bush pepper. He has also succeeded in layering of bush pepper too like many other horticultural crops. He has developed methods to revitalize bush pepper and speed up the vigour and growth by pruning off of the spikes to control spiking behaviour. For a three year old bush pepper plant with full spikes, the price offered is up to Rs.500 making bush pepper the most promising product in the local market.

Nowadays bush pepper is a sought after gift for house warming, beautifying the landscapes and fulfilling herbal and culinary needs of the homes. Indeed it is true that from a good yielding pepper vine of six years, production of more than twenty five bush pepper plants is quite possible. Hence thousands of rupees can be earned through bush pepper from a single vine if planned properly.

(The farmer can be contacted in the following address: Jojo Jacob, Randuplackal House, Avadukka P.O., Kozhikode-673528, Kerala, Phone - 09446668879)



Bush pepper in the Home yard of Jojo



Innovative technique for multiplying bush pepper



Multi-spiked variety



Multi-spiked branches of elite selection
Participatory mode production of rooted planting materials of black pepper for rehabilitating pepper gardens in different agro-ecological units of Kerala

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Introduction

Black Pepper production in the country has declined (28%) from 73,210 tones in 2003-04 to 52,616 tonnes in 2012-13. Kerala, which is a main contributor showed a decline of 33 % in production from 69,015 tonnes to 46,298 tonnes in the same period. Kannur district of Kerala which ranks 3rd in area and production next only to the hilly districts of Idukki and Wayanad, represents an important production area among the plains of Kerala, where almost 42% of decline in production is noticed. The low productivity of pepper is mainly due to the poor soil health status and improper management practices along with changes in climatic factors. This ultimately results in incidence of biotic and abiotic stress. Predominance of senile and uneconomic vines also contributes to low productivity.

Encouraging and increasing the efficiency of critical inputs in a need based manner is absolutely essential to rehabilitate black pepper in poor soil health areas of different agro ecological units of Kerala. Use of biocontrol organisms and integrated pest and disease management practices provide an added advantage for rehabilitation. A proper investigation in to the existing problems of black pepper and offering technology solutions through area wide approach is necessary to revitalize pepper cultivation.

The investigation about the low productivity of black pepper revealed that lack of quality planting materials is one of the major problems faced by farmers for the rehabilitation of black pepper in the state. Farmers are depending on research stations and farms for their planting material requirement and 30-40 percent of the requirement is being met by these government agencies. The rest is supplied by private nurseries without any quality check and famers are ultimately exploited by cultivating uneconomic poor quality cuttings. In order to achieve the requirement of good quality rooted cuttings it is absolutely essential to transfer the low cost method of planting material production by the farmers through participatory mode in each agro ecological units.

Methodology

Kerala is blessed with 23 different agro ecological units with unique features and black pepper is being cultivated in almost all units. To have a better crop establishment it is highly essential to produce planting materials in respective agro ecological units. As planting material production is



confined to department farms and research stations farmers have to transport the rooted cuttings from the production centers to their fields with different climatic properties leading to poor establishment. Hence in situ production of planting material is highly essential to establish good pepper garden in each agro climatic units. The properties of black pepper also vary with respect to the agro ecological units.

The demand of planting material is to the tune of 20-25 lakhs in Kannur district and about 5-6 lakhs seedlings are being produced by public sector research and development centers and private nurseries altogether. The wide gap between demand and supply of planting materials needs popularization of the production and use of healthy planting materials to develop a sustainable black pepper production in each agro ecological units and in the country.

To effectively address this problem mini nurseries are to be established in each house holds for meeting their demand. KVK Kannur has started to initiate this by way of frontline demonstrations to convince the farmers about the easiness in planting material production. Frequent training is also providing by the KVK on technical and scientific aspects to start mini nurseries by the farmers to meet their needs and ensure quality of plants.

Different techniques of planting material production

Periodical replacement of disease and senile vines forms an integral part of pepper cultivation. Good quality disease free planting materials of high yielding varieties are an important pre-requisite for improving the productivity of the vines.

The following different techniques of planting material productions are decentralized in progressive farmers of different agro ecological units of Kannur under participatory mode

1. Establishing Mother vine garden for rooted planting material production

Production of rooted pepper cuttings usually starts from February by collecting runner vines from the mother plants after the harvest of black pepper. These vines are then made in to two nodded cuttings and these cuttings are then planted in polythene bags filled with potting mixtures and mulching will be provided for inducing sprouting. The sprouted cuttings are to be maintained in the nursery for 4- 5 months before planting in the main field.

The main disadvantage of this technology is that the availability of good quality disease free runner vines and the materials produced by this method are available only for a shorter period. It is absolutely essential to ensure good quality runner vines for large scale production of planting materials. As the availability of runners is limited due to the predominance of senile and diseased gardens, farmers depend private plantations without checking the quality of mother plants and unknowingly spreading pests and diseases.

KVK Kannur has initiated a programme for decentralized mother vine production units in different parts of the districts to address the shortage of runners during the nursery season. Entrepreneurship development programme training on establishing mother vine production units and production of quality rooted pepper cuttings were conducted to the selected farmers having minimum infrastructures to take up the activities.

Nucleus planting materials of released promising varieties were given to the trainees to develop mother vine garden as intercrops in coconut and arecanut by modified rapid multiplication method. Annual yield from a 5 meter length of RMP is about 100-150 meters during the first year and in subsequent years the yield is 500,1200,2500 meters., means the production of quality disease free rooted pepper cuttings can be increased from 500 to 10000 numbers within three years. At

present a decentralized mother vine production centre in agro ecological unit 11(Northern laterites) is functioning well with a production capacity of 20000 meters of runner vine by modified rapid multiplication technique. The main advantage of the unit is that varietal mixing is controlled by separate RMP lines for the released high yielding varieties. KVK is monitoring the nursery at frequent interval and about 10 varieties are being maintained in the unit including Thevam, Vijay and Panniyur 8.

The main advantage of these types of production units is that the RMP germplasm of the vines is being conserved for years and the quality of the planting material are ensured. These types of mother vine production units can supply runner vines to the agricultural farms, accredited approved nurseries and research stations for large scale production of rooted cuttings suitable to the agro ecological units rather than collecting planting materials from different agro ecological units.

Economics of mother vine progeny garden (5 cents)

Are	ea	: 5 cents	: 5 cents						
Nu	mber of varieties	: 6 (Pani	niyur1,2,5,8,	Vijay and The	vam)				
Uni	it length of RMP/varieties	: 10 mete	: 10 meters x 6 = 60 meters						
Qua	antity of nucleus material required	: 300 roo	: 300 rooted cuttings (50 cuttings/variety)						
Sl.No	Particulars	Non recurring cost	Recurring cost	Beneficiary contribution	Total				
First Y	/ear								
1	Organic manure @3kg/meter = 180 kg @Rs5/-kg		900	900	900				
2	Materials for RMP. Wooden poles, <i>Glyricidia</i> , twine etc	5000		2500	5000				
3	Polythene mulch	500			1000				
4	Fertilizers (NPK) Urea 1.5 kg Rajphos 3.0 kg, Potash 1.2 kg		100		100				
5	Growth promoters and foliar nutrients		2000		2000				
6	Bio control agents and plant protection measures		2000		2000				
7	Labour requirement 50 mandays @700/			35000	35000				
	Total				46000				

Sl.No	Particulars	Non recurring cost	Recurring cost	Beneficiary contribution	Total
Secon	d year				
1	Organic manure @3kg/meter = 180 kg @Rs5/-kg		900	900	900
2	Materials for RMP. Wooden poles, <i>Glyricidia</i> , twine etc	5000		2500	5000
3	Polythene mulch	500			1000
4	Fertilizers (NPK) Urea 1.5 kg Rajphos 3.0 kg, Potash 1.2 kg		100		100
5	Growth promoters and foliar nutrients		2000		2000
6	Bio control agents and plant protection measures		2000		2000
7	Labour requirement 40 mandays @700/			28000	28000
					39000

Production

Sl.No	Production (meters)	No of rooted cuttings	Income @ Rs. 10/ cuttings	Expenditure	Profit/loss
First year	600 m	2400	24000	46000	-22000
Second year	1200 m	4800	48000	39000	-9000
Third year	2000 m	8000	80000	39000	41000
Fourth year	4000 m	16000	160000	39000	121000
			312000	163000	131000

Third year onwards the production unit will be on profit and the unit can be maintained for 10 years with minimum management. The advantage of this unit is that maintained for each variety. The manpower available in each house hold can be effectively utilized by making this centre as a livelihood activity for the farming community.

1. Serpentine method of propagation in black pepper

Serpentine layering is a versatile method for production of rooted cuttings of black pepper irrespective season. In a nursery shed with roofing sheet or shade net, rooted black pepper cuttings are planted in polythene bags holding about 500 g potting mixture, which will serve as mother plants. As the plant grows and produces few nodes small polythene bags (15cm x10 cm) filled with potting mixture (1:1:1 soil, coir pith and farm yard manure) may be kept under each node and the vines are allowed to grow horizontally towards eastern direction. Care should be taken to roll back the top portion of the bag by 1-2 cm. The node may be kept gently pressed in to the mixture assuring contact with the potting mixture by clipping with the help of a flexible twig or mid rib of a coconut leaflet ('v' shaped) to enable rooting at that junction. Roots start growing from the nodes and the cuttings keep on growing further. The process of keeping potting mixture filled polythene bags at every node to induce rooting at each node is repeated. Foliar application of nutrients and growth promoters are made at weekly interval for quality growth with complete withdrawal of plant protection measures. Once ten nodes get rooted, the first bag with rooted nodes will be separated by cutting at the internodes with a sharp sterile blade treated with fungicide. The rolled top portion of the bag is released so that the internodal stub will be covered by adding potting mixture to get profuse rooting and sprouting. Daily irrigation can be given with a rose can, taking care not to expose the inter nodal stub and roots. The rooted nodes will produce new sprouts in a week time and after three months it will be ready for planting in the main field. On an average, 60 -75 cuttings can be harvested from each mother line in a year by this method. A nursery structure with a minimum of 100 square meters can produce 500 to 700 cuttings per week without varietal mixing as separate mother vines are maintained for each variety.

Num	ber of varieties	: 6 (Pan	: 6 (Panniyur1,2,5,8, Vijay and Thevam)						
Mot	her plants Unit /varieties	: 100 nu	: 100 numbers						
Qua	ntity of nucleus material required	: 600 ro	: 600 rooted cuttings (100 cuttings/variety)						
Sl.No	Particulars	Non recurring cost	Recurring cost	Beneficiary contribution	Total				
First	First Year								
1	Potting mixture(soil + coir pith + cowdung) for 600 bags	÷	1500	1500	1500				
2	Rain shelter 100 m ²	30000		30000	60000				
3	Dolomite/lime			300	300				
4	Organic growth promoters cow urine+groung nut cake <i>etc</i> ,.		1000		1000				
5	Foliar nutrients		2000		2000				
6	Bio control agents and plant protection measures		2000		2000				
7	Labour requirement 50 mandays @700/			35000	35000				
	Total				101800				

Economics of serpentine method of planting material production (100 m²)

Sl.No	Particulars	Non recurring cost	Recurring cost	Beneficiar contributio	ry Total on			
Secon	d year							
1	Potting mixture (soil+coirpith+cowdung) for 600 bags			3000	3000			
2	Dolomite/lime			1000	1000			
3	Organic growth promoters cow urine+ground nut cake etc,.		1000		1000			
4	Foliar nutrients		2000		2000			
5	Bio control agents and plant protection measures		2000		2000			
6	Labour requirement 150 mandays @700/			105000	105000			
	Total				114000			
Production of rooted cuttings								
	Mother No of rooted plant lines cuttings	Inc @]	ome E Rs 10/	Expenditure	Profit/loss			

	Fourth year	1000	@50/line=50000	500000	114000	386000				
				1070000	443800	626200				
The 1	The main advantage of this technique is that throughout the year good quality pest and disease									
free 1	free rooted cuttings can be produced with minimum management. Here the roots are developed									
first a	and sprouts will	emerge af	ter one week of separate	aration of the r	ooted nodes f	from the serpentine				

line so that the quality and tolerance to biotic and abiotic stress are more to these cuttings.

@5/line = 3000

@20/line=14000

@50/line=40000

cuttings

30000

140000

400000

101800

114000

114000

-71800

26000

286000

Conclusion

First year

Second year

Third year

600

700

800

Decentralized production of rooted cuttings and establishing mother vine garden through participatory mode has to be replicated in major pepper growing tracts of India to meet the requirement of quality planting materials in different agro ecological units. The current level of production from public sector is not at all sufficient to meet the demand of rooted cuttings during the peak season. The germplasm of quality mother vines and local cultivars to be maintained in different agro ecological units with the help of local self governments through participatory mode by providing training on recent advances in quality planting material production. Pepper samithies in different panchayats are to be strengthened to take up these activities. More over the demand of bush pepper and orthotrophs are also increasing among the farmers and production of these planting materials for urban areas are also achieved. Conservation and multiplication of local promising cultivars suitable to particular agro ecological units is another area which can be well exploited by participatory mode.

Production of elite planting material in spices : Success stories of entrepreneurs

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Karnataka is known for cultivation of spices in arecanut and coconut based cropping system. The arecanut and coconut occupy an area of 52,552 ha and 5,756 ha in Shivamogga district in Karnataka. Among these more than 50 per cent of the gardens are in bearing stage and multistoried cropping system with spices as inter/mixed crop is not followed in all the gardens. Hence, there is huge scope for development of spices in the arecanut and coconut based cropping system. As the area under spices increase, there is increase in demand for the planting material. The success of the establishment of the garden depends on the quality of the planting material. The major spices grown in Shivamogga district are: pepper, ginger, turmeric, clove, nutmeg, chilli, cardamom and cinnamon. Due to crop diversification, additional income and government interventions farmers are interested in cultivation of spices as mixed/intercrop in coconut and arecanut based cropping system. Hence, production of planting material from certified nursery is important. Many private and public sector nurseries are operating in Shivamogga district and all are not producing the planting material pertaining to spices. Only few nurseries are producing quality planting material are documented here.

Sri B.R. Krishna, resident of Gajanuru village, Shivamogga taluka is a diploma holder in automobiles. Initially he wanted to pursue his career in automobiles but was influenced by his father Late Shri Rangappa who was also a pioneer horticulturist and awarded Marigowda Memorial Award from Dept of Horticulture, Govt of Karnatak for his contributions. Sri Krishna's father motivated him to continue in horticulture as entrepreneur. Initially, he started his venture by maintaining the multistoried arecanut based cropping system and got an idea of producing planting material due to the farmer's enquiry about planting material. He started small nursery named as 'Varashree Nursery' at Gajanur, Shivamogga taluk with production of pepper, nutmeg and clove. By supplying good quality planting material and his service motto to the farming community his business has increased a lot. The Krishi Vigyan Kedra (KVK) and Department of Horticulture, Shivamogga have explained him about the nursery accreditation done by National Horticulture Board, Gurgaon and its implication. He was convinced by the officials and applied for the accreditation. In first round of visit his nursery has got single star and in subsequent rounds of visit his nursery graded as two and three star nursery. Along with his nursery activities, he is also involved in development of other horticultural and agricultural activities. He established polyhouse (2000m²), shadenet (2000m²), mother block of pepper, nutmeg, clove for collection of seeds and scion material. He is an innovative nurseryman and taking up nursery profession on entrepreneurial mode. He was awarded "Best Organic Farmer Award" for vanilla cultivation and "Best Farmer of Shivamogga



District" in 2005 and 2012 respectively. He is producing elite planting material of pepper (6 lakh cuttings and 1.5 lakh grafts), clove (0.35 lakh seedlings), nutmeg (0.50 lakh seedling and grafts) with a net profit of Rs. 25 lakh per annum.

Sri B.M. Sundaresh, resident of Abblagere, Shivamogga taluka is growing arecanut, coconut, cocoa, pepper, nutmeg, clove, all spice, sandalwood and agarwood from the last 25years. Earlier he was concentrating only on production of these crops and from the last few years he started producing planting material of spices *viz*. pepper, clove and nutmeg. He established polytunnels for propagation of pepper, shadenet for other nursery activities. He is producing pepper (2 lakh cuttings), nutmeg (0.1 lakh) with a net profit of Rs. 4 lakh/annum. He is having skilled nurseryman and has maintained mother blocks for collection of seeds, scions. For innovative approaches of farming, processing, post harvest management and nursery activity he bagged "Marigowda Memorial Award" and "Krishi Pandit Award" in 2003 and 2008 respectively. Due to constant efforts of KVK and Dept of Horticulture he also applied for NHB accreditation. In first round of selection his nursery named 'Gagan Nursery' rated as single star nursery from NHB.

Sri Girish N Hegde belongs to Hakkare village in Sagara taluka is in Shivamogga district is also practicing nursery activity since from 15 years. He is having the well established mother blocks in arecanut, pepper and nutmeg. He is active and much interested in farming activities started producing planting materials of pepper, clove, nutmeg, arecanut and bird chilli in his nursery. Among different spices he is producing pepper is having high demand. He also produces both grafts and cuttings in pepper. He is producing pepper (5 lakhs), nutmeg (0.25 lakh) and clove (0.2 lakh) planting material from his approved nursery and making profit of Rs. 10 lakh/annum. His nursery popularly known as 'Sahyadri Nursery' is also recognised by NHB as single star nursery.

These entrepreneurs were following quality standards including varietal purity. They are in constant touch with the Department of Horticulture, institutes, KVK and taken production of planting material as entrepreneurial mode and became model for other nurseries as well as farmers.

Kochukudy – A farmer's nutmeg variety

Jose Mathew Kochukudy Kaloor P.O., Kaloorkkadu, Muvattupuzha.

My farm is situated on the banks of river Kaliyar, in Kaloorkad village of Ernakulam district is my 15 acre farm which gives me my livelihood. Nutmeg is the major horticultural crop in my farm, there are around 750 nutmeg trees in the age group of 10-35 years. I have a super nutmeg tree with bold nut and thick mace, producing about 2000-5000 fruits/tree. I wanted to popularize this variety named *Kochukudy* nutmeg and started making budded plants for supply to the farmers around. Convinced about the superiority of my variety, more and more people came to my farm in search of the budded plants of this variety.

Gradually I wanted to expand the unit to a full scale nursery. I had the privilege to get the latest scientific aspects of nutmeg cultivation, propagation and plant protection techniques from Kerala Agricultural University. Dr. E.V. Nybe, Dr. N. Mini Raj and Dr. Sally K. Mathew were kind enough to visit my farm and offer valuable suggestions for quality budding production. Based on their advise I switched over to *Myristica fragrance* root stock from *M. beddomei* and *M. malabarica*. I could improve the health of my mother trees and nursery by the timely adoption of plant protection measures as suggested by them. The nursery practices which I follow are given below.

- 1. Root stock seedlings (*M. fragrans*) are raised in polybags (9x15 size) after filling it with potting mixture containing FYM, Pseudomonas and soil .
- 2. Seedlings are given only organic manures .
- 3. They are kept under shade net pandals
- 4. Straight shoot bud sticks are cut from bearing mother trees early in the morning
- 5. Immediately they are budded on to one and half year old rootstocks by patch budding.
- 6. After 45-60 days, polythene tape is cut and the root stock is bent above the bud union
- 7. Sprouting occurs within 45-60 days
- 8. Sprouts are allowed to grow up to two steps
- 9. Bordaeux mixture and Pseudomonas are sprayed on budded plants and organic manures are given.

I do budding year round and get maximum success during September - January. I make around 15,000 budlings in an year. At present I have 6000 budlings in my nursery for sale. Farmers from

Kerala, Tamil Nadu and Karnataka come to me for purchase of budlings. I sell the two step grown budling @Rs.850/- My nursery earns me a substantial income in addition to the income from the sale of nut and mace. I also get a 20-30% premium price for my *Kochukudy* variety in the market.

From my own experience I have few tips to offer to nutmeg growers.

- 1. Multiply and plant only good varieties
- 2. Use only straight shoot buds
- 3. Use your own budwood
- 4. Use *M.fragrance* rootstocks in the age of one and half years(3 step grown plant)
- 5. Keep record of your sales and try to get feedback on the performance of the budlings

My efforts were recognized by the award of plant genome savior honour during 2010-11 recommended by KVK Njarakkal, Ernakulam and the National innovation foundation honour during 2014 -15, recommended by Peerumade Development Society. I also got financial support from State Horticulture Mission for the infrastructure development for nursery.

Seed rhizome production in ginger cv. IISR - Mahima – A success story

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Karnataka state has emerged as a leading state in ginger cultivation. However, the crop is frequently devastated by infection of rhizome rot. One of the major causes for this is use of infected seed rhizome and non availability of healthy planting material. In ginger, the recommended planting material requirement is 1500kg/ha. Supply of such large quantity planting material is a big task. In this direction, a farmer in Mundagod taluk of Karnataka has been producing large quantity of planting material of IISR-Mahima for the last few years. The farmer, Mr. Jomin who hails from Kasargod district of Kerala cultivates ginger on leased land of twenty acres. The paper highlights the success story of the farmer in ginger cultivation which is being utilized for seed rhizome in the region.

It was in December 2014 when a team of scientists from University of Agricultural Sciences, Dharwad during a survey to study the impact of intensive cultivation of ginger in Utter Kannada district of Karnataka met Mr Jomin accidentally. He was assisting a local farmer (Mr. G.S Patil) for harvesting ginger. Mr. Patil from Karaginakoppa, Mundagod taluk expressed that he had incurred large losses due to rhizome rot. It was then Mr. Jomin came forward to show his ginger field in Ajalli village in Mundagod taluk. The team followed him to his field. He then showed his ginger field of 5 acre with Mahima (as claimed by the farmer) and Rio de Janero, majority of which he sold as planting material. It was worth to see the disease free ginger fields with excellent growth.

Mr. Jomin, a resident of Kasargod district of Kerala, is a diploma holder in paramedics. He left his job in Dubai as laboratory technician. He was inspired by his relatives doing ginger farming and moved to Karnataka to start ginger cultivation on a land of one acre. He is involved in ginger cultivation for last five years.

We followed him in the next season i.e., 2015-16. He took up cultivation of Mahima on a leased land of 20 acre in Ajalli village almost exclusively for seed purpose. We visited his field at various stages of growth. At the time of harvest what we saw was only seen to be believed, A single clump yielding more than 4kg. Average weight of clumps in a bed was more than 2 kg. The yield of fresh rhizomes was more than 20 tonne/ha.

Our observations indicate the following points as the keys for success for his ginger cultivation.

- 1) Selection of land moderate rain fall, gently sloping land, sandy loam soils of slightly acidic to neutral in reaction.
- 2) Selection of seed material meticulous selection for seed material during cropping season and marking them.



- 4) Strict crop rotation ginger will be cultivated on a land only if the crop was not grown on the same land for previous eight season.
- 5) Seed treatment seed treatment with Emissan + Quinolphos for 10 minute.
- 6) Preparation of land
 - a) Land thoroughly ploughed during December, exposed to sun and brought to fine tilth with rotavator.
 - b) Trench of > 45cm opened with a JCB machine at 4.5m width.
 - c) Lime application @1 q/acre.
 - d) Cross drainage at 100-150cm for preparation of beds.
- 7) Planting
 - a) Planting done in a planting hole of 5cm
 - b) Covered with powered cow dung and then with soil (FYM required /ha).
 - c) Mulching with grass and covered lightly with soil.
 - d) Copious irrigation till sprouting.
- 8) Nutrition split application of manures
 - a. 1st dose inorganic fertilizers in the form of 100 kg Factomphos, (10:26:26) given 2 bag/ acre after 80% of sprouting of rhizomes.
 - b. 2nd dose inorganic fertilizers in the form of 150kg DAP, 150kg Factomphos and 5kg mangala gold (micronutrients) for 1 acre given at the interval of 20 days after 1st dose.
 - c. 3rd dose Inorganic fertilizers same as the 2nd dose after 20 to 30 days
 - d. 4th dose inorganic fertilizers are 100kg MOP and 100kg urea applied last time. Care is taken to avoid contact with the foliage.
 - e. Spic cytozyme and soluble fertilizers (19:19:19) are applied along with plant protection chemicals
- 9) Irrigation Irrigation is carried out through micro sprinklers at an interval of almost every 3rd day during Feb June and there after based on rainfall.
- 10) Plant Protection :
 - a. Prophylactic Spraying with TATA master + quinolphos every 20 days after the first dose of fertilizer application
- 11) Harvesting
 - a. For seed rhizome, the beds are irrigated once in 8-10 days after the drying of the foliage till harvesting.
 - b. When the seed rhizomes are to disposed of, the rhizomes are dug.
- 12) Eonomics:
 - a. The cost of cultivation is around Rs. 3.5 lakh per acre (as reported by the farmer)
 - b. At an yield of 20 tonne/acre, the income from one acre works out to be around Rs.5,40,000 (at a selling price of Rs. 27000/tonne).

Mr. Jomin takes pride in explaining and sharing his experiences of ginger cultivation. His fields have been visited by dignitaries like Dr. Nirmal Babu, Project Coordinator (Spices), scientists of UHS Bagalkot. In fact UAS Dharwad had conducted a training programme on ginger cultivation in his field during February, 2016. He (Mr. Jomin) can be contacted on his mobile no. 8105538968.

From Common Man to a Commercial Producer - The success story

Danda Veeranjaneyulu

Sri Danda Veeranjaneyulu, born to late Sri. D. Rama Swamy and Smt. Rama Tulasamma on 6th June,1960 was introduced to agriculture while he was in 9th standard itself and the journey of a school kid started way back in 1973.

Sri. D. Rama Swamy, a native of Bobbepalli village, Marturu mandal of Prakasm dist., A.P. was a small farmer with a land holding of just 4.5 acres. Marturu falls in arid tropical zone and is characterized by scanty rainfall, high temperatures, poor soils etc. The soils are shallow with a depth of one foot and the subsoil is hard impervious rock and in some cases calcarious which make them unfit for perennial fruit trees. Even the performance of annuals also is not upto the expectations unless some measures are adopted. Sri Rama Swamy found it very difficult to meet both ends since he had to support a big family with available 4.5 acres of land. The financial constraints prompted him to venture something new to earn some extra money and thus has taken up production and sale tobacco nursery in the year 1955. Later, from the year 1970 he extended the nursery activity to produce nursery of chilli (OP varieties) in open fields. However, his financial crisis continued and the eldest son Veeranjaneyulu at the age of 13 years had to discontinue his studies at 9th standard (in the year 1973) to support his father.

Gradually, Sri Veeranjaneyulu took over the nursery activity and intensified it to produce the nursery of chilli hybrids also by 1995. He started concentrating on horticultural crops rather than field crops and could reap the dividends. By the year 2000, he started producing seedlings on raised beds using micro sprinklers and in 2004, he first erected a shade net in area of just 50 cents to produce healthy seedlings and could establish a brand name for "Sri Veeranjaneya Chilli & Vegetable Nursery". The shade net house has been extended to 5 acres area in 2007 with hi-tech facilities such as drip/fertigation, foggers etc. Tasting the success, soon the net house was extended by another 5 acres in the year 2009 and in addition to chilli, seedlings of different vegetables, flower crops such as marigold were also being produced. Today, the net house is utilized not only for producing seedlings but also for commercial production of high value vegetables (Capsicum, red cabbage, cherry tomato, European cucumber) and flowers . The first polyhouse was constructed in the year 2010 and today Sri Veeranjaneya Nursery proudly owns Insect Proof Net House in an extent of 3.0 acres and is all set to produce seedlings in this net house from the ensuing year 2016.

Once a small farmer, Sri D. Veeranjaneyulu today owns 60 acres of land and along with another 40 acres of leased land is utilized for raising more than twenty types of vegetables and field crops and the entire farm area is fitted with drip system. His innovative ideas to have catchment pits and farm pond to harvest rain water has facilitated quality production. He uses organic manures such as vermicompost, FYM to improve the soil. The Portable Net House, his brain child is a testimony of his innovative ideas.



Net house for chilli seedling production



Farmers visit to nursery

Many private seed companies such as Mahyco Seeds, Rasi Seeds, Dutch Agri Seeds and even Dr. YSR Horticultural University take up minikit testing at this farm to evaluate their new varieties.

The nursery is providing employment for about 300 agrl. labourers. It produces and supplies chilli nursery for about 3000 ha and vegetable nursery for 300 ha on orders from farmers every year.

The nursery has a sale counter in the farm premises and the seedlings and the produce are sold at the farm gate itself. Many farmers, students and officers visit the nursery every year as place of learning. Sri Veeranjaneyulu displays his produce at various exhibitions across the state including State horticulture shows and won many laurels. In recognition of his services to the farming community, the State Government has honoured him with the Best Farmer Award in the year 2010 and he has many district level awards to his credit. Dr. YSR Horticultural University, Andhra Pradesh has nominated him as Member of its Research and Extension Council in the year 2015.

SESSION - IV

Statewise scenario of planting material production in spice crops



Plant quarantine procedure for exchange of planting material for propagation needs and seed certification

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Introduction

The quarantine measures are of most relevance to a country like India whose economy is largely based on agriculture. The awareness to quarantine measures in India started in early 20th century when the Indian Government in 1906, ordered compulsory fumigation of imported cotton bales to prevent the introduction of the dreaded Mexican cotton boll weevil (Antonymous grandis). On February 3, 1914 Comprehensive Plant Quarantine Act, known as Destructive Insects and Pests Act, (DIP Act) became operative. Over the years, the DIP Act was revised and amended several times. However it needs to be periodically reviewed and amended to meet the growing requirements of liberalized trade under WTO. In 1946, the Directorate of Plant Protection, Quarantine and Storage, under the Ministry of Food and Agriculture was set up. In 1946, Plant quarantine activities commenced with the initiation of plant introduction scheme in the Botany Division at Indian Agricultural Research Institute (IARI) New Delhi. In October 1949, the Directorate started its quarantine activities at Bombay seaport. On December 25, 1951 the first plant Quarantine and Fumigation Station in India was formally inaugurated. In August, 1976 the National Bureau of Plant Genetic Resource (NBPGR) was created. In 1978, the Division of Plant Quarantine was created with Entomology, Plant Pathology and Nematology sections. In October, 1988, the Plants, Fruits and seeds (Regulation of Import into India) order, 1989 popularly known as PFS order came into force.

List of Pests which are introduced into India from different countries

- 1. Coffee rust Sri Lanka 1879
- 2. Late blight of potato -England 1883
- 3. Flag smut of wheat (Urocystis tritici) -Australia 1906
- 4. Downey mildew of grapes Europe 1910
- 5. Rust of chrysanthemum(Puccinia carthami) Japan/Europe 1904
- 6. Downey mildew of cucurbits (P. cubensis) Sri Lanka 1918
- 7. Downey mildew of maize (S. philippinensis) -Java 1912

- 8 .Foot rot of Rice (Fusarium moniliforme) South East Asia 1930
- 9. Black rot of crucifers (X. campestris) Java 1929
- 10. Leaf spot of sorghum South Africa 1934
- 11. Powdery mildew of rubber (Oidium heveae)- Malaya 1938
- 12. Blank Shank of Tobacco (P. nicotianae) Holland 1938
- 13. Fire blight of pear England 1940
- 14. Crown gall of Apple/pear (A. tumefaciens) England 1940
- 15. Bunchy top virus Sri Lanka 1940
- 16. Canker of apple (Sphaeropsis spp.)- Australia 1943
- 17. Wart of potato (Synchytrium endobioticum) Netherlands 1953
- 18. Bacterial blight of paddy (X. oryzae) -Philippine 1959
- 19. Golden Nematode of potato Europe 1961
- 20. San Jose scale of apple Italy 1900
- 21. Wooly aphid of apple -Australia 1928
- 22. Sunflower downey mildew Australia 1985

These are some exotic pests introduced into our country and cause extensive damage in India. Therefore, the challenge for all disciplines of agriculture is to increase production and improve quality of produce. In the past many diseases have been responsible for food scarcities including famines.

The main objectives of plant quarantine are:

- To prevent the introduction and spread of exotic pests that is destructive to crops.
- To prohibit/regulate/restrict the import of plants/plant material both for consumption & propagation;
- To prohibit/regulate the import of germplasm for research purpose;
- To prohibit/regulate the import of GMOs/transgenic plant material for research purpose;
- To gain market access for diversified agricultural products from India.
- To facilitate and promote safe global trade in agriculture by assisting the procedures and exporters by providing a technically competent and reliable phytosanitary certification system to meet the requirements of the trading partners.
- To prohibit the import of deleterious weed species;
- To regulate the import of bio-control agents/live insects/fungi & other microbial cultures;
- To regulate/restrict the import of primary agricultural commodities.
- To regulate the import of packaging material/growing media such as soil & peat etc.

The Plant Quarantine regulatory measures to prevent the introduction and spread of destructive pests are operated through the 'Destructive Insects and Pests Act, 1914 (Act 2 of 1914)'. The purpose and intent of this Act is to prevent the introduction in to India and spread from one State to another of any insect, pathogen or other pest, which is or may be destructive to crops. The Directorate of Plant Protection, Quarantine and Storage was established under the Ministry of Agriculture & Farmers' Welfare (Department of Agriculture , Cooperation & Farmers' Welfare) in 1946 and entrusted with the responsibilities of administering and implementation of the Plant Quarantine Regulations issued under the Destructive Insects and Pests Act, 1914 to prevent introduction of exotic pests through various Plant Quarantine Stations functioning at international airports, seaports and land border check posts , across the country.

Ministry of Agriculture & Farmers Welfare has introduced New Seed Policy in 1988 with the main objectives of providing access to the Indian farmers, the best planting material grown anywhere in the world in order to increase agricultural production . Further, the New Seed Policy laid special emphasis for time bound strengthening of Plant Quarantine facilities at five major Stations viz., Amritsar, Chennai, Kolkata, Mumbai and New Delhi through which import of seed and other planting material is permitted. Subsequently, Ministry of Agriculture issued a notification entitled "Plant Quarantine (Regulation of Import into India) Order, 2003" replacing earlier notification under the above said Act to regulate the import of seed, plants, fruits and other plant materials through notified points of entry so as to prevent the entry of destructive pests of crops.

The significant highlights of the existing Plant Quarantine Order 2003

Schedule I	: Points	of Entry	for	Imports	of	plants/pla	ant	materials	and	other	arti	icles	are
	listed. ' Schedu	Totally le I	40 s	seaports,	19	Airports	and	14 land	Fron	tiers a	are	listed	l in

- Schedule II : Inland Container Depots and Container Freight Stations for import of plants and plant products listed. Totally 70 Inland Container Depots are listed in Schedule II.
- Schedule III : Foreign Post Offices for import of plants and plant products are listed. Totally 11 Foreign Post Offices for import of plants and plant products are listed.
- **Schedule IV** : Plants/planting materials and countries from where import is prohibited along with justification are listed. Totally 14 planting materials are listed in Schedule IV.
- Schedule V : Plants and plant materials restricted for import and permissible only by authorized institutions with additional declarations and subject to special conditions. Totally 17 planting materials are listed in Schedule V.
- Schedule VI : Plants/plant materials permitted for import with additional declarations and special conditions are listed. Totally 692 plant materials are listed in this Schedule VI.
- Schedule VII : List of plants/planting materials where imports are permissible on the basis of phytosanitary certificate issued by the exporting country, the inspection conducted by Inspection Authority and fumigation, if required, including all other general conditions. 294 plant materials are listed in Schedule VII. Spices crops like Allspice, Aniseed, Asafoetida, Basil,Caraway seeds, Car-

	damom, Cassia, Cinnamom, clove, Coriander, Fennel, Fenugreek, Garlic, Ginger, Turmeric, Chillies, Pepper, etc., are listed in this Schedule .
Schedule VIII	: List of Quarantine Weed Species. Totally 31 plant materials are listed in Schedule VIII.
Schedule IX	: A-Inspection Fees; B-Fumigation/disinfection/disinfestation/supervision charges are listed.
Schedule X	: List of Permit Issuing Authorities for Import of Seeds, Plants and Plant Prod- ucts and other articles are listed.
Schedule XI	: List of Inspection Authorities for Certification of Post Entry Quarantine fa-

Post Entry Quarantine

The inspection authority of concerned area of jurisdiction or any officer authorized by the Plant Protection Adviser in this behalf, in association with a team of experts shall inspect the plants grown in the approved post-entry quarantine facility at such intervals as may be considered necessary in accordance with the guidelines issued by the Plant Protection Adviser, with a view to detect any pests and advise necessary phytosanitary measures to contain the pests. The inspection authority shall permit the release of plants from post-entry quarantine, if they are found to be free from pests and diseases for the period specified in the permit for importation. Where the plants in the post-entry quarantine are found to be affected by pests and diseases. Where destruction of any plant population is ordered by the inspection authority, the importer shall destroy the same in the manner as may be directed by the inspection authority and under his supervision

cilities and Inspection of growing plants is listed.

Schedule XII : Quantities of seeds permitted for trial purpose/accession to gene bank of National Bureau of Plant Genetic Resources are listed.

Imports

- i. No consignment of seeds /planting materials shall be imported into India without a valid 'import permit ' which is to be issued by a competent authority to be noticed by the central Government from time to time in the official Gazette.
- ii. No consignment of seeds /planting materials shall be imported into India unless accompanied by a phytosanitary Certificate' issued for the official plant quarantine service of the source country.
- iii. All consignments of Plants and seeds for sowing propagation /planting purposes shall be imported into India through land customs station, seaport import and such other entry points as may be specifically notified by the central Government from time to time where there shall be inspected by and if necessary, fumigated disinfected by authorized plant quarantine official before quarantine clear once.
- iv. Seeds /Planting materials requiring isolation grow under deflection shall be grown in post entry quarantine facility approved and certified by the designated inspection Authority (DTP) to conform to the conditions laid down by the plant protection advises to the Govt. of India.
- v. Import of soil, earth, sand, compost, and plant deters is accompanying seeds/planting material shall not be permitted. However, soil can be imported for research purpose



under a special permit issued by the plant protection adviser. The DIP Act empowers the central Govt. to make rules for regulating the import of seeds/planting materials into India, & also the movements of the material form one state Govt. are also empowered to enact rules/regulation to regular the movement of materials from one region to another with in state.

Import permits

Regulatory features of imports include the following:

- Separate formats have been devised for applications for the issue of import permits and also for the permit letters issued for consumption purposes as opposed to those for propagative plant materials.
- Commercial imports of seeds of coarse cereals, pulses, oil seed, fodder crops and planting materials of fruit plant species require prior clearance.
- Applications for seeds and planting materials must be accompanied by (1) a registration certificate issued by the National Seeds Corporation or the Director of Agriculture or Director of Horticulture of the state government and (2) a certificate of approval of post entry quarantine facilities issued by the designated inspection authority.
- Permits are to be issued within a maximum period of three working days of submission of an application.
- Pest risk analysis has been made a precondition for import of new agricultural commodities.
- Permits for import of soil or peat and for import of live insects, microbial cultures or biocontrol agents are to be issued only by the Plant Protection Adviser, the technical head of the plant quarantine service.
- Permits for import of germplasm, genetically modified organisms and transgenic material are to be issued by the Director of the National Bureau of Plant Genetic Resources, New Delhi.
- Issued permits are valid for six months. This may be extended a further six months.
- Permits are not transferable and no permits are to issued for landed consignments.
- Relaxations from the conditions of the new Order, necessitated by emergency or unforeseen circumstances, are to rest with the Ministry of Agriculture.

Export of Agricultural commodities

- Phytosanitary certificate (PSC) can be obtained from any of the Plant Quarantine stations or the State PSC issuing authorities notified for this purpose.
- The details of phytosanitary procedures and all PSC issuing authorities list is available in the 'export' section at the home page of the website: http://plantquarantineindia.nic.in
- Exporters are advised to register themselves on-line on the above website as an exporter and there after apply on-line for obtaining phytosanitary certificate from a Plant Quarantine station.

- Uniform pre-printed stationery for issuance of phytosanitary certificate with security features is used for issuance of PSC by all Plant Quarantine offices in India.
- Issue of Phytosanitary Certificates (PSCs) for export of agricultural commodities is carried out as per International Plant Protection Convention (IPPC) of FAO.

Pest Risk Analysis (PRA) in Plant Quarantine

Pest risk analysis aimed at identifying, quantifying and reporting of the possible management options on account of probable, introduction of a pest along with an imported plant commodity. Analysis of pest risk while introducing seeds planting materials is essential to determine the potential of a pest to cause damage. In general, risks are more with the introduction vegetative propagules than true seed. In case of true seed, risks are more with deep seated infections than surface contaminated seed. Further, risks are more with virus, viroid smuts, downy mildew etc. Risk increases with size of import. Bulk import creates more quarantine problems. i. Complete prohibition: When the pest risk is high and safeguard against it is not available in the country, hence import should be prohibited. ii. High risk -adequate safeguard: The pest risk is very high but adequate safe guard in the form of post entry isolation facilities or salvaging techniques are available. iii. Restricted: Pest risk is not very high and import permit is require indicating condition for entry, inspection and treatment.

Pest surveillance in Plant Quarantine

As far as quarantine pests are concern we generally discuss about those exotic pests, which have not entered into India but have potential and probability of entering into India through international trade or otherwise we also discuss about the exotic pests, which have already entered, in our country through the movement of imported agricultural material. There are various illegal ways and means by which certain pest shave been introduced in our country and for such pests the plant quarantine regulations are not applicable. Since plant quarantine is legal strategy to restrict the entry of any exotic pest, other possibilities of the entry of exotic pests such as barrier free border, smuggling etc, have largely been ignored. Leaf curl virus of cotton has entered in Rajasthan and Punjab bordering Pakistan during early nineties.

Plant Quarantine information System

PQIS is a online of this document is to describe the functional requirements and the specifications to develop the application software for Plant Quarantine Information System: The software shall be developed and implemented for the Directorate of Plant Protection, Quarantine and Storage, New Delhi. This document is primarily intended for use by the members of Directorate (Officials of Directorate, DAC) of PQS, and National and Regional Plant Quarantine Stations. For submitting application PQIS is required.

Conclusion

The Plant Quarantine procedure acts as an important tool in excluding pests from exchange of planting material from country to country and crop. Effective implementation of quarantine is highly emphasized for management of exotic pests, which in turn helps in maintaining pest population and the productivity of crops.



Guidelines for accreditation and rating of horticulture nursery

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Introduction

Availability of true to type, quality planting material is crucial for success of commercial horticulture. This necessitates having a net-work of Horticulture Nurseries which conform to Model Nursery Standards in terms of Infrastructure, Quality of Seed and Planting Materials and adoption of Nursery Management Practices.

State Governments ensure supply of quality planting materials for fruit crops by enactment of Fruit Plant Nursery (Regulation) Act and enforcement of its provisions through licensing of horticulture nurseries. However, all the States have not enacted Horticulture Nursery Acts. Further, rules framed under existing acts generally do not provide for Technical Specification for Quality of Planting Material and Process of Production, Infrastructure required for production of quality planting material and Good Nursery Management Practices. The Acts in present form also do not deal with planting materials of flowers, ornamental plants, plants and vegetables. Therefore, it has become necessary to find a solution to the problem by putting in place a system of Recognition of Horticulture Nurseries.

National Horticulture Mission has taken initiative to specify the Nursery Standards by specifying Infrastructure required for setting up of Model Horticulture Nursery etc. With a view to ensure availability of Good Quality planting material, NHB has started a system of Recognition of Horticulture Nurseries on voluntary basis.

Scope

The scope of the scheme is to establish a network of quality nurseries across the country for the purpose of propagation and distribution of quality planting material of specified horticulture crops.

The recognition shall be accorded to the nurseries for:

• Production of quality planting material of one or more specified crops by adopting Good Nursery management Practices,

• Nursery Premise only where sale of specified quality planting material of recognized source are being carried out by creating necessary infrastructure facilities and proper record keeping.

• The recognition shall be accorded to the nurseries for the crops specified in the Document of recognition

• Recognition shall be granted as such or after up gradation as per requirement.

• Nursery Farms licensed under State Act by Competent Authority shall be given Provisional Recognition for a period of one year under the purview of this scheme but their Final Recognition will be subject to assessment by Technical committee.

• Recognition of Nursery with NHB shall be period specific.

Procedure for nursery recognition and renewal of recognition

The Nursery seeking NHB Recognition shall apply to NHB. Each such application shall be accompanied by layout of Nursery showing location of infrastructure components and land utilization plan, details of technically qualified staff in the nursery, major farm machineries and operational manual prepared by nursery for selection and maintenance of mother plants, process followed for production of planting material and management of inventory of planting material. The Nursery shall submit details regarding source of Mother Plants used for propagation of Horticulture plants and shall also maintain a register for sale of horticulture plants.

- The application form duly completed along with necessary enclosures shall be submitted to NHB, Head Office at Gurgaon.
- Each application will be considered by NHB based on criteria specified for recognition of nursery.
- The recognition of nursery by NHB shall generally be considered product wise/aspect wise as required.
- On receipt of the application for recognition, assessment would be done by agency identified by NHB with the help of a Technical Committee.
- Agency shall submit its assessment report to NHB along with recommendations.
- On the basis of the assessment report NHB shall decide whether to register the nursery with or without up-gradation.
- The decision of NHB shall be conveyed to the concerned nursery. In case of recognition, the period of validity of recognition with other terms and condition shall be indicated. In case of any deficiency, the nursery shall be given time frame for compliance; failing which, the application shall be rejected. In case of requirement, additional assessment visits may be undertaken.

Criteria for nursery assessment

The criteria have been aligned with Infrastructural requirement of Modal Nursery and Product specific technical requirement and adoption of Good Nursery Practices for propagation of good quality planting material as detailed below:

- a) Product specific criteria to asses for capability and competence of nursery follow technical programme for specific crop as laid down in "Handbook of Seed and Planting Material Testing manual for Horticulture crops" prepared by ICAR.
- b) Prescribed Nursery Management Practices and Adoption of Model layout plan.



Assessment Criteria (A system of Graded Certification)

It is essentially different from licensing of Horticulture Nurseries under provision of some Act or administrative orders. It is based on continuous evaluation of source of parent material, propagation in disease free condition by adoption of technically prescribed method, adoption of Good Nursery Management Practices, Reliable record keeping and training of staff. Each parameter will be critically examined by assessment team as per laid down criteria. Following grading shall be provided for fruit & vegetable plant nurseries

Excellent	-	*	*	*
Very Good	-	*	*	
Good	-	*		

Procedure for application to higher grade

- 1. On receipt of an application for recognition, to higher grade from existing lower grade, the application will be considered to register the nursery, for fresh assessment.
- 2. On the basis of the report submitted and the recommendations of the pre assessment of the Committee, the Competent Authority will decide on the need to proceed with processing the case of the nursery for up gradation and subsequent recognition or otherwise.

Renewal of recognition

- 1. The Nursery seeking renewal of recognition shall apply in prescribed form.
- 2. The renewal of recognition shall be done based on the satisfactory performance reported as per the surveillance/periodic inspection carried out during the validity period and fresh assessment if felt necessary by NHB.

Assessment and assessment committee

NHB shall nominate one Agency to coordinate the process who will take in to consideration assessment report from a Technical Committee, hereinafter referred to as Assessment Committee which may have Representatives from:

- State Agriculture University in the State concerned
- Apex Horticulture Institute, NRC or Regional Station of ICAR
- Nursery Men Association
- National Horticulture Board
- State Directorate of Horticulture/ Agriculture

The members in the Assessment Committee shall be nominated by NHB in consultation with agencies concerned. Assessment Committee shall conduct pre assessment, final assessment and periodic / surveillance of the nurseries. The committee shall submit report and their recommendations to Agency designated by NHB for this purpose.

Validity period of recognition

In case of approval, initially, recognition shall be granted for a period of two year. The effective date of recognition shall be considered from the date of issuance of certificate.

SURVEILLANCE / MONITORING

Surveillance visit shall be carried out at least once in a year or as required depending on the performance of the nursery. The designated team shall essentially conduct surveillance visit during validity of recognition.

Issue of recognition certificate

In case, Technical Committee satisfies that the Nursery conforms to the requirements of this recognition, it will recommend for recognition of the nursery. The recognition shall bear an identification number. Recognized Nursery shall have to sign a MOU with NHB for terms & conditions of recognition.

- Any change in the location, layout, design or capacity of the nursery shall be intimated to NHB.
- The date of validity of the nursery recognition shall be specified on the recognition certificate
- The recognition certificate once issued shall continue to be in force till the date specified in the certificate unless suspended or cancelled at earlier date by Competent Authority. The issuing Authority may institute surprise checks through its officers in order to ensure that the nursery has maintained the standard as required for issue of the recognition certificate.

Refusal/cancellation of nursery recognition

Issue of recognition certificate may be refused or, if issued, may be cancelled or suspended:

- If the nursery does not conform/fail to perform as per requirements of this scheme
- If there are adverse reports from the farmers/users or any other complaints made to NHB by any other entity and upon enquiry duly conducted it is established that the Nursery has breached any of the conditions of recognition,
- On expiry of the recognition date specified in the Recognition Certificate the recognition ceases to be valid unless renewed.

Present Status of Accreditation & Rating of Horticulture Nurseries in India by NHB

- This scheme was approved in 2008-09 by Govt. of India on voluntary basis, however it was started from 2009-10 by National Horticulture Board throughout the country for ensuring availability of good quality and disease free planting materials under the scheme of NHM & TMNE.
- Initially it was extended for accreditation and rating of fruit plant nurseries only, however accreditation and rating of vegetable nurseries also has been started by the Board w.e.f. January, 2015.
- Total applications received so far 2514 no. in case of fruit & vegetable plant nurseries as on 31.03.2016.
- Out of 2514 no. of fruit & vegetable plant nurseries, 1413 no. of nurseries have been accredited in the grade of 1 to 5 star in case of fruit nurseries and 1 to 3 star in case of vegetable nurseries as on 31.03.2016.
- 267 no. of fruit & vegetable plant nurseries are yet to be visited by the Assessment Team of NHB.



Nursery Status from	inception	of the	scheme	(2009-2010)	as on	31.03.2016.
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SI. Na	StateName	Nursery Accrediation proposals received	Nursery proposals inspected	Nursery proposals yet to be inspected	Total nuisery accredited	1 Star	2 Star	3 Star	4 Star	5 Star
1	Andhra Pradesh	82	74	8	47	36	10	1	0	0
2	Arunachal Pradesh	1	0	1	0	0	0	0	0	0
3	Assam	20	19	1	5	3	1	1	0	0
4	Bihar	51	50	1	38	30	6	2	0	0
5	Chhattisgarh	88	68	20	35	18	14	3	0	0
6	Gujarat	176	129	47	90	75	11	4	0	0
7	Haryana	37	36	1	23	14	7	1	1	0
8	Himachal Pradesh	155	121	34	93	57	20	11	4	0
9	Jammu & Kashmir	343	339	4	238	191	43	3	1	0
10	Jharkhand	4	3	1	3	0	2	1	0	0
11	Karnataka	190	186	4	97	69	23	9	5	0
12	Kerala	33	32	1	21	3	12	4	2	0
13	Madhya Pradesh	192	124	68	44	30	12	2	0	0
14	Maharashtra-Nagpur	114	103	11	68	27	36	4	0	1
15	Maharashtra Nashik	62	59	3	45	42	2	1	0	0
16	Maharashtra-Pune	70	69	1	45	25	11	3	6	0
17	Manipur	4	0	4	0	0	0	0	0	0
18	Mizoram	36	22	14	3	3	0	0	0	0
19	Nagaland	49	42	7	5	4	0	1	0	0
20	Odisha	177	174	3	124	73	42	9	0	0
21	Punjab	57	57	0	52	25	16	9	2	0
22	Rajashthan	53	45	8	21	9	10	1	1	0
23	Sikkim	46	39	7	25	23	2	0	0	0
24	Tamil Nadu	87	83	4	63	31	28	3	1	0
25	Telangana	0	0	0	0	0	0	0	0	0
26	Tripura	20	19	1	11	9	2	0	0	0
27	UP BARAUT	12	12	0	4	2	2	0	0	0
28	UP LUCKNOW	157	153	4	95	68	18	7	2	0
29	Uttrakhand	101	96	5	62	46	16	0	0	0
30	West Bengal	97	93	4	57	39	12	6	0	0
	TOTAL	2514	2247	267	1413	943	358	86	25	1

Seed certification and its role in ensuring quality seed production in seed spices

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Introduction

India is traditionally known as the spice bowl of the world. There was well organized spice trade between India & Rome. About 60 spices are widely grown in our country and have worldwide reputation as the only country which produces almost all kind of spices. These spices had significant role in the economy of country in the past & even today, with the export of raw spices as well as spice products. There is robust demand of the spices in domestic and international market.

India is the number one country in the production & processing of spices. Nearly 180 spices & their products are being exported to 150 nations and the net share of Indian spices in world trade is about 35%. World's 25.30% pepper, 35% of ginger & 90% turmeric production is in India. In India Rajasthan is having the first position in fenugreek production (77.42%), Ajawain (67.25%), fennel 58.81%, coriander 57.26% whereas it stands second in cumin production (28.15%). Kerala tops in pepper production with 96% and cardamom with 53% of the total production.

The most popular & common use of spices and their products is as condiment, to develop and increase in taste and flavor of food, oil & medicinal use. The demand in local and global market is increasing regularly hence area of production is also increasing. With the use of advance technology productivity of seed spics can be increased. The increase of productivity can also be facilitated with the availability of certified seed of high yielding, disease resistant, short duration and climate insensitive or climate tolerant varieties.

What is Seed certification ?

"Seed certification is a legally sanctioned system to control seed multiplication in scientifically & systematically designed procedure with a defined control measures." In real sense it is a kind of third party guarantee for quality seed. Seed certification Agency is established under section 8 of Seed act, 1966

What is the need of seed certification ?

To achieve genetic identity & purity and other prescribed standards to maintain and make available to the farmers high quality true to type seed & propagating material through certification of notified kind & varieties. The planting of a certified seed of notified variety gives a guarantee of good germination resulting in higher & uniform plant population. Crop free from weeds and other undesired plants which ultimately convert in to higher production and good sell in market,



so the certified seed plays an important role to enhance the prosperity of farmer. To ensure the availability of best quality of seed through seed certification, state seed certification agencies were established in most of the states under section 8 of Seeds Act, 1966.

At present Coriander, Cumin, Fennel, Ajawain, Suwa, Tamarind, Ginger, Fenugreek, Celery, Chillies & Garlic crops comes under purview of seed certification, because notified varieties and seed certification standards for these crops are prescribed by government of India in "Indian minimum seed Certification Standard" (IMSCS) under Seed Act, 1966 and Seed Rule, 1968. Black pepper, Cardamom, Mint, Dill, Nigella, Caraway etc. are not covered under seed certification because their standards are not notified for the purpose of seed certification, although label standards have been declared under section 6 of seeds act,1966

Functions of Seed Certification

- Certify seeds of any notified kinds or varieties.
- Outline the procedure for submission of applications, for growing, harvesting, processing, storage and labeling of seeds for certification till the seed lots are finally approved for certification
- Maintain a list of recognized breeders
- Verify, upon receipt of an application for certification that the variety is eligible for certification
- Verification of seed source used for planting
- Inspect fields to ensure that the minimum standards for seed crop field are being maintained at all times.
- Inspect seed processing plants to see that the physical admixtures of other kinds and varieties are not introduced
- Samples tested in notified seed testing laboratory to ensure that the seed conforms to the prescribed standards of certification
- Issue of certificates (including tagging, packing and sealing)
- Carry out educational programmes designed to promote the use of certified seed including a publication listing certified seed growers and sources of certified seed

Type of Seed

1. Breeder seed

Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed. Breeder seed's genetic purity should be equal or higher than foundation seed, so that foundation seed class shall confirm to the prescribed standard of genetic purity. Physical purity, inert matter and germination shall be indicated on the golden yellow label on actual basis.

2. Foundation Seed

Certified foundation seed shall be the progeny of Breeder seed, or be produced from Foundation seed (in case of scarcity of breeder seed) which can be clearly traced to breeder seed. Thus, Foundation seed can even be produced from Foundation seed. Breeder seed to foundation seed is known as foundation seed stage I and foundation seed produced from Foundation seed stage I shall be called as foundation seed stage II. In both the cases same seed standards shall be applicable and white certification tags shall be attached on seed container.

3. Certified Seed

Certified Seed shall be the progeny of Foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified. Certified seed may be produced from certified seed (if there is acute shortage of foundation seed), provided this reproduction does not exceed three generation beyond foundation seed stage I.

Phases of Seed Certification

Certification shall be completed in six broad phases listed as under:

- a. Receipt and scrutiny of application
- b. Verification of seed source, class and other requirements of the seed used for raising the seed crop;
- c. Field inspections to verify conformity to the prescribed field standards;
- d. Supervision at post-harvest stages including processing and packing;
- e. Seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
- f. Grant of certificate and certification tags, tagging and sealing.

The important aspects of field Inspections are to-

- 1. Conduct minimum three field Inspections as per IMSCS in Ajawain Cumin, Suwa (Indian Dil), Coriander, Fennel and minimum two inspections are conducted for fenugreek crop to ensure the quality of seed at field stage of seed crop.
- 2. Check that land of seed field is free from volunteer plants.
- 3. Check and verify the isolation distance in accordance to the standard prescribed, this is very important for the varietal genetic purity.
- 4. Count the off types in seed crop field and objectionable weed seed plants to maintain varietal genetic and physical purity of seed.
- 5. Rouging of undesired plants-Certification inspection officer identify the off type plants and other undesired plants give the instruction to the seed grower and/or representative of seed producer to remove contaminants from isolation distance if isolation is unsatisfactory, and from seed crop field.

6. Final part is estimation of yield in view of crop condition, maturity and productivity of crop.

Sl. No.	Сгор	Number of Inspections	Minin Isola Dista (mete	Minimum Isolation Distance (meter)		Offtypes % (maximum)		nalRemarks ants % mum)	
			F/S	C/S	F/S	C/S	F/S	C/S	
1	Ajawain	3	200	100	0.10	0.20			
2	Cumin	3	800	400	0.10	0.50	0.050	0.10	Plantago pumila *
3	Coriander	3	200	100	0.10	0.50	None	None	Lathyrus *
4	Fennel	3	200	100	0.10	0.50	None	0.50	Dodder (Cuscuta)*
5	Suwa (Indian Dil) 3	200	100	0.10	0.50			
6	Fenugreek	2	50	25	0.10	0.20	0.01	0.02	*Senji (Melilotus) spp.

Table showing standards permissible in seed crop of seed spices crop

Post harvesting operation

Seed grower is required to take the utmost care during harvesting of the seed crop at proper stage of maturity and threshing to avoid admixture during these operations. Seed production agency is supposed to ensure that produce of same seed field is delivered at processing plant which has been inspected & declared standard by certification agency. A small negligence during harvesting threshing, bagging of produce and transportation may spoil the quality of seed.

Produce received at seed processing center is cleaned in mechanical grading on the defined screen aperture size to obtain bold and uniform size seed, free from weed, other crop, damaged, shriveled, small size seed and inert matter. A separate lot number is assigned to the produce of each individual seed grower, variety and stage.

A homogeneous and representative seed sample is drawn from graded seed of each seed lot for the analysis of germination, physical purity, moisture etc. from notified seed testing laboratory as per IMSCS.

Issuance of Certificate

The seed lot meeting all parameters as detailed above, in seed analysis, shall be packed in the respective class of seed. A white tag is affixed on the seed container of foundation seed class and azure blue tag is affixed on seed container of certified seed class. An opal green label of seed producer printed with seed standards are affixed bellow the certification tag. A certificate under section 9 of seed act, 1966 is issued to the seed lot certified by certification agency. The validity of certificate is for nine month from the date of test of seed testing laboratory.

An unfortunate part of spice seed industry is that majority of farmers are using farm saved seed for raising of crop because of limited quantity of availability of certified seed, even though spices are the major contributor in the earning of foreign currency.

SI. (dop	Pure seed % (min	a nimum)	Inert m % (maxii	atter num)		H	Permissible m per kş	aximum seed	H		Germinati age (minir	% uc (unu	Moistur age (maxi	e % mum
						Other Cro	p Seed	Weedse	ed	Objeconable	weedseed				
		F/S	C/S	F/S	C/S	F/S	C/S	F/S	C/S	F/S	C/S	F/S	C/S	F/S	C/S
$1 \downarrow$	Ajawain	67	67	\mathfrak{C}	б	10	20	10	20	I	I	65	65	10	10
5	Cumin	67	67	\mathfrak{S}	б	10	20	10	20	5	10	65	65	10	10
3	Coriander	67	70	\mathfrak{S}	б	10	20	10	20	none	none	65	65	10	10
4 F	Tennel	67	67	\mathfrak{C}	б	10	20	10	20	5	10	65	65	10	10
5	Suwa (Indian Di	1) 97	67	\mathfrak{c}	ю	10	20	10	20	I	I	65	65	10	10
6 F	Genugreek	98	98	7	0	10	20	10	20	7	5	70	70	8	8

Important Issues

- 1. Limited availability of notified varieties.
- 2. Need of development of high yielding, short duration, disease resistance and climate (frost, cold waves etc.) tolerant varieties.
- 3. Supply of poor quality of breeder seed.
- 4. Minimum two field inspection should be conducted by BSP team, preferably at flow-ering and maturity stage.
- 5. B/S certification should also be included in IMSCS.
- 6. At present seed replacement rate (SRR) of seed spices crops are very meager, which needs to be increased at a respectable level and for this -
 - There is need to increase production and availability of sufficient high quality breeder seed for foundation seed production, as none supply/less supply/very late supply of breeder seed is being faced.
 - There is need of financial support in form of incentive to farmers for foundation seed and certified seed production by government of India.



Seed certification standards for quality planting material production in spices

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Introduction

In India, horticultural crops comprises of Fruits, Vegetables, Flowers, Aromatic crops, Spices, Plantation Crops and Honey, occupies 24.19848 million ha with a production of 277. 352 million tones during 2013-14, out of which spices crop occupies 13.0% area and 2.1% production. India - a 'Home of spices' grows as many as 70 spices. However, under the act of Parliament, a total of 52 spices are brought under the purview of Spices Board out of 109 spices notified by the ISO. ICAR- Indian Institute of Spices Research(IISR), Kozhikode has mandated to work on black pepper (*Piper nigrum* L.), cardamom (*Elettaria cardamomum* Maton), ginger (*Zingiber officinale* Roscoe), turmeric (*Curcuma longa* L.), cinnamon (*Cinnamomum verum* J.S. Presl), clove (*Syzygium aromaticum* (L.) Merr. & L.M. Perry), nutmeg (*Myristica fragrans* Houtt), vanilla (*Vanilla planifolia* Andrews), paprika (*Capsicum annuum* L.), garcinia (*Garcinia gummi-gutta* L.) Roxb. and Garcinia cambogia (Gaertn.) Desr. The chilli (*Capsicum annuum* L.) works is under taken at ICAR institutes like ICAR-Indian Horticulture Research Institute(IIHR), Bengaluru; ICAR-Indian Agricultural Research Institute(IARI), New Delhi and many SAU's and SHU's are working on various spices as each state grow one or other spices. Presently spices are grown in 3.16 million ha with production of 5.91million tones.

The General Seed Certification Standards are applicable to all crops which are eligible for certification, and with field and seed standards for the individual crops, shall constitute the Minimum Seed Certification Standards. The word 'Seed' or 'seeds' as used in these standards shall include all propagating materials.

I. Purpose of Seed Certification

The purpose of seed certification is to maintain and make available to the public, through certification, high quality seeds and propagating materials of notified kind and varieties so grown and distributed as to ensure genetic identity and genetic purity. Seed certification is also designed to achieve prescribed standards.

II. Certification Agency

Certification shall be conducted by the Certification Agency notified under Section 8 of the Seeds Act, 1966.

III. Certified Seed Producer

Certified seed producer means a person/organization who grows or distributes certified seed in accordance with the procedures and standards of the certification.

IV. Eligibility Requirements for Certification of Crop Varieties

Seed of only those varieties which are notified under Section 5 of the Seeds Act, 1966 shall be eligible for certification.

V. Classes and Sources of Seed

A. Breeder Seed

Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed.

Breeder seed shall be genetically so pure as to guarantee that in the subsequent generation i.e. certified Foundation seed class shall conform to the prescribed standards of genetic purity. The other quality factors of Breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis.

B. Certified Seed

Certified seed shall be the seed certified by Certification Agency notified under Section 8 of the Seeds Act, 1966 or seed certified by any Certification Agency established in any foreign country provided the Certification Agency has been reorganized by the Central Government through notification in the Official Gazette. Certified seed shall consist of two classes, namely, Foundation and Certified seed and each class shall conform to the following description:

- 1. Certified Foundation seed shall be the progeny of Breeder seed, or be produced from Foundation seed which can be clearly traced to Breeder seed. Thus, Foundation seed can even be produced from Foundation seed. During the production of certified Foundation seed, the following guidelines shall be observed:
 - (a) Certified Foundation seed produced directly from Breeder seed shall be designated as Foundation seed stage-I;
 - (b) Certified Foundation seed produced from Foundation seed stage-I shall be designated as Foundation seed stage-II;
 - (c) Certified Foundation seed stage-II will not be used for further increase of Foundation seed and shall be used only for production of Certified seed class;
 - (d) Minimum Seed Certification Standards shall be the same for both Foundation seed stage-I and II unless otherwise prescribed;
 - (e) Certification tag shall be of white colour for both Foundation seed stage-I and II and shall contain the information as to its stage;
 - (f) Production of Foundation seed stage-II shall ordinarily be adopted in respect of such crop varieties provided, when it is expressly felt by the Certification Agency that Breeder seed is in short supply;



- (g) Production of Foundation seed stage-II may be adopted for the following group of crops:
 - vegetatively propagated crops;
 - apomictically reproduced crops;
 - self-pollinated crops;
 - often cross-pollinated and cross-pollinated crops, these being gene pools should not loose their genetic identity and purity if measures to safeguard the same are adequately taken;
 - composite and synthetics;
 - parental line increase of hybrids.
- 2. Production of Foundation seed stage-I and II shall be supervised and approved by the Certification Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to conform to certification standards specified for the crop/ variety being certified.
 - 3. (a) Certified seed shall be the progeny of Foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified;
 - (b) Certified seed may be the progeny of Certified seed provided this reproduction does not exceed three generations beyond Foundation seed stage-I and
 - It is determined by the Certification Agency that genetic identity and genetic purity will not be significantly altered; and
 - When the Certification Agency is satisfied that there is genuine shortage of Foundation seed despite all the reasonable efforts made by the seed producer.
 - (c) Certification tag shall be of blue colour (shade ISI No. 104 AZURE BLUE) for Certified seed class.
 - (d) Certified seed produced from Certified seed shall not be eligible for further seed increase under certification. Certification tags for such production which is not eligible for further seed increase under certification shall be super scribed with, "not eligible for further seed increase under certification".

VI. Phases of Seed Certification

Certification shall be completed in six broad phases listed as under:

- (a) receipt and scrutiny of application
- (b) verification of seed source, class and other requirements of the seed used for raising the seed crop;
- (c) field inspections to verify conformity to the prescribed field standards;
- (d) supervision at post-harvest stages including processing and packing;
- (e) seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
- (f) grant of certificate and certification tags, tagging and sealing.

The Indian Minimum Seed Certification Standards is available for around 191 crops and eight Tissue Culture Raised Propagule (Table 1). Only Ginger, Turmeric, Onion, Garlic, Chilli, Ajawain, Cumin, Coriander, Fennel, Suwa(Indian Dill), Tamarind are notified in spices for certification. However, certification standards are formulated for black pepper, cardamom, nutmeg, clove, cinnamon, vanilla also presented here.

Sl No	Seed Certification Standards	Nos.
1.	Cereals	7
2.	Millets	14
3.	Pulses	12
4.	Oilseeds	13
5.	Fiber Crops	3
6.	Forage Crops	16
7.	Green manures	3
8.	Sugar crops	1
9.	Narcotics	2
10.	Fruit Vegetables	7
11.	Cucurbits	29
12.	Cole crops	6
13.	Green/Leafy Vegetables	7
14.	Bulb Crops	4
15.	Tubers & Rhizomes	6
16.	Root Crops	12
17.	Spices	*6
18.	Fruit Crops	32
19.	Flower Crops	11
20.	Tissue Culture Raised Propagule	8
	Total	199

Table 1 Group of crops eligible for Seed Certification

*Ajawain, Cumin, Coriander, Fennel , Suwa, Tamarind



1. BLACK PEPPER (Piper nigrum L.)

In black pepper, the rooted cuttings constitute the planting material. Hence the standards are for the production of quality rooted cuttings.

Phase of certificate

1. Field Inspection for selection of the field (for single season certified nursery – conventional method – three nodded cuttings).

1.1. Selection of mother vines:

The material meant for multiplication should be selected only from an uniformly established gardens free from diseases/inoculants of diseases such as Phytophthora foot rot, Stunt and Phyllody diseases. Elite mother vines are to be identified at such gardens with the following characteristics.

- a. Age of the elite mother vines should at least be not less than 7 years.
- b. The vine should have given stable yield of at least 2 kg dry pepper/vine/year for 4 consecutive years.
- c. Management practices followed for those vines during the last five years should be noted.
- d. These selected vines should be monitored at least once in a year for a possible infection of the disease and continuously monitored for future use.

Vines with above characters are identified, labeled and runner shoots from such lines only should be used for large scale multiplication. In any such selection, varietal purity should be maintained. Close examination is essential to avoid physical mixing of varieties. To avoid such mixing, support trees and vines should be examined carefully so that if more than one variety of pepper vines are growing on the same tree support, such vines should be rejected.

1.2 Field inspection team:

The field from which planting material are to be collected should be inspected by a team consisting of a breeder, pathologist, entomologist and nematologist besides an agronomist.

1.2.1. Minimum specific number of field inspection:

Two inspections are to be carried out; one during October-November for identifying mother vines with the specifications of the crop field as mentioned in para 1.1 and the other during January-February to inspect field for the incidence of pests and diseases if any particularly to locate *Phytophthora* foot rot and stunt/phyllody diseases. A certificate to the effect the vines selected meet the standards para 1.1. It is mandatory for any commercial nursery to obtain this certificate annually.

2. Standards for planting material production methods

2.1 Nursery inspection – standards

The area in which nursery is to be established in a well drained preferably in a slightly elevated place. This surface soil (0-15 cm depth) in this area should be tested for the present/absence of disease causing fungi/bacteria/nematodes particularly for the fungus *Phytophthora capsici*, nematode viz., *Radopholus similes* and *Meloidogyne incognita*. These tests should be carried out by the qualified personnel.
2.2 Method

Collect the runner shoots from the mother vines selected as per the criteria in the para 1.1. Keep the vines to prevent them from striking roots in the soil. Separate the runner shoots from the vines during February-march. The middle one third portion of runner shoots are preferred for planting. Avoid very tender and too hard portions for the shoot. Cut the shoots into pieces of 2-3 nodes. Clip the leaves, if any leaving a small portion of the petiole on the stem. Dip the lower cut end (up to 2 cm) of the cuttings in 1000 ppm solution of 3 Indol Butyric Acid (IBA) for 45 seconds will substantially increase root formation and development (This solution can be prepared by dissolving 1 g of IBA in one litre of water containing 3-5 g of sodium carbonate (Washing soda). Adhere to the dipping period of 45 seconds as any deviation from this may be injurious.

Treating the cuttings with Seradix B2 is equally effective. But IBA treatment is cheaper and hence is recommended for large nurseries where technical supervision. Seradix B2 can be conveniently used by the farmers and small scale nurseries.

Plant the treated cuttings in polythene bags (20 x 10 cm size with 300 gauge thickness) filled with potting mixture. The potting mixture is prepared by mixing two parts of fertile top soil, one part of river sand and one part of well decomposed Farm Yard Manure or Compost. When polythene bags are used sufficient number of holes about 20) may be provided at the base to ensure good drainage. The cutting should be planted at least on node deep in the soil.

In large commercial nurseries, where the soil contains more than 200 nematodes per gram of soil, the potting mixture should be fumigated with methyl bromide @ 500g per tonne of soil to destroy the nematodes (to be used only by pest control operators under the supervision of Govt. experts or experts approved by the Plant Protection Advisor to Govt. of India). Planting of cuttings in such a potting mixture is to be taken up only after 21 days of fumigation. The cuttings after planting should be kept under good shade. The cuttings are to be well protected from direct sun light. Light and frequent watering in recommended in the nursery to maintain a humid and cool atmosphere around the cuttings. Heavy watering which makes the soil slushy and cause water logging is to be avoided.

2.3. Minimum specifications for the rooted cuttings of black pepper

- i. The age of the rooted cutting should be $2\frac{1}{2}$ months old from the date of planting in the polythene bags.
- ii. A minimum of five leaves should be preset with vigorous growth without exhibiting any nutrient deficiency symptoms
- iii. Profusely developed roots with the absence *Phytophthora capsici* spores and nematodes viz., *Radopholus similis* and *Meloidogyne incognita* on the cuttings as well as in the potting mixture
- iv. Maintaining varietal purity.
- v. Each such bag may contain a minimum of two such rooted cuttings

Black pepper rooted cuttings fail to meet above requirements should not be considered as a quality planting material of black pepper.

3. Multi-season Nurseries

These nurseries are based on the bamboo method of rapid multiplication.



3.1. Nursery inspection

The nurseries should be inspected by an expert team consisting of a plant pathologist, nematologist, entomologist and an agronomist and certify that the nursery plants are free from sources of inoculums specifically for the fungi *Phytophthora capsici*, nematodes *Meloidogyne incognita* and *Radopholus similis*, viral disease symptoms, Stunt and Phyllody disease. This expert should inspect the nursery at least once in six months and issue certificate as the case may be.

3.2. Minimum specifications for the rooted cuttings of black pepper

The standards prescribed as in para 2.3 are applicable here.

- i. The age of the rooted cutting should be $2\frac{1}{2}$ months old from the date of planting in the polythene bags.
- ii. A minimum of five leaves should be present with vigorous growth without exhibiting any nutrient deficiency symptoms
- iii. Profusely developed roots with the absence *Phytophthora capsici* spores and nematodes viz., *Radopholus similis* and *Meloidogyne incognita*.
- iv. Maintaining varietal purity
- v. Each such bag may contain a minimum of two such rooted cuttings

Black pepper rooted cuttings fail to meet above requirements should not be considered as a quality planting material of black pepper.

II. Land requirement/Nursery requirement

- Nursery shed to be used for propagation of black pepper shall be of convenient size e.g., 24 m x 6m. Roof should allow sufficient light to pass through it 50-75% light).
- Rooting medium made of forest soil, sand, compost (or powdered cattle manure @ 2:1:1)
- Poly bag 20 x 10cms size.

III Field inspection / Nursery Inspection

Minimum of two inspections shall be made as follows:

- 1. The first inspection shall be made about 30-35 days after planting the cuttings in the poly bag to check the sprouting.
- 2. The second inspection shall be made about 75-90 days to verify cutting growth *Phytophthora*, mealy bugs and scales infestation.

IV Field standards

A. General Requirements

1. Isolation

The cuttings of particular variety shall be isolated from contaminants (1m distance).

2. CAPSICUM (SWEET PEPPER) (Capsicum annuumL.) var. grossum Bailley) AND CHILLI (HOT PEPPER) (Capsicum frutescens L.)

I. Application and Amplification of General Seed Certification Standards

The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of Capsicum and Chilli seed.

II. Land Requirements

Land to be used for seed production of Capsicum and Chilli shall be free of volunteer plants.

III. Field Inspection

A minimum of three inspections shall be made, the first before flowering, the second at the flowering and fruiting stage and the third at mature fruit stage and prior to harvesting.

IV. Field Standards

A. General requirements

1. Isolation

Seed fields offered for certification shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said table:

Contaminants	Minimum distance (meters)	
	Foundation	Certified
1	2	3
Fields of other varieties	500	250
Fields of the same variety not conforming to varietal purity requirements for certification	. 500	250
Fields of Capsicum from Chilli and vice versa	500	250
B. Specific requirements		

Factor	Maximum pern	Maximum permitted (%)*	
	Foundation	Certified	
1	2	3	
Off types	0.10	0.20	
** Plants infected seed borne diseases.	0.10	0.50	

*Maximum permitted at and after flowering in the case of off-types and at the final inspection in the case of seed borne diseases.

**Seed borne disease shall be:

Leaf blight: (Alternaria solani Sorauer.);

Anthracnose (Ripe rot, Die back) : Colletotrichum capsici (Syd.) Butler & Bisby)

V. Seed standards

Factor	Standard for each class	
	Foundation	Certified
1	2	3
Pure Seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crops seeds (maximum)	5/kg	10/kg
Weed seeds (maximum)	5/kg	10/kg
Germination (minimum)	60%	60%
Moisture (maximum)	8.0%	8.0%
For vapour-proof containers (maximum)	6.0%	6.0%

3. TAMARIND (Tamarindus indica L.)

I. Application and Amplification of General Clone Certification Standards

- A. The General Clone Certification Standards are basic and, together with the following specific standards constitute the standards for certification of Tamarind Clone.
- B. The General Standards are amplified as follows to apply specifically to Tamarind. All certified clones shall be produced by asexual methods like air Layering or Patch budding or Ring budding.

II. Land Requirements

Land to be used for clone propagation of Tamarind shall be free from volunteer plants.

III. Field Inspection

A. Rootstock

A minimum of one inspection shall be made before budding when the rootstock has attained buddable stage.

B. Mother Plant/Scion

Mother plant should be healthy, true to type and free from pests and diseases. The trees should be certified for the desirable characters by the certifying agency and a certificate to this effect shall be given to the nurseries. A minimum of one inspection shall be made at the time of fruit maturity for health and fruit quality of the mother tree.

C. Clones (Budded/Air Layers)

A minimum of one inspection shall be made before the sale of the clones after attaining the specified size to verify relevant factors.

IV. Field Standards

- A. General requirements
 - 1. Isolation

The clone propagation plots of Tamarind shall be isolated from the contaminants as shown in the following table:

Contaminants	Minimum distance (meters)	
	Foundation	Certified
1	2	3
Fields of other varieties	3	3
Fields of same variety not conforming to varietal purity requirements for certification	3	3

- **2. Spacing**: the spacing between plants in clone propagation plots should be 25 cm and between row 40 cm.
- **3. Rotation**: Nursery should be rotated to other plots after raising line Tamarind three times in the same plot.

B. Specific requirements

A. Foundation clones

Foundation clones being a group of common ancestry shall be genetically pure in absolute terms. Off types should be discarded under the supervision of Certification Agency.

B. Certified Class

Factor	Maximum permitted (%)* Certified
Off-type	0.10

* Standards for off-types shall be met at final inspection.

V. Clone Specifications

The specification in respect of size of clones for foundation and certified classes shall be as follows:

- 1. The diameter of the stock should range from 0.75-1.0 cm
- 2. The height of the grafting should range from 15-20 cm.
- 3. The diameter of the grafts at 10 cm above the graft union should range from 1.0-1.25 cm and height of the graft 50 cm 100 cm.
- 4. The diameter of the Air layer at 10 cm above the ground level should range from 1.0-1.25 cm and height of the Air layer 50-100 cm.
- 5. The grafted clone should be free from suckers
- 6. In the clone lot, clones not conforming to specified size shall not exceed 5.0% (by number)



VI. Clone Standards

Factor	Standards for	Standards for each class		
	Foundation	Certified		
Pure living clones (minimum)	99.5% (by number)	98.0% (by number)		
Other living plants including rootstocks (maximum)	0.5% (by number)	2.0% (by number)		

7. GINGER (Zingiber officinale Rosc.)

I. Application and Amplification of General Seed Certification Standards

- A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of seed ginger.
- B. The general standards are amplified as follows to apply specifically to ginger
- C. All certified classes shall be produced by vegetative propagation of underground rhizome, whose source and identity may be assured and approved by the certification agency.

II. Land Requirements

- Partial shade with gentle sloppy landscape
- Soil should be loose, friable and offer minimum resistance to rhizome development. Soil depth 30 cm or more, high organic matter and pH of 6-6.5 are favourable. Virgin forest soil particularly after disinfestation is ideal.
- Planting should be avoided if soil is infested with *Pythium* sp., *Pseudomonas* solanacearum, and *Meloidogyne incognita*.
- Land to be used for seed/planting material production of ginger shall be free from volunteer plants.

III. Field Inspection

A minimum of four inspections shall be made as follows:

- A. The first inspection shall be made at the time of planting variety isolation, rhizome rot, seed piece weight and spacing.
- B. The second inspection shall be made about 45-125 days after planting to check germination, sprouting, rhizome rot and shoot borer incidence.
- C. The third inspection shall be made about 180-190 days after planting to check off types, rhizome rot and *Phyllosticta* leaf spot.
- D. The fourth inspection shall be made before harvest of or between 240-250 days after planting to verify rhizome rot, scale insect and mealy bug infestation.

IV. Field Standards

A. General requirements

1. Isolation

The fields/blocks of seed ginger shall be isolated from the contaminants shown in the column 1 of the table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants		Minimum distar	nce (meters)	
		Foundation	Certified	
1		2	3	-
Fields of other varieties		3	3	_
Fields of the same variety to varietal purity requirem	not conforming ents for certification	n 3	3	
B. Specific requirements				
Factor	Inspection stage	Foundation	Certified (Maximum)	_
1.Spacing	Ι	45 x30 cm	45x30cm	
2.Seed piece weight	Ι	20-25 g	20-25 g	
3.Rhizome rot	Ι	0	0	
4. Shoot borer	II to IV II to III	01.0%	05.0%	
5.Off-types	III	0.5%	1.0%	
6. <i>Phyllosticta</i> Leaf spot: Bacterial wilt		1.0%	5.0%	
(Rhizoctonia solanacearum)	III	1.0%	1.0%	
7.Scale insect	IV	1.0%	5.0%	
8.Mealy bugs	IV	1.0%	5.0%	

Note:

- 1. All off-types and diseased plants should be rogued out along with rhizomes and destroyed.
- 2. Gaps in the seed plot should not be more than 10.0%

V. Seed Standards

Factor	Foundation	Certified
1. Appearance	Healthy & Plumpy	Healthy & Plumpy
2 .Uniformity (Minimum)	95.0%	85.0-95.0%
3. Dry rot (Maximum)	1.0%	5.0%
4. Phyllosticta (Maximum)	5.0%	10.0%
5. Scales (Maximum)	1.0%	5.0%
6. Mealy bugs (Maximum)	1.0%	5.0%

Note:

- 1. In a seed lot, rhizomes not conforming to specific characteristics of a variety shall not exceed 0.5% and 1.0% (by number maximum) for foundation and certified seed classes, respectively.
- 2. The seed material shall be reasonably clean healthy and firm.
- 3. Cut, bruised, or those damaged by insects shall not exceed more than 1.0% (by weight)

8. TURMERIC (Curcuma longa L.)

I. Application and Amplification of General Seed Certification Standards

- A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of seed turmeric.
- B. The general standards are amplified as follows to apply specifically to turmeric.
- C. All certified classes shall be produced by vegetative propagation of underground rhizome, whose source and identity may be assured and approved by the Certification Agency.

II. Land Requirements

- Soil should be loose, aerable and offer minimum resistance to rhizome development.
- Soil depth 30 cm or more, high organic matter of acidic soil.
- The crop of seed turmeric shall not be eligible for certification if grown on the land infested with *Pythium* sp., *Pseudomonas solanacearum*, and *Meloidogyne incognita*.

III. Field Inspection

A minimum of four inspections shall be made as follows:

- A. The first inspection shall be made at the time of planting to verify isolation, rhizome rot, seed piece weight and spacing.
- B. The second inspection shall be made about 45-50 days after planting to check germination, sprouting, rhizome rot and shoot borer incidence.
- C. The third inspection shall be made about 120-180 days after planting in order to verify off types, shoot borer and rhizome rot.
- D. The fourth inspection shall be made before harvest or between 240-250 days after planting to verify rhizome rot, scale insect and meal bug infestation.

IV. Field Standards

A. General requirements

1. Isolation

The fields/blocks of seed turmeric shall be isolated from the contaminants shown in column 1 of the table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants	Minimum distance (meters)		
	Foundation	Certified	
1	2	3	
Fields of other varieties	3	3	
Fields of the same variety not conforming to varietal purity requirements for certification	3	3	

5.0%

- · · · I · · ·	- 1			
Fact	or	Inspection stage	Foundation	Certified (Maximum)
1.Sp	pacing	Ι	45 x30 cm	45x30cm
2.Se	ed piece weight	Ι	20-25g	20-25 g
3.Rł	nizome rot	Ι	0	0
4. S	hoot borer	II to III	1.0%	5.0%
5.01	ff-types	III	0.5%	1.0%
6. S	cale-insect	IV	1.0%	5.0%

IV

C. Specific requirements

7.Mealy bugs

Note:

1. All Off-types and diseased plants should be rogued out along with rhizomes and destroyed.

1.0%

- 2. Gaps in the seed plot should not be more than 10.0%
- 3. Land should be free from volunteers

V. Seed Standards

Factor	Foundation	Certified
1. Appearance	Healthy & Plumpy	Healthy & Plumpy
2 .Uniformity (Minimum)	95.0-100.0%	85.0%
3. Dry rot (Maximum)	1.0%	5.0%
4. Scales (Maximum)	1.0%	5.0%
5. Mealy bugs (Maximum)	1.0%	5.0%

Note:

- 1. In a seed lot, rhizomes not conforming to specific characteristics of a variety shall not exceed 0.5% and 1.0% (by number maximum) for foundation and certified seed classes, respectively.
- 2. The seed material shall be reasonably clean healthy and firm.
- 3. Cut, bruised, or those damaged by insects shall not exceed more than 1.0% (by weight)

9. CARDAMOM (Eletteria cardamomum Maton)

I. Application and amplification of general seed certification standards

a. The general seed certification standards are basic and together with the following specific standards constitute the standards for certification of cardamom.



b. The general standards are amplified as follows to apply specifically to cardamom.

All certified classed shall be produced by seedlings raised from field collected open pollinated seeds, seedlings, from hybrid seeds produced in clonal seed production gardens and vegetative through suckers (slips).

II. Nursery requirement/ land requirement

The nurseries should be established as far as possible only in virgin soils or in soil where cardamom/ other related zingiberaceous crops were not planted earlier.

- avoid soil infected with *Pythium*, *Phytophthora*, *Rhizoctonia*, nematodes and soil borne insect pests
- the land after preparation can be subjected to soil solarization.

III Field inspection/ Nursery inspection

- For selection of mother plants for collection of open pollinated seeds minimum two visits are needed. The first inspection should be at time of the full bearing stage in the previous season (August- September) for marking the plants having high yield parameters. The second inspection shall be made just before the harvesting season of the current year (September) for assessing the performance of the selected plants and also for pest and disease incidence.
- For hybrid seeds from clonal crossing blocks minimum three inspection shall be made i.e. before flowering, during flowering to rogue off unsuitable plants if any, and also to ascertain the freedom from pests and diseased, third inspection shall be at harvest to assess the quality of seed capsules.
- In case of nursery, minimum three inspection shall be made, first at 3 months after sowing and second at 6 months to check off types, pest and disease and seedlings shall be transferred to poly bags and final inspection made before/ at the time of distribution (9-10 months) to assess the quality of seedlings and pest and disease incidence.

IV Field standards

A. General requirements

1. Isolation

The clonal crossing blocks of cardamom shall be isolated from the contaminants

Contaminants	Foundation	Certified
Fields/blocks of general cultivation	200m	100m

Note: In nursery minimum 3 m isolation distance is required between varieties

Standards	Foundation	Certified	
1. Uniformity of the crop	0	0	
2. Presence of diseases			
a) katte virus	0	0	
b) Clump rot	0	0	
c) Azhukal (capsule rot)	0	0	
d) Kokke kandu	0	0	
3. Presence of pests			
a) Thrips	0	0	
b) Capsule/ shoot/ panicle borer	<5%	<10%	
c) Root grubs	0	0	
d) White flies	<5%	<10%	

B. Specific requirements

V Capsule/ seedling standard

A.Capsule Standard		
Standards	Foundation	Certified
1. Appearance	Bold and Healthy	Bold and Healthy
2. Uniformity	>95%	>85%
3. Thrips affected capsules	<5%	<10%
4. Borer affected capsules	<5%	<10%
5. Deformed capsules	<5%	<10%
6. Contamination with other varieties	<1%	<5%
7. Colour of the seed	Brownish Black	Brownish Black
8. Germination percent		
a) Without acid treatment	60%	50%
b) With acid treatment	80%	70%
B. Seedlings standard		
Standards	Foundation	Certified
1.Height	60-75 cm	60-75 cm
2.No of leaves	5-7	5-7
3.No.of suckers	-	-
4. Presence of diseases		
a) katte virus	0	0
b) kokke kandu	0	0
c) Fungal diseases	0	0
5. Insect pest	<1%	<5%
6. Undesirable seedlings	<5%	<10%

Note: The seedlings are first sown in raised beds of convenient size and at 6 months seedlings are transferred to secondary nursery i.e in poly bags of 25 x 10 cm size filled with nursery mixture.



- I. Application and amplification of general seed certification standards
 - A. The general seed certification standards are basic and together with the following specific standards constitute the standards for certification of clove.
 - B. The general standards are amplified as follows to apply specifically to clove
 - No distinct varieties are recognized in India. The common method of propagation is through seeds collected from healthy and regular bearing trees.

II. Nursery requirements

- In order to select elite mother clove tree, minimum two inspection shall be made. One before flowering second at the time of flowering
- In the nursery, only one check at the time of distribution shall be made to assess the quality of seedlings

III Field standards

A. General requirements

1. Isolation

- As there are no distinct varieties, isolation is not required. However, in nursery clove seedlings kept 2 meter away from other crop seedlings to avoid pest infestation.
- B. Specific requirements

Healthy and regular bearing mother clove tree with following characters:

- 1. Number of terminals per branch >10 First inspection
- 2. Number of clusters per branch >14 First inspection
- 3. Number of flower branch >100 Second inspection
- 4. Length of flowers >1.5 cm Second inspection

IV. Seedlings standard

Height -50 cm

Note:

- To reach sufficient height it will take 9-24 months depending upon management
- First, seed will be sown in sand beds, after germination seedlings will be transferred to poly bags
- Normally no pest and diseases infests clove seedlings in the nursery

11. CINNAMON (Cinnamomum verum Bercht. & Prest.)

In cinnamon, the rooted cuttings constitute the planting material. Hence the standards are for the production of quality rooted cuttings.

1. Nursery requirements

- a) A nursery shed which can allow 75% sunlight
- b) IBA or IAA 2000 ppm or Seradix-B

- c) Polythene bags of 30x22 cm size and 300gz thickness for rooting
- d) Coir dust and sand mixture (1:1 ratio)
- e) Potting mixture made up of well powdered garden/forest soil, pure fine sand and well powdered dried cow dung (3:3:1 ratio)

2. Parent tree requirements

The parent trees must have a very good regeneration capacity, high quality bark with good yield. IISR Navashree and IISR Nithyashree are the national varieties released recently.

3. Planting material (rooted cuttings) production

Six month old shoot cuttings with 2-3 nodes are to be made from the present tree. Half leaf only has to be retained at each node. The lower cut end of the cutting (up to 2 cm) has to be dipped in 2000 ppm solution of IBA or IAA for few seconds (quick dip method). This will substantially increase root formation and development. This solution can be prepared by dissolving 1g of IBA or IAA in 2 l. of water containing 3 to 5 g of Sodium Carbonate (washing soda). Treating the cutting with Seradix B2 is equally effective. But IBA or IAA treatment is cheaper and hence recommended for large nurseries where technical supervision is feasible. Seradix B-2 can be conveniently used by farmers and small scale nurserymen. The shoot cuttings which were kept in the polythene bags could be taken 2 to 3 months later, when roots were found through the polythene bag. The rooted cuttings must be carefully lifted and separately planted in polythene bag containing 3:3:1 garden soil, sand and farm yard manure (dried and well powdered). At the time of planting, care has to be taken that primary root is well developed (minimum 25 cm) with lot of lateral roots (about 20). One year old such bagged cuttings must be used for planting. It should have attained a minimum height of 25 to 30 cm.

12. NUTMEG (Myristica fragrans)

Method of propagation -vegetative Epicotyl grafting.

Scion Preparation

Age of scion shoots - 3-4 month old.

Number of leaves - 2-3 leaves

Diameter of scion shoots - 0.5 cm

Root stock preparation

Name of the root stock -Myristica fragrans (seed sprout/seedlings.)

Age of the root stock -20 days after germination at the first leaf stage.

Diameter of the rootstock - Diameter of 0.5 cm or more

Root stock propagation -Fresh Seed- undried.

Standards of the planting material

Height of the plant -> 15 cm

Height and condition of the union - > 15 cm, strongly united.

Scion and root diameters at the union - > 0.6 cm and above



Growth of the plant – Vigorous.

Root system of the plant - Tap root.

Condition of the earth ball - Intact and moist

Disease incidence.

i) Name of disease - Die back, Causal organism -Diplodia sp.

Detection and Diagnosis - The disease is characterized by drying up of mature and immature branches from the tip down wards.

ii) Name of disease - Shot hole Causal organism -Colletotrichum gloeosporioides.

Detection and Diagnosis - Visual

Insect pest incidence i) Causal organism - Black scale (Saissetia nigra)

Detection and Diagnosis - Visual. Nematode incidence -Nil.

13. VANILLA (Vanilla planifolia Andr.)

Information regarding parent material

Method of propagation - Vegetative (Cutting)

Standards of planting material

Height of cuttings - 60-120 cm in length,

Number of internodes - 15-20

Diameter - 0.8 cm.

Number of leaves - 13-15 nos

Disease incidence

i) Name of disease - Stem rot

Causal organism - *Fusarium oxysporum* f.sp.*vanillae* and *Phytophthora meadii* Detection and diagnosis -Visual

ii) Name of disease - Root rot

Causal organism - Phytophthora meadii and Sclerotium rolfsii

Detection and diagnosis - Visual

iii) Name of disease - Tip rot and die back

Causal organism - Cucumber mosaic virus, Cymbidium mosaic virus, Vanilla mosaic virus.

Detection and diagnosis Visual, ELISA, Polymerase chain reaction (PCR) tests

14. Certification standards for protray nursery of turmeric and ginger

The technology of transplanting ginger and turmeric is become popular and many farmers or nurseryman commercially producing and selling using this technique nurseries. The Tamil Nadu Agricultural University (TNAU), Coimbatore is a leading Institution has standardised portray technique for turmeric, ICAR-Indian Institute of Spices Research (IISR), Kozhikode, Kerala has standardised similar technique for ginger.

2

S1 N	0	Parameter Standard	
1	Planting material	Finger rhizome with single bud weighing approximately 4-6 g	
2	Seed treatment	Treat the single bud sprouts (Mancozeb 0.3%) for 30 min be- fore planting	
3	Seed rhizome rate	600 – 750 kg / ha	
4	Media	Cocopeat + <i>Pseudomonas fluorescens</i> or partially decomposed coir pith and vermicompost (75:25), enriched with PGPR/ <i>Trichoderma</i> 10g/kg of mixture	
5	Growing condition	50% Shade net with micro irrigation	
6	Age of the seedling	30 - 35 days	
7	Shoot length during transplanting	20 – 25 cm	
8	Number of leaves/shoot	3 - 4	
9	Root structure	Coiled root mat	
10	Root length during transp	planting 10 – 12 cm	

The following standard is recommended for protray raised.

Conclusion

Spices are important group of horticultural crops, human always in need of them for day-to-day uses. Spices are having different life span and mode of propagation. Most of the perennial spices propagate through vegetative method. The quality planting material plays very important role in establishment of good spice gardens/fields. Hence, they should be produced with utmost care by following all possible recommended technologies. Nursery and planting material produced should be approved by authorised accreditation agency for propagating quality material. The seed certification standards are available for spices have to be adopted for production quality planting material to achieve the objective of spreading good quality seed in Indian Agriculture.

Source and Further Readings

- Indian Minimum Seed Certification Standards. 2013. The Central Seed Certification Board Department of Agriculture & Co-operation, Ministry of Agriculture, Government of India, New Delhi (Compiled by Trivedi R K & Gunasekaran M)
- Guidelines for Recognition of Spices Nursery. 2014. Directorate of Arecanut and Spices Development, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Calicut, Kerala
- http://tmnehs.gov.in/writereaddata/Standards_for_Planting_Material.pdf Standard Guidelines for Planting Material of Horticultural Crops (Accessed on 26 March 2016)
- Guidelines for Recognition of Horticulture Nursery. 2008. http://nhb.gov.in/guideline/horticulture-nursery.pdf National Horticulture Board (NHB), Gurgaon.

http://seednet.gov.in/



Impact of nursery accreditation in Shivamogga district in Karnataka

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Abstract

At present majority of planting material are supplied from the private nurseries in spice crops in Shivamogga district in Karnataka. The identification of the genuineness of the planting material is herculean task. By realising the scope and immense potentiality of the accreditation, Department of Horticulture (DOH) and Krishi Vigyan Kendra (KVK), Shivamogga motivated the nurserymen for accreditation by National Horticulture Board (NHB). Initially the nurserymen not responded. But due to continuous persuasion from the DOH and KVK, Shivamogga they agreed to apply for the accreditation. The accreditation process started in 2011-12 and seven nurseries were applied for the accreditation and all the nurseries were ranked as 'single star' nurseries by the NHB. Hence, the nurserymen motivated and competency among the nurserymen to produce elite propagules was started. With constant intervention for re-accreditation by the DOH and KVK, Shivamogga in establishing scion banks, improved propagation techniques, varietal identification, management of pests and diseases in the nurseries with special reference to spices out of seven nurseries one was raised to the level of 'three star', one nursery raised to the level of 'two star' and remaining five nurseries as remained as 'single star' nurseries by NHB from 2011-2015 based on the improved production techniques adopted. From these seven nurseries yearly different quality planting of spices viz., 10.45 lakh of pepper (rooted cuttings and graft), 1.20 lakhs of clove (seedling origin), 1.50 lakh of nutmeg (seedling origin and grafts) and 1.25 lakh of curryleaf (seedling origin and root suckers) were being supplied to farmers/departments/NGOs. Thus nursery accreditation in Shivamogga District in Karnataka created high impact in production of quality planting material worth of Rs. 52 lakh/annum, development of the entrepreneurial and behavioural skills of the nurserymen and other nurserymen also applying for the accreditation.

Introduction

India is the largest producer, consumer and exporter of spices and spice products in the world and produces more than 52 spices. At present, production is around 3.2 million tonnes of different spices valued at approximately 4 billion US \$, and holds a prominent position in world spice production. But, inadequate availability of quality planting material is one of the important deterring factors in development of a sound spice industry. At present 30-40 per cent demand for planting material is being met by the existing infrastructure. Farmers do not have access to certified disease free material as a result of which production; productivity and quality of the produce

suffers. Much of the dependence is on the unregulated and unmonitored private nurseries in most of the states. The existing nurseries lack modern infrastructure such as greenhouses, mist chambers, shade net, efficient nursery tools and gadgets, implements and machinery.

Accreditation of nurseries in Shivamogga district

In Shivamogga district in Karnataka majority of planting material are supplied from the private nurseries in spice crops. The identification of the genuineness of the planting material is herculean task. By realising the scope and immense potentiality of the accreditation, Department of Horticulture (DOH) and Krishi Vigyan Kendra (KVK), Shivamogga motivated the nurserymen for accreditation by National Horticulture Board (NHB). Totally, seven nurseries *viz.*, 1) Chetana High Tech Nursery, Holehanasawadi, Shivamogga Taluka; 2) GMR Biotech Nursery, Sogane Camp, Shivamogga Taluka; 3) Kalpataru Nursery, Tavarekoppa Village, Shivamogga Taluka; 4) Shree Krishna Farms and Nursery, Raminakoppa, Shivamogga Taluka; 5)Varashree Nursery, Gajanur Post, Shivamogga Taluka ; 6) Gagan Nursery, Melinahanasavadi, Abbalageri Post, Shivamogga Taluka; and 7) Sahyadri Nursery, Hakkare, Sasaravalli (Post), Sagara Taluka in Shivamogga district were motivated for accreditation.

The Seeds Act and the Nursery Registration Act have been in operation since December 1966. However, the Nursery Registration Act is presently in force in respect of horticulture nurseries only in the States of Punjab, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttrakhand, Jammu and Kashmir, Orissa and Tamil Nadu. Some system of registering/ monitoring exists for horticulture nurseries in the States of Andhra Pradesh, Assam, Bihar, Goa, Haryana, Karnataka, Kerala while there is no horticulture nursery act in the States of Arunachal Pradesh, Chattisgarh, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura and West Bengal. In the absence of any formal system of quality assurance for horticulture planting material, it is not feasible to put any kind of quality control related restrictions on horticulture nurseries which do not have adequate production-related infrastructure and pedigreed mother plants. Hence, much emphasis was given to accreditation. Initially, the nurserymen not responded in Shivamogga District. Due to continuous persuasion from the DOH and KVK, Shivamogga they agreed to apply for the NHB accreditation. The aim of the NHB accreditation scheme is to establish a network of quality nurseries across the country for the purpose of propagation and distribution of quality planting material of specified horticulture crops.

The recognition shall be accorded to the nurseries for:

- 1) Production of quality planting material of one or more specified crops by adopting good nursery management practices,
- 2) Nursery premise only where sale of specified quality planting material of recognized source are being carried out by creating necessary infrastructure facilities and proper record keeping.

The criteria have been aligned with infrastructural requirement of 'Model Nursery' and product specific technical requirement and adoption of 'Good Nursery Practices' for propagation of good quality planting material. The rating followed by the NHB is as follows: Outstanding (5 stars), Excellent (4 stars), Very Good (3 stars), Good (2 stars), Satisfactory (1 star).

Conclusion

With constant intervention by the DOH and KVK, Shivamogga in establishing scion banks, improved propagation techniques, varietal identification, management of pests and diseases in the nurseries with special reference to spices facilitated easy accreditation / re-accreditation. In 2011 initially all seven nurseries were rated as single star nurseries. Consequently during re-accreditation, out of seven nurseries one was raised to the level of 'three star', one nursery raised to the level of 'two star' and remaining five nurseries as remained as 'single star' nurseries by NHB from 2012-2015 based on the improved production techniques adopted. From these seven nurseries yearly different quality planting of spices *viz.*, 10.45 lakh of pepper (rooted cuttings and graft), 1.20 lakhs of clove (seedling origin), 1.50 lakh of nutmeg (seedling origin and grafts) and 1.25 lakh of curryleaf (seedling origin and root suckers) were being supplied to farmers/departments/NGOs. Thus nursery accreditation in Shivamogga District in Karnataka created high impact in production of quality planting material worth of Rs. 52 lakh/annum, development of the entrepreneurial and behavioural skills of the nurserymen and other nurserymen also applying for the accreditation. By the intervention of Krishi Vigyan Kendra, Shivamogga and Department of Horticulture, Shivamogga farmers are getting genuine and quality planting material in spice crops. For maintaining the quality of the planting material these nurseries have to be monitored regularly.



Protection of Plant Varieties and Farmer's Rights Authority Ministry of Agriculture, Govt. of India

Considering the national requirements and also the obligations under international agreements, Government of India has enacted the Protection of Plant Variation and Formany' Pickta (PDV & FD). Act in 2001, It provides an effective

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- of protection of plant varieties and rights of farmers, communities, plant breeders and researchers
- Important Provisions under the Act:
- * Breeders Rights: to produce, sell, market, distribute, import or export the variety registered under the Act
- * Researcher's Rights: to use the variety for experiment or research for developing other variety
- * Farmers Rights: As per the Act, the Farmer is regarded as a cultivator, conserver of biodiversity and as a breeder.
- The Farmer is entitled to use, re-use, sell or exchange seeds of registered varieties amongst them.
- They are entitled for reward and recognition for conservation of agro-biodiversity.
- Farmers are exempted from fee in any legal proceedings.
- They are eligible for benefit sharing from use or misappropriation of their material for development of new varieties by breeders.
- They can claim compensation for loss suffered from non-performance of registered variety.
- Above all, akin to breeders, farmers can register new and traditional varieties developed or conserved by them
- Application may be filed for registration of varieties of the particular crop species (which have been notified) under the categories of

New plant varieties,

- Essentially Derived Varieties (EDV),
- Extant varieties (notified under the Seeds Act, 1966), extant (Variety of Common Knowledge) and
- Farmer's varieties

Awards, Rewards & Recognitions

• The Authority is operating the National Gene Fund constituted by the Government of India under the Act. The Plant Genome Saviour Community Award (five awards of Rs.10 lakhs each) has been instituted and is being awarded since 2009-10 for supporting the conservation and sustainable use of genetic resources, especially in areas located in agro-biodiversity hotspots (22 Agro-biodiversity hotspots distributed over 7 agro-geographical zones) and till now total 10 Plant Genome Saviour Community Award has been given.

• A farmer who is engaged in the conservation of genetic resources of land races and wild relatives of economic plants and their improvement through selection and preservation is entitled to a reward called the "Plant Genome Saviour Farmer Reward". This reward comprises of citation, memento and such an amount of

cash as may be decided by Central Government to be conferred annually to maximum of ten farmers and till now total 10 Plant Genome Saviour Farmer Reward has been given.

• In addition to this, the Government of India has also approved maximum of 20 recognition certificates to be conferred annually which will comprise of citation, memento and such an amount of cash as may be decided by Central Government and till now total 15 Plant Genome Saviour Farmers Recognition Certificate has been given.







The Book contains all the Statistics on area, production, productivity, export, import and price of various spices produced in the country for the last 5 years Price Rs. 250

For Copies request may be sent to

The Director, Directorate of Arecanut and Spices Development, West Hill P.O., Calicut - 673005, Kerala (Telephone: Office: 0495 - 2369877, Director: 2765501, Fax: 0495 - 2765777, Email: spicedte@nic.in) along with a Demand Draft drawn for an amount of Rs. 250 in favour of The Pay and Accounts Officer, Department of Agriculture and Cooperation payable at Ernakulam.



Use Planting Materials from Accredited Cashew/Cocoa nurseries only

भारत सरकार Govt. of India

Quality standards-Cashew Grafts

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Characters	Standards
Age of the graft	6 months
Number of leaves	5-7 functional leaves
Height of the graft	30-45 cm
Height of the graft Joint	15 -20 cm from collar region.
Growth	Healthy and vertical growing
Graft joint	Perfect without any girdling or constriction.
Nature of Polythene bag	Intact and not torn
Side sprout	Free from side sprout from the root stock

Quality standards - Cocoa hybrid seedlings

Characters	Standards
Age of the seedling	5-6 months
Number of leaves	5-6 pairs
Height of the graft	45-50 cm
Growth	Vigorous seedlings growing straight at the middle of the poly-bag.
Jorquetting	No jorquetting



Directorate of Cashewnut and Cocoa Development (DCCD) , Kochi is the national agency approved by Government of India for accreditation of cashew/cocoa nurseries. Application and other guidelines for accreditation is available in DCCD website www.dccd.gov.in.



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कृषि एवं किसान कल्याण मंत्रालय Ministry of Agriculture and Farmers Welfare कृषि, सहकारिता एवं किसान कल्याण विभाग Department of Agriculture, Cooperation and Farmers Welfare केर भवन, कोच्ची - 682 011 Kera Bhavan, Kochi-682011 Web: http://dccd.gov.in |E-mail : dccd@nic.in | Phone: 0484 -2377151 Fax: 0484-2377239

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Cardamom facts

The parrot green queen of spices needs no explanation or description as such to put forth its intrinsic values. The pungent flavour has since time immemorial been delighting the palates of millions of food lovers around the globe. Indigenous to the lush green Western Ghats, cardamom had its impact in the history of spice trade. With its intense aromatic flavour, the spice, along with pepper, has been a predominant reason for attracting foreigners to the Indian soil, boosting the Indian economy.

Normally people tend to look up at the top of a tree or in certain cases, beneath the soil for fruits or seeds. But cardamom 'gently walks on top of the soil'. The pods are seen at the bottom of the plant, spread on top of the soil in capsules. The flowers of cardamom plants with the help of pollinators, the honey bees, turn into the very aromatic and intrinsic cardamom capsules. Cardamom needs the canopy of rich forests for its flourishing growth. This means that cardamom plant has a very important role in maintaining the ecosystem.

Cardamom is not a mere condiment; it is a compliment to the food delicacies. It seeks to bring together the east and the west. With its myriad capacities and capabilities, cardamom finds place in beverages, confectioneries, bakery, perfumery, desserts and is also a major ingredient in garam masala, the foundation of many Indian dishes. Still, cardamom remains a mystery and a velled treasure for the western soil. There are more curious facts.

Is it only the taste that matters? Obviously not! This evergreen produce has many medicinal and nutritional properties. From being a mouth freshener to a prestigious gift item, cardamom has stood the test of time for specific reasons.

According to Ayurveda, cardamom, an aphrodisiac and a stimulant, aids digestion and is useful against flatulence. It is used in South Asia to treat infections in teeth and gums, throat troubles, congestion of lungs and pulmonary tuberculosis, inflammation of eyelids and helps to break down kidney stones and gall stones. The phytochemicals in cardamom have anti-microbial and anti-cancer properties and can reduce blood pressure in stage one hypertensive individuals. So why are you

keeping cardamom at bay? Go for it and make it a habit!

Revathy S Mohan



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