GOOD AGRICULTURAL PRACTICES

BLACK PEPPER (*Piper nigrum* L.)

Directorate of Arecanut and Spices Development
Department of Agriculture and Cooperation
Ministry of Agriculture, Government of India
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Cover Design
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Printed at
Kozhikode District Co-operative Press
Kozhikode - 2

PREFACE

Black pepper, the King of spices, is one traded spice of the world, which brought many seafarers to the shores of India from the ancient times. It was this spice, the trade of which has become an important part of the world history, and lead to the great adventure, exploration, conquest and naval rivalry. The Western Ghats spread over the States of Kerala, Karnataka and Tamil Nadu is the centre of origin of Black Pepper.

India enjoyed a premium position in the Global pepper trade because of the intrinsic quality of Indian Black pepper. Of late, newly emerging pepper producing countries gained competitive edge over the traditional producers through high productivity and low cost of production. Productivity of pepper in India varies from 400 to 500 kg/ha where as in Vietnam, Malaysia, Brazil it is recorded more than 1500 kg/ha. Stringent food laws in importing countries also demands more on quality of the pepper produced.

Application of scientific production technologies could play an important role in improving productivity and returns from the crop bringing back its past glory. It is imperative that the farmers cultivate Black Pepper in tune with nature, preserving the health of the soil, creating the environment for microflora to assist the crop so that we get sustained production, year after year with minimum inputs.

Hence the Directorate of Arecanut and Spices Development, constituted an Expert Committee to recommend good agricultural practices required for the cultivation of black pepper. The recommendations of the committee are being published by the Directorate as "Good Agricultural Practices (GAP) - Black Pepper".

I am sure that this publication drafted by the Committee, will be a good guide to the farmers in achieving higher production and productivity through sustainable cultivation practices.

Calicut
11 June, 2015

Dr Homey Cheriyan
Director

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GOOD AGRICULTURAL PRACTICES FOR BLACK PEPPER

Black pepper requires warm humid climate. A well distributed rainfall of 1250 to 2800 mm is ideal for its cultivation. Though it tolerates a minimum of 10°C and a maximum of 40°C, the optimum temperature is 20-30°C. It comes up well in a variety of soils with pH ranging from 4.5 to 6.5. Pepper grows luxuriously and is productive at elevation upto 1200m above MSL.

Varieties

High yielding varieties/Hybrids:

Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Panniyur-6, Panniyur-7, Panniyur-8, Vijay, Sreekara, Subhakara, Panchami, Pournami, IISR Sakthi, IISR Thevam, IISR Girimunda, IISR Malabar Excel, PLD-2.

Popular cultivars: Karimunda, Neelamundi, Jeerakamundi, Chengannurkodi, Kottanadan, Kuthiravally ,Balankotta

Selection of site

Sites with slight to moderate slope are ideal for pepper cultivation, since it would ensure good drainage. Slopes facing south west are to be avoided as far as possible. When such slopes are to be used for cultivation, the young plants may be sufficiently protected from the scorching sun during summer.

Pepper Nursery and its Management

Propagation

1. Raising of rooted cuttings

Selection of mother plants

1. Select mother plants of varieties which are proven high yielder.
2. Select mother plants in the age group of 5-12 years, which are

consistently high yielding and are free from diseases including viral diseases.

3. Mark and label selected mother plants during October-November for the collection of runner shoots.
4. It is desirable to avoid unselected bulk as a source of planting material.

Preparation of nursery mixture

The Nursery mixture is prepared by mixing two parts of fertile top soil, one part of river sand and one part of cattle manure (2:1:1). The moistened nursery mixture should be solarized to get rid of some of the soil borne plant pathogens. To solarize, the moistened nursery mixture is spread on a levelled surface with 1 m width and 25 cm height and of convenient length. These beds should be located in an area exposed to bright sunlight. The beds are covered with transparent polythene sheet of 100-150 guage, without leaving any air gaps. The beds are to be sealed on all the sides with a mud plaster. This would ensure heat buildup, a process called solarization. About 35-45 days of solarization is necessary to be effective. Later polythene sheets are removed. To prevent pathogen contamination, the solarized nursery mixture should be immediately mixed with biocontrol agents viz. *Trichoderma harzianum* or *T. viride* (1 g per kg of nursery mixture), *Pseudomonas fluorescens* (Strain P1) (20 g dissolved in 1 litre water and 50 ml of this solution to be used for one kg of nursery mixture) and VAM/AMF (vesicular arbuscular mycorrhiza /arbuscular mycorrhizal fungi) @ 100cc per kg of nursery mixture, *Pochonia chlamydosporia* (1-2g/kg of nursery mixture). Such solarized nursery mixture mixed with above biocontrol agents would prevent root infection in the pepper cuttings.

Where solarisation of nursery mixture is not possible, unsolarised nursery mixture can also be mixed with biocontrol agents that would

protect roots from infection. The nursery mixture is then filled in polybags of size 20X10cm or 15X10 cm, with enough holes to ensure proper drainage.

Preparation of cuttings

Select runner shoots produced at the base of mother plant and keep them coiled and raised on a stake to prevent soil contamination and from striking roots in the soil. Separate them from the vines during February-March. The middle one-third portion of runner shoot is preferred for planting. Very tender and too woody shoots are to be avoided. The selected runner shoots are cut into 2-3 noded cuttings. Leaves, if any are to be clipped off leaving a small portion of the petiole on the stem.

Cuttings are to be treated with *Pseudomonas flourescens* culture by dipping cut ends of the cuttings in slurry of *P. flourescens* culture (250 g in 750 ml of water) for 20 minutes. Treated cuttings are planted in polythene bags at the rate of 2-3 cuttings /bag.

Planting of cuttings in poly bags

The cuttings should be planted at least one node in the soil during February. After planting, the nursery bags should be kept under good shade. In large nurseries, pandals with 50% shade net are to be erected. During rainy season, the top of the pandals may be covered with 200 gauge UV stabilized polythene sheets to prevent dripping of water into the polybag. Judicious watering is recommended in the nursery to ensure high humidity and moderate temperature conducive for optimum sprouting of the cuttings. Heavy watering leading to stagnation should be avoided. Housing the cuttings for about 20 days in a moist chamber covered on all sides with transparent polythene would ensure higher percentage of sprouting and better establishment.

The cuttings with 3 to 4 leaves of 3 to 4 months old would be ready for planting in May-June.

2. Serpentine method

The method requires grown up rooted cuttings in 20 x 10 cm poly bags. Rooted cuttings are arranged in one end of the nursery and each cutting is trained to grow horizontally. As shoot grows, bags filled with the nursery mixture are kept underneath each node and allowed to strike roots. It is essential to ensure that each node touches the mixture. The shoot is then allowed to grow for about 3 months that can produce about 10-15 single noded rooted cuttings. This process continues in such a way that a single node gets rooted in each bag until the shoot reaches the last bag in a row. Once 20 nodes get rooted, the first 10 polythene bags with rooted nodes should be separated by cutting the internodes and the cut ends are also pressed into the bag. The axillary bud from each node in the bag sprouts and develops into 4-5 noded rooted cuttings in about 2-3 months. After a gap of another 20-30 days, the rest of the bags also can be separated. About 40-60 rooted cuttings can be produced from a single plant during a year.

Fig 1. Serpentine method of propagation

3. Pepper shoot multiplication

Mature pepper shoots can be raised on inclined bamboos under shade conditions (coconut grove) or in a net house. These mature shoots can be utilized to raise 2-3 noded rooted cuttings. For this, plant rooted cuttings at one feet depth and distance. Cuttings are allowed to grow on a bamboo/ wooden stake, which are kept at an angle of 45^0. To prevent root infection, add decomposed farm yard manure mixed with biocontrol agents to each row, and provide irrigation during summer. After an year the shoots may be harvested. About 15-25 numbers of 2-3 noded cuttings can be produced from a single shoot per year.

Fig 2.Bamboo method

4.Orthotropic shoots.

Orthotropic shoots are erect growing leader shoots along the support/ standard (climbing shoots). Orthotropic shoots can be cut or extracted from the top up to 6 - 7 nodes down on the support. Too tender or too woody shoots need to be avoided. The medium matured green shoots are selected. These shoots with 5-6 node bits are planted directly in the planting pits. Two or three shoots per standards are

used and their number varies from place to place. Orthotropic shoots as source of planting materials are obtained from 2-3 year old vines. Plants raised with these shoots generally flower early and fruiting laterals start right from the base of the vine.

Management of Diseases in the Nursery

The diseases would amply be under control if the below mentioned prophylactic measures during nursery raising are strictly followed. Rooted cuttings raised in nursery mixture mixed with biocontrol agents would prevent root rot. However, if stray disease incidence is noticed, necessary plant protection measures are adopted.

Measures to be taken up to prevent the occurrence of diseases in nursery

- Spray and drench the plants at fortnightly intervals with 2% *Pseudomonas fluorescens* suspension.
- Maintenance of hygiene in the nursery is most important to avoid pest and disease problems.
- It is desirable to change the site of the nursery at least once in two years to avoid pathogen population build up.

Chemical control

Chemical control may be resorted to only in case of disease occurrence.

***Phytophthora* infection:** Spraying and drenching the nursery bags with potassium phosphonate 0.3% (3 ml / litre of 40% formulation) or Metalaxyl-mancozeb 0.125% (1.25 g of Ridomil-mancozeb per 1 litre) at monthly interval is recommended. Alternatively, spraying the cuttings with Bordeaux mixture 1% and drenching with copper oxychloride 0.2% (2 g per litre) at monthly interval can also be adopted.

Fig 3. *Phytophthora* infection in seedling

Anthracnose and basal wilt: The disease can be controlled by pre-planting treatment of cuttings by immersing in a solution of carbendazim + mancozeb 0.1% for 30 min and spraying Bordeaux mixture 1% or carbendazim+ mancozeb 0.1%.

Fig 4. Anthracnose symptom on leaves

Leaf rot and blight: This disease can be controlled by spraying Bordeaux mixture 1%.

Nematode infestation: Root infection (root rot) due to plant parasitic nematodes would result in poor growth, foliar yellowing and some times interveinal chlorosis of leaves of the rooted cuttings. As a preventive measure , nursery mixure may be fortified with talc based formulation of biocontrol agents such as *Pochonia chlamydosporia* or *Trichoderma harzianum* @ 1-2 g/kg of soil, the product containing 10^6 cfu fungus/g of substrate. Regularly check the nursery for nematode infection, if any, and remove such bags with severely infected cuttings from the nursery. Application of neem cake @ 1Kg /Pit at the time of planting may also prevent nematode infestation.

Fig 5. Nematode infestation on roots

Viral Infection

1. Remove and destroy immediately whenever virus infection such as mosaic/yellow mottle symptoms are seen on the leaves. Such uprooted infected vines may be burnt or buried deep in the soil.
2. Insect vectors such as aphids and mealy bugs on the plant once noticed should be controlled with insecticide spray. Insecticides like dimethoate 0.05% can control aphids, mealybugs and other sucking insects. Because of the closed placing of cuttings, chances of spread of mealy bug are more in the nursery. Hence regular monitoring of the nursery for mealy bug is important.

Fig 6. Virus infected seedling

Establishment of Plantation

If the terrain of the land is sloppy or uneven, carry out contour bunding or terracing to prevent soil erosion. Planting of live standards is to be taken up in April-May with the onset of pre-monsoon showers. “Nadan Murikku” (*Erythrina variegata*), Karayam or Kilinhil (*Garuga pinnata*), *Ailanthus sp., Glyricidia sp*., Jack fruit tree etc. are suitable live standards / supports recommended for trailing pepper. In high altitude areas, Dadap (*Erythrina lithosperma*) and Silver oak (*Grevillea robusta*) can be successfully used as standards for pepper. *Erythrina subumbrans* may be used as standarad in areas where gall wasp is noticed. The soil should be well pressed to keep the standards firm in the soil. Seedlings of Silver oak, Jack etc are to be planted 2-3 years before planting pepper. The cuttings of standards are to be planted in narrow holes of 40 to 50 cm depth.

Spacing

The spacing recommended is 3 x 3 m on plain lands and 2 m between plants in rows across the slope and 4 m between rows on sloppy lands.

Field Planting

For planting pepper, prepare pits on the northern side of standards, 15 cm away from it. The pit size should be 50 x 50 x 50 cm. Fill the pits with a mixture of topsoil and compost or well rotten cattle manure @ 5 kg/pit along with recommended products of biocontrol viz., *T. harzianum or T. viride* (50 g/pit), Vesicular arbuscular mycorrhizae (VAM) (100 g/pit) and *P. chlamydosporia* (50g/pit). With the onset of southwest monsoon in June-July, plant 2-3 rooted cuttings in the pits at a distance of about 30 cm away from the standards. Press the soil around the cuttings to form a small mound slopping outward and away from the cuttings to prevent water stagnation around the plants. The growing portions of the cuttings are to be trailed and tied to the standards. Provide shade to the plants during dry period to ensure good field establishment.

Management after Planting

Digging the base of the vines should be avoided. According to necessity weeds are removed by slashing in interspaces. Removed weeds may be recycled back as organic residue. In the early stages (1-2 years), tie the vines to the standards.

When pepper is grown in open places, shading and watering of the young rooted cuttings may be done during summer months for the first three years according to necessity. The young plants may be completely covered with dry arecanut leaves, coconut leaves or twigs of trees during summer months to avoid sun scorching. Mulching the basins of pepper with dry leaves during summer months is highly

advantageous. Hanging shoots may be pruned, wherever necessary.

To regulate shade, prune the branches of the live standards during April-May every year. This is necessary to provide optimum sunlight to the vines. The effective height of the standard is to be limited to about 6m. A second pruning of the standards may be done in August-September, if there is excessive shade in the garden. The base of the vines should not be disturbed to avoid feeder root damage.

Manuring

Manuring pepper vines is to be done in bands around the vine, at 30-75 cm away from the base of the vine, depending upon their growth. Apply 10 kg of decomposed cattle manure / compost / green leaves and 1 kg neemcake per plant with the onset of southwest monsoon and 5 kg of decomposed cattle manure and 1 kg neem cake per plant at the onset of northeast monsoon and cover lightly with soil. It is desirable to apply lime or dolomite @ of 500 g/vine in April-May, with the receipt of pre-monsoon showers, in alternate years.

Apply biofertilizer products of Azospirillum (50g/plant), Phosphobacteria (50g /plant) and VAM (100 g/plant) along with decomposed cattle manure during May- June. One more dose of biofertilizer, Azospirillum (50g/plant), Phosphobactor (50g/plant) may be given during September-October along with organics. Apply biofertilizers in a circle of radius 30 cm around the vine. Biofertilizer products may be applied along with farm yard manure/compost with a time gap of 15-20 days before chemical fertilizer application.

Manuring and fertilizer application for pepper has to be done for proper establishment and growth of vines. Proper soil testing may be done prior to fertilizer application to know the soil fertility and site specific fertilizer recommendation may be adopted. Recommended nutrient dosage for black pepper vines (3 years and above) is NPK 50:50:150 g/ vine/year (General recommendation).

Only one-third of this dosage should be applied during the first year which can be increased to two-thirds in the second year. The full dose is given from the third year onwards. It is better to apply the fertilizers in two split doses, one in **May-June** (pre-monsoon) and the other in **August- September** (post-monsoon). The following is the recommended fertilizer dosage:-

Time of Application	Urea (g/vine)	Mussoriephos or Rajphos (g/vine)	Muriate of Potash(MOP) (g/vine)
May-June	50	150	125
August-September	50	150	125

If the soil is high in any of the said nutrient the recommended dose may be reduced to half or one third .The fertilizers are applied at a distance of about 30-75 cm all around the vine and covered with a thin layer of soil. Care should be taken to avoid direct contact of fertilizers with roots of black pepper. When biofertilizer like Azospirillum is applied @ 100 g/vine, the recommended nitrogen dose may be reduced by half to 25 g/vine. In soils that are deficient in zinc, magnesium foliar application of zinc sulphate 0.25% $ZnSO_4$ twice a year (May-June and September-October) soil application of 150 g/vine magnesium sulphate respectively are recommended. Otherwise spray black pepper micronutrient mixture twice in a year for correcting the deficiency.

Plant Protection

Steps for reducing occurrence of diseases in plantations

1. No tillage or minimum tillage should be adopted.
2. Timely and judicious shade regulation should be practiced
3. Provide good drainage in the plantation.
4. Prophylactic chemical control measures to be adopted with the onset of South- West and North-East monsoon.

Diseases

1. *Phytophthora* foot rot

Phytophthora foot rot (quick wilt disease) caused by *Phytophthora capsici* is the most destructive of all diseases and occurs mainly during the south-west monsoon season. All parts of the vine are prone to infection and the expression of symptoms depend upon the site or plant part infected and the extent of damage. But root infection might continue even up to October as long as soil moisture remains high.

Symptoms

- During south-west monsoon period, one or more black spots appear on the leaves which have a characteristic fine fibre like projections at the advancing margins of the spots which rapidly enlarge and cause defoliation.
- The tender leaves and succulent shoot tips of freshly emerging runner shoots trailing on the soil turn black when infected. The disease spreads vertically to the entire vine, from these infected runner shoots and leaves, during intermittent showers due to rain splash.
- If the main stem at the ground level or the collar is damaged, the entire vine wilts followed by shedding of leaves and spikes with or without any black spots on leaves or tender stem. The branches of the affected vines break off at nodes and the entire vine collapses within a month.

If the damage is confined to the root or stem, the expression of aerial symptoms is delayed till the cessation of rain. The affected vine exhibits gradual yellowing, defoliation, wilting and drying up of a part of the vine. This may occur during October-November onwards. These vines occasionally might survive for more than two seasons till the root infection leads to collar rot and death of the vine.

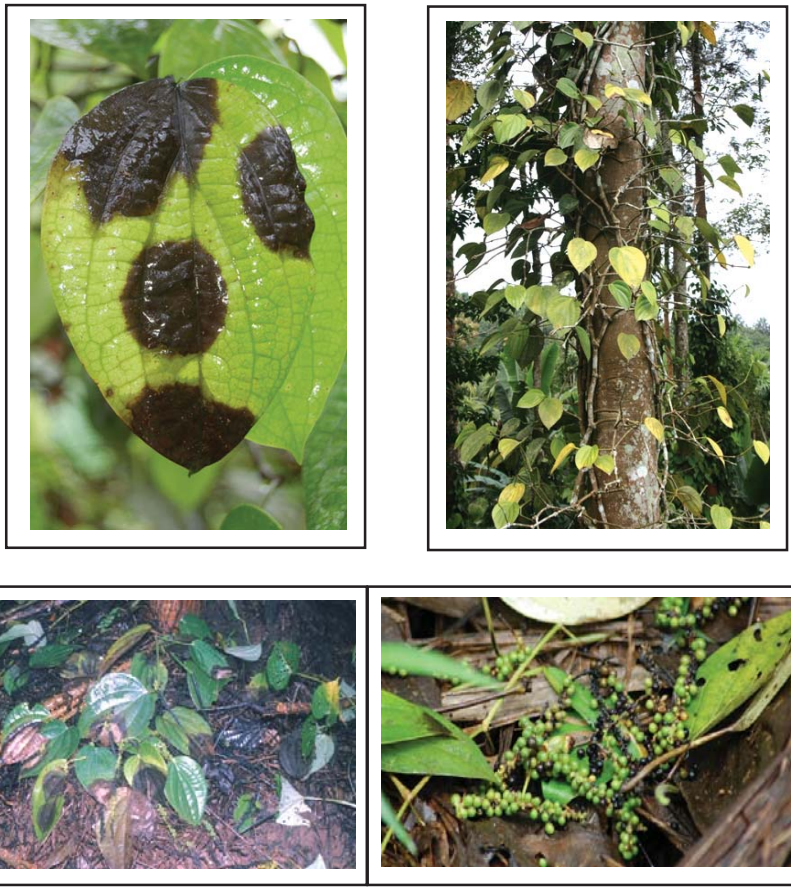

Fig 7. Symptoms of foot rot disease in pepper plantation

Symptoms of foot rot disease in pepper plantation

Management of the disease

Phytosanitation

All infected or dead vines along with the root system are to be collected in a gunny bag, removed and burnt. After removal of the vine along with entire root system, the area to be drenched with copper oxychloride 0.2% (2 g/l) @ 5-8 litres to check the population build-up of the pathogen. Wherever water stagnation is a problem, effective drainage of both surface and sub-soil should be ensured. Runner shoots are to be pruned or tied back to vines before the onset of monsoon. With the onset of monsoon, the branches of live standards may be lopped off to allow penetration of sunlight and avoid build up of humidity. Apply 2 kg neem cake per vine per year in two splits both as pre and post-monsoon treatment, in disease prone areas. This would ensure build up of microbial load to suppress soil borne plant pathogen.

Chemical control

Any one of the following control measures may be adopted as a prophylactic measure to check *Phytophthora* foot rot disease. After the receipt of few monsoon showers (May-June), all vines to be given a foliar spray of Bordeaux mixture 1% accompanied with drenching of soil around the vines over a radius of 45-50 cm with copper oxychloride 0.2% @ of 2-5 litres/vine (pre-monsoon).This may vary according to the age of the plant. Spraying and drenching are to be repeated just before the northeast monsoon (post-monsoon). A third round of drenching may be given during October, if the monsoon is prolonged

OR

After the receipt of a few monsoon showers (May-June), all vines may be given a foliar spray and drench the soil around the vines over a

radius of 45-50 cm with potassium phosphonate 0.3% or metalaxyl – mancozeb 0.125% (1.25g/litre) @ of 2-5 litres per vine (pre-monsoon). This varies according to the age of the plant. A second spraying and drenching with potassium phosphonate 0.3% or metalaxyl-mancozeb 0.125% is to be repeated just before the northeast monsoon (post-monsoon). If the monsoon is prolonged, a third round of drenching may be given during October.

Biological control

For protection against fungal diseases, *Trichoderma* and *Pseudomonas* may be applied to all the vines at the rate of 50 g/vine (10^8 cfu /g) during May - June and again during August - September. They may be multiplied in cowdung medium in 1:50 proportion for 2 weeks and may be applied at the rate of 2 - 2.5 kg/vine. *Pochonia chlamydosporia* may also be applied during May-June and August - September for protection against nematodes.

Note: 1. All chemical and biological control measures are prophylactic in nature and application of chemicals to vines in advanced stages of disease would be ineffective and hence removal of the affected vine is recommended.

2. Under high disease pressure biological control would be ineffective. Hence chemical control can be adopted to reduce disease to the minimum. Later biocontrol measures can be adopted to check disease out break.

3. If biocontrol agents are applied avoid drenching with 0 .2% copper oxychloride.

2. Slow decline (Slow wilt)

Slow decline is a debilitating disease of black pepper. Foliar yellowing, defoliation and die-back are the aerial symptoms of this disease. In severe cases withering and defoliation are noticed. With

the onset of south west monsoon during May/June, some of the affected vines recover and put forth fresh foliage. However, the symptoms reappear in subsequent seasons after the cessation of the monsoon and the diseased vines gradually loose their vigour and productivity. The root system of diseased vines shows varying degrees of root rot/ degeneration (necrosis and lesions) due to infestation by plant parasitic nematode *Radophalous similis*. Root galls are noticed if plants are infested by root knot nematode *Meloidogyne incognita*. Such damage to root tissues leads to rotting of feeder roots. This can be caused by nematodes and *Phytophthora capcisi* either independently or together in combination.

There is no spatial segregation of plant parasitic nematodes and *P.capsici* in the soil under field conditions. Hence, the need for holistic approach to check *P.capsici* and plant parasitic nematodes has to be done.

Fig 8. Slow wilt affected plant

Management of the disease

- Severely affected plants with less than 50% of the canopy may be removed along with root system and burnt off. Treat the pit with copper oxychloride 0.2%. Replanting to be taken up during the next year with healthy planting material.
- In areas severely infested with root knot nematodes, planting of the resistant variety 'Pournami' is recommended. Biocontrol agents like *Pochonia chlamydosporia* and *Trichoderma harzianum* can be applied @ 50g/vine twice a year (during April- May and September-October).

3. "Pollu" disease (Anthracnose)

This disease is caused by a fungus, *Colletotrichum gloeosporioides*. It can be distinguished from the 'pollu' (hollow berry) caused by the flea beetle by the presence of characteristic cracks on the infected berries. The disease appears towards the end of the monsoon. The affected berries show brown sunken patches during early stages and their further development is affected. In later stages, the discolouration gradually increases and the berries show the characteristic cross splitting. Finally, the berries turn black and dry. The fungus also causes angular to irregular brownish lesions with a chlorotic halo on the leaves. In high ranges round brownish spots on the leaves are noticed. Leaf infection is noticed throughout the year with different intensities. The variety, Panniyur – 5 shows field tolerance to Pollu disease in high-ranges. The disease can be controlled by spraying Bordeaux mixture 1% or carbendazim + mancozeb 0.1% or mancozeb 0.1% on new foliage and spikes.

4. Stunted disease

This disease is caused by viruses. The affected vines exhibit shortening of internodes to varying degrees. The leaves become small

and narrow with varying degrees of deformation and appear leathery, puckered and crinkled. Chlorotic spots and streaks also appear on the leaves occasionally. The yield of the affected vines decreases gradually. Two viruses namely *Cucumber Mosaic Virus* (CMV) and *Pepper Yellow Mottle Mosaic Virus* (PYMV), a *Badnavirus* are associated with the disease. The major mode of spread of the virus is through the use of infected stem cuttings. The disease can also be transmitted through insects like aphids and mealy bugs. The following strategies are recommended for the management of the disease.

- Use virus free healthy planting material.
- Infected vines should not be used as mother vines and source of planting materials.
- Regular monitoring to remove and burn the infected plants.
- Insect vectors such as aphids and mealy bugs on the plant or standards should be controlled with insecticide spray such as dimethoate @ 0.05%.

Insect Pests

1. "Pollu" beetle

The pollu beetle *Lanka ramakrishnai* formerly known as *Longitarsus nigripennis* is the most destructive pest of black pepper and is more serious in plains. The adult beetles feed and damage tender leaves and spikes. The females lay eggs on tender spikes and berries. The emerged grubs bore into and feed on the internal tissues. The infested spikes turn black and decay. The infested berries also turn black and crumble when pressed. The term 'pollu' denotes the hollow nature of the infested berries in Malayalam. The pest infestation is severe in heavily shaded areas in the plantation. The pest population is higher during September-October in the field.

Fig 9. Spike infested with pollu beetle

Control measures

1. Regulation of shade: Pruning of the branches of the live standard /support in the plantation reduces the population build up of the pest in the field.
2. In case of severe infestation, spray quinalphos (0.05%) during June-July (2 weeks after berry set) and September-October or quinalphos (0.05%) during July and neem based insecticide (0.5%) during August, September and October is effective for the management of the pest.
3. The underside of leaves (where adults are generally seen) and spikes are to be sprayed thoroughly.

2. Top shoot borer

The top shoot borer (*Cydia hemidoxa*) is a serious pest in young plantations. The adult is a tiny moth with a wing span of 10-15 mm with crimson and yellow fore wings and grey hind wings. The larvae bore into tender terminal shoots and feed on internal tissues resulting in blackening and decaying of affected shoots. When successive new shoots are attacked, the growth of the vine is affected. The pest

Fig 10. Symptoms of borer infestation

infestation is higher during July to October when numerous succulent shoots are available in the vines. Spray quinalphos (0.05%) on tender terminal shoots; repeat spraying at monthly intervals (during July- October) to protect emerging new shoots.

3. Leaf gall thrips

Infestation by leaf gall thrips (*Liothrips karnyi*) is more serious at higher altitudes especially in younger vines and also in nurseries in the plains. The adults are black and measure 2.5-3.0 mm in length. The larvae and pupae are creamy white. The feeding activity of thrips on leaves causes the leaf margins to curl downwards and inwards resulting in the formation of marginal leaf galls. Later the infested leaves become crinkled and malformed. In severe cases of infestation, the growth of younger vines and cuttings in the nursery is affected. Spray dimethoate (0.05%) during emergence of new flushes in young vines in the field and cuttings in the nursery. Repeat spray after 21 days if necessary.

Fig 11. Pepper leaves infested by leaf gall thrips

4. Scale insects

Among the various scale insects recorded on black pepper, mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus*

destructor) cause serious damage to black pepper vines at higher altitudes and also to older cuttings in nurseries in the plains. They feed on plant sap and cause yellowing and wilting of infested portions. If the infestation is mild, spray neem oil 0.3% or neem-based insecticide 0.3% (3 ml of neem oil/neem-based insecticide in 1 litre of water and a small piece of bar soap may be added) or fish oil rosin 3% (30 ml of fish oil rosin in 1 litre of water). In cases of severe infestation, the affected portions of vines dry up. The pest infestation is more severe during the post monsoon and summer periods. Clip off and destroy severely infested branches. Spray dimethoate (0.1%) on affected vines after harvest. Repeat spraying after 21 days to control the infestation completely.

5. Root mealy bug

Root mealybug infestation caused by *Planococcus* sp. has become serious in some plantations especially in higher altitudes. Severe root infestation causes yellowing and wilting of leaves and branches. This can be controlled by drenching the base of the vines with chlorpyriphos (0.075%) and adopting adequate control measures against *Phytophthora* and nematodes.

6. Erythrina gall wasp

The Erythrina gall wasp (*Quadrastichus erythrinae*) is a serious invasive pest on *Erythrina sp*. in most of the black pepper areas. The pest infestation results in crinkling and malformation of tender shoots and leaves, stunting, drying up of affected branches and also mortality of severely affected trees. Planting of *Erythrina* types less susceptible to the gall wasp (*Erythrina subumbrans*) and other standards such as *Ailanthus, Garuga pinnata* and *Glyricidia* are viable alternate standards which are not found susceptible to wasp.

Fig 12. *Erythrina* branch with gall wasp infestation

Harvesting

The harvest season extends from December to March in the high ranges. During harvest the whole spike is handpicked when one or two berries in the spike turn yellow to bright orange. The berries are separated from the spikes and dried in the sun for 7-10 days. The optimum moisture content in dried pepper to prevent mould attack is 12%. The berries can be separated manually or mechanically using threshers. Threshers with capacities varying between 0.5 to 1.5 tons per hour are available. This enhances speedy and hygienic separation of black pepper berries. When dried, the berries retain the characteristic wrinkled appearance of black pepper of commerce. The fresh berries dipped in boiling water for a minute before drying in the sun would result in an attractive black color, reduces mould growth and the drying time. For the production of white pepper, ripened berries may be harvested whereas for extraction of value added products like oils and oleoresins, immature berries will be ideal. The recommended drying surfaces are bamboo mat coated with fenugreek paste and high density black polythene which gives better appearance and cleanliness to the dried black pepper.

CALENDAR OF OPERATIONS FOR BLACK PEPPER CULTIVATION

October - December	**Nursery** • Mark and label selected mother plants ▸ Select mother vines of only varieties which are proven to be highly productive and tolerant to biotic and abiotic stress. ▸ Select mother plants of the age group of 5-12 years, which give consistently regular high yields and are free from diseases including viral diseases. • Runner shoots from selected mother vines are coiled and raised on a stake to prevent it from soil contamination and striking roots in the soil. **Plantation** • Tie growing shoots of young vines to the standards. • Remove hanging shoots in older plants. • Undertake slash-weeding of the interspaces. • Undertake hand-weeding at the basins of the vines and mulch the basins with dry leaves. • Inspect and remove plants showing symptoms of phyllody and stunt diseases (viral).

	• If monsoon is prolonged, drench the basins of the vines with Potassium phosphonate 3 ml/litre @ 2-5 litre per vine, depending on the size of the vine. • In case infestation of root mealy bugs are noticed, drench chlorpyriphos 0.075% on affected vines; repeat drenching after 21 days in case the infestation persists • In case infestation of scale insects are noticed, spray neem oil 0.3% or neem-based insecticide 0.3% on affected vines; repeat spraying after 15 days in case the infestation persists. In case the infestation is severe, clip off severely infested branches and spray dimethoate 0.1%; repeat spray after 21 days. In case berries are available on the vine, the spray has to be given only after harvest of berries. Root mealybug infestations can be controlled by drenching with chlorpyriphos 0.075%.
January - April	• Prepare the potting mixture and put for solarization for 30 to 45ays. • Immediately after solarization mix the solarized potting mixture with biocontrol agents viz. *Trichoderma harzianum* or *T. viride* (1 g per kg of potting mixture), *Pseudomonas fluorescens* (20 g dissolve in 1 liter water and 50 ml of

	this solution in 1kg of potting mixture),VAM (100 cc per kg of potting mixture)and *Pochonia chlamydosporia* (1 - 2 g / kg of nursery mixture) to prevent soil contamination. (The biocontrol agents can also be mixed with nursery mixture, even if it is not solarized). • Fill the polybags of size 15X10 cm (with enough perforations) with treated nursery mixture. • Separate the runner shoots from the mother plant. Avoid using, too tender or too woody shoots. • Cut the selected runner shoots into 2 to 3 noded cuttings.Leaves, if any are clipped off leaving a small portion of petiole on the stem. • Treat the cuttings with cut ends dipped in *Pseudomonas* formulation (250g in 750 ml water) for 20 minutes. • Plant treated cuttings @3 to 5 per bag and incubate in mist chambers for 20 days. When cuttings start sprouting, they are taken out or removed from the mist chamber. Remove unsprouted and infected cuttings, if any from the nursery. • Water the plants at the required frequency so as to maintain low temperature and high humid conditions.

	• Spray and drench the plants at fortnightly interval with 2% *Pseudomonas fluorescens* (Strain P1) • Drench the infested bags with Chlorpyriphos 0.075%, if mealy bugs damage is noticed. • Spray with dimethoate (0.05%), if leaf gall thrips or scale insects incidence is noticed. • Spray with potassium phosphonate 0.3% or metalaxyl-mancozeb 0.125% (1.25 g/litre) at fortnightly interval, if *Phytophthora* disease incidence is noticed. • Alternatively spray the foliage with Bordeaux mixture 1% and drench with copper oxychloride0.2%. • Remove bags with infected cuttings to prevent spread of disease. **Plantation** • Undertake slash-weeding of the interspace. • Undertake hand-weeding at the basins of the vines and mulch the basins with dry leaves. • Remove hanging shoots in older plants. • Cover the young vines so as to prevent drying. • Inspect and remove plants showing symptoms of phyllody and stunt diseases (viral).

	• Harvest matured berries and process. **New plantation** • During the month of April, plant live standards like Murikku (*Erythrina indica*), Karayam or Kilingil (*Garuga pinnata*), *Ailanthus sp., Glyricidia sp.,* Jackfruit tree etc., suitable for trailing pepper. In high altitude areas, Dadap (*E. lithosperma*) and silver oak (*Grevillea robusta*) can be successfully used as standards for pepper. Seedlings of silver oak and jackfruit tree are to be planted 2-3 years before planting pepper. • The spacing recommended is 3 x 3 m on plain lands. On sloppy land 2 m between plants in rows across the slope and 4 m between rows. • Irrigate the standards till the monsoon starts.
May – July	**Nursery** • Continue watering at the required frequency. • Spray and drench the plants with *Pseudomonas fluorescens* (2%) at fortnightly interval. • Spray with potassium phosphonate 0.3% or metalaxyl mancozeb 0.125% (1.25g/litre) at fortnightly interval, if Phytophthora disease incidence is noticed. Alternatively spray the foliage

with Bordeaux mixture 1% and drench with copper oxychloride 0.2%.

- Drench the infested bags with chlorpyriphos 0.075%, if mealy bugs damage is noticed.
- Spray with dimethoate (0.05%), if gall thrips or scale insects incidence is noticed.
- Remove bags with infected cuttings or on nursery to prevent spread of disease.
- Select healthy, robust rooted cuttings for replanting.

New Planting

- Prepare pits (50 x 50 x 50 cm) on the northern side of standards, 15-30 cm away from the base of the standard. Fill the pits with a mixture of topsoil and compost or well rotten cattle manure @ 5 kg/pit mixed with biocontrol agents viz., *T. harzianum* or *T. viride* (50 g/pit) and VAM (110 g/pit) and *P. chlamydosporia (*50 g/pit).
- Plant 2-3 rooted cuttings in the pits at a distance of about 30cm away from the standards.
- Press the soil around the cuttings to form a small mound slopping outward and away from the cuttings to prevent water stagnation around the plants.
- Tie and trail the growing shoots to the standards.
- Provide shade to the plants if the land

is exposed and if there is a dry spell.

Plantation

Phytosanitation

- Remove all infected or dead vines along with the root system.
- Prune the runner shoots or tie back to the standards before the onset of monsoon.
- Prune off the branches of live standards to allow better aeration and sunlight that would reduce the chances of infestation.
- Provide good drainage in areas prone to water stagnation.
- Tie growing shoots of young vines to the standard.
- Undertake slash- weeding in the interspaces.

Manuring

- Undertake manuring and fertilizer application with the receipt of few pre-monsoon showers.
- Apply organic manures @ 10kg/vine (decomposed cattle manure or compost or green leaves).
- Apply neem cake @ 1 kg/ mature vine.
- Apply lime @ 500 g / vine in alternate years.
- Apply Azospirillum (50 g/vine) and *P. solubilizer* (50 g /vine).

Note: Application of chemical fertilizers can be undertaken two weeks after application of manures and bio fertilizers/ bio-inputs.

Chemical fertilizer application

- Apply the recommended dose of chemical fertilizer at the rate of NPK 50:50:150 g/vine/year (Urea 100 g: Rock Phosphate 300 g: MOP 250 g) in two splits
- Provide half of the dose during June (Urea-50g: Rock Phosphate-150g: MOP 125g).
- Apply only two-third of the dose to the two year old vines and full dose of fertilizers from 3rd year onwards.
- Apply zinc sulphate 0.25% as a foliar spray and also magnesium sulphate (150 g/vine) as soil application, in zinc deficient and magnesium deficient soil, respectively

or

- Black pepper Micronutrient mixture as foliar spray twice in a year.

Plant protection

- Undertake foliar spray with Bordeaux mixture 1% followed by soil drenching over a radius of 45-50 cm around the vines

  with copper oxychloride 0.2% (@ 2-5 litres per vine), immediately after first monsoon showers.

	OR Drench the soil and spray foliage with potassium phosphanate 0.3% Or metalaxyl mancozeb 0.125% (@ 2-5 litres per vine). • Undertake foliar spray with quinalphos (0.05%) to check pollu beetle or top shoot borer. Leaf gall thrips can be controlled by spraying dimethoate (0.05%) • Apply first round of biocontrol agents (AMF, *Trichoderma*, *Pseudomonas fluorescens* and *Pochonia chlamydosporia*) along with organics Avoid copper oxychloride drenching if biocontrol agents are applied.
August - September	**Plantation** • Continue new-planting / replanting • Undertake slash - weeding • Tie growing shoots of young plants to the standards. • Prune the branches of support trees to regulate shade. • Apply 5 kg of decomposed coffee manure and 1 kg neemcake per vine with the onset of north east monsoon. • Apply balance half dose of the recommended fertilizers (Urea-50g : Rock Phosphate-150g : MOP 125g). • Apply second round of biocontrol

	agents (AMF, *Trichoderma Pseudo monas fluorescens* and *Pochonia chlamydosporia*) along with organics. • Apply Azospirillum (50 g/vine) and *P. solubilizer* (50 g/vine along with decomposed cowdung. • Spray the foliage with Bordeaux mixture 1% and drench the basin of the vines with copper oxychloride 0.2% @ of 2-5 litres/vine. • Avoid copper oxychloride drenching if biocontrol agents are applied. OR • Spray foliage and drench the soil with potassium phosphonate 0.3% or metalaxyl mancozeb 0.125% (@ 2-5 litres per vine). • Undertake foliar spray with quinalphos (0.05%) or check pollu beetle and top shoot borer infestations.