

BLACK PEPPER

Scientific Name : *Piper nigrum*

Family : *Piperaceae*

English name : Black Pepper

Indian name: *Kali Mirch* (Hindi), *Kare*

Menasu (Kannada), *Kurumaluku*,

Nallamulaku Malayalam), *Maricha*

Ushana, *Hopusha* (Sanskrit), *Milagu*

(Tamil), *Miriyalu* (Telugu).



Black pepper is admired as “king of spices” and “Block gold” is one of the oldest and the world's most important spices. Among all the spice crops, pepper which has the highest contribution to foreign exchange and trade turn over. Black pepper of commerce is the dried, matured and un-ripened fruit of *Piper nigrum*.

The alkaloid piperine is considered to be the major constituent responsible for the biting taste of black pepper. The other pungent alkaloids present in black pepper in smaller amounts, are chavicine, piperidine and piperetine. The characteristic aromatic odour of pepper is due to the presence of a volatile oil in the cells of the pericarp. On steam distillation, crushed black pepper yields 1.0-2.6% (upto 4.8%) of the volatile oil.

Pepper is used for a variety of purposes. It is more frequently and regularly used than any other spice, as a condiment. It stimulates the digestive organs and thus produces an increased flow of saliva and gastric juices. It is used for seasoning many dishes and it imparts its characteristic blend of flavour and pungency to the cuisine.

The ancient Aryans considered pepper as a powerful remedy for various disorders of the anatomical system and prescribed it as an effective cure for dyspepsia, malaria, delirium tremors, haemorrhoids, etc. The Egyptians used it for embalming. The Asians are said to have used it as an aphrodisiac. However, its value as an essential preservative for meats and other perishable foods has been known for centuries. It is, therefore, largely used by meat packers and in canning, pickling, baking, confectionery and the preparation of beverages. It is also used as flavouring in culinary seasonings of universal use and an essential ingredient of numerous commercial foodstuffs.

Origin and distribution

Pepper is originated in the tropical evergreen forests of Western Ghats of India. It occurs wild in the hills of Assam and North Burma. The Malabar Coast of India was the centre of pepper trade from time immemorial. It is a perennial climbing plant, mostly cultivated as a mixed crop in coffee, citrus and arecanut plantations in Kerala and Karnataka. Besides India, pepper is now grown in Indonesia, Malaysia, Brazil, Madagascar, Sri Lanka, Vietnam, Thailand, China and the Federated State of Micronesia. In India it is grown mainly in Kerala, Karnataka, Tamilnadu and to a little extent in Goa, Orrissa, Assam and Andaman Islands. Kerala is the major state accounts for 95 % of countries area and production.



Area Production and Export

In India pepper is cultivated in an area of 1.95 lakh ha. with annual production of 51 metric tonnes. The average productivity is 300 kg/ha. Pepper accounts 1.3 % of the total area under spice crops (2009-10). Kerala has the largest share of pepper production accounting for 96%, followed by Karnataka (3.9%) and Tamil Nadu (0.1%). During 2010-11 India exported 18,1850 tonnes value at Rs.383.18 crores. India still maintains its position as the largest exporter of pepper and ground pepper to United States, Germany, Brazil, Indonesia and China.

Scope and Importance:

The black pepper is originated in tropical forests of Western Ghats in India, the hilly region and coastal climate of the country are more favourable for cultivation of pepper. Similarly the prevailing soil types, red sandiloom, lateritic soils and forests soil rich in humus are ideal for cultivation of this crop. Pepper is shade loving crop and suitable for cultivation as inter/mixed/multistoried cropping system in arecanut, coconut, coffee, tea, cardamom and cashew plantations. The large area available in these crops has good scope for expansion of area under this crop. It is considered to be good remunerative crop in these plantations. Among the spices the black pepper contribute maximum for an exchange to the Indian economy. Pepper and its products are great export demand. Pepper is used as whole and powder form as spice in culinary preparations, peppering essential oil and oleoresins extracted from pepper has got great demand in pharmaceutical and cosmetic preparations. The value added products of pepper has great demand in food processing

industries. Considering the demand, importance and favourable agro-climatic conditions of the country have good scope for expansion of area and to enhance the productivity of the crop by utilizing the high yielding varieties and scientific practices available.

Description of the Plant

Pepper is a large genus, with over 1,000 species, in the family *Piperaceae*. They are mostly herbaceous or woody climbers or shrubs distributed in the tropics of both hemispheres. The other economic species of the genus *Piper* are *P betle* L. (Betel vine) and *P methysticum* Forst (Kava). In addition to *P nigrum* which now provides the true pepper of commerce, some of the species that have also been used as spices and as pepper substitutes are *P cubeba* (Cubeba or tailed pepper), *P longum* (Indian long pepper), *P retrofractum* (Java long pepper), etc.

Piper nigrum is a climbing evergreen plant, growing to a height of 10 m or more. The vines branch horizontally from the nodes and do not attain much length. The pepper branches are dimorphic comprising: (i) the orthotropic vegetative climbing branches with 5- 12 cm long internodes which give the framework of the plant, their stems are swollen at the nodes when young but become woody on aging; and (ii) a plagiotropic fruiting branch develops from the auxiliary bud present at each swollen node beside a leaf. The short adventitious roots produced at the nodes enable the plant to cling to the standard (climbing support). The leaves are alternate and simple, dark green and shiny above and pale green underneath. They are smooth and entire, broadly lanceolate but there is wide variation in leaf shape. The petioles are 2-5 cm long, and are grooved above.

1. Main stem : Originate from a seed or from stem cutting, it climbs on a support with the help of aerial or adventitious
2. Runner shoots: Are produced from the basal portion of the main stem, growing at right angle to the main stem, usually restricted upto 50 cm from the ground.
3. Fruiting branches (plagiotropes): Are produced from the nodes of the main stem and they grow laterally more or less to the right angle to main stem bears berries/spikes.
4. Top shoots (Orthotropes): After a period of growth, top portion of the main stem attain bushy appearance with short thicker inter nodes and profuse branching with large number of adventitious roots at the nodes. This portion of the main stem/shoot called top shoot or orthotropes.
5. Hanging shoots (Geotropes): In a fully grown vine at the top portion, some plagiotropes are give rise to a special type of shoots which hang down and grow geotropically.

Leaves: Alternate, simple, lamina leathery, ovate, round or obtuse.

The spike is a catkin type of inflorescence, which emerges opposite the upper leaves, on the plagiotropic branches. It is 3-15 cm long with 50-150 minute white to pale yellow flowers. The flowers are either unisexual with monoecious or dioecious forms, or bisexual, as seen in many cultivars. Under intense shade conditions, the hermaphrodite type produces more female flowers and less bisexual flowers. The flowers are cross-pollinated and thus much variation occurs among the progeny. Moreover, hermaphrodite flowers are protogynous; i.e., they attain receptivity well in advance of the pollen maturity, which results in uneven fertilisation of flowers and non uniform, incomplete filling of the spikes.

Flowering begins at the base of the spike and continues to the tip over a week. It is found that bagged inflorescence produces fruits, indicating that the hermaphrodite cultivars (Eg: Balankotta, Kalluvalli) are self-fertile and self-pollination can occur without the aid of rain or wind. The pollen is in glutinous masses of several grains, which is broken up by light showers and the grains are trapped in the papillae of the stigma. But wind pollination has not been found to be very efficient. It seems that pollination is confined mainly to individual spikes. The fruit is a one-seeded green berry, sessile usually globose and sometimes elongated or oval. The seed is surrounded by a thin, soft pericarp. During ripening, it becomes yellow and turns light red afterwards. The period taken from flowering to maturity is about 6 months.



Climate

Pepper is essentially a crop of the humid tropics and requires adequate rainfall and humidity. However, it thrives well even in the hot and humid climate of the foothills of the Western Ghats. It grows well at 500-1500 m elevation from the mean sea level. It requires a temperature of 10-40°C, below which the pollination and fruit set will be adversely affected. An optimum rainfall of 1250-2000 mm per annum distributed throughout the year is desirable. Though it is a shade-loving vine, too much of shade will affect flowering and fruiting. To avoid sun-scorching, it should be planted towards the eastern slopes avoiding the southwest sunlight.

Soil

Pepper thrives best on virgin soils rich in humus and naturally well drained; red lateritic soils or alluvial soils rich in humus are also highly suitable. Heavy clays and sandy soils should be avoided. In Kerala, pepper is also grown on the raised bunds of water-logged paddy fields. A pH range of 4.5 to 6.5 is ideal.

Varieties

The germplasm collection of black pepper at IISR is 2,776 (2,492 indigenous, 5 exotic and 279 wild). In India, out of about 100 varieties which are under cultivation, only ten have assumed commercial importance. The distinguishing characters of some of the important varieties are as follows.

Cheriyakaniyakkadan

The leaves are small and elliptic; the spikes are of medium length, closely set with medium-sized dark-green fruits. It is a popular type and bears regularly, the yield is heavy (42% dried pepper) and of high quality, it is wilt resistant and popular in north and central Travancore (Kerala).



Cheriakodi

The leaves are narrow, and dark green; the spikes are short, with dark or pale-green fruits, which are the smallest among all the types. The plant is a dwarf and sturdy type, bearing in alternate years, and of a high quality. It yields 38% dried pepper and is popular in north Travancore and north Malabar (Kerala).

Daddagya

The leaves are broad and the spikes are long, and curved. The fruits are large among Mysore types. It is a uniform yielder, esteemed for making white pepper; it yields 38% dried pepper. It is popular in North Kanara (Karnataka).

Kalluvally

It is a promising cultivar of north Kerala, being a hardy and regular yielder. The leaves are medium, ovate, elliptic and the spikes are medium and are the twisting type due to very thick setting. The berries are small to medium, heavy and have high driage (about 40%). It is a regular bearer and reportedly tolerant to water stress and diseases. Studies have shown that it is moderately tolerant to *Ph* ytophthora wilt. Though it is a very promising cultivar, its distribution is rather restricted to settlement areas of the submontane pepper tracts of Wynad and Cannanore districts.

The Kalluvally found in many areas in Cannanore and north Wynad does not conform to the above description. More than one cultivar is known by this name and some of these are rather poor yielders. They do not seem to be as hardy as the name indicates. The Kalluvally types are also found to differ in quality factors. For example, three Kalluvally types gave the following values; oleoresin (%) 8.8, 10.9 and 8.4; piperine (%) 4.2, 4.6 and 5.4, essential oil (%) 3.4, 0.4 and 3.0 and starch (%) 31.5, 29.0 and 20.7.

Kaniakkadan

The name Kaniakkadan appears to have been derived from Kaniakkar, a tribal sect inhabiting the hilly Western Ghat areas of the present day Idukki district. There are four different Kaniakkadan types. These are Cheriya kaniyakkadan, Valiakaniakkadan, Karutha Kaniakkadan and Valutha Kaniakkadan, of which the first two are more important.

Cheriya kaniyakkadan is a popular cultivar of the eastern parts of Kottayam and QuiIon districts. It is also commonly found in many areas of north Kerala. It is a bisexual type, with small elliptical leaves, medium-long spikes and medium-sized berries. It is an average and regular bearer and has 30% driage. It gives 9% oleoresin, 3.9% piperine and 3.7% essential oil.

Valiakaniakkadan has slightly larger leaves, longer spikes, and bold and heavy berries, and its berry setting is good. It is a moderately high yielding type.

The other two Kaniyakkadans are also moderate yielders.

Arakkulamunda

This is a moderately good and regular bearer from the central area of Kerala. It derives its name from a village Arakkulam in the Thodupuzha taluk of Idukki district. It is commonly found in the settlement areas of north Kerala. It yields regularly and comes to maturity earlier than most other cultivars. The spikes are medium-long and the berries are bold and heavy. This cultivar gives 9.8% oleoresin, 4.4% piperine and 4.7% essential oil.

Balan cotta

This cultivar is confined to north Kerala and grows very vigorously. It has the largest leaves among all the Kerala cultivars. The vines are large, growing to the top of the large supporting trees like mango and jackfruit. The spikes are medium long to long, the setting moderately good, and the berries are bold and pale-green. The variety is early to medium in duration, the berries give about 30% driage. It gives 9.3% oleoresin, 5.1% essential oil and 4.2% piperine. Its oil content is high and so has a very high flavour quality.

Balancotta is reportedly tolerant to moisture stress and is also somewhat tolerant to *Phytophthora* wilt. In the Malanad areas of North Kanara, this cultivar is grown under the name Malabar Pepper, especially in Sagar, Koppa, Sirsi and adjoining areas.

Karimcotta

The leaves are large, dark green and the spikes are short and curved with closely-set, large, dark-green berries. It is a hardy, regular bearer and a good yielder. It yields 42% dried pepper. It is popular in the north Travancore and north Malabar areas of Kerala.

Kartmunda

The name Karimunda might have come from the bluish-black tender shoots and dark-green leaves and berries. It is the most popular cultivar grown throughout Kerala. This had been the traditional cultivar of central Kerala comprising Palai, Ponkunnam and the adjoining areas. The cultivar is bisexual and is characterised by small more or less oval leaves and short to medium-long, closely-set spikes. The spikes are 4 to 10 cm long and even more in certain cases, with a mean length of around 6.5 cm. In central Kerala, most of the vines have short, well-filled spikes, but the spikes found in the Idukki district and also in parts of Wynad are much longer. It is a prolific and regular bearer, having medium-sized berries of good driage (35%) and yields good quality pepper. This cultivar has about 11% oleoresin, 4.4% piperine and 4.0% essential oil content.

Its flowering time is in May-June, coinciding with the monsoon. The irrigated plants flower almost continuously. This cultivar is of medium maturity, and is suitable for intercropping and also for high density monocropping.

Kottanadan

It is the most popular pepper cultivar in South Kerala. This is a vigorous growing bisexual variety with large, broad, ovate leaves, long spikes, high fruit set and medium-sized berries. The cultivar is a high and regular yielder. Studies have shown that Kottanadan has the highest oleoresin content (17.8%). It has a high piperine content too (6.6%), though the volatile oil is comparatively less (2.5% to 4.2%). It gives about 37% driage and produces high quality, heavy pepper.

In the Wynad area, Kottanadan is grown as Aimpiriyam, the name being derived from the fact that berries are arranged in 5 distinct rows on the spike. In south Kerala, it flowers by April-May and is ready for harvest by January. In Wynad, it matures late and comes to harvest only by April.

Kumbhakodi, a cultivar grown in certain areas of Quilon, seems to be a variant of Kottanadan/Aimpiriyam.

Kuthiravally

A south Kerala type, now found in many pepper-growing areas throughout Kerala, Kuthiravally is a moderately high yielder, but an alternate bearer. The ovate leaves are medium-large, the spikes are very long and slender (like a horse's tail, hence the name Kuthiravally) and the flowers are bisexual. The berries are medium-large, having high driage (over 39%). It yields about 15% oleoresin, 6.0% piperine and 4.5% essential oil. Kuthiravally thus produces high quality pepper. A cultivar called Thommankodi, grown in certain areas in eastern parts of Calicut (Koodaathai, Anakkampoyil areas), seems to be a variant of Kuthiravally. In Thommankodi, the spikes are slightly shorter and the berry filling somewhat better than those of Kuthiravally. A quality analysis of this cultivar has not been carried out.

Aranavalan, a cultivar found in the Malayattoor-Kaladi areas, also seems to be a variant of Kuthiravally.

Malligesara

This is the common cultivar of North Kanara district of Karnataka. In the Malnad areas of North Kanara, this is usually intercropped with arecanut. Two types of Malligesara are known. Karimalligesara and Bilimalligesara, which can be differentiated based on the anthocyanin colouration of the emerging shoots. In Karimalligesara it is purple- white and in Bilimalligesara it is pale-green. It is a moderate yielder, having medium-large leaves and spikes.

Narayakkodi

This is another central Kerala cultivar from the Kottayam-Champakkara-Mallappally tract, but is now found in many settlement areas throughout Kerala. The leaves are small to medium, ovate and

have a characteristic twisting that results from a thick berry setting. The persistent stigmatic base looks like a 'pin' and hence the name `Narayakkodi' (Narayam is a long iron-nail like tool used in the olden days for writing on palm leaves). It is a regular average yielder, having high driage (37.5%). It gives 11% oleoresin, 5.4% piperine and 4.0% essential oil.

The farmers in central Kerala are of the opinion that `Narayakkodil has a longer life span than `Karimunda¹ and is also much less affected by diseases. Studies conducted in the Central Plantation Crops Research Institute, Regional Station, Calicut, have shown that Narayakkodi is more tolerant to foot-rot caused by *Phytophthora* than most other cultivars.

The following are some of the improved varieties and hybrids released from the Pepper Research Station, Panniyur, Taliparamba, Cananore district, Kerala and Indian Institute of Spice Research (IIS,Calicut).

Table 1. High yielding varieties of black pepper and their characteristics

Variety / Year of release	Pedigree / Parentage	Institution / University	Avg. yield kgl/ha (dry)	Salient features
Panniyur 1 1971	Inter-cultivar hybrid of x Cheriyanakaniyakadan	Pepper Research Station (KAU), Panniyur, K arirnbam 670 143, K	1242 (Pot! yield 8800)	Vigorous growing vine. Donot tolerate shade. Long spikes, clo se setting 0 f berries, bold b errie s, oleoresin !1.8%, piperine 5.3%, essential oil 3.5%, dry recovery 35.3%
Panniyur 2 1991	Clonal selection from op en pollinated progeny of B alankotta	-do-	2570 (Pot! yield 3313)	Shade tolerant, suitable for intercropping, medium maturity group, medium quality, oleoresin 10.9%, high piperine (6.6%), essential oil 34%, dry recovery 35.7%
Panniyur 3 1991	Inter-cultivar hybrid of x Cheriyanakaniya kadan	-do-	1953 (Pot!. yield	Suitable for all pepper growing regions, performs well under open situation. Late maturity group. Long spikes and bold berries, piperine 5.2%, oleoresin 12.7%, essential oil 3.1%, dry recovery 27.8%
Panniyur 4 1991	Clonal sel ection from Kuthiravally type II	-do-	1277 (Pot!. yield	Stable yielder, performs well under adverse condition also, tolerant to shade, later maturity, 44% piperine, 9.2% oleoresin, 2.1% essential oil and 34.7% dry recovery

Panniyur 5 1996	Clonal selection from open pollinated progeny of Perumkodi	-do-	1110 (Pot! yield	Suitable for both mono and mixed cropping in coconut / arecanut gardens, shade tolerant, medium maturity, tolerant to nursery disease. Long spikes, piperine 5.3%, oleoresin 12.33%, essential oil 3.8% and dry recovery 35.7%
Panniyur 6 2000	Clonal selection from Karirundatye III	-do-	2127 (Pot! yield 3359	A vigorous vine. Tolerant to drought and adverse climatic conditions, stable and regular bearer, medium maturity group. Suitable for open condition as well as partial shade, spike 6-8 cm, more number of spikes/unit area, close setting and attractive bold berries, piperine 4.9%, oleoresin 8.27% and essential oil 1.33% and 33.0% dry recovery
Panniyur7 2000	Open pollinated progeny of Kalluvssly	-do-	1410 (Pot! yield 2770)	Vigorous vine and a regular bearer, long spike, a hardy type vine, tolerates adverse climatic condition, suitable for open and shaded conditions, very long spike (16-24 cm) high piperine content (5.6%), oleoresin 10.6%, essential oil 1.5% and 34.0% dry recovery

Sree kara 199 0	Clonal selection from Karirnunda	Indian Institute of Spices Research, ICAR., Calicut - 673 012 Kerala	2677 (PotL yield, 4200)	Suitable for all pepper growing regions including high elevations as well as for intercropping, medium maturity, gives quality pepper with 5.1% piperine, 130% oleoresin, 7.0% essential oil and 35.0% recovery	Kerala, South Kamata ka and Tarnil nadu
Subh akara 1990	Clonal selection from Karimunda	-do-	2352 (PotL yield 4487)	Wide adaptability to all pepper growing tracts. Suitable [or intercropping as well [or high elevations, high quality, medium maturity, piperine 3.4%, oleoresin 6.0% essential oil and 35.0% dry	Kerala, South Kamata ka and Tarnil nadu
Panc hami 2001	Clonal selection from Aimpiriyan	-do-	2828(Potl. yield 6528)	High yielding, spikes twisting, late maturing, suitable for high elevations, excellent fruit set, piperine 4.7%, 12.5%,3.4% essential oil and 34.0% dry	Keral a Kam ataka

				recovery.	
Pou mam i 2001	Clonal selection from Ottaplackal	-do-	2333(Potl. yield 5326)	Tolerant to root knot nematode and Medium maturity, suitable for intercropping with arecanut and banana. Piperine 4.1%, oleoresin 13.8%, essential oil 3.4% and dry recovery 31.0%	Kerala and Kamataka
IISR Thevam	Clonal selection from germplasm of Thevanmundi	-do-	2437(5.00 kg/vine fresh)	Stable yielding, grow vigorously, field tolerant to <i>phytophthora</i> , medium suitable for high altitude areas of South India up to 3000 ft MSL in coffee and tea estates. Piperine 1.6%, oleoresin 8.15%, essential oil 3.1 % and dry recovery	Kerala and altitude areas of South India up to 3000 ft MSL
IISR Mal abar Excel	A hybrid of Cholarnundi x Panniyur - 1	-do-	1453 (3.00 kg/vine fresh)	Recommended for rain fed condition including coffee and teaplantation. Oleoresin 11.7%, piperine 2.4%,	Kerala and high altitude of South India

				essential oil 2.8%, dry recovery 32.3%. Suitable high elevations and plains	
IISR	A hybrid of Cholamundi x ,	-do-	2880 (6.00 kg/vine/	Recommended for rain fed conditions	Kerala and other

Girimunda	Panniyur -1			including tea and coffee estates. :maturity group. Piperine 2.2%, oleoresin 9.65%, essential oil 3.4 % and dry rec 320%.	high altitude areas of S. India
IISR-Sakthi (P-24)	Open pollinated seedling progeny of cv. Perambra munda a clonal cultivar	-do-	(5.2kg/vine, fresh) (PotL yield 5755)	'Tolerant to <i>P. capstci</i> , piperine 3.3%, oleoresin 10.2%, essential oil 3~7% and dry age 43.0%.	Kerala and Karnataka and high ranges
PLD - 2 1996	Clonal selection from Kottanandan	NRC [or Oil Palm, Regional Station, ICAR, Palode, Pacha (Post) - 695562, Kerala	2475 (PotL yield 4732)	Late maturity high quality cultivar, contains piperine 3.0%, oleoresin essential oil 4.8%. Suitable for plains and higher elevations.	Kerala

Propagation

Pepper can be propagated by seeds as well as by vegetative means.

Propagation by seeds:

The fully ripe berries are collected, soaked in water overnight and later rubbed with a paste of cow dung. The treated seeds are sown in the nursery. The seeds are viable upto 20 days after the harvest. They germinate within a month in the nursery beds and will be ready for transplanting within 45 days. In India, transplanting is done in July- August.

The seedling progenies show a lot of variation, since pepper is a cross-pollinated crop. They take 7-8 years to come to the first bearing.

Propagation by Vegetative methods:

Selection of Mother Vine:

The mother plants selected for the preparation of cuttings should possess the desirable attributes: such as regular and high yielding, healthy free from pests and diseases and preferably 5-12 years of age.

Conventional method:

Mother plants selected for collecting cuttings should be marked during October-November. The runner shoots from these vines are kept coiled on wooden pegs fixed at the base of vines to prevent shoots from coming in contact with soil. The runner shoots are separated during February-March and 2-3 nodal cuttings of 20 cm length are made. These are planted either in nursery beds or polythene bags filled with potting mixture (made of soil, sand and farmyard manure in 1:1:1 ratio) after trimming the leaves. Dipping the lower cut end in IBA 1000 ppm solution for 45 seconds will substantially increase rooting. Sufficient holes are to be provided at the base of polythene bags to ensure good drainage. Three node cuttings should be planted by keeping one node below the soil. The cuttings after planting should be kept under shade. Light irrigation is to be provided daily to maintain a humid and cool atmosphere around the cuttings. The cuttings will strike roots and become ready for planting in May-June when 4-5 leaves are produced.

Rapid multiplication method:

The modified rapid multiplication technique developed by IISR, Calicut is adopted for quick multiplication of rooted cuttings. This method originally developed from Sri Lanka. A suitable area having good drainage is selected and levelled. Overhead shade is provided by using 50 % shade net, Coconut leaves can also be used for roofing. Trenches of 30 cm width, 45 cm dept and of convenient length are taken and filled with soil, sand and farmyard manure (1:1:1). Bamboos of 8-10 cm diameter are selected and cut into 1.25-1.50 m long pieces and split into halves keeping the septa intact. Coal tar is smeared to prolong the life of bamboo splits. The bamboo splits are arranged at an angle of 45° alternatively either side on straight wooden poles or strong supports fixed on small supports from ground and tied to each other with coir rope at the free end. Rooted cuttings are planted in the trench, one of each bamboo split.

As the cuttings start growing, the bamboo splits are filled with rooting mixture composed of farmyard manure, coir dust and sand in equal proportions. Each tender node is tied carefully to the bamboo using banana fibre, so that every node is in contact with the rooting medium. For rapid

growth, daily irrigation through rose can is essential. Nutrient solution consisting of urea (1 kg), super phosphate (0.75 kg), muriate of potash (0.5 kg) and magnesium sulphate (0.25 kg) in 250 litres of water can be applied as foliar spray for good growth. Alternatively, spraying the vines with cow dung solution 0.1 % once in a month also encourages plant growth. When the vines reach the top of the bamboo, the tip is nipped off and the vine is crushed at the base of 3rd or 4th node from the ground, to activate the buds. After 7-10 days, the vine is cut at the crushed point and removed from the bamboo with the roots intact and with the adhering soil. The vine is cut into single noded pieces and each cutting is planted in a polythene bag filled with potting mixture of soil, sand and farmyard manure (1:1:1) or mixture with solarised soil fortified with bio- control agents or vermicompost.

After planting in the bamboo, the first harvest of cuttings can be done after 3-3 ½ months and the subsequent harvest at every 2-2 ½ months. Each rooted vine can give about 10 cuttings in one harvest and about 40 cuttings will be obtained in a year. A shed of 6 m x 24 m would accommodate 600 bamboo splits. On an average 20,000 cuttings can be produced annually by this method. The method is thus advantageous for producing a large number of rooted cuttings within a short period, throughout the year. The cuttings are also robust due to the abundance of roots leading to more than 90 % establishment in the field.



Serpentine method:

This is the best propagation technique for black pepper. Three node cuttings planted in polythene bags are kept in a corner of the nursery. When the plant develops two leaves they are trailed horizontally in polythene bags containing potting mixture kept below each tender node. Each node should be pressed into the mixture in polythene bags with V shaped midribs of coconut leaves. As new shoots arise, these are to be trailed horizontally in polythene bags containing potting mixture. Once 20 nodes get rooted, the first 10 polythene bags with the rooted nodes should be separated by cutting at the inter nodes. The intermodal stub should be pushed back into the potting mixture.

These stubs also produce a secondary root system. Daily irrigation is to be given using a rose can. After 3 months these cuttings are ready for planting in the field. On an average, 60 cuttings can be obtained in a year by this method from each mother cutting. The serpentine method is simple, less costly quick and can be adopted by small and marginal farmers. The recovery percentage is higher compared to rapid multiplication technique.

Pit Method:

A pit of 2 m x 1 m x 0.5 m dimension is dug in a cool, shaded area. Single node cuttings 8-10 cm long and their leaf intact, taken from runner shoots of field grown vines are planted in polythene bags of 25 cm x 15 cm (200 gauge) size. Sufficient drainage holes are to be provided at the bottom of the bag. Soil, sand and farmyard manure in equal proportion (1:1:1) are mixed and used for filling the bag. The single nodes are to be planted in the bags in such a way that leaf axil rests above the potting mixture. The bags with the planted single nodes should be arranged in the pit. Approximately 150 bags can be kept in a pit. 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 stones or weights on the corners. The cuttings should be watered at least five times a day with a rose can.

After two to three weeks of planting, the cuttings will start producing roots. After initiation of rooting, watering may be reduced to three to four times a day. After 1 month, shoots start emerging from the leaf axil. At this stage it is advisable to keep the pit open for about 1 hour per day so that the cutting will not suffer from any shock when they are taken out of the pit. Two months after planting, the cuttings can be taken from the pit and kept in a shaded place and watered twice a day. These cuttings will be ready for field planting after about another two and a half months. By this method, 80-85% success can be obtained.

This method is simple, less costly and quick. The cuttings are ready to be planted in the field after about 4-4 ½ months as compared to 6 months in bamboo method. This method is suited to small and marginal farmers. Saving of planting material is also possible since single nodes are used instead of three nodes in the conventional method.

Micro-propagation:

Micro-propagation of black pepper *in vitro*, using shoot explants both from mature and juvenile plants, were standardized at the Indian Institute of Spices Research (IISR), Calicut. The multiplication rate is around six shoots per culture in 90 days. The protocols for plant regeneration were also standardized and the plants were successfully micro-propagated from the callus cultures derived both from leaf and stem explants

Vegetative propagation by grafting

Single-node cuttings could be successfully grafted, either by means of side grafting or inarching. Varieties like Uthirankotta can be successfully top worked with bisexual types and made productive.

Establishment of plantations/Cultivation

Selection of site.

The site selected for cultivation of pepper should be cleared with shrubbery and wild growth. When it is grown in slopes, the slopes facing south should be avoided and the lower or half of the northern and north-eastern slopes preferred for planting so that the vine are not subjected to the scorching effect of the southern sun during summer. In slopes, suitable soil conservation measures are to be adopted.

Preparation of land and planting standards:

With the receipt of the first rain in May-June, primary stem cuttings of *Erythina sp.* (Murukku) or *Garuga pinnata* (kilinjil) or *Grevillea robusta* (silver oak) are planted in pits of 50 cm x 50 cm x 50 cm size filled with cow dung and top soil, at a spacing of 2.5-3 x 2.5-3 m which would accommodate about 1100-1600 ppm standards per hectare. Seedlings of *Alianthus malabarica* (Matti) can also be planted and the black pepper vines can be trailed on it after 3 years when they attain sufficient height. Whenever *E. Indica* is used as standard, application of phorate*10 G@ 30 g may be done twice a year (May/June and September/October) to control nematodes and stem and root borer. When *E. Indica* and *G. Pinnata* are used, the primary stems are cut in March / April and staked in shade in groups. The stacked stems start sprouting in May. The stems are planted in the edge of the pits dug for planting black pepper vines.

When pepper is grown as a mixed crop in coffee and coconut plantations or areca gardens, there is no need to plant standards or shade trees. The coconut or areca trees themselves provide shade and serve as standards. While planting, groups of 3 to 4 rooted cuttings are planted per standard. Usually the planting of vines is done during June-July in pits of 50 cm³, dug on the northern side of the standard 60-120 cm away from the standard. The cuttings are planted with two nodes below the ground level. The pepper vine grows rapidly and after one year reaches a height of 2 m. As the vines grow they have to be tied to the standards at an interval of 30 cm. Also, the vines are brought down to ground level after a year and a half. They are cut and buried in the ground surrounding the standard. This helps in putting forth more shoots and good root systems.

Planting

Pits of 50 cm³ 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 and Trichoderma harzianum @ 50 g also may 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 on the northern side of each standard. At least one node of the cutting should be kept below the soil for better anchorage.

Cultural Practices.

Training and Pruning: As the planted cuttings grow the shoots are trained by tying to the standards as often as required. Train the vine all-round the standards and allow to grow 68 meters. Then prune the top shoots. Pruning is not regularly followed in India, it is done mainly in young vine when they are about 6 months old. Terminal shoot is pruned back to 3 to 4 nodes from the ground, terminal shoots are then selected and trained on support. Pruning of hanging shoots dead and damaged shoots facilitates for better aeration and enhance the productivity of the plant.

Shade Management:

Pepper is a shade loving plant, excess shade is detrimental since it affects the physiological activities of the plant. It requires 50 % shade or lesser than this for better growth and production. Pepper is usually tried on living standards, which also served as shade trees. In coffee plantation shade tree are used as standards for pepper. In order to maintain 50 % of shade excess and unwanted branches are to be removed every year prior to commencement of monsoon April-May. Shade regulation helps for better penetration of lights during monsoon. The lopped branches put fourth new growth and providing shade during the commencement of summer period. Thus, lopping of branches of shade trees is essential to regulate shade or sun light suit to the crop.

Liming:

Pepper is cultivated in heavy rain fall areas of hilly region, top soil along with nutrients or eroded as a result soils are acidic. Before application of fertilizers soil ph as to be corrected by adding lime based on the soil test results. However, every two years once 2 to 3 tonnes of lime per hecters or 500 g per vine is recommended and this as to be applied during April-May. Agricultural lime and dolomite lime are commonly used liming materials to correct the soil acidity.

Manures and Fertilizers

The dose of manures and fertilisers to be applied per unit area varies according to the soil fertility. Manuring for pepper vines is to be done in basins in a semicircular band on the northern side of the standard around the plants, 10-15 cm deep and 50-75 cm radius, depending upon the growth of the plants. Cattle manure/compost/ green leaves should be applied at the onset of the Southwest monsoon. It is desirable to apply lime at the rate of 500 g per vine in April-May in alternate years.

The following is the nutrient dose for pepper (3 years and above): adopted in Karnataka.

	Per vine per year
FYM or Compost or green leaves	10 kg
N	100 g
P205	40 g
K2O	140 g

In Kerala fertilizers dose recommended for panniour – 1 is 140:55:270 g of NPK per vine.

A one-third dose should be applied for one year old plants and half dose for two year old plants. The fertilizers may be applied in two split doses, the first in May-June and the second in August-September.

Intercultivation

During the first year, a thorough digging is given once during August- September and again in October-November around the standard and the vines to remove the weeds. Mulching is very essential where pepper is grown with minimum shade, to conserve moisture, using banana trash, dried grass and other substances. Cover crops like *Calapogonium mucanoides*, *pureria phaseoloides*, *Mimosa invisa* can be sown during April-May and during October- November and they are cut and ploughed into the soil when they flower. Sawdust, areca husk and straw can also be used for mulching.

Weeding:

Regular weeding is essential to keep the basin clean to avoid competition of weeds for moisture and nutrients. The three weeding are done during May-August and November manually without disturbing the roots. Gramoxoane, weedicide at the rate of 600-1200 ml per ha. can be used to arrest the weed growth.

Use of growth regulators:

Spike shedding disorder is observed in pepper as a result 10 to 40 % of yield loss is recorded to overcome this problem apart from application of major and micro nutrients and control of diseases and pests, application of IAA (50 ppm), or planofix (50 ppm) and 2, 4-D (5 ppm) is recommended to control the spike shedding disorder.

Harvesting and yield:

Pepper commences bearing third year after planting. Flowering and harvesting depend on climatic factors, the most important being rainfall. In India, pepper plants start flowering during May-June with onset of south west monsoon and harvesting is usually done in Dec.-January. At higher altitudes, the fruit growth and maturity get delayed. Generally harvesting is done when one or two berries in a few spikes turn orange or red. Care should be taken to harvest only mature spikes. Harvesting is done using single pole ladder kept leaned on to the support tree. Harvested spikes are collected in clean sacs or bags tied at back of worker. Harvested spikes are spread on a clean floor and threshed manually by trampling with legs or by using mechanical thresher. Manual threshing is more common in India. The harvested spikes are piled up in a heap to initiate browning and then threshed. It makes threshing¹ easy and also gives good colour to finished product. The yield varies widely in different pepper producing areas depending upon: elevation, temperature, distribution of rainfall, soil fertility, cultural practices, type or variety and, age of the vine. In India, the yield varies from 300 to 1,000 kg/ha.



Processing

Black pepper

Black pepper of commerce is produced from whole, ripe but fully developed berries. After threshing, they are spread on suitable drying floor for sun drying. Berries are raked to ensure uniform colour and to avoid mould development. Drying takes about 3-5 days by

which time moisture content will be brought down to 10-12 %. The dried berries are garbled, graded and packed in double lined gunny bags.



Blanching berries in boiling water for one minute prior to drying accelerates browning process as well as rate of drying. It also gives a uniform lustrous black colour to finished product and prevents mouldiness of berries. But prolonged blanching should be avoided, since it can deactivate enzymes responsible for browning process (Nybe, 2001). The black colour that pepper acquires on drying is due to oxidation of colourless phenolic compounds present in skin. Dry recovery varies from 29 to 38 % among cultivars. Solar driers and mechanical driers are now available for drying pepper.

White pepper

White pepper is prepared from ripe berries or by decorticating black pepper. Bright red berries after harvest are detached from stalk and packed in gunny bags. Bags are allowed to soak in slow running water for about one week during which bacterial rotting occurs and pericarp gets loosened. Then the berries are trampled under feet to remove any adhering pericarp, washed in water and then sun dried to reduce moisture content to 10-12 % and to achieve a cream or white colour. White pepper is garbled, sorted and packed in gunny bags. Approximately 25 kg white pepper is obtained from 100 kg ripe berries.

Central Food Technology Research Institute, Mysore, India improved the method in which fully mature but unripe berries are harvested and boiled in water for 10-15 minutes to soften the pericarp. After cooling, skin is rubbed off either manually or mechanically, washed and sun dried to obtain white pepper. Since no retting operation is involved, product will be free from any unpleasant odour. But white pepper produced by this method gives pepper powder of light green colour due to gelatinisation of starch in contrast to pure white powder obtained by traditional method.



Decorticated black pepper

This is a form of white pepper produced by mechanical decortication of outer skin of black pepper. Appearance of decorticated kernel is inferior to traditionally prepared white pepper, but is satisfactory when ground. Also the milling operation requires considerable skill to avoid excessive volatile oil loss.



Pepper oil

Black pepper is crushed to coarse powder and steam distilled to obtain 2.5 to 3.5 % colourless to pale green essential oil which becomes viscous on ageing. It is used in perfumery and in flavouring. Oil can also be distilled from white pepper but high price of white pepper and low oil yield do not favour its commercial production.



Pepper oleoresin

Extraction of black pepper with organic solvents like acetone, ethanol or dichloro ethane provides 10-13 % oleoresin possessing the odour, flavour and pungent principles of spice. Piperine content of oleoresin is 35 to 50 %. One kilogram of oleoresin when dispersed in an inert base can replace 15 to 20 kg of spice for flavouring purpose.

Garbling and grading

Before packing, dried pepper is cleaned to get rid of extraneous matters like dirt, grit, stones, stalks, leaves etc. and berries are graded according to size or density. In India, generally garbling and grading are done at exporters premises. Garbling machines remove dust, chaff and grade pepper according to densities. Manual cleaning is also done by hand picking the contaminants such as plant debris and other extraneous matter. Good garbled pepper should have a bulk density of 500-600 gram/liter. Light berries should be less than 1% and pin heads (unfertilized) less than 4%. Malabar Garbled (MG), Malabar Ungarbled (MUG), Tellichery Garbled Black Pepper Special Extra Bold (TGSEB), Tellicherry Garbled Extra Bold (TGEB), Garbled Light Pepper (GL) and Pin Heads (PH) are the important grades of black pepper.

Standard specifications for pepper:

The Indian Government, through the Ministry of Agriculture and Food, has prescribed the obligatory grading and standardization of agriculture products under the label "AGMARK". This specifies limits for extraneous matter, light berries and moisture content. They provide a compulsory quality control and pre-shipment inspection apart from meeting the requirements of importing countries. For export, the American Spice Trade Association standards are generally followed adulterants like phellandrene, dipentene and caryophyllene, which are also natural components of the oil itself.

Pepper oleoresin

It is prepared by the solvent extraction of ground pepper. The production process uses a number of equipments like precleaners, pulverizers, extractors and solvent recovery units. Besides, for quality control measures, instruments like gas chromatography and ultraviolet spectrophotometer are used. The oleoresin of pepper can be prepared based on the customer's quality requirement.

Piperine

The alkaloid piperine (3-6%) is the major constituent responsible for the biting taste of black pepper. The other pungent alkaloids are chovicine and piperidine.

Green pepper in brine

Bottled green pepper has great demand in non-traditional areas. The green colour is maintained under the high salinity of the steeping liquid. The minimum salt level should be 12%. The addition of a small amount of citric acid prevents the discolouration due to phenols.

Dehydrated green pepper

Keeping the freshly harvested, despiked pepper in boiling water for over 10 minutes deactivates the bleaching enzyme. Treatment with sulphur dioxide reduces the chances of darkening. As sun-drying destroys chlorophyll and the green colour, to make dehydrated green pepper, drying should be done in hot air or in a microwave oven.



Frozen green pepper

This is prepared using blast freezers. Such peppers, on thawing, are almost equivalent to the fresh material.

Other products like spice essences and emulsion, spice decoctions, encapsulated spices, fat-based spices, etc., are also prepared from black pepper.