Biology and cultivation of black pepper, the king of spices

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Black pepper (*Piper nigrum* L.) (Family: *Piperaceae*) is a perennial climbing vine grown for its berries, extensively used as spice and in medicine, often referred to as 'King of Spices' or 'Black Gold'. Black pepper has immensely influenced the geopolitical history of the world as it was a much sought after commodity since very ancient days. An essential condiment in the western and eastern cuisines as food additive and preservative, black pepper was highly priced and frequently used to pay rent, tax and even dowry. Black pepper has been an integral part of the traditional medicines of the orient also.

Origin and distribution

Black pepper is native to the Western Ghats of India, where it still occurs wild in the forests. This area is considered to be the centre of origin of the crop. Center of diversity of the crop is also in this tract as cultivated forms are very high in number here and it is believed that black pepper spread out to other tropical countries from India. The major black pepper growing countries at present are India, Indonesia, Tropical Africa, Malaysia, Thailand, Brazil, Sri Lanka, Vietnam and China. Vietnam is the leading producer currently.

In India black pepper is grown in about 129,000 ha with an annual production of 55,000 MT (2015-16). Kerala, Karnataka and Tamil Nadu and to a limited extent Maharashtra, Assam, Tripura, Arunachal Pradesh, Meghalaya and Andaman Nicobar are the black pepper growing states/regions in India. Kerala and Karnataka account for a major portion (97.7%) of production of black pepper in the country.

Climate and soil

Black pepper prefers humid tropics with high rainfall and humidity. The hot and humid climate of sub mountainous tracts of Western Ghats is ideal for its cultivation. It grows successfully between 20° North and South latitudes, and from sea level up to 1500 m above sea level with temperatures between 10°and 40° C and a well distributed annual rainfall of 1250-2000 mm. Black pepper can be grown in a wide range of soils with a pH of 4.5 to 6.5. In its natural habitat it thrives well in red laterite soils.

In India, black pepper is being grown either as a homestead crop in the plains or as a plantation crop in the midlands and hills (800-1500 m) besides in valleys in the north eastern states of the country.

Varieties and crop improvement

Over 75 cultivars of black pepper are being cultivated in India. The most important

cultivars are *Karimunda* (all over Kerala), *Kottanadan* (South Kerala), *Narayakodi* (Central Kerala), *Aimpiriyan* (Wayanad), *Neelamundi* (Idukki), *Kuthiravally* (Kozhikode and Idukki), *Balancotta*, *Kalluvally* (North Kerala), *Malligesara* and *Uddagare* (Karnataka). Self grown seedlings also contribute to cultivar diversity in black pepper. A few important cultivars and their salient features are given below.

Most of the cultivated black pepper varieties are monoecious while in the wild they are dioecious. Cultivated black pepper is predominantly self-pollinated (geitonogamy). Even though protogyny occurs in black pepper, it is ineffective in preventing selfing.

Selections (germplasm, clonal and open pollinated) and hybridisation are the important breeding strategies adopted in improving black pepper. Viable sexual reproduction coupled with excellent mode of vegetative multiplication is a boon in the improvement

Important cultivars of black pepper

Cultivar	Fresh mean yield (kg/vine)	Quality attributes				Features
		Oleoresin (%)	Piperine (%)	Essential oil (%)	Dry recovery (%)	
Aimpirian	4-5	15.7	4.7	2.6	34	Good for higher elevations, good in quality, late maturing
Arakulan munda	2	9.8	4.4	4.7	33	Moderate and regular bearer
Balankotta	1-2	9.3	4.2	5.1	35	Moderate and irregular bearing
Karimunda	2-3	11.0	4.4	4.0	35	Suitable for all pepper growing areas, high yielder, shade tolerant.
Kalluvally	1-2	8.4-11.8	2.5-5.4	3.0	35-38	Good yielder with high dry recovery, drought tolerant
Kottanadan	5	17.8	6.6	2.5	34-35	High yielding, drought tolerant
Kuthiravally	3	15.0	6.0	4.5	35	High yield, good quality
Narayakodi	1-2	11.0	5.4	4.0	36	Moderate yielder with medium quality
Neelamundi	2	13.9	4.6	3.3	33-34	Good yielder, tolerant to *Phytophthora* infection
Vadakkan	3	10.8	4.2	3.2	-	Medium quality and yield

Improved varieties of black pepper

Variety/ Hybrid	Pedigree	Mean yield (dry) (kg/ ha)	Dry recovery (%)	Piperine content (%)	Oleoresin content (%)	Essential oil content (%)	Features
Panniyur -1	Hybrid between *Uthirankotta* x *Cheriyakaniakadan*	1242	35.3	5.3	11.8	3.5	Not suited to heavily shaded areas
Panniyur -2	Selection (Col. 141) from cv. *Balancotta*	2570	35.7	6.6	10.9	-	Shade tolerant
Panniyur -3	(KAU) Hybrid (Cul. 331) *Uthirankotta* x *Cheriyakaniakadan*	1953	27.8	5.2	12.7	-	Late maturing
Panniyur -4	Selection from *Kuthiravally*	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 (HB20052), Panniyur 6 x Panniyur 7	1365	39.0	5.7	12.2	1.2	High yielding, and tolerant to diseases
Panniyur-9	Open Pollinated Progeny Selection	3150	40.0	6.11	12.71	5.0	Suited to Kerala, Karnataka and Andhra Pradesh
Vijay	Panniyur 2 x *Neelamundi*	-	-	-	-	-	Field tolerant to foot rot disease
Subhakara	Selection from *Karimunda* (KS-27)	2352	35.5	3.4	12.4	6.0	Suited to all black pepper tracts

Variety/ Hybrid	Pedigree	Mean yield (dry) (kg/ ha)	Dry recovery (%)	Piperine content (%)	Oleoresin content (%)	Essential oil content (%)	Features
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 Thiruvana-nthapuram 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 between *Narayakodi* x *Neelamundi*	2880	32.0	2.2	9.65	3.4	Suited to high altitudes
IISR Malabar Excel	Hybrid between *Cholamundi* x Panniyur-1	1440	32.0	4.95	14.6	4.1	Suited to high altitudes; rich in oleoresin
Arka Coorg Excel	OP seedling selection	3267	37.8	2.1	6.9	1.6	High yielding with long spike.

of black pepper. Barring *Vadakkan* which is a triploid, almost all other black pepper cultivars are diploid (2n=52).

Twenty improved varieties of black pepper have been released for cultivation (Table 2) in India. Panniyur-1 and Panniyur-3 are hybrids evolved at the Pepper Research Station, Panniyur (Kerala) and have *Uthirankotta* and *Cheriyakaniakadan* as their female and male parents, respectively. Vijay is another hybrid developed by the College of Horticulture, Thrissur, India. IISR Girimunda and IISR Malabar Excel are the two hybrids released from the ICAR-Indian Institute of Spices Research, Kozhikode. In the case of Girimunda the female and male parents are *Narayakodi* and *Neelamundi* while *Cholamundi* and Panniyur I are the female and male parents of Malabar Excel.

Propagation

Though seeds are viable, black pepper is mainly propagated using rooted cuttings. Runners and orthotrops (top shots) are used for generating rooted cuttings. Rooted plagiotrops or fruiting branches are bush peppers. Different propagation methods are employed in black pepper.

Traditional method

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 Cow dung in 1:1:1 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. During good rains, direct planting of runner shoots is also done.

Rapid multiplication method

In this method, a trench of 45 cm depth, 30 cm width and convenient length is made. The trench is filled with rooting medium comprising of forest soil, sand and farm yard manure in 1:1:1 ratio. Split halves of bamboo with septa or split halves of PVC pipes of 1.25-1.50 m length and 8-10 cm diameter provided with plastic septa at 30 cm intervals are fixed at 45° angle on a strong support. Rooted cuttings are planted in the trench made earlier at the rate of one cutting for each bamboo split. The lower portions of the bamboo splits are filled with rooting medium (preferably weathered coir dust-farm yard manure mixture in 1:1 ratio) and the growing vine is tied to the bamboo split in such a way as to keep the nodes pressed to the rooting medium. Dried banana leaf sheath fibers or coir fibres are used for tying. The cuttings are irrigated regularly using a rose can. As the cuttings grow on the bamboo splits, the splits are filled with rooting medium and each node is pressed down to the rooting medium and tied. For rapid growth of vines on the bamboo splits, a foliar spray 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 is to be given @ 0.25 litre per vine at monthly intervals.

When the vine reaches the top of the bamboo splits, (3-4 months after planting of the cutting) the terminal bud is nipped off and the vine is crushed at about three nodes above the base, in order to activate the axillary buds. After about 10 days, the vine is cut at the crushed point and removed from the rooting medium and cut at each node which has striked roots. Each single nodde cutting with the bunch of roots intact is planted in polythene bags filled with fumigated potting mixture. Trichoderma @ 1g and VAM @ 100 cc/kg of soil can be added to the potting mixture. Care should be taken to keep the leaf axil above the soil. The polythene bags should be kept in a cool and humid place and should be covered with thin polythene (200 gauges) sheet to retain humidity. The buds start developing in about three weeks and then the polybags can be removed and kept in shade till main field planting. The advantages of this method of propagation are rapid multiplication rate (1:40), well developed root system, higher field establishment and

vigorous growth as a result of better root system.

Trench method

A simple, cheap and efficient technique for propagating black pepper from single nodes of runner shoots taken from field grown vines has been developed at IISR. A pit of 2.0 m x 1.0 m x 0.5 m size is dug under a cool and shaded area. Single nodes of 8-10 cm length with intact leaves are, taken from runner shoots of field grown vines. They are then planted in polythene bags (25 cm x 15 cm, 200 gauge) filled at the lower half with a mixture of sand, soil, coir dust and cow dung in equal proportions. The single nodes are to be planted in the bags in such a way that their leaf axil is exposed above the potting mixture. The polythene bags with the planted single nodes are arranged in the pit in rows. After keeping the bags in the pit, the pit should be covered with a polythene sheet. This sheet may be secured in position by placing weights on the corners. The cuttings should be irrigated at least five times a day with a rose can. Care should be taken to cover the pit with the polythene sheet immediately after each irrigation. The poly bag soil is drenched 2-3 times with copper oxychloride (2g/L).

After 2-3 weeks of planting, the cuttings will start producing roots which are visible through the polythene bags. After the initiation of roots the frequency of irrigation may be reduced to 3-4 times a day. After about 1 month, new 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 cuttings would harden and will not dry when they are taken out of the pit. The cuttings can be taken out of the pit after two months of planting and kept in a shaded place and watered twice a day. These cuttings will be ready for field planting after about 2½ months. By this method 80-85% success rate can be obtained. Foliar application of nutrient solution will also enhance the growth of the cuttings.

Serpentine method

Serpentine layering technique can be used for the 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 a few nodes, small polythene bags (20x10 cm^2) filled with potting mixture may be kept horizontally under each node. The node may be kept gently pressed in to the mixture in the bag 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 ploythene bag is cut just below the rooted node. The cut end is then also buried into the mixture to induce more roots. Polythene bags used are filled with solarized potting mixture fortified with biocontrol agent. The potting mixture is prepared by mixing two parts of fertile topsoil, one part of river sand/granite powder and one part of FYM(2:1:1).The rooted nodes will produce new sprouts in a week time and will be ready for field planting in 2-3 months of time. The growing vines are to be irrigated every day with a rose can. By this method, on an average, 60 cuttings can be harvested per mother plant in a year.

Nursery diseases

Many pests affect the cuttings while in the nursery. Some of the most serious ones are given below.

Phytophthora infection

Phytophthora infection is noticed on leaves, stems and roots of cuttings in the nursery. Dark spots with fimbriate margins

appear on the leaves, which spread rapidly resulting in defoliation. The infection on the stem is seen as black lesions which result in blight. The symptoms on the roots appear as rotting of the entire root system. Spraying 1% Bordeaux mixture and drenching with 0.2 % copper oxychloride (2g/L) at monthly intervals prevents the disease. Alternatively, 0.01% metalaxyl (1.25 g/L water) or 0.3% potassium phosphonate could also be used. The potting mixture may be sterilized through solarization.

Anthracnose

The disease is caused by *Colletotrichum gloeosporioides*. The fungus infects the leaves causing yellowish brown to dark brown irregular leaf spots with a chlorotic halo. Spraying 1% Bordeaux mixture alternating with 0.1% Carbendazim (2g/L) is effective against the disease.

Leaf rot and blight

The disease is caused by the fungus *Rhizoctonia solani* and is often serious in nurseries during April-May when warm humid conditions prevail. The fungus infects both leaves and stems. Grey sunken spots and mycelial threads appear on the leaves and the infected leaves are attached to one another with the mycelial threads. On stems, the infection occurs as dark brown lesions which spread upwards and downwards. The new flushes subtending the points of infection gradually droop and dry up. Leaf spots caused by *Colletotrichum* sp. are characterized by yellow halo surrounding the necrotic spots. A prophylactic spray with 1% Bordeaux mixture prevents both the diseases.

Nematode infestation

Root knot nematodes (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis)* are the two important nematode species infesting rooted cuttings in the nursery. Soil solarization or steam sterilization can be done for sterilizing the nursery mixture. The sterilized nursery mixture may be fortified with biocontrol agents such as *Pochonia chlamydosporia* or *Trichoderma harzianum* @ 1-2 g/kg of soil. A prophylactic application of nematicide may also be needed.

Planting and management of vines

Being a perennial crop, use of healthy rooted cuttings is very important for raising plantations.

Preparation of land and planting standards

In India, planting of wines is done in harmony with the monsoon seasons. With the receipt of the first rain in May-June, primary stem cuttings of shade trees like *Erythrina* sp., *Garuga pinnata* or *Grevillea robusta* or seedlings of *Ailanthus malabarica* are planted in pits of 50 cm x 50 cm x 50 cm size filled with cow dung and top soil. Planting is done at a spacing of 3 m x 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. Homestead plants such as coconut, arecanut, jack, mango, drum stick, etc. can also be used as black pepper standards. Dead standards (dead wood, reinforced concrete columns, earthen pipes, etc.) are also being used as black pepper standards.

Planting

Pits of 50 cm^3 or still bigger, at a distance of 30 cm away from the base, on the northern 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, *Trichoderma harzianum* @ 50 g also may be mixed with the mixture at the time of planting. With the onset of monsoon, rooted cuttings of black pepper are planted individually in the pits on the northern side of each standard.

Cultural practices

As the cuttings grow, the shoots are tied to the standards 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. Adequate mulch with green leaf or organic matter should be applied towards the end of north east monsoon. The base of the vines should not be disturbed so as to avoid root damage.

During the second year, the same cultural practices are repeated. However, lopping of standards should be done carefully from the fourth year onwards, not only to regulate height of the standards, but also to shade the black pepper vines optimally. Lopping may be done twice (during June and September) in a year. Excessive shading during flowering and fruiting encourages pest infestations. Weed regulation, base cleaning and mulching need to be followed periodically.

Manuring and fertilizer application

Manuring and fertilizer application for pepper vines is to be done for proper establishment and growth of plants. General recommended nutrient dosage for black pepper vines (3 years and above) is NPK 50:50:150 g/vine/year. 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 fertilizers are applied in two split doses, one in May-June and the other in August-September. 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. 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. Application of lime @ 500 g/vine in April-May during alternate years is also recommended under highly acidic soil condition. When biofertilizer like *Azospirillum* is applied @ 100 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 150 g/vine magnesium sulphate, respectively is recommended.

Summer irrigation

Irrigating black pepper vines during summer (March II fortnight to May II fortnight) at fortnightly interval enhances productivity by 90 to 100 per cent compared to unirrigated crop. Vines are irrigated at the basin through hose. 50 L per vine is recommended for vines that have crossed 15 years of age while 40 L is enough for vines between 11-15 years age group and 30 L to vines aged between 5-10 years. Spiking will be uniform in irrigated crop and most of the spikes (> 90 %) emerge in July while in rainfed crop, around 60% spikes emerge in July whereas the rest emerge in September. Spike length will be comparatively more in irrigated crop.

Diseases and their control

Black pepper is affected by many diseases. The important ones are listed below:

Foot rot disease

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 vulnerable to the disease and the expression of symptoms depends upon the site or plant part infected and the extent of damage. Varieties like Thevam and Sakthi are tolerant to the disease. The disease can be controlled by adopting integrated disease management strategies such as phytosanitation, drainage management, deploying tolerant varieties and spraying any of the appropriate fungicides as suggested below:

(1) 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 0.2% Copper oxychloride @ 5-10 litres/vine. A foliar spray with Bordeaux mixture 1% is also to be given. Drenching and spraying are to be repeated once again during August-September. A third round of drenching may be given during October if the monsoon is prolonged.

(2) After the receipt of a few monsoon showers, all the vines are to be drenched with 0.3% Potassium phosphonate @ 5-10 litres/vine. A foliar spray with 0.3% Potassium phosphonate is also to be given. A second drenching and spraying with 0.3% potassium phosphonate is to be repeated during August-September. If the monsoon is prolonged, a third round of drenching may also be given during October.

(3) After the receipt of a few monsoon showers, all the vines are to be drenched with 0.125% Metalaxyl mancozeb @ 5-10 litres/vine. A foliar spray with 0.125% Metalaxyl mancozeb may also be given.

(4) At the onset of monsoon (May-June), apply *Trichoderma* around the base of the vine @ 50g/vine. (This quantity is recommended for a substrate containing *Trichoderma* @ 10^{10} cfu). A foliar spray with 0.3% potassium phosphonate or 1% Bordeaux mixture is also to be given. A second application of *Trichoderma* and foliar spray of 1% Bordeaux mixture or 0.3% potassium phosphonate is to be given during August-September.

Pollu disease (Anthracnose)

This disease is caused by *Colletotrichum gloeosporioides*. It can be distinguished from the pollu (hollow berry) caused by beetles by the presence of characteristic cracks on the infected berries. The disease appears towards the end of the monsoon. The disease can be controlled by spraying 1% Bordeaux mixture.

Viral diseases

The affected vines exhibit shortening of internodes to varying degrees (stunting). 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* and a *Badna virus* are associated with the diseases in black pepper. Virus diseases can be managed by using virus free healthy planting material, regular inspection and removal of infected plants and burning or deep burying of the removed plants, spraying insecticides such as 0.05% Dimethoate or Monocrotophos to control the vectors and providing adequate nutrients including micronutrients to the vines.

Slow decline (slow wilt)

Slow decline is a debilitating disease of black pepper. Foliar yellowing, defoliation and dieback are the aerial symptoms of this disease. The affected vines exhibit varying degrees of root degeneration due to infestation by plant parasitic nematodes. The root system of diseased vines show varying degrees of necrosis and presence of root galls due to infestation by plant parasitic nematodes such as *Radopholus similis* and *Meloidogyne incognita* leading to rotting of feeder roots. The damage to feeder roots is caused by these nematodes and *P. capsici* either independently or together. It is necessary to adopt a combination of fungicide and nematicide application for the management of the disease.

Insect pests and their control

Major insect pests of black pepper are pollu beetles, top shoot borer, leaf gall thrips and scale insects.

Pollu beetle

The *pollu* beetle (*Longitarsus nigripennis* = *Lanka ramakrishnai* Prathapan & Viraktamat) is the most destructive pest of black pepper and is more serious in plains and at altitudes below 300 m. The adult beetles feed on tender leaves and spikes. The females lay eggs on tender spikes and berries. The grubs bore into 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 term *pollu* denotes the hollow nature of the

infested berries in the vernacular language of Kerala State of India, Malayalam. The pest infestation is more serious in shaded areas in plantations. The pest populations are higher during September-October in the field. Regulation of shade in plantations reduces the populations of the pest in the field. Spraying Quinalphos (0.05%) during June-July and September-October or Quinalphos (0.05%) during July and Neemgold (neem based insecticide) (0.6%) 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. Fully grown larvae are greyish green and measure 12-15 mm in length. When successive new shoots are attacked, the growth of the vine is affected. The 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.

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. 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.

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. The 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; repeat spraying after 21 days to control the infestation completely. Initiate control measures during early stages of pest infestation. In nurseries spraying neem oil (0.3%) or Neemgold (0.3%) or fish oil rosin (3%) is also effective in controlling the pest infestation.

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.

Organic black pepper production

For certified organic production of black pepper, at least 18 months the crop should be under organic management. In new plantations the first crop of pepper can be sold as organic, as the yielding starts from third year. To convert an existing plantation to organic, a conversion period of 36 months is set for perennial crops. The conversion period may be relaxed if the organic farm is being established on a land where chemicals were not previously used, provided sufficient proof of history of the area is available. It is desirable that organic method of production is followed in the entire farm; but in the case of large extent of area, the transition can be done in a phased manner for which a conversion plan has to be prepared.

The entire pepper holding can be converted to organic production when pepper is grown as sole crop. When grown in a mixed cultivation system, it is essential that all the crops in the field are also subjected to organic methods of production. Black pepper as a best component crop in agri-horti and silvi-horti systems, recycling of farm waste can be effectively done when grown with coconut, arecanut, coffee, rubber etc.

As a mixed crop it can also be intercropped with green manure/ legume crops enabling effective nutrient built up.

In order to avoid contamination of organically cultivated plots from neighboring non-organic farms, a suitable buffer zone with definite border is to be maintained. In smallholder groups, where the pepper holdings are contiguous, the isolation belt is needed at the outer periphery of the entire group of holdings. Pepper grown on this isolation belt cannot be treated as organic. In sloppy lands adequate precaution should be taken to avoid the entry of runoff water and chemical drift from the neighboring farms.

Management practices

For organic production, traditional varieties adapted to the local soil and climatic conditions that are resistant or tolerant to diseases, pests and nematode infection should be used. All crop residues and farm wastes like green loppings, crop residues, grasses, cow dung slurry, poultry droppings etc. available on the farm can be recycled through composting, including vermicomposting so that soil fertility is maintained at high level. No synthetic chemical fertilizers, pesticides or fungicides are allowed under organic system. Farmyard manure may be applied @ 5-10 kg/vine along with vermi/leaf compost @ 5-10 kg/vine based on the age of the vine. Based on soil test, application of lime/dolomite, rock phosphate/bone meal and wood ash may be done to get required quantity of phosphorus and potassium supplementation. When the deficient conditions of trace elements become yield limiting, restricted use of mineral/chemical sources of micronutrients and magnesium sulphate are allowed as per the limits of standard setting or certifying organizations. Further, supplementation of oil cakes like neem cake (1 kg/vine), composted coir pith (2.5 kg/vine) or composted coffee pulp rich in potassium and suitable microbial cultures of *Azospirillum* and phosphate solubilizing bacteria will improve fertility.

Use of biopesticides, biocontrol agents, cultural and phytosanitary measures for the management of insect pests and diseases forms the main strategy under organic system. Management of pollu beetle by Neemgold (0.6%) spray at 21 day intervals during July-October, shade regulation and management of scale insects by removing severely infected branches and spraying Neemgold (0.6%) or fish oil rosin (3%) are recommended.

Application of biocontrol agents like *Trichoderma* or *Pseudomonas* multiplied in suitable carrier media such as coffee husk or coir pith compost, well rotten cow dung or quality neem cake may be done regularly to keep foot rot disease in check. To control fungal pollu and other foliar diseases spraying of 1% Bordeaux mixture may be done restricting the quantity to 8 kg copper per hectare per annum. Application of quality neem cake mentioned earlier along with the bioagent *Pochonia chlamydosporia* will be useful to check the nematode population and thereby slow decline of the disease.

Certification

Certification and labeling is usually done by an independent body to provide a guarantee that the production standards are met. Govt. of India has taken steps to have indigenous certification system to help small and marginal growers and to issue valid organic certificates through certifying agencies accredited by APEDA and Spices Board. The inspectors appointed by the certification agencies will carry out inspection of the farm operations through records maintained and by periodic site inspections. The grower has to document all the details with respect to field map, field history sheet, activity register, input record, output record, harvest record, storage record, pest control records, movement record, equipment cleaning record, labeling records, etc. Documentation of farm activities is must for acquiring certification especially when both conventional and organic crops are raised. Group certification programmes are also available for organized groups of producers

and processors with similar production systems located in geographical proximity.

Harvest and post-harvest management

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 of Western Ghats. Harvest starts when one or two berries turn yellow. The spikes are nipped off by hand and collected in bags. Normally, single pole bamboo ladder is used as a support for harvesting.

Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity required at harvest for processing into different pepper products is given below:

Product	Stage of maturity at harvest
Canned pepper	4-5months
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 with maximum starch
White pepper	Fully ripe

Post-harvest processing

Post-harvest processing operations followed for black pepper involve threshing, blanching, drying, cleaning, grading and packaging. During processing care should be taken to maintain quality during each step of operation. Though manual threshing is more common, mechanical threshers with capacities varying from 50 kg/h to 2500 kg/h are available which can thresh quickly and provide cleaner products.

The quality of the black pepper can be improved by a simple treatment of dipping the mature berries taken in a perforated vessel in boiling water for a minute before drying. This processing technique imparts uniform colour, reduces the microbial load and helps to dry the product within 3-4 days as against 5-6 days required when following the traditional practice and removes extraneous impurities like dust from the berries.

Pepper has a moisture content of 65 to 70 per cent at the time of harvest, which should be brought to safer levels of 10 per cent by adequate drying. The green colour of matured pepper is due to the presence of chlorophyll pigment. 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 the product turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on concrete floor and dried under sun for 3-5 days to bring the moisture content below 10 per cent. Dried black pepper with high moisture content (>12 %) is susceptible to fungal attacks. Mycotoxins produced by fungal attack render the product unfit for human consumption. In order to get quality dry product, pepper berries are spread on clean dry concrete floor, bamboo mats or PVC sheets and dried in the sun for a period of 4-6 days. Average dry recovery varies between 33-37 per cent depending on the varieties and cultivars.

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.

Packaging

Organically grown black pepper should be packaged separately and labeled. Mixing different types of pepper is not good from a commercial point of view. Ecofriendly 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.

Storage

Black pepper absorbs moisture from air during rainy season when there is high humidity and 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-layered 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.

Uses

Black pepper is traded as whole dried corns, white pepper, powder, extracts, spice blends and mixtures. Apart from its use as a spice and flavouring agent, black pepper has antimicrobial, antioxidant, anti-inflammatory and antitoxic properties. It also has carminative, digestive, antioxidant and antidepressant properties. Black pepper is also a remedy for skin diseases, flu and congestion, cough and cold, dental problems, vitiligo, dandruff and even cancer. Besides, it is diuretic and diaphoretic. Black pepper is one of the most common spices used in different cuisines around the world. It is used in both the whole and grounded form.