NUTMEG

An update

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NUTMEG - *Myristica fragrans* Houtt. (Family: Myristicaceae)

The nutmeg tree is unique among spice plants as the donor of the two distinct spices, nutmeg and mace. Nutmeg is the seed kernel inside the fruit and mace is the covering (aril) on the kernel. Native of Indonesia (Moluccas Islands), nutmeg tree grows there abundantly and is now naturalized in West Indies, Srilanka, India, Phillipines, Tropical America and Pacific Islands. In India, it is grown in 15, 131 ha. mostly in certain pockets of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, North East India and Andamans. Over 50 per cent of the world's nutmeg and mace originate from Indonesia, followed by Grenada. It is also grown in a small scale in Srilanka, Trinidad, China, India, Tobago, Zanzibar and Mauritius.

Nutmeg is a stimulant, carminative, astringent, aphrodisiac and hallucinogenic. Mace is used for flavouring cigarettes and chewing to mask foul breath. Oil of nutmeg or mace is employed for flavouring food products and liquors, soaps, tobacco, dental creams and perfumery products. The volatile oil from the leaf has weedicidal properties. Nutmeg butter is used as a stimulant in ointments, hair lotions and is used in cases of rheumatism, paralysis and sprains. The fleshy pericarp of the fruit is used for making pickles and jelly. Quality pectin from nutmeg waste (rind) is also obtained.

Growth habit

Nutmeg is a dioecious or occasionally monoecious evergreen aromatic tree, usually 10-20m in height with spreading branche which carry oblong-ovate leaves, acute at apex and base, 5-15cm long and 2-7 cm wide, of leathery structure, dark green and lustrous. The shoot growth in nutmeg is cyclical, a

period of growth followed by quiescence. Six flushes are observed in a year. All the flushes are not seen in all the shoots, whichh results in continuous growth. Two growth peaks are observed, in May-June and September.

The Inflorescence of *M.* fragrans is an axillary raceme. It is branched, in male plant and simple cyme in female plant. Flowers are drooping, creamy yellow and fragrant. Though nutmeg is usually dioecious, five different types of trees viz., pure male, pure female and bisexual male, bisexual female and hermaphrodite were identified. The hermaphrodite nature is very rare whereas the bisexual types are seen in about three per cent of the trees flowered.

The flower is bracteate and bracteolate. The perianthis receiving ten vascular traces and has postulated a pentamerous origin. The androecium consists of a solid column or androphore to which is attached 14-22 bilocular anthers. The single pistil is more or less flask shaped with a short to non-existant style and bilobed stigma. The ovule is single. The fruit is pyriform and yellow in colour. The pericarp is fleshy, when the fruit matures; it splits into two exposing the scarlet-coloured net like aril covering the dark brown seed.

In seed, there is a massive vascular supply to the testa, tegmen and aril. The testa and tegmen are thick and multiplicative. Nucellus enlarges by cell growth without division, then it is absorbed and crushed by the enlarging endosperm tissue. Endosperm is oily and starchy. Ruminations formed by outgrowths of the inner brown vascular layer of the tegmen, push the nucellar tissue into the endosperm, except at the pointed microphylar end. The aril arises from the outer integument, but considered funicular in origin. The highest pollen germination of 96.9 per cent was obtained in a nutrien medium

containing four per cent sucrose, 25 ppm calcium nitrate and 75 ppm boric acid.

Flowering and Fruit Set

Flowering pattern of male and female trees differ. The month variation was also observed in the extent of flowering of both mal and female trees under Kerala conditions. In female trees, flowerin continued to seven months, whereas in male trees, flowering w observed throughtout the year. Highest flowering in both the cas was in July followed by October. The flower bud development male and female trees followed specific pattern. Male flowers took only about half the period taken by the female flowers to develop. The female flowers took 154 days for complete development. In male flowers, peak anthesis was between 21.00 hrs and 03.00 hrs. Anther dehiscence occurred about 24 hours prior to anthesis. The stigmatic receptivity lasted for six days after anthesis, the highest is during the first three days.

Studies at Kallar and Burliar in Tamil Nadu have shown that the pistillate and staminate flowers open between 6 and 7 pm and anther dehiscence occurred 12 hrs ahead of opening of flowers. The stigma was then receptive and it retained the receptivity till 2.30 pm on the day after flower opening. The chief agent of pollination is wind. The percentage of set varied among the trees and for different aspects. Highest fruit set is in trees on western and eastern aspects. The mean percentage of fruit drop after set was 74.4. Number of fruits harvested amounted to only 8.5 per cent of the total flowers produced. The period of maximum drop after set coincided with the period of maximum

development of the fruit. The fruits attained maturity in 206 to 237 days after fruit set. The developing fruits followed a sigmoid growth pattern.

Dioecy

Attempts to characterize dioecy in nutmeg yielded no definite methods to identify the male and female plants. Scientists have postulated a method for distinguishing the sex by the shape of calcium oxalate in the lower epidermal cells of the leaves of seedlings of at least two years age. Male plants showed a single large rhomboidal or prismatic crystal with rectangular or square flat faces. Female plants have a large cluster of small crystals. Colour differences were observed in the leaf extracts of male and female nutmeg plants when treated with ammonium molybdate. It was observed that the average leaf width was found larger in female compared to male plants. The length by width ratio of leaves was found higher in male plants than in female plants. A slightly higher percentage of essential oil was noticed in females whereas in male's leaf phenol content was slightly on the higher side. However, the observations did not conform to a definite pattern. The differences in the steroid degradation pattern of male and female trees, revealed that the specific compound, 1-dimethyl, 2-ethylbutylmethyl ketone present in male tree was absent in female trees. This can be used as a marker compound to identify male trees. The DNA isolation and RAPD protocol in nutmeg was also useful for determination.

Crop Improvement

Hardly any work has been done in crop improvement. The main difficulties are the long juvenile phase, the difficulty in propagating vegetatively, the dioccy and the single ovule in female flowers.

Genetic Resources

The genus *Myristica* consists of about 120 species of which five have been described from India. They are *M. fragrans* Houtt, *M. malabarica* Lamk, *M magnifica* Bedd, *M. beddomei* King and *M. contorta* Warb. The wild and related species of *Myristica* occurring in India. Germplasm of nutmeg is being conserved at the Indian Institute of Spices Research, and the present holding is about 482 accessions. At Pechiparai (under TNAU) 22 collections are maintained. Dapoli (KKVP) has a collection of 87 accessions.

Variability

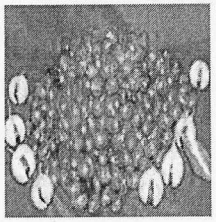
A high amount of variability has been reported in growth rate, productivity, size and shape of the leaf, flower size and shape and size of the fruit and seed. Variability and inter character association for fruit number, fruit weight, seed plus mace weight, seed weight and mace weight were also studied by different scientists. The studies indicated high variances for fruit number per tree which had a significant negative correlation with mace weight; seed weight also had very high positive significant association with mace weight. So selection will effective improving fruit number nutmeg and selecting nutmeg trees with optimum fruit number and moderately good seed weight desirable.

It was also observed that fruit characters viz. weight of fresh nutmeg and aril, pericarp weight, total fruit weight, weight of dried nutmeg and aril showed positive and significant genotypic and phenotypic correlations with yield. The high estimate of heritability for fruit attributes along with the moderately high

genetic advance suggested that these characters are under the control of additive gene action.

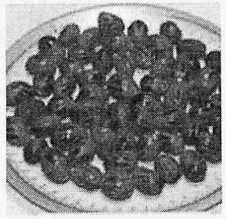
Varieties

Konkan Sugandha



This cultivar was developed at Konkan Krishi Vidyapeeth (BSSKV) at Regional Fruit Research Station, Vengurle. This the only hermaphrodite variety released. It yields 2.63 kg dry seeds (526 seeds) per tree the age of 15 years. The seed size is 5 g. and the average mace weight 1.2g.

Konkan Swad

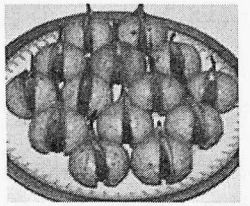


It developed the Coconut Research Station, Bhatye, under the BSSKV. This is selection from the seedling population raised from the Ratnagiri collections. Average yield 761 fruits/tree.

IISR-Vishwasree

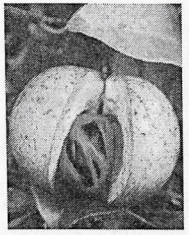
This is high yielding nutmeg selection from IISR Kozhikode. It gives an average yield of 3122 kg nuts/ha (dry) and 480 kg mace (dry)/ha. This variety possesses 7.1 per cent oil in seed and mace, 13.0 per cent oleoresin in mace and 2.5 percent oleoresin in seed. Butter content seed is 30.9 percent.

Konkan Shrimanthi



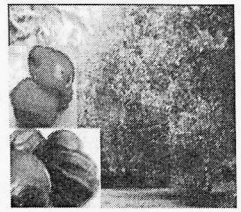
Year of released 2005, yield per trees 900 fruits, this is high yielding variety with bold nut weighing 10.20g. The oil content 39.85 percent. This is suited for konkan areas for higher yield and better nut quality.

Ceylon



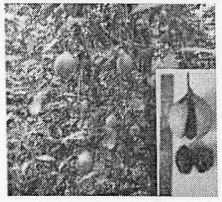
Ceylon nutmeg, which **contains an acute flavor of hazelnut,** is widely used to sweeten dishes. This conventional spice is considered to be sweet whereas the mace is strong and tart. Ceylon nutmeg is a wonderful ingredient to include in Sheppard's pies, cheese dishes and root vegetable purees.

Kuchukudy



The Kochukudy variety of nutmeg has many advantages over other varieties. It is today the one that **gives the highest yield to farmers**. The trees which start yielding from the third year, gives around 2000 fruits in the 8th year. The variety sprouts more branches, and this in turn lead to higher yield.

Gold improved nutmeg



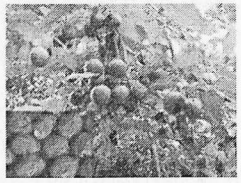
The variety produces more fruits per plant (200kg/annum in 10-years old plant) with good shelf life (5 days) of raw fruits. It is also suitable for the

cultivation in shady areas like in cardamom estates. The variety produces high quality bold nuts and dark red mace; nut contains higher essential oil content (13-15 %).

Sindushree nutmeg

This is a high yielding variety. The nuts split at correct stage. The mace is thick and dark red in size. The red colour of mace is permanent for longer period. It yields high essential oil.

Keralashree nutmeg



This was released during the year 2013. This variety cultivated in all nutmeg tracts of Kerala, Tamil Nadu and Karnataka. The first harvest is done after six years. The average mace yield is 480 kg/ha. The potential yield of nuts 31220 kg/ha (25 years).

Propagation

Nutmeg is generally propagated through seed. Well matured seeds are collected. Husks of the seeds are removed and dried for day before sowing. One kilogram contains about 200 small seeds or 90 big sized seeds. The average number of small, medium and big seeds is 125 in kilogram. The seeds are generally collected from regular bearing and high yielding trees, yielding more than 10,000 fruits per tree per year and having 30g weight fruit, 1g fresh mace fruit and 10g fresh weight nuts fruit. Seeds from healthy ripe fruits are naturally split and harvested during June-July used. Seeds sown immediately after extraction as the germination falls when sown three days after extraction. Sowing within 24hours of extraction was found best Kallar. Studies seed

viability showed that seeds stored polythene bags or moss remained viable 15 days. Old seeds and those which kernels rattle inside shell will not germinate. They are sown with the in the nursery beds over which pandals are erected provide shade. Seeds be sown a spacing about 30cm apart and 2.5-5.0cm deep. Regular watering necessary good germination. Heavier seeds sown immediately after harvest ie., during June recorded highest germination percentage and maximum vigorous seedlings. Seeds commence germination four six weeks. The seeds generally not germinate hills above 1200m. MSL due to prevailing low temperature.

Germination commences from about 40th day and lasts upto 90 days after sowing. The germinated sprouts must be transferred without much delay polythene bags (30cm x 15 cm) containing mixture soil, sand and well decomposed cowdung the ratio 3:3:1. One-year old seedlings are transplanted bigger polythene (35 x 20 cm). Seeds treated with 200 ppm gibberellic acid increased the germination percentage (75%). This treatment also showed earlier germination. Height the seedlings was also increased gibberellic acid treatment. Seedlings are transplanted the main field after 19 months. In Malaysia, it is a practice to plant seedlings 15 cm; sometimes seeds are sown situ. In India, planting done during the South West monsoon period. Seedlings planted pits of 60 cm cube with spacing 8-9 meters either way.

Growth pattern

Nutmeg tree exhibits dimorphic growth pattern. The tree exhibits orthotropy the trunk and plagiotropy the branches. Attempts have been made modify the growth pattern by various workers, but with little success. The

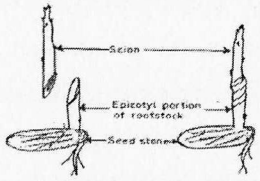
severe pruning can induce orthotrops or otherwise plagiotropic shoots. Age the wood was the main deciding factor in the induction of orthotrops. Physical or chemical treatments imposed could not induce orthotrops on nutmeg grafts having one-year old plagiotrop as the scion part.

Vegetative propagation

Nutmeg being dioecious crop, proper ratio of female and male plants is to be maintained in the plantation. Vegetative propagation is the practical way to achieve this. Various vegetative propagation methods were tested to develop a suitable method for relatively rapid multiplication. Vegetative propagation techniques like stem cuttings, air layering, approach grafting, epicotyl grafting, budding and top working were tried in nutmeg with varying degree of success.

Epicotyl grafting

At Central Plantation Crops Research Institute (CPCRI), Kasaragod, the epicotyl grafting using *M. beddomei* as rootstock has given 48 per cent survival of grafts. A grafting success of 80 per cent was obtained during the month of August when *M. fragrans* was used as the rootstock. At the Indian Institute of Spices Research, Kozhikode, epicotyl grafting has been found to be the most successful method. The technique of epicotyl grafting is given below:



Epicotyl grafting

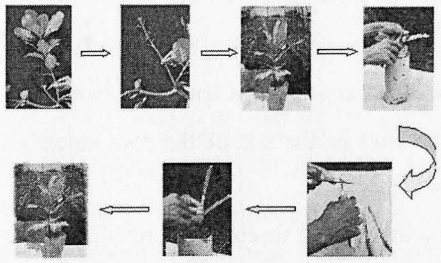
- Take 20 days old healthy sprout (root stock)
- Select a good scion (of lead pencil thickness) from a high yielding female tree.
- Cut the top of the rootstock and make a vertical split to length Of 3-4 cm.
- Make a wedge cut of 3-4 cm length in scion
- Insert the scion in the slit of the root stock and tie it firmly with a polythene strip
- Transplant the grafted sprout to the polythene bag filled with the potting mixture. Grafted portion is covered with a polythene bag to ensure high humidity which helps in graft union.
- Remove the cover bag when new leaf emerges. Also remove the polythene strip at the side of the grafting.
- High percentage of successful grafts (about 80%) could be obtained if grafting is carried out during August-September.
- It is essential to cover the scion stick with polybag, especially in post rainy season.

The harvesting season of nutmeg in Konkan region is confined from June to October. Hence availability of rootstock, particularly for epicotyl grafing is a limitation.

Soft wood grafting

The grafting method developed at Regional Coconut Research Station, Bhatye, Maharashtra provides scope for grafting nutmeg for prolonged period. May was the best season for soft wood grafting with maximum success of 80 per cent. The retension of leaves on rootstock did not influence the success of

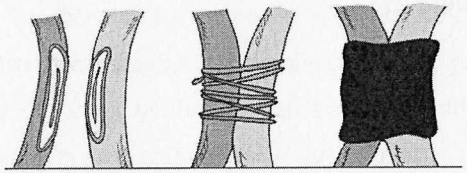
softwood grafting. The characteristic of scion stick and method of grafting were similar to that of epicotyl grafting.



Softwood grafting

Approach grafting

In India, successful approach grafting has been done on root stocks of *M. fragrans, M. malabarica* and *M. beddomei*. Those on *M. beddomei* and *M. malabarica* developed into low spreading trees whereas nutmeg seedlings generally develop into tall trees. The grafts came to flowering in 4-6 years after planting whereas seedling takes 6-8 years. Rasalam, a nurseryman from Parasalai in Kanyakumari claimed 100 per cent graft success on wild species of nutmeg, when erect branches of female nutmeg trees were used as the scion, and in such cases flowering commenced in the second year after grafting.



Spliced Approach Graft

The trial on approach grafting at Dapoli showed that the approach grafts can be prepared through out the year. High percentage of graft success was recorded on wild nutmeg rootstocks (*M. malabarica*, 30-100%), while on *M. fragrans* it was 40-90 percent. The mortality after separation of grafts was 30 per cent on *M. fragrans* and 50 percent on *M. malabarica*. However, approach grafting is a time consuming and tedious method of grafting.

Budding

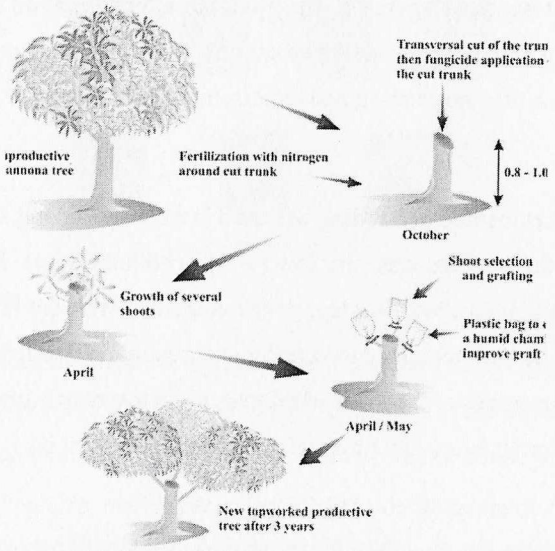
Forket method of budding was tried in *M. fragrans* and *M. beddomei* and observed that success was very low (4 %) in both the cases. It was noted that maximum bud take was in May, which coincided with the flushing season in nutmeg. The buds remained alive without sprouting even after one year. Forket budding on sprous of the top worked trees also gave only initial success, which failed to sprout even with physical and chemical treatments.

The commercial coverage through vegetative propagules is very much limited due to the unaviliability of orthotropic shoots for use as scion. As a result, plagiotropic shoots are collected as the scion material. But such plants have a peculiar spreading habit resulting in squatty plants with stunted growth compared to seedlings of the same age. Therefore, the fruiting area is comparatively less resulting in low yield. Because of these factors, seeds continue to be the major propagating material even now.

Top working

The sex of nutmeg tree can be identified only 7-8 years after planting, when they begin to flower. Generally, male and female trees are produced in

1:1 ratio. Since a single male tree is sufficient for every 20 female trees for pollination, the rest of the unproductive male trees can be made productive by converting them into female trees by top working.



Trials on topping of male trees indicated that cutting the trees above the first tier during August was found to be the best with regard to sprout production and reducing the time for sprouting. Forket budding on new sprouts gave only initial success, which failed to sprout even with physical and chemical treatment. Successful graft union was obtained during March with scion shoots having mature leaf and full green stem and stock having two months growth. The IISR, standardized the top working technique as follows:

The male trees are beheaded about 30 cm above the ground level in May and the cut end is smeared with Bordeaux paste. Decapitated trees are irrigated

regularly till the onset of monsoon. New shoots develop from the main trunk within 45-60 days. The newly emerged shoots are ready for grafting when they attain about 20 cm length of the shoot. A longtitudinal cut of about 3 cm is made from the top downwards on the retained stock. This slit gives a shape when split open. Orthotropic scions of the same thickness as that of the stock are collected in water from high yielding female trees of nutmeg on the same day of grafting. Scions with two leaves are used for grafting. The lower end of the scion is shaped into a wedge by removing the bark with a little wood from both the sides of the scion with a sharp knife. The scion inserted into 'v' shaped slit of the stock and secured in place firmly with a 1.5 cm wide polythene strip. The grafted shoot is covered with a polythene cover to maintain humidity and to prevent from drying. A temporary shelter is provided above the tree to prevent the harmful effects of ram or scorching sun. The polythene cover is removed after 30-45 days when perfect union takes place. Development of new buds from the grafted scion is an indication of perfect union. After successful union, all other shoots are removed from the main trunk and Bordeaux paste is applied on the cut surface. Overhead shade can be removed after ensuring successful union of the graft. If the graft fails, regrafting can be done on either the same shoot or on a different shoot. This technique assures cent per cent success. Top working can be used for conversion of unproductive male and female trees to productive female trees. The top worked trees yield from the 3rd year onwards. After care of top worked trees include removal of new shoots that sprout from the main trunk and regular management practices especially irrigation.

In situ budding

In situ budding is now the most popular method followed by farmers of Kerala to solve the two major problems that restrict large scale cultivation of nutmeg namely doiecy and long juvenile phase. Budding can be done on plants within 2-5 years of planting. Orthotropic scion shoots from elite mother trees are budded on seedlings of two years after planting in the main field. The rootstock and scion should be at the bark slipping stage. Budding is done just above the first whorl lower of leaves.

Studies at Kerala Agricultural University proved that in situ budding on hard trunk was most successful. Forket method with brown bud wood having fallen leaves and the buds inserted by leaving space on all four sides gave maximum success. In order to achieve a quicker bud burst, stumping the plant two months after budding was found most effective. Budding on hard trunk could be done with maximum success in three-year-old plants and July was found to be the best season. Maximum success with patch and forket method *M. beddomei* obtained. August found be the situ budding and July for budding poly bag plants. Partial shade found ideal for better bud than the chamber conditions. Stumping the rootstock above bud retaining the whorl of lower leaves gave better sprouting and late survival.

Crop Production

Soil and Climate

Nutmeg requires a humid no pronounced dry season. The soil should be rich in organic matter and well drained. It is grown and produces satisfactorily

within annual temperature 24-29°C with 75-90 percent humidity. It can be successfully grown as a rainfed crop in areas receiving rainfall in the range of 1500-3000mm with a dry period of 2-3 months. The tree prefers shade. Sheltered valley are the best suited. It can be grown upto about 900 m above MSL.

Area with soils of clay loam, sandy loam and red lateritic with high humus content is ideal for its growth. Both dry and water logged conditions are not preferred by nutmeg.

Field Preparation and Planting

In India, seedlings planted during South West monsoon. Various spacings and pit size recommended are furnished below.

Spacing (m)	Pit size (cm^3)
8.0 x 9.0	60
9.0 x 9.0	75
6.0 x 6.0	80
8.0 x 8.0	80

The pits filled with top soil and compost well decomposed farmyard manure. Ten males may be retained for pollination remaining male trees may be either removed converted to females by top working.

After Care

Nutmeg is a shade loving plant. Young as well as grown up plants require certain amount of shade. Locations with permanent natural shade will be the

optimum. For open space, artificial shade is provided by growing *Glyricidia* sp, Dadap, banana, *Acacia* sp and Subabool. Lopping of branches may be done at later stages to regulate shade

As an intercrop in coconut plantations, nutmeg is planted in between two rows of coconut so as to accommodate 50-60 plants per acre. In the Andaman and Nicobar Islands, combinations of coconut or arecanut + nutmeg + robusta coffee + or forest trees + nutmeg robusta coffee + pepper have been found successful. A spectacular yield increase of coconut palm and thereby total yield per unit area can be obtained by intercropping nutmeg in coconut plantation.

Regular weeding and mulching keep the field clean and conserves moisture. Cover crops like *Mimosa* sp. and *Stylosanthes* sp. may also be cultivated for suppressing weed growth. Application of herbicide mixture (gramaxone and fernoxone) checked weeds upto six months. Seedlings may be irrigated periodically during summer. In general, four year old plants require 20 lit. of water per plant thrice in a week and the quantity of water is to be increased at later stages of growth.

Nutrient Management

While studying the influence of macro and micronutrient deficiencies on the foliar level of nutrients, the flowering shoots registered significantly higher C/N ratio in leaves than that of non flowering shoots. The flowering shoots always registered a relatively higher P/S, Ca/S, N/P and N/K ratio and a lower foliar level of Ca/ Mg, N/P and N/K ratios.

Deficiency symptoms

Deficiency symptoms of macronutrients are first manifested on the older leaves with the exception of calcium and sulphur while that of micronutrients on younger leaves. Symptoms of nitrogen deficiency were first seen as yellowing of leaves with the appearance of orange tinge all over the leaf excepting the midrib and lateral veins followed by development brownish blotches bright yellow halos. Bronze purple discoloration leaves with appearance of purplish brown necrotic blotches are the symptoms of phosphorus deficiency.

Potassium deficiency symptoms are characterized by the appearance of chocolate brown necrosis along the leaf tip and margins which later spread to the distal one third to two third portion of leaf laminae. The younger leaves become thick, brittle and reduced in size with blunt end in respect of calcium deficiency. Light orange yellow chlorosis develop along the leaf margins and ups followed by the appearance of necrotic spots with bright orange yellow zone adjacent to the necrotic areas. Magnesium deficiency is characterized by the yellowing of the midrib and lateral veins and adjacent areas from the base of the leaf followed by yellowing of the entire laminae combined with necrosis and outward cupping of margins. In the case of S deficiency, the younger leaves become uniformly lemon yellow in colour which later develop the characteristic "Birds eye spot" and "shot holes".

Interveinal chlorosis of the young leaves is the most commonly observed symptoms of micronutrient deficiencies. However, the symptoms are specific to each nutrient. Uniform straw yellow discoloration of leaves with pale green

midrib and lateral veins followed by the formation of necrosis from the leaf tip towards base, downward cupping of leaves and asymmetrical laminae are the typical symptoms of iron deficiency. Manganese deficiency is marked by pale yellowish intervenial chlorosis and crinkling of leaves. Development of water soaked spots starting from the margin and tip towards the midrib in a wavy way followed by the downward cupping, appearance of coppery red necrosis and leaf distortion are the symptoms of copper deficiency. Symptoms of Zn deficiency at manifested in the form of abnormally long and narrow leaves with a typical mottling and reduced internodes. Boron deficiency symptoms are expressed in younger levels as crinkling and the prevalence of orange yellow chlorotic patches develop in-between the lateral veins followed by the development of necrosis from margins and tips at the distal portion. Cracks develop at the necrotic areas and the lea gets torn off.

Among the macro and micronutrients, iron manifests the symptom much earlier during the third month followed by Mg and S which exhibit deficiency symptoms during fourth month. N deficiency is seen during fifth month, P and B during seventh months. K, Cu and Zn deficiency is during eight month and calcium and manganese during ninth month or later. Vegetative growth is markedly reduced due to the deficiency of macro and micronutrients. Calcium, P, K, Mg and Zn are the elements which reveal profound influence on root growth. The growth of plant is found to be completely arrested at a comparatively carly stage during fifty month due to Mg, S and Fe deficiencies, (fifth month) followed by B (7^{th} month) nitrogen (9^{th} month), P, K, Ca, Cu and Zn (10^{th} months) and Mn (10.5^{th} month).

Nutrient requirement

A fertilizer schedule of 1 kg each of ammonium sulphate, super phosphate and muriate of potash along with 50 kg of compost per year to mature plants is recommended under Tamil Nadu conditions. Seedlings and young plants are to be supplied with one tenth and half the dose respectively. The fertilizers are to be applied during May-June and September-October. The Kerala Agricultural University has recommended a fertilizer schedule of (20:18:50g of NPK along with 15 kg of compost per year during the first year of planting which is to be gradually increased to 500:250:1000g NPK and 50 kg of compost per year from 15^{th} year onwards. Under Andaman and Nicobar Islands conditions, a dose of 400:320:400g of NPK respectively for an adult tree per year is recommended.

Method of application

The whole quantity of organic manures may be applied in one dose just at the commencement of monsoon in May-June. The fertilizers should be applied at least in two doses, one in May-June along with the organic manures and again in September-October. The manures should be applied in shallow trenches dug around the plant. As a large number of roots are seen almost on the surface of the soil, trenches should not be deep or very near to the plant. About 8 to 10 cm deep and 15-20 cm wide trenches may be taken about 10-20 cm away from one year old plant. The distance from the base of the plant to the trench should be increased every year and for a 15-year-old plant it should be about 1 to 1½ metres. The trench should be covered after application of manures.

Crop Protection

Pests

No serious insect pests are noticed on nutmeg. Occasionally mealy bugs and scale insects attack tender portions of the stem and cause drying of parts by sucking sap.

Black scale (*Saissetia nigra*)

The black scale infests tender stems and leaves especially in the nursery and sometimes-young plants in the field. The scale is clustered together and are black, oval and dome shaped. Black scales feed on plant sap and severe infestation causes the shoots to wilt and dry. It can be controlled by spot spraying with quinalphos 0.025%.

White scale (*Pseudaulacaspis cockerelli*)

The white scale is greyish white, flat and shaped like a fish scale and occurs clustered together on the lower surface of leaves especially in nursery seedlings. The pest infestation results in yellow streaks and spots on affected leaves and in severe infestations the leaves wilt and dry.

Shield scale (*Protopulvinaria mangiferae*)

The shield scale is creamy brown and oval and occurs on tender leaves and stems especially in nursery seedling. The pest infestation results in wilting of leaves and shoots.

Control

The scale insects mentioned above other species that may also occur sporadically on nutmeg can be controlled by spraying dimethoate 0.05% or quinalphos 0.025%.

Black scale (*Saissetia nigra*), **White scale** (*Pseudaulacaspis cockerelli*) and the **shield scale** (*Protopulvinaria mangiferae*)

Symptoms

The scales infest tender stems and leaves especially in the nursery and sometimes young plants in the field. The scales are clustered together oval and dome shaped. Scales feed on plant say and severe infestations cause the shoots to wilt and dry.

Management

The scale insects mentioned above and other species that t may also occur sporadically on nutmeg can be controlled by spraying dimethoate 0.05 per cent and spray quinalphos 25EC @ 1.25ml/lit. in nursery.

Diseases

Die back (*Diplodia* sp.)

Symptoms

The disease is characterized by drying up of mature and immature branches from the tip downwards.

Management

The Infected branches should be cut and removed and the ed end pasted with Bordeaux mixture 1 per cent.

Thread blight (*Marasmius pulcherima; Marasmius equicrinus*)

Symptoms

Two types of blights are noticed in nutmeg. The first is a while thread blight wherein fine white hyphae aggregate to form fungal threads that traverse along the stem underneath the leaves in a fan shaped or irregular manner causing blight in the affected portion. The dried up leaves with mycelium form a major source of inoculum for the spread of the disease. The second type of blight is called horse hair blight. Fine black silky threads of the fungus form an irregular, loose network on the stems and leaves. These strands cause blight of leaves and stems. However, these threads hold up the detached, dried leaves on the tree, giving the appearance of a bird nest, when viewed from a distance. Both the diseases are severe under heavy shade.

Management

- These diseases can be managed by adopting phytosanitation and shade regulation.
- In severely affected gardens, Bordeaux mixture 1 per cent spraying may be undertaken in addition to cultural practices.

Fruit rot (*Phytophthora* sp. and *Diplodia natalensis*)

Immature fruit split, fruit rot and fruit drop are serious in a majority of nutmeg gardens. Immature fruit splitting, rotting of mace and shedding of fruits are noticed in some trees without any apparent infection.

Symptoms

In the case of fruit rot, the infection starts from the pedicel as dark lesions and gradually spreads to the fruit, causing brown discolouration of the rind resulting in rotting. In advanced stages, the mace also rots emitting a foul smell. *Phytopthora* sp. And *Diplodia natalensis* have been isolated from affected fruits. However, the reasons for fruit rot could be both pathological and physiological. Infection may also spread to aril and mace in severe cases. The rotting area is gradually covered with mycelial growth.

Management

Bordeaux mixture 1 percent may be sprayed when the fruits are half mature to reduce the incidence of the disease.

Leaf spot and shot hole (*Colletotrichum gloeosporioides*)

Symptoms

Sunken spots surrender by a yellow halo are the initial symptoms. Subsequently the central portion of the necrotic region drops off resulting in shot hole symptoms. Dieback symptoms are also observed in some of the mature branches. On young seedling drying of the leaves and subsequent

defoliation are seen. The disease can be controlled by spraying 1% Bordeaux mixture two or three times during rainy season.

Management

A prophylactic spray with Bordeaux mixture 1 per cent is effective against the disease

Fruit Drop (*Coryneum myristica*)

Symptoms

The unripe fruit opens on the trees and falls prematurely and spice obtained from them is generally shriveled and of poor quality Dark green sunken areas appear on the surface of the exocarp with a brown discoloration beneath. It is more severe in wet season of high humidity at times of over cropping.

Management

Bordeaux mixture 1 per cent spraying may be undertaken to control the disease

Root Rot (*Fornes noxius*; *F. camaoensis*, *Rosellinia pepo*)

Symptoms

The trees suffering from this disease loose their turgidity and all the fruits appear crinkled and dehydrated. Eventually the leave turn brown and fall and then die. It has been reported that *R. pepo* may be the cause of a root-rot in wet areas resulting in wilting of the trees.

Management

Bordeaux mixture 1 per cent spraying may be undertaken to control the disease

Harvest and Yield

Fruiting commences from fifth or sixth year but may take ever eight or nine years. Plants that begin to fruit early are short lived. Delayed fruiting in the 9th year is the best. Optimum productivity is attained in about 15 years. Adequate yield is obtained even from 45 years old trees. Fruits are reported to ripe in 6-9 months after flowering. Trees raised from seedlings begin to bear 5-8 years after planting whereas vegetatively propagated trees fruit much earlier. In India, fruits that split on the tree exposing crimson coloured an are harvested. Peak harvesting periods vary in different places Konkan region, it is confined from June to October, whereas Kerala it is June-July

Yield varies among trees and plantations. The average yield a good tree in full bearing is reported to be 3000 fruits between 15th And 30th year of growth. Average weight of a single fruit is 60g of which the seed weighs 6-7g, mace 3-4 g and the rest pericarp. Ratio of mace to nutmeg is 1:8. Immature fruit drop occurs to an extent of 74.4 per cent due to degeneration of embryos resulting from inadequate pollination, water scarcity and root competition due to closer planting or interplanting with shade trees, nutritional imbalance, fungal attack and physiological reasons.

Fruits are collected from the tree by hand or with hooked sticks or allowed to fall naturally on the ground and are gathered everyday.

The fruit is composed of three parts. It is the pericarp or husk, the mace and the seed. The pericarp is removed and the mace, which envelops the shell, is peeled off. The "blades of mace" as the peelings are called are flattened by hand or between boards and are spread out to dry in the sun. In good dry weather, the drying operation is accomplished in two or three days. Sun drying leads to a certain amount of colour fading. To prevent such bleaching artificial drying is often resorted to. Exceptional care must be taken to prevent mace getting mouldy. A perfect sample of mace consists of entire double blades, not broken, flattened and of large size, horny in texture and not too brittle and of a good, clear and bright colour. Nut is left in the shell and dried in the sun or in drying ovens. Drying is complete when the seed rattles. In Kerala the harvesting season coincides with the monsoon season. So sun drying often becomes impossible. Hence artificial drying becomes essential for which various improvized techniques are used by the growers. Nutmeg lose about 25 per cent of their weight by drying. Shell is then cracked with wooden hammers or mechanically in specially designed machines and discarded or used as fuel and the nutmeg removed and dried. The ratio of dried nutmeg to dried mace is approximately 20:3.

The aromatic ethers which are the chief components that determine the flavor and drug action in nutmeg oil was maximum one month prior to the fruit splitting stage. In mace oil it was found to be high two months prior to the fruit splitting stage. So if nutmeg and mace oils are intended for medicinal purpose, then it may be worthwhile to harvest fruits at the sixth month for extracting kernel oil and at the fifth month for extracting mace oil.

Post harvest handling and Processing

Packaging of Mace Nutmeg

Nutmeg from West Indies, Grenada and Indonesia packed 50-60-kg capacity double jute sacks. In Sri Lanka, double polypropylene used. Minimum quantities purchased are 2-5 tonnes lots. Maximum quantities are 100-200 tonnes. There is a tendency prefers larger amounts, as freight is cheaper.

Mace usually packed in wooden cases of 60kg capacity each smaller sizes are sometimes shipped Minimum quantities are for nutmegs. Mace pickings may pressed into 90kg bales.

East Indian **nutmeg** oil is packed in 180-200 kg capacity steel drums (suitably enamal coated).

The nutmeg oleoresin is normally packed in plastic PVC pails of various capacity viz., 15, 20 and 25 kg PVC of which 25 kg is the most popular in the industry.

Grading

Mace

Commercial mace consists of flattened lobed pieces, 2.5-cm or more in length, some-what less breadth and 1 mm thick. When Soaked water, the lobes swell up and regain their original form. It is dull yellowish red, translucent and brittle. In odour and taste, it resembles nutmeg, but is softer and more delicate. Four grades or types of mace are recognized as follows.

i. **Banda Mace** is considered to the finest. It has bright orange colour and fine aroma.

ii. **Java Estate Mace** golden-yellow, interspersed with brilliant crimson streaks, like banda mace. It is free from insect infestation.

iii. **Siauw Mace** is of lighter colour than Banda mace and contains less volatile oil.

iv. **West Indian Mace** comparatively inferior in quality.

v. **Papua Mace** is often regarded as the fourth grade of Eas Indian mace. It contains comparatively little volatile oil and That too of an undesirable turpentine-like aroma. It is entirely unsuitable for distillation purposes.

"Banda" and "Penang" Maces are considered by the trade all over the world over as of superior quality. This 'true' mace must be differentiated from mace consisting of aril of *Myristica argentica* Warsh known as Macassar" or "Papua Mace" or of aril of *Myristica malabarica* known as "Bombay Mace" or "Wild Mace. The first tree is native to New Guinea and the second to India

Being a thin lacy material, the mace is very light in weight and consequently, for every 100 kg of nutmeg, a tree produces only 3- 31/2 kg of mace. Its quality depends upon its essential oil content. Mace is available in the market as 'whole', 'broken' or 'ground.

Nutmeg

The following classification has been adopted in nutmeg trade.

Whole Sound Nutmeg: a. Large (80 to a lb), these are in greater demand; b. Medium (110 to a lb); c. Small (130 to a lb). There is also a grade ABCD' un-mixed unassorted.

Out of these ranges from 80, 110 and 130 nuts per pound, the greatest demand is for 80 nuts per pound. These nuts are of interest to spice trade, but are usually too highly priced for oil distillation.

Sound Shrivel: These are employed for grinding, but are usually too expensive for oil distillation

Rejections: Considerably lower priced, this grade can be used for oil distillation.

Broken and Wormy: This is the cheapest grade, large quantities of which have been shipped yearly to Europe, especially to Hamburg, for oil distillation. This quality grade comprises all broken and loosened up nutmegs, which seem to contain much less fatty oil than the sound nuts. For this reason, it is very suitable for distilling. The United States customs regulations forbid importation of this grade except for oil distillation. The United States and England import mainly sound nutmegs, Germany (Hamburg) imports the highest and lowest grades, the latter only for distilling. France buys only broken and wormy nutmegs

Grinds or Particle Size. Fine grinds are not recommended both for nutmeg and mace as they promote caking. A practical grind for both these is the one, which passes 95 per cent of the contents in the US Standard sieve no. 25 or Tyler sieve no. 24.

Quality/Composition of Mace and Nutmeg

Mace

Moisture: 15.9%, protein: 6.5%; ether extract: 24.4%; carbohydrates: 47.8%; fibre: 3.8%; mineral matter: 1.6%; calcium: 0.18%, phosphorus: 0.10%; iron: 12.6 mg/100g. It contains volatile oil (4-15%), amylodextrin (25%), reducing sugar, pectin, resins and colouring matter. It also has vitamins B_1: 0.37; vit B_2: 0.56; niacin: 1.2; vit C: 12mg/100g and vit A: 1751U/100g. The chief constituents are the volatile oil (oil of mace) to which the flavour is mainly due to an amylodextrin naturally present therein.

Nutmeg

Comparative analysis of the nutmeg gave the following values moisture: 14.3%; protein: 7.5%, ether extract: 36.4%; carbohydrates: 28.5%; fibre: 11.6%, mineral matter: 1.7%; calcium: 0.12%, phosphorus: 0.24%, iron: 4.6 mg/100g. Nutmeg also contains a volatile oil: 6-16%, starch: 14.6-24.2%; pentosans: 2.25%; furfural: 1.5% and pectin: 0.5-0.6%. It is a fair source of vitamins.

Processed products

Mace Products

Oil of Mace

It resembles nutmeg oil in odour, flavour and composition and no distinction is made between them in the trade like nutmeg oil, mace oil also becomes viscous on storage due to absorption of oxygen. Old mace yields more

viscous oil than the fresh one; hence, it is important to judge the freshness of mace.

Fixed Mace Oil

Mace yields a fat similar to that from nutmeg but in a much smaller quantity. A sample of Indian mace gave 26% of a red coloured fat (18-20% after removal of volatile oil) on extraction with carbon tetrachloride. It has the following characteristics: specific gravity: 0.984, refractive index: 1.4850, acid val 3.4, sap. val: 108, iodine value: 153-157, R.M. val: 7.2, Acetyl val: 65 67, and Unsapon matter: 35%. The amylodextrin is present in mace in the form of granules, visible under miscroscope. They are compound and irregular shape with distinct hilum.

Adulteration Mace

Pure mace, whole or broken, is sometimes adulterated with 'Wild Mace' (*M.malabaricum*) of inferior quality. In the case ground mace, the common adulterants are ground wild or cheaper mace.

Nutmeg Products

Volatile Oil

The percentage of volatile oil in nutmeg varies from 6 to 15 per cent, according to origin and quality of spice. Wormy nutmeg give a much higher yield than sound ones; the former, most of the fixed oil, present in endosperm, which tends to retain the volatile during distillation, would have been devoured by worms, while the strongly aromatic oil the inner layer of perisperm remains intact. Commercial oil is derived from broken and wormy nutmegs. The

material is pressed to remove fixed oil, and immediately subjected to steam distillation. Loss of volatile oil from ground nutmegs relatively rapid (in about 2 months). Collection of distilled water necessary for recovery of the total oil.

Oil of nutmeg is a mobile, almost colourless or pale-yellow liquid with characteristic odour on ageing. It partly resinifies and becomes viscous storage. The aroma of East Indian oils is much more pronounced and more characteristic of the spice than that of West Indian oils. The latter has lower specific gravity and refractive index, but high optical rotation. The nutmeg oil has been found to be effective arresting growth of aflatoxin B produced by *Aspergillus parasiticus* fungi by 40 per cent.

Nutmeg Butter

Nutmeg contains 38-43 per cent of ether extractable material which, in addition to glycerides, contains volatile oil (6-13%), a small quantity of resin, and a substantial proportion of unsaponifiabl material. Commercial nutmeg butter, a highly aromatic fat, is obtained from undersized, damaged or worm-eaten kernels which are unfit for sale as spice. The material is ground and cooked or steamed before pressing. An yield of 24-30 percent is reported. The fat may be obtained by solvent extraction also but this process is not usually employed.

Nutmeg butter is soft, solid (m.p.38-51) yellow or yellowish red, with the odour and taste of nutmeg. The analytical characteristics of the commercial product vary a great deal superior according to the method of preparation and the proportion of volatile oil and resin present.

Volatile Oil of Bark

The bark of the tree yields 0.14 percent of a volatile oil with the following characteristics-specific gravity: 0.871; optical rotation: 12.21, sap val: 14: ester val. after acetylation: SI 37.5.

Volatile Oil from Flowers

A volatile oil is obtained also from flowers.

Stem Utilization

The stem contains a tannin-mucilage complex.

Edible Food Products from Fruit Rind

Fresh pericarp from ripe fruit (about 80%) contains an acidic (2.3%) astringent juice with an aromatic flavour. Analysis of the fruit rind gave the following values-moisture: 86.8%, protein: 1.0%, ether extract: 0.4%, carbohydrates: 11.2% and mineral matter: 0.6%; calcium: 0.04%, phosphorus: 0.01%, iron: 2 mg/100g and carotene (as vitamin A): 81U/100g. Fresh nutmeg rind or husk constitutes about 80-82% of the whole nutmeg fruit (moisture 85-88%). Fresh husk is a rich source of pectin (12-14%) of good quality (225-250 jelly grade). Besides, a number of delicious edible food products of commercial importance such as nutmeg Jelly, chutney, preserve-candy, pickles, beverages, jam, mixed fruit jam and canned fruit cocktail in combinanon with pineapple, papaya, orange and banana, etc have been developed.

Adulteration of Nutmeg

Nutmegs sometimes are adulterated with 'false' nutmegs (*M malabaricum*) or Bombay nutmegs, which are practically odourless and tasteless. The oil is sometimes adulterated by addition of turpentine oil or pinene, limited amounts of which scarcely affect it physical and chemical constants. Since pinene is a natural constituent of nutmeg oil, it is difficult to detect moderate additions by chemical means. An expert will employ organoleptic tests in the evaluation of this oil.

Uses

Nutmeg

Both nutmeg and mace are used as condiment, particularly sweet foods, baking etc. and in medicine. In Eastern countries, they are used more as a drug than as a condiment. Nutmeg is a stimulant, carminative, astringent and aphrodisiac; it is used in tonics and electuaries and forms a constituent of preparations prescribed for dysentery, stomach-ache, flatulence, nausea, vomiting, malaria, rheumatism, sciatica and early stages of leprosy. Excessive dose have a narcotic effect; symptoms of delirium and epileptic convulsion appear after hours. Mace is similarly used; it is also chewed for masking foul breath.

Oil of nutmeg or mace is employed for flavouring food products and liquor. It is used for scenting soaps, tobacco and dental creams and also in perfumery. The oil is official in Indian Pharmacopea. It is mildly counter irritant and used in linaments and hair lotions. It has been recommended for

the treatment of inflammations of bladder and urinary tract, the oil is somewhat toxic owing to the presence of myristicin and should be used with caution.

Nutmeg butter is used as a mild external stimulant in ointments hair lotions and plasters and forms a useful application in cases of rheumatism, paralysis and sprains. It is used in perfumes for imparting a spicy odour and in the manufacture of soaps and candles. Fats from other *Myristica* spp. sometimes substitute nutmeg butter.

Alcoholic extracts of nutmeg show antibacterial activity against *Micrococcus var aureus*. Aqueous decoctions are toxic to cockroaches. Myristicin present in the kernel may be employed as an additive to pyrethrum to enhance toxicity of the later to houseflies; myristicin by itself is inactive. The volatile oil from the leaf has weedicidal properties. It may also be used for scenting soaps, dentifrices, chewing gums and tobacco.

The pericarp or rind of the ripe fruit is locally used in pickles, it is used also in the preparation of jellies, jams, chutneys, canned fruit, cocktail, preserves, candies, beverages, etc. Half-ripe fruits are candied in Malaysia. It is also good source of pectin for manufacture of jellies

Mace

Nutmeg and mace are generally classified as baking spices since both are particularly good in sweet foods (dough nuts and sweet doughs, especially). However, they find a much wider range of use than other baking spices. They are frequently included in recipes for curried meat and other products. They are much used in soups and reserves, in sauces in combinations with dairy

products. Nutmeg, in general, tends to be sweeter and more delicate than mace. For light coloured foods, such as pound cakes, cream pies and cream soups, mace is often chosen because of its own light orange colour. In India, mace and nutmeg are used more as drugs than as a condiment due to their valuable medicinal properties. Both are stimulant, carminative, astringent and aphrodisiac and are used in pharmaceutical preparations for dysentery, stomach ache, flatulence, nausea, vomiting, malaria, rheumatism, sciatica and leprosy (early stage). Excessive doses, however, have a narcotic effect. Mace, which has got similar uses, is also chewed for masking foul breath. However, use of nutmeg is greater in the kitchen and in medicine than that of mace. Their volatile oil is used as a flavoring agent in liquor, tobacco and dental creams.