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ICAR

GOOD Agricultural Practices

Black Pepper

ICAR-Indian Institute of Spices Research
ICAR-All India Coordinated Research Project on Spices

BLACK PEPPER

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Good Agricultural Practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while consideringeconomic, social and environmental sustainability as defined by the Food and Agricultural Organization (FAO). GAP recommends addressing environmental, economic and social sustainability for on-farm production and post-production processes resulting in safe and healthy food and non-food agricultural products. A broadly accepted approach using GAP principles, generic indicators and practices will help guide debate on national policies and actions and on the preparation of strategies to ensure that all stakeholders participate in and benefit from the application of GAP in the food chain. The aim of GAP is to promote Sustainable Agriculture and Development and with effective input use, are one of the best ways to increase smallholder productivity. GAP in addition to improving the yield and quality of the products, also has environmental and social dimensions.

Practising GAP improve the safety and quality of food and other agricultural products and it helps to reduce the risk of non-compliance with national and international regulations, standards and guidelines set by Codex Alimentarius Commission, World Organisation for Animal Health and the International Plant Protection Convention IPPC regarding permitted pesticides, maximum levels of contaminants food and non-food agricultural products, as well as other chemical, microbiological and physical contamination hazards. Moreover, adopting GAP promotes sustainable agriculture and contributes to meeting national and international environment and social development objectives.Its social dimension would be to protect the agricultural workers' health from improper use of chemicals and pesticides. It is a particularly opportune time to promote GAP when second generation of reforms in agriculture which would have a Critical impact on Indian agriculture, are planned by the Indian Government. However, farmers need to be adequately informed, technically prepared and organised to meet this new challenge with governments and public agencies playing a facilitating role.

GOOD AGRICULTURAL PRACTICES FOR BLACK PEPPER

Black pepper (*Piper nigrum* L.) (Family: Piperaceae) is one of the most traded spices in the world and the spicy property is attributed to the presence of the chemical substance piperine. Black pepper a perennial vine grown for its berries which is extensively used as spice and in medicine.

India is one of the major producer, consumer and exporter of black pepper in the world and the spice is cultivated to a large extent in Kerala, Karnataka and Tamil Nadu and to a limited extent in Maharashtra, North eastern states and Andaman & Nicobar Islands. Kerala and Karnataka account for a major portion of production of black pepper in the country.

SITE SELECTION

The information on soil condition, water logging, industrial waste and effluents, source of irrigation water and meteorological data need to be available with the farm management before starting black pepper cultivation.

Climate and soil

Black pepper is a plant of humid tropics requiring high rainfall and humidity. It grows successfully between 20° North and South latitudes, and up to 1500 m above sea level. The favourable temperature range is 23–32° C and the ideal temperature is around 28° C. The ideal range of relative humidity for the crop is 75–80%. A well distributed annual rainfall of 1250–2000 mm is considered ideal for black pepper. Black pepper can be grown in a wide range of soils with a pH of 5.5 to 6.5, though in its natural habitat it thrives well in red laterite soils.

SEEDS AND PROPAGATION MATERIAL

Varieties

A majority of the cultivated types are monoecious (male and female flowers found in the same spike) though variation in sex expression ranging from complete male to complete female is found. Over 75 cultivars of black pepper are being cultivated in India. Karimunda is the most popular cultivar in Kerala.

The other important cultivars are Kottanadan (South Kerala), Narayakodi (Central Kerala), Aimpiriyan (Wayanad), Neelamundi (Idukki), Kuthiravally (Kozhikode and Idukki), Balancotta, Kalluvally (North Kerala), Malligesara and Uddagare (Karnataka). Kuthiravally and Balancotta exhibit alternate bearing habit. In terms of quality, Kottanadan has the highest oleoresin (17.8%) content followed by Aimpiriyan (15.7%). Eighteen improved varieties of black pepper

have been released for cultivation (Table 1). Panniyur-1, Panniyur-3 and Panniyur-8 are hybrids evolved at the Pepper Research Station, Panniyur (Kerala Agricultural University). IISR Girimunda and IISR Malabar Excel are the two hybrids released from ICAR-Indian Institute of Spices Research, Kozhikode, Kerala.

SREEKARA

IISR SHAKTHI

IISR GIRIMUNDA

IISR MALABAR EXCEL

IISR THEVAM

PANNIYUR 1

Table 1. Improved varieties of black pepper and their characteristic features

Variety	Pedigree	Mean yield (dry) (kg/ha)	Dry recovery (%)	Quality attributes			Features
				Piperine (%)	Oleoresin (%)	Essential oil (%)	
	Kerala Agriculture University (KAU), PRS, Panniyur, Kerala						
Panniyur -1	Hybrid, Uthirankotta × Cheriyakaniakadan	1242	35.3	5.3	11.8	3.5	High yielding, not suited to heavily shaded areas
Panniyur -2	Selection (Cul. 141) from cv. Balancotta	2570	35.7	6.6	10.9	-	Shade tolerant
Panniyur -3	Hybrid (Cul. 331), Uthirankotta × Cheriyakaniakadan	1953	27.8	5.2	12.7	-	Late maturing
Panniyur -4	Selection from Kuthiravally Type	1277	34.7	-	9.2	-	Stable yielder
Panniyur -5	Open pollinated progeny selection from Perumkodi	1098	-	5.5	12.3	3.8	Tolerant to shade
Panniyur -6	Clonal selection from Karimunda	2127	32.9	4.9	8.3	1.3	Suited to all black pepper tracts
Panniyur -7	Open pollinated progeny selection from Kuthiravally	1410	33.6	5.6	10.6	1.5	Suited to all black pepper tracts
Panniyur -8	Hybrid (HB 20052), Panniyur 6 × Panniyur 5	1365	39.0	5.7	12.2	1.2	High yielding, field tolerant to *Phytophthora* foot rot and drought
	Indian Institute of Spices Research, Kozhikode, Kerala						
Subhakara	Selection from Karimunda (KS-27)	2352	35.5	3.4	12.4	6.0	Suited to all black pepper tracts
Sreekara	Selection from Karimunda (KS-14)	2677	35.0	5.3	13.0	7.0	Suited to all black pepper tracts
Panchami	Selection from Aimpiriyan (Coll. 856)	2828	34.0	4.7	12.5	3.4	Late maturing
Pournami	Selection from Ottaplackal (Coll. 812)	2333	31.0	4.1	13.8	3.4	Tolerant to root knot nematode
PLD -2	Clonal selection from Kottanadan	2475	-	3.3	15.5	3.5	Suited to Thiruvananthapuram and Kollam districts of Kerala
IISR Shakthi	Open pollinated progeny of Perambramundi	2253	43.0	3.3	10.2	3.7	Tolerant to *Phytophthora* foot rot.
IISR Thevam	Clonal selection of Thevamundi	2481	32.0	1.65	8.15	3.1	Tolerant to *Phytophthora* foot rot; Suited to high altitudes and plains
IISR Girimunda	Hybrid, Narayakodi x Neelamundi	2880	32.0	2.2	9.65	3.4	Suited to high altitudes
IISR Malabar Excel	Hybrid, Cholamundi x Panniyur-1	1440	32.0	4.95	14.6	4.1	Suited to high altitudes; Rich in oleoresin

Propagation

Black pepper vines produce three types of shoot, namely (1) Primary climbing shoot with long internodes having adventitious roots at nodes which cling to the supports/ standards; (2) Runner shoots which originate from the base of the vine and creep on the ground, have long internodes which strike roots at each node and (3) Fruit bearing lateral shoots. Cuttings are raised mainly from runner shoots, though terminal shoots can also be used. Cuttings from lateral branches develop a bushy habit. Rooted lateral branches are used for raising bush pepper. Though seeds (berries) are fully viable, they are not generally used for raising plantations as seedlings will not be genetically uniform.

Production of rooted cuttings

Traditional method

Runner shoots from high yielding and healthy vines are kept coiled on wooden pegs fixed at the base of the vine to prevent the shoots from coming in contact with soil and striking roots. The runner shoots are separated from the vine during February-March, and after trimming the leaves, cuttings of 2-3 nodes are planted either in nursery beds or in polythene bags filled with potting mixture (soil, sand and farm yard manure in 2:1:1 ratio). Adequate shade has to be provided and the polythene bags are to be irrigated frequently. The cuttings become ready for planting during May-June.

Serpentine method

Serpentine layering technique can be used for production of rooted cuttings of black pepper in a cheap and effective manner. 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 (20 ×10 cm) filled with potting mixture may be kept under each node. The node may be kept gently pressed in to the mixture assuring contact with the potting mixture with the help of a flexible twig such as mid rib of a coconut leaflet. 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 junction to induce rooting at each node is repeated. In three months the first 10 to 12 nodes (from the mother plants) would have rooted profusely and will be ready for harvest. Each node with the polythene bag is cut just below the rooted node. The cut end is also buried into the mixture to induce more roots. Polythene bags used are filled with solarized potting mixture fortified with biocontrol agent. The rooted nodes will produce new sprouts in a week time and will be ready for field planting in 2-3 months. By this method, on an average, 60 cuttings can be harvested per mother plant in a year.

Soil-less nursery mixture

Partially composted coir pith and vermicompost (75:25) enriched with *Trichoderma* (in talc formulation, 10^7cfu/g at the rate of 10 g/kg) is an ideal potting medium for black pepper nursery for healthy planting material production using plug-trays compared to conventional multiplication.

Plug-tray nursery technique

The technique Involves initial multiplication of black pepper runners in a modified serpentine method, i.e. by allowing runners to strike roots in the partially decomposed coir pith and vermicompost (75:25) bed of convenient dimension (1.5 m width, 10 cm height and convenient length). The vines trail on rooting medium and strike roots at every node. After 45-60 days, leaving the terminal 5 nodes, about 15-20 node rooted runner is cut into single node rooted cuttings and transferred to plug-trays (cell dimension of 7.5 × 7.5 × 10.0 cm) filled with soil-less nursery mixture [composted coir pith and vermicompost (75:25) enriched with *Trichoderma*]. Better rooting and establishment is recorded under humidity controlled green house (27±2°C) with intermittent mist. The cuttings are retained in the trays for about 45-60 days (4–5 leaf stage) for initial establishment. The established cuttings are then transferred to shade net/ naturally ventilated green house for hardening (45–60 days). Healthy black pepper rooted cuttings are ready for field planting after 120-150 days.

Vertical column method

A novel method of intensifying quality planting material production has been standardized using vertical columns with soil-less media. The technique involves growing orthotropic shoots on vertical column (2 m height, 0.3 m diameter) made of half an inch plastic coated welded wire mesh. The column is filled with partially decomposed coirpith and vermicompost @ 3:1 ratio fortified with bio-control agent *Trichoderma harzianum*. Growing the vine on vertical column can be effectively utilized for the production of three types of planting material i.e., single node cuttings, top shoots with lateral branch (use of top shoots for field planting is having advantage of producing fruit bearing branch from the base and start yielding early) and laterals or plagiotropic shoots which can be used for production of bush pepper.

The hi-tech poly house (temperature of 25–28°C and relative humidity 75–80% with intermittent misting) is advisable for the above production system. Eight to ten cuttings can be planted around each vertical column. The cuttings are allowed to trail on the column ensuring that each node comes in contact with the medium. It takes about four to five months for the cuttings to reach the top of the column. At this stage each vine will have around 20 nodes with few lateral branches (at 12–15 node). The top 5–7 nodes with lateral branches can be used as orthotropic shoots for field planting.

In four to five months time, about 150 single node cuttings, 10–15 laterals and 10 top shoots can be produced in this method. Two hundred such columns can be accommodated in a poly house size of 320 m^2. In a year, three harvesting cycles can be made. These cuttings can be rooted further for field planting using pro-trays.

SOIL CONDITIONS/MANAGEMENT

- The soil analysis report of the selected site and analytical report on irrigation water especially with respect to heavy metals and pesticide residues contents need to be recorded.
- The quantity, quality and type of soil amendments used for the selected site need to be recorded.

Preparation of land and planting standards

For planting black pepper in slopes, the lower half of northern and north eastern slopes are preferred to save the vines from scorching sun during summer. With the receipt of first rains in May-June, primary stem cuttings of standard trees such as *Erythrina* spp., *Garuga pinnata*, *Grevillea robusta* (silver oak), seedlings of *Alianthus malabarica* (Matti) can be planted in pits of 50 cm × 50 cm × 50 cm size filled with cow dung and top soil. The planting is done at a spacing of 3 m × 3 m which would accommodate about 1110 standards per hectare. The black pepper vines can be trailed on the standards after three years when they attain sufficient height. When *E. indica* and *G. pinnata* are used, the primary stems are cut in March/April and stacked in shade till the stems start sprouting in May.

CROP MANAGEMENT FOR CULTIVATION

- The spacing for the crop, in terms of row to row and plant to plant distance need to be adopted as per the agronomic requirement.
- Gap filling of plants to compensate mortality losses should be carried out within a reasonable time frame.
- Based on the soil analysis and crop requirement, organic manure preferred for the crop supplemented with mineral nutrition through inorganic source need to be applied.
- Application of mineral supplements must be based on complete soil analysis in a competent laboratory.
- Specialized nutritional application for distinct needs viz., root production or enhancement of leaf bio mass need to be taken up as per the requirement of the crop.
- In order to optimize water usage and to reduce wastage of water irrigation management plan need to be prepared for the crop.
- Efficient system for irrigation need to be adopted so as to conserve water for the whole cropping season and to reduce the water usage.

- Records need to be maintained for irrigation schedules, fertigation application and water requirement.
- Depending on the nature and stage of the crop, inter-cultivation practices need to be adopted to reduce the incidence of weeds.
- Comprehensive package of pest and disease management schedules including prophylactic measures required for the crop need to be adopted to minimize the crop loss and its quality.
- In order to reduce pesticide residue in produce, correct dose of pesticides, time of application and mode of application need to be ensured and recorded correctly.
- Use of bio control agents and bio pesticides is preferred and plans for this should be available.

Planting

Pits of 50 cm^3 at a distance of 30 cm away from the base, on the north, eastern or north eastern side of supporting tree are taken with the onset of monsoon. The pits are filled with a mixture of top soil, farmyard manure @ 5 kg/pit and 150 g rock phosphate. Neem cake @ 1 kg enriched with *Trichoderma harzianum* @ 50 g also may also be mixed with the mixture at the time of planting. With the onset of monsoon, 2-3 rooted cuttings of black pepper are planted individually in the pits.

Cultural practices

As the plants grow, shoots are tied to the standard as often as required. The young vines should be protected from hot sun during summer by providing artificial shade. Regulation of shade by lopping the branches of standards is necessary not only for providing optimum light to the vines but also for enabling the standards to grow straight. The base of the vines should not be disturbed to avoid root damage. Lopping may be done twice (during June and September) in a year. Excessive shading during flowering and fruiting encourages pest infestations. Growing cover crops like *Calapogonium mucunoides* and *Mimosa invisa* are also recommended under West Coast conditions as an effective soil cover to prevent soil erosion during rainy season. During summer the cover crops dry up leaving thick organic mulch.

Manuring and fertilizer application

Manuring and fertilizer application is critical for proper establishment and growth of plants. Application of lime or dolomite @ 500 g/vine in April-May during alternate years is recommended under highly acid soil conditions. Organic manures in the form of cattle manure or compost can be given @ 10 kg/vine during May. Neem cake @ 1 kg/vine can also be applied.

Recommended blanket nutrient dosage for black pepper vines (3 years and above) : NPK 50: 50: 150 g/vine/year (General recommendation). Only one-third of this dosage should be applied during the first year which is increased to two-thirds in the second year. The full dose is given from the third year onwards.

The recommended dose of nutrients for varying soil test values of N, P and K is given in Table 2. The fertilizers are to be applied in two split doses, one in May-June and the other in August-September and sufficient soil moisture must be ensured. The fertilizers are applied at a distance of about 30 cm all around the vine and covered with a thick layer of soil. Care should be taken to avoid direct contact of fertilizers with roots of black pepper. When biofertilizers like *Azospirillum* is applied @ 50 g/vine, the recommended nitrogen dose may be reduced by half. In soils that are deficient in zinc or magnesium, foliar application of 0.25% zinc sulphate twice a year (May-June and September-October) and soil application of 200 g/vine magnesium sulphate, respectively is recommended. Foliar application of micronutrient mixture specific to black pepper is also recommended (dosage @ 5 g/L) twice, starting at flowering and followed at monthly intervals for higher yield.

Table 2. Soil test based fertilizer recommendations for dry yield target levels

Soil test value for available nutrients (kg/ha)	Fertilizer nutrient recommended (kg/ha) for yield targets	
Nitrogen	**3.0 t/ha**	**6.0 t/ha**
< 150	50	100
150-250	25	80
250-400	10	55
>400	-	20
Phosphorus		
< 10	40	80
10-30	30	70
30-50	10	55
>50	-	30
Potassium		
< 110	150	310
110-300	125	275
300-500	80	250
>500	35	110

Bush pepper

Rooted lateral branches grown as bushes are known as bush pepper. Bush pepper can be raised as potted bushes or field grown bushes. Bush pepper yields green pepper throughout the year and the fresh yield per bush can be up to 1 kg after 3 years of planting.

Microbial consortium

A talc based formulation (IISR Biomix) consisting of a consortium of Plant Growth Promoting Rhizobacteria [*Micrococcus luteus* (BRB 3)] + [*Enterobacter aerogenes* (BRB 13)] + [*Micrococcus* sp. (BRB 23)] is also applied to black pepper in the nursery and main field for enhanced growth and yield. During application, 20 g of talc formulation is mixed in one litre of water and is applied at the rate of 250 mL per vine in the field and at the rate of 100 mL per bag in the nursery. Alternatively, 1 kg of talc formulation can be mixed with 100 kg of farmyard manure (or well decomposed cow dung) and applied at the rate of 1 kg per vine in the basin i.e. around the root zone. It can be applied twice a year (during May-June and September-October).

Summer irrigation

Irrigating black pepper vines during summer (March 15th to May 15th) at fortnightly interval enhances productivity by 90 to 100% compared to unirrigated crop. Vines are irrigated at the basin through hose and 50 litres per vine is recommended (15 years and above). This can be reduced to 40 litres per vine for 11-15 years age group and 30 litres for vines aged between 5 - 10 years. The spiking will be uniform in the irrigated crop as most of the spikes (> 90%) emerge by July while in rain fed crop only around 60% of spikes emerge in July and may extend till September. Spike length will be comparatively more in irrigated crop.

PLANT HEALTH MANAGEMENT

- Farmers are advised to identify the pest properly with the help of plant protection experts and to follow IPM strategies for sustainable production.
- Farmers shall keep a record of the plant protection chemicals used during the cropping season.
- Proper precautions should be taken while spraying chemicals to avoid contamination beyond the application area.
- Preparation of spray fluids should be carried out in a designated area away from any natural water bodies, drinking water sources, human dwellings etc.
- It is advisable to use protective clothing, face mask and gloves while preparing and applying pesticides.
- Plant protection chemicals must be stored in a dry, well ventilated facility with displayed information on hazardous chemicals inaccessible to children and unauthorized people.
- Farmers should follow the waiting period recommended by authorized Institutes for repeated application of pesticides and advised not to mix pesticides.

- Spray should not be done during peak period of bee activity to protect bees.
- It is advised to spray pesticides in the afternoon hours avoiding strong windy condition and rains.
- Avoid carrying bulk pesticides (dust/granules) on head shoulders or on the back.
- Avoid eating, drinking, smoking or chewing while preparing spray solution and the containers, buckets etc used for mixing pesticides should not be used for domestic purpose.
- Select right kind of sprayer with appropriate nozzles for spraying. It is advised not to blow/clean clogged nozzle with mouth.
- Left over spray solution and empty containers should not be disposed in ponds, water bodies etc.
- Combustible containers can be burnt if the container labels permits burning.
- Containers made of paper, cardboard & plant materials can be disposed off by burning. Non combustible containers should be broken or deformed by punching holes at several places to prevent reuse.

Disease management

Foot rot disease

Foot rot (quick wilt) caused by *Phytophthora capsici* is the most destructive of all diseases and occurs mainly during the south west monsoon season.

Symptoms :

- One or more black spots appear on the leaves which have characteristic fine fimbriate margins 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.
- 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 black spots. The branches break up at nodes and the entire vine collapses within a month.
- If the damage is confined to the feeder roots, the expression of symptoms is delayed till the cessation of rain and the vine starts showing declining symptoms such as yellowing, wilting, defoliation and drying up of a part of the vine. This may occur during October-November onwards.

***Phytophthora* infection on leaves**

Management

The disease can be controlled by adopting integrated disease management strategies.

Phytosanitation

- Removal and destruction of dead vines along with root system from the garden is essential as this reduces the buildup of inoculum (*Phytophthora* population).
- Planting material must be collected from disease free gardens and the nursery preferably raised in fumigated or solarized soil.

Cultural practices

- Adequate drainage should be provided to reduce water stagnation.
- Injury to the root system due to cultural practices such as digging should be avoided. The freshly emerging runner shoots should not be allowed to trail on the ground.
- They must either be tied back to the standard or pruned off.
  The branches of support trees must be pruned at the onset of monsoon to avoid
- build up of humidity and for better penetration of sunlight.

Chemical control

After the receipt of a few monsoon showers (May-June), all the vines are to be drenched at a radius of 45-50 cm with copper oxychloride (0.2%) @ 5-10 litres/vine. A foliar spray with Bordeaux mixture (1%) is also to be given. Drenching and spraying are to be repeated during August-September. A third round of drenching may be given during October if the monsoon is prolonged.

Once the symptoms are observed in field, all the vines are to be drenched (@ 5-10 litres/vine) and sprayed with metalaxyl -mancozeb (0.125%). A second application can be given during August-September. Alternatively, all the vines can be drenched and sprayed with potassium phosphonate (0.3%). A second spraying with potassium phosphonate (0.3%) is to be repeated during August-September. If the monsoon is prolonged, a third round of drenching and spraying may also be given during October

At the onset of monsoon (May-June), apply *Trichoderma harzianum* around the base of the vine @ 50 g/vine (this quantity is recommended for a substrate containing *T. harzianum* @ 10^{10}cfu/g). A second application of *T. harzianum* needs to be given during August-September.

Anthracnose/Pollu disease

This disease is caused by *Colletotrichum gloeosporioides*. It can be distinguished from the pollu (hollow berry) caused by the 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 the discolouration gradually increases with characteristic cross splitting and finally the berries turn black and dry. The fungus also causes angular to irregular brownish lesions with a chlorotic halo on the leaves. The disease can be managed by prophylactic spraying of Bordeaux mixture (1%) or carbendazim - mancozeb (0.1%). Drench and spray with Pseudomonas fluorescens P1 (2%) during May – June and October for foot rot and anthracnose management

Anthracnose /Pollu disease

Spike shedding

Spike shedding is seen when the pre-monsoon showers are delayed and flowering and spiking occur during June-July. These spikes predominantly produce female flowers instead of bisexual flowers. Heavy spike shedding may occur due to lack of pollination and anthracnose infection. Irrigation of vines from second fortnight of March (50-60 litres/ vine at fortnightly intervals) coupled with prophylactic spraying with bordeaux mixture (1%) or carbendazim - mancozeb (0.1%) reduces the intensity of spike shedding.

Stunt disease (Viral diseases)

The vines exhibit shortening of internodes to varying degrees. The leaves become small and narrow and appear leathery, puckered and crinkled. Chlorotic spots and streaks also appear on the leaves occasionally. The yield of the affected vines decreases gradually.

The following strategies are recommended for the management of the disease.

- Use virus free healthy planting material
- Regular inspection and removal of infected plants; the removed plants may be burnt or buried deep in soil
- Aphids and mealy bugs should be controlled by spraying insecticide such as dimethoate (0.05%).

Viral disease

Phyllody disease

Some of the floral buds are transformed into narrow leaf like structures, exhibiting phyllody symptoms. Some of the floral buds are transformed into narrow leaf like structures, exhibiting phyllody symptoms. In advanced stages, the leaves become small and chlorotic, and the internodes are also shortened. The affected

fruiting laterals give a witches broom appearance. Severely affected vines decline rapidly and become unproductive within 2 to 3 years. The infected vines are to be destroyed to prevent further spread of the disease.

Phyllody disease

Slow decline

Slow decline is a debilitating disease of black pepper. Foliar yellowing, defoliation and die-back are the aerial symptoms of this disease. The foliar yellowing appears from October onwards coinciding with depletion of soil moisture. 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 vines gradually lose their vigour and productivity. Nematodes such as *Radopholus similis* and *Meloidogyne incognita* infestations lead to necrosis and development of galls on roots and rotting of feeder roots. The damage to feeder roots is caused by these nematodes and P. capsici either independently or combined.

Management

- Severely affected vines should be removed from the plantation and destroyed.
- The pits for planting should be treated with Carbosulfan 0.1% at the time of planting.
- Nematode free rooted cuttings raised in fumigated or steam sterilized nursery mixture should be used for planting in the field.
- Along with nematicides the basins should be drenched with either copper oxychloride (0.2%) or potassium phosphonate (0.3%) or metalaxyl-mancozeb (0.125%).

- In areas severely infested with root knot nematodes, cuttings of the resistant variety 'Pournami' may be planted.
- Biocontrol agents like *Pochonia chlamydosporia* or *T. harzianum* can be applied @ 50 g/ vine twice a year (during April-May and September-October). Apply talc based formulation of *Bacillus macerans* @10g/vine in basins at the time of planting of vines or just before the monsoon period in established plantations.

Slow wilt disease

Pest management

Pollu Beetle

Pollu beetle (*Lanka ramakrishnai*) is the most destructive pest of black pepper and is more serious in plains and at altitudes below 300 m. The adult beetles feed and damage tender leaves and spikes. The grubs bore into berries and feed on the internal tissues and the infested spikes turn black and decay. The infested berries also turn black and crumble when pressed. The pest infestation is more serious in shaded areas in the plantation. The pest population is higher during September-October in the field.

Pollu beetle damage

Regulation of shade in the plantation reduces the population of the pest in the field. Spraying quinalphos (0.05%) during June-July and September-October or quinalphos (0.05%) during July and Neemgold (0.6%) (neem-based insecticide) during August, September and October is effective for the management of the pest.

Top shoot borer

The top shoot borer (*Cydia hemidoxa*) is a serious pest in younger plantations in all black pepper areas. The larvae bore into tender terminal shoots and feed on internal tissues resulting in blackening and decaying of affected shoots. The pest infestation is higher during July to October. Spray quinalphos (0.05%) on tender terminal shoots; repeat spraying at monthly intervals (during July-October) to protect emerging new shoots.

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 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. Spray dimethoate (0.05%) during emergence of new flushes in young vines in the field and cuttings in the nursery.

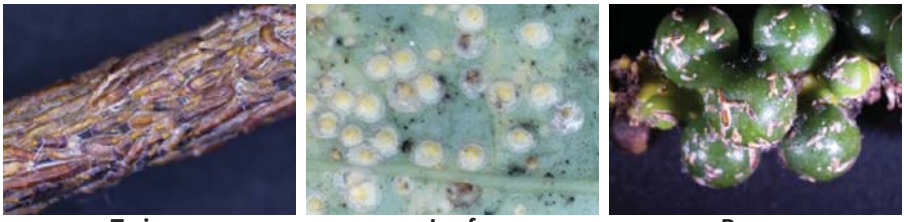
Top shoot borer damage

Leaf gall thrips damage

Scale insects

Among the various scale insects recorded on black pepper, mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) causes serious damage to black pepper vines at higher altitudes and also to older cuttings in nurseries. Scale insects are sedentary, and appear as encrustations on stems, leaves and berries. They feed on plant sap and cause yellowing and wilting of infested portions; in severe cases 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 of produce; repeat spraying after 21 days to control the infestation completely. In nurseries spraying neem oil 0.3% or Neemgold 0.3% or fish oil rosin 3%. is also effective in controlling the pest infestation.



Twig Leaf Berry

Scale infestation on black pepper

Minor pests

Leaf feeding caterpillars, especially *Synegia* sp., damage leaves and spikes of younger vines and can be controlled by spraying quinalphos (0.05%). Mealybugs, gall midges and aphids infest tender shoots especially in nurseries. Spraying dimethoate (0.05%) may be undertaken if infestations are severe. Mealybug infestation on roots can be controlled by drenching with chlorpyriphos (0.075%) and undertaking control measures against *Phytophthora* and nematode infections.

Mealy bug infestation on black pepper

HARVEST AND POST HARVEST MANAGEMENT

Harvesting season is determined and followed on the basis of qualitative parameters set for the end product.

- Clear instruction should be available for farm worker to use proper cutting devices and avoid harvest of unwanted plants.
- A documented procedure should exist for cleaning containers and avoiding mixed up and contamination of produce.
- Washing and cleaning methods need to be ensured for the freshly harvested materials to ensure removal of soil particles adhering to the materials.
- Processing area must be clean with a proper platform and shade.

- Proper drying techniques need to be adopted for drying and storage of harvested crop produce. Drying procedure and the temperature employed should be in conformity with the quality needs of the farm produce.
- Sorting procedure need to be carried out after the completion of drying phase and before the material is packed.
- Selection of packaging material must be based on the quality requirements and possible length of storage before consumption/processing and need to be kept clean, dry and undamaged.
- Storage area must be kept clean and free from insect pests. Proper separation need to be implemented to keep different products of the crop separately.

Harvesting

Black pepper takes about 7-8 months after flowering to reach full maturity. In India the crop is harvested during December –January in plains and January-April in the high ranges. Harvest starts when one or two berries turn yellow. The spikes are nipped of by hand and collected in bags. Harvested spikes are generally collected in clean gunny bags. Spikes which are fallen on to the ground may be collected separately, cleaned and then pooled to the general lot. The level of maturity required at harvest for processing into different pepper products is given below.

Product Stage of maturity at harvest:-

- Canned pepper -4-5 months
- Dehydrated green pepper -10-15 days before maturity
- Oleoresin and essential oil -15-20 days before maturity
- Black pepper- Fully mature and 1-2 berries start turning from yellow to red in each spike
- Pepper powder -Fully mature
- White pepper-Fully ripe

Post harvest processing

Post harvest processing operations followed for black pepper involves threshing, blanching, drying, cleaning, grading and packaging. During processing care should be taken to maintain the quality at each step of operation.

Threshing

Threshers with capacities varying from 50 kg/ha to 2500 kg/ha are available which can thresh quickly and provide clean product.

Blanching

The quality of the black pepper can be improved by a simple treatment of dipping the mature berries taken in perforated vessel in boiling water for a minute before drying.

This processing technique has several advantages:

- Uniform coloured black pepper is obtained after drying.
- Reduces the microbial load.
- Pepper can be dried in 3-4 days as against 5-6 days required when following the traditional practice
- Removes the extraneous impurities like dust from the berries.

Drying

Pepper has moisture content of 65% to 70% at harvest, which should be brought to safer levels of 10% by adequate drying. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. In order to achieve a quality dry product, pepper berries are spread on clean dry concrete floor / bamboo mats/ PVC sheets and dried in the sun for a period of 4 - 6 days. The average dry recovery varies between 33-37% depending on the varieties and cultivars. Dried black pepper with high moisture content (>12%) is susceptible to fungal attack. Mycotoxins produced by the fungal attack render the pepper unfit for human consumption. Mechanical driers developed by various agencies are also used to dry black pepper. Models of varying capacities operated either electrically or by burning agricultural wastes are available for drying of black pepper by maintaining temperature below 55^0 C.

Cleaning and grading

The threshed and dried black pepper has extraneous matter like spent spikes, pinheads, stones, soil particles etc. mixed with it. Cleaning and grading are basic operations that enhance the value of the produce and help to get higher returns. Cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such units consist of a fan/ blower and a feeding assembly. Spiral seperators can also be used to seperate these impurities The lighter fractions (dust, immature berries, pin heads and spent spikes) are blown away. Grading of black pepper is done by using sieves and shifting black pepper into different grades based on size.

The major grades of black pepper are:-

- Tellicherry Garbled Special Extra Bold (TGSEB) (4.8 mm)
- Tellicherry Garbled Extra Bold (TGEB) (4.2 mm)
- Tellicherry Garbled (TG) (4.0 mm)
- Malabar Garbled (MG grades 1 and 2)
- Malabar ungarbled (MUG grades 1 and 2).

Packaging

Eco friendly packaging materials such as clean gunny bags or paper bags may be adopted and the use of polythene bags may be minimized. Recyclable/ reusable packaging materials shall be used wherever possible. All the bags need to be labelled seperately.

Storage

Black pepper is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity may result in mould and insect infestation. Before storage it is to be dried to less than 10 per cent moisture. The graded produce is bulk packed separately in multi layer paper bags or woven polypropylene bags provided with food grade liners or in jute bags. The bags are arranged one over the other on wooden pallets after laying polypropylene sheets on the floor. A state of the art spice processing unit adhering to latest quality standards is operational at ICAR- IISR experimental farm, Peruvannamuzhi., which caters to the training on processing requirements in spice sector.

IDENTIFICATION AND TRACEABILITY

- The final produce need to be legibly labelled with the product name, month and year of harvest and the name of farmer/farming agency.
- If the produce was tested before, an appropriate label may be used indicating quality approval.
- The products need to be traceable back to the registered farm (and other relevant registered areas) from where it has been grown.

PERSONNEL AND EQUIPMENT

- Key resource persons engaged at the site (such as farm owner/ supervisor) must be familiar with all aspects related to the crop such as, quality requirements of the end product, crop husbandry etc.
- The personnel engaged in cultivation should have basic exposure to subject matters like safety and hygiene.

Protective clothing for workers

- The machinery used for fertilizer and pesticide application must be calibrated at prescribed schedules and calibration certificates / records should be maintained.
- Equipments must be clean and mounted where ever applicable, in an easily accessible manner. Scheduled servicing procedures must be adhered to keep them in working order. Additional care should be taken for cleaning those machine parts that get into direct contact with the harvested produce.

- Workers need to be equipped with suitable protective clothing. Complete sets of protective clothing, (e.g. rubber boots, waterproof clothing, protective overalls, rubber gloves, face masks, etc.) with label instructions and legal requirements as authorized by a competent authority need to be complied.
- All workers handling and/or administering plant protection chemicals, disinfectants, biocides or other hazardous substances and all workers operating dangerous or complex equipment should have certificates of competence .
- Permanent and legible signs indicating potential hazards, e.g. waste pits, fuel tanks, workshops, access doors of the plant protection product / fertiliser / any other chemical storage facilities as well as the treated crop etc. must be made available.

Inputs storage shed

Black pepper thresher

Black pepper spiral separator

Black pepper cleaner cum grader

Toxicity class of fungicides/insecticides recommended for black pepper cultivation

Potassium phosphonate		Slightly toxic
Carbendazim - mancozeb		Slightly toxic
Metalaxyl –mancozeb		Moderately toxic
Dimethoate		Highly toxic
Carbosulfan		Highly toxic
Quinalphos		Highly toxic
Chlorpyriphos		Highly toxic