PLANTATION CROPS

FSC-221

(Practical Manual)





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FOREWORD

Indian horticulture sector contributes about 33% to the agriculture Gross Value Added (GVA), making very significant contribution to the Indian economy. Apart from ensuring nutritional security of the nation, it provides alternate rural employment opportunities, diversification in farm activities, and enhanced income to farmers. Production of plantation crops has increased from 16.12 MT in 2019-20 to 16.63 MT in 2020-21. In fiscal year 2022, volume of coconut production in India is estimated to have amounted to over 13.3 million metric tons. Among Indian plantation crops, coconuts accounted for the highest share, followed by areca nut and cashews. India is the leading country in the total production of certain plantation crops in the world. For instance, our production meets the share of 47 per cent in tea and 66 per cent in each of cashew and arecanut.

This practical manual has been prepared for imparting the practical knowledge to B.Sc. Horticulture students as per the 5th Deans' Committee report. I appreciate the efforts of authors for bringing out this practical manual covering valuable information on different aspects of plantation crops grown in India.

(Anupam Mishra)

PREFACE

The term plantation crop refers to those crops which are cultivated on an extensive scale in contiguous area, owned and managed by an individual or a company. The crops include tea, coffee, rubber, cocoa, coconut, arecanut, oil palm, palmyrah, date palm and cashew. These are high value commercial crops of greater economic importance and play a vital role in improving Indian economy, especially in view of their export potential, employment generation and poverty alleviation particularly in rural sector. Coconut, cashew nut, cocoa, arecanut, oil palm and palmyrah come under Ministry of Agriculture while tea, coffee and rubber are dealt by Ministry of Commerce. Accordingly the syllabus of UG Horticulture, subject (Practical) of Plantation crops designed by the Fifth Deans' Committee giving a very holistic approach to develop perfect understanding of practical aspects of different plantation crops. While drafting the Practical Manual concerted efforts have been made to elaborate the concerned exercise so that student can attempt the practical problems with full of understanding and confidence.

We hope that the information furnished in this manual will be useful for the students of Horticulture. The readers are ardently requested to freely indicate the corrections and suggestions for their incorporation in the second edition to safeguard the interest of these crops in India.

(Authors)

CONTENTS

Exercise No. 1

Title: Identification and description of coconut varieties.

Objective: To identify different varieties of coconut morphologically and physically.

There are two distinct varieties of coconut, the tall and dwarf and their characteristics are given below:

A. Tall coconut

- Tall coconut is scientifically known as *Cocus nucifera* var. Typica.
- The variety has a long and stout trunk with a swollen base which is called as bole.
- It grows up to a height of 15-18 m.
- The mature palm will be having 25-40 leaves on the crown.
- The length of the fully opened leaf will be around 6m.
- The palm lives up to a age of 80-90 years.
- The palms come to bearing at the age of about 7 years.
- It is a cross pollinating variety.
- The palm yields copra, oil and fibre of good quality.
- The inflorescence comes to maturity within 12 months after pollination.
- Colour varies from green to shades of brown in talls.

B. Dwarf coconut:

- It is botanically known as *Cocus nucifera* var. nana.
- It is short in stature.
- It comes to bearing in 3-4 years.
- It is self-pollinating in nature.
- It has a thin trunk with a swollen base.
- The maximum height will be around 5m.
- The economic life span is around 25-30 years.

- The quality of the copra is poor.
- It is mainly planted for tender coconut purpose.
- It is used for crossing programme with talls to produce hybrids.
- In India dwarf types are classified as Javanica and Nana types.
- Javanica types are vigorous palms coming to bearing in four years, either cross pollinating or self-pollinating.
- Purely self-pollinating which comes to bearing in three years are called as Nana types.
- Colour varies from green, yellow and orange.

Some important tall varieties of coconut with their characteristics.

1. Chandra Kalpa

The average annual yield is 100 nuts/palm. The palm grows in all types of soil and it can withstand moisture stress. This cultivar is recommended for cultivation in the states of Kerala, Karnataka, Andhra Pradesh and Maharashtra.

2. Kerachandra

The annual average yield is 110 nuts/palm. This is recommended for the west coast region including Kerala, Konkan, coastal Andhra Pradesh and West Bengal.

3. Kalpa Pratibha

This variety has the potential to produce 23,275 nuts per hectare per year. The quantity of tender nut water is 448 ml. This is recommended for cultivation in Kerala, Maharashtra, interior zone of Tamil Nadu and coastal zone of Andhra Pradesh

Chandrakalpa

Kerachandra

Kalpa Pratibha

4. **Kalpa Dhenu**

It commences flowering in 67 months after planting in the field. This variety has the potential to produce 22,794 nuts per hectare per year. The quantity of tender nut water is 290 ml. This

is recommended for cultivation in Kerala, East Coast region of Tamil Nadu, Andhra Pradesh and Andaman & Nicobar Islands.

5. Kalpa Mitra

This variety has the potential to produce 80 nuts/palm/year. The quantity of tender nut water is 495 ml. This is recommended for cultivation in Kerala and West Bengal.

6. Kalpatharu

This variety is recommended for ball copra production. It yields around 116 nuts per palm per year with copra content of 176g, under rainfed situations. This is recommended for cultivation in Karnataka, Kerala and Tamil Nadu.

7. Kera Keralam

The average annual yield under rainfed condition is 80 nuts per palm. The fruits of the variety weigh about 800- 900 g and copra content of 176 g/nut, with copra oil content of 68%. Suitable for ball copra production. It is recommended for large scale commercial cultivation in the states of Tamil Nadu, Kerala and West Bengal.

8. Kalpa Haritha

A superior high yielding tall selection with lesser incidence of eriophyid mite infestation. The average nut yield is 118 nuts per palm per year under rainfed conditions with estimated copra yield of 25.5 kg per palm per year. This variety is suitable for copra and tender nut purpose. Recommended for Kerala and Karnataka.

9. Kalpa Shatabti

The variety gives high copra outturn of 28.65 kg per palm per year or 5.01 t/ ha copra. The variety is characterized by large fruits with average copra content of 272.9 g and higher volume (612 ml nut-1) of good quality tender nut water and gives an average nut yield of 105 nuts per palm per year. Recommended by for cultivation in the coconut growing tracts of Kerala, Karnataka and Tamil Nadu.

Kalpa Dhenu

Kalpa Mitra

Kalpatharu

10. Kalpa Ratna

A high yielding variety suitable for tender nut, copra and inflorescence sap production. The annual average nut yield is 133 nuts per palm per year, with copra out turn of 24.47 kg per palm per year. Recommended for Kerala, Tamil Nadu.

Kalpa Keralam

Kalpa Harita

Kalpa Shatabti

Kalpa Ratna

Some important dwarf varieties of coconut with their characteristics.

1. Chowghat Orange Dwarf

This is an early flowering cultivar and takes about 3-4 years for initial flowering. The average annual yield is 63 nuts/palm/year. It is best suited for tender nut water. This cultivar was released by ICAR-CPCRI in 1991 for cultivation as tender nut variety.

2. Kalpasree

Kalpasree has superior quality of coconut oil, very sweet tender nut water and meat and is resistant to root (wilt) disease. This is the earliest flowering cultivar and takes about 2.5 to 3 years for flowering. It is tolerant to root (wilt) disease. The mean annual yield is 90 nuts/palm with a copra content of 96.3g/nut. This variety is released for cultivation inroot (wilt) prevalent areas of Kerala.

3. Kalpa Jyothi

Dwarf variety with yellow fruits, higher average yield of 114 nuts per palm per year with estimated copra yield of over 16 kg per palm per year. Recommended for cultivation in Kerala and Karnataka for tender nut purpose.

4. Kalpa Surya

Dwarf with Orange fruits recommended for cultivation in Kerala, Karnataka and Tamil Nadu for tender nut purpose. The average yield is 123 nuts per palm per year with estimated copra out turn of 23 kg per palm per year.

5. Kalparaksha

This is a semi tall variety with sweet tender nut water and with higher resistance to root (wilt) disease of coconut. It comes to flowering by 54 months from planting. Its annual yield is 87 nuts/palm, 16.38 kg copra/palm and 10.65 kg oil/palm. In root (wilt) disease affected tracts, it

gives an annual yield 65 nuts/palm. The quantity of tender nut water is 290ml. This is released as a variety for tender nut and for cultivation in root (wilt) prevalent areas of Kerala.

Chowghat Orange Dwarf

Karpasree

Kalpa Jyothi

Kalpa Surya

Kalparaksha

Some important dwarf of coconut hybrids with their characteristics.

1. Chandra Sankara

It is a cross between COD with WCT. The palms come to bearing early when compared to tall palms. It is a heavy yielder and produces 116 nuts/palm with a range of 100-150 nuts. The copra content in nut is 160-230 g. It is susceptible to drought and hence irrigation is required during summer months. Chandrasankara was released by ICAR-CPCRI in 1985 for cultivation in Kerala and Karnataka.

2. Chandra Laksha

It is a hybrid between LCT X COD. The hybrid palm comes to bearing in about 4- 5 years after planting. The annual yield is 109 nuts/ palm with a copra content of 150-210g/nut.

3. Kera Sankara

It is a hybrid between WCT and COD. The palm comes to bearing by the fourth year of planting. The mean annual yield of nuts is 108 with a range of 70-130 nuts. The copra content is 187g/nut. This hybrid was released by ICAR-CPCRI in 1991, for large scale cultivation in Kerala, coastal Andhra Pradesh and coastal Maharashtra.

4. Kalpa Samrudhi

It is a hybrid between MYD and WCT. The mean annual yield is 117 nuts per palm. The copra yield is 4.38 t/ha and oil is 3.04 t/ha. The hybrid is suitable for tender nut purpose. This hybrid was recommended for cultivation in Kerala and Assam.

5. Kalpa Sankara

It is a hybrid between root (wilt) disease free Chowghat Green Dwarf and root (wilt) disease-free West Coast Tall. The mean annual yield is 85 nuts per palm. The copra yield is 2.5 t/ha and oil is 1.69 t/ha. This hybrid was recommended for cultivation in root (wilt) disease prevalent tracts of Kerala.

6. **Kalpa Sreshta**

It is a high yielding, hybrid involving MYD and TPT. The mean yield is 167 nuts/palm/year, with estimated high copra out turn of 35.9 kg/palm/year or 6.28t/ha copra. The hybrid is suitable for tender nut purpose. This hybrid is recommended for cultivation in Kerala and Karnataka States.

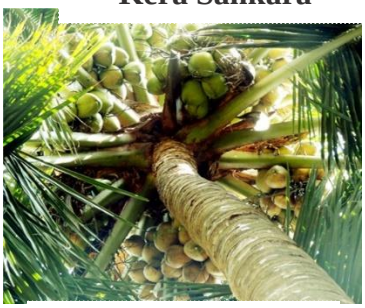
Chandra Sankara

Chandra Laksha

Kera Sankara

Chandra Samrudhi

Kalpa Sankara



Chandra Sreshta

Students activities:

1. Differentiate between tall and dwarf coconut with suitable diagram.
2. Write down the characteristics of different tall varieties of coconut.
3. Write down the characteristics of different dwarf cultivar of coconut.
4. Write down the parents and characteristics features of coconut hybrids.

Exercise No. 2

Title: Identification and varietal description of Arecanut.

The Arecanut palm (Areca catechu) is one of the important commercial crops of India. The crop is mainly grown in the states of Kerala, Karnataka, Tamil Nadu, Assam, West Bengal, Meghalaya, Maharashtraand Andaman & Nicobar Island. The economics produce is the fruit called betel nut or supari which is used mostly for masticatory purpose. It is a monoecious palm and its inflorescence is a spadix produced in the leaf axil and is completely enclosed in a sealed boat shaped spathe. The spadix is having a main rachis divided subsequently into secondary and tertiary rachis. Female flowers are confined to tertiary and distal end of the secondary rachis, while male flowers are produced on filiform branches arising below and beyond the female flowers. Both female and male flowers are sessile, with two whorls of perianth. The fruit is a monolocular, one seeded berry and it consists of a fibrous outer husk, enclosing a single seed. It is a cross pollinated crop and fruit set normally varies from 12.0 to 40.0 percent and the time taken from full bloom to maturity of the fruit ranges from 35 to 47 weeks.

Tall Varieties

1. Sumangala:

It is a tall type with partially drooping crown. Under good management, palms flowers in 4-5 years. The colour of the ripe nuts is deep yellow to orange and oblong to round in shape. The variety recorded an average yield of 3.28 kg chali/palm/year. This variety is recommended for Coastal Karnataka and Kerala.

2. Sreemangala:

The palm is tall with partially drooping crown with longer internodes and sturdy stem. It starts flowering in 4-5 years. It is high yielder with an average chali yield of 3.18 kg per palm per year. Ripe nuts are usually oblong to round in shape with deep yellow colour. This variety is recommended for coastal areas of Karnataka and Kerala.

Sumangala

Sreemangala

Swarnamangala

3. Swarnamangala:

It is a tall high yielding variety with homogeneous population. Nuts are bigger and heavier with high recovery of chali or dry kernel. Average yield of this variety is 3.88 kg chali/ palm/year. It is recommended for cultivation in Karnataka and Kerala.

4. Mohitnagar:

Mohitnagar was released for commercial cultivation during 1991. The important feature of this variety is its greater uniformity. The bunches are well placed and nuts are loosely arranged on spikes which help in their uniform development and also enable efficient plant protection measures. The variety is consistently high yielder with an average chali yield of 3.67 kg/palm/year. This variety is recommended for West Bengal and coastal areas of Karnataka and Kerala.

5. Kahikuchi Tall

The variety is high yielding with medium thick stem, longer internodes, partially drooping crown, homogeneous population, regular bearer, consistent in yield, bunches are well placed on the stem, orange colour, bold and round shaped nuts, high recovery of chali from fresh nuts, comes to bearing by 5th year. The variety is consistent high yielder with an average chali yield of 3.70 kg /palm/year. The variety, released during 2009, has been recommended for commercial cultivation in Assam and Meghalaya.

6. Madhuramangala:

The yield performance of the variety is higher than the released varieties viz., Mangala, Sumangala, Sreemangala and traditional local types, suitable for both tender nut and ripe nut processing. Also fetches higher price in the market because of its quality and marble appearance of the split nut. The average yield is 2.95 kg dry tender processed nuts/palm/year or 3.54 kg dry kernel/palm/year. The variety has been recommended for commercial cultivation in Karnataka and Maharashtra.

7. Nalbari:

The yield performance of the variety is higher as compared to all the earlier released varieties and found suitable for ripe nut processing. The variety possesses high yielding nature, tall type with medium thick stem, longer internodes, partially drooping crown, homogeneous population, regular bearer, consistent in yield, bunches are well placed on the stem, round shaped yellow colour nuts, high recovery of dry kernel from fresh nuts, comes to bearing by 5th year. The average yield is 4.15 kg dry kernel/palm/year. The variety has been recommended for release during 2014 for cultivation in Karnataka, West Bengal (North Bengal) and North East.

Mohitnagar

Kahikuchi Tall

Madhuramang

Nalbari

Semi Tall Varieties

1. Mangala:

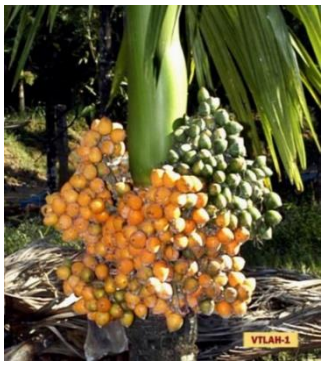
This variety possesses characters such as earliness in bearing, more number of female flowers per inflorescence, higher nut set, quicker stabilization of production and lesser height in comparison with S.K. Local variety, average yield is 2.90 kg chali/palm/year. The variety was released in the year 1972 for coastal areas of Karnataka and Kerala.

2. Shatamangala:

High yielding arecanut variety released during 2016. The yield performance of the variety is higher than the released varieties viz., Mangala, Sumangala, Sreemangala and traditional local types, suitable for both tender nut and ripe nut processing. The average yield is 3.26 kg dry tender processed nuts/palm/year or 3.96 kg dry kernel/palm/year. The variety has been recommended for commercial cultivation in Karnataka and Gujarat.

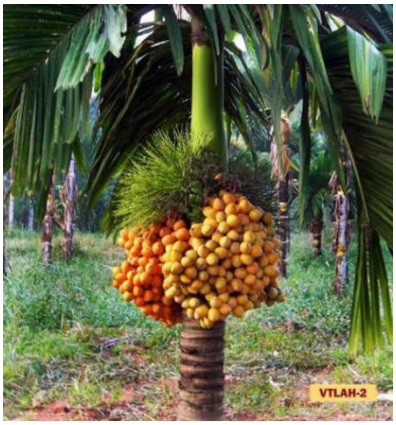
Dwarf hybrids

1. VTLAH -1: Vittal Arecanut Hybrid-1 (HD × Sumangala)



This hybrid is dwarf in nature. Sturdy stem with super imposed nodes, reduced canopy size, well spread leaves, partial drooping crown, medium sized oval to round and yellow-orange colored nuts, early stabilization in yield and high recovery of chali are the striking features of this hybrid. The average chali yield of this hybrid is 2.54 kg/palm/year. Released for commercial cultivation in Karnataka.

2. VTLAH -2: Vittal Arecanut Hybrid-2 (HD × Mohitnagar)



Vittal Arecanut Hybrid-2 is dwarf in nature. Medium thick stem with super imposed nodes, reduced canopy size, well spread leaves, drooping crown, medium sized oval nuts, early stabilization in yield and high recovery of chali are the other features of this hybrid. The average chali yield of this hybrid is 2.64 kg/palm/year. Released for commercial cultivation in Karnataka.

Student activities:

1. Write down the identification characteristic of tall varieties of arecanut.
2. Write down the identification characteristic of semi tall varieties of arecanut.
3. Write down the identification characteristic of dwarf hybrids of arecanut.

Exercise- 3

Title: Different types of cocoa and their identification

Cocoa is an important commercial plantation crop of the world. It is a popular beverage crop after tea and coffee popularly known as ***"Food of the Gods''.*** Cocoa is an evergreen tree. The cacao tree can be as tall as 8-12 meters, and its fruits (pods) are 15-40 cm long. The three different types of cocoa are Criollo, Forestero and Trinitario.

The characteristics features of three different types of cocoa are given in table below:

Characters	**CRIOLLO TYPE**
Pod colour	Red to orange (Ripe)
Pod Shape	Pronounced point, thin wall, rough surface
Bean colour	White/ ivory cotyledons, plumpy
Bean number	20-30/pods
Fermentation	Very quick (3 days)
Flavour	Blended & pleasent
Vigour	Less vigolous
Adaptability	Less
Reaction to pest and disease	Susceptible

Characters	**FORESTERO TYPE**
Pod colour	Green to yellow (Ripe)
Pod Shape	Melon shaped, rounded, smooth, inconspicuous.
Bean colour	Pale to deep purple cotyledons, flat
Bean number	30 or more
Fermentation	Slow (6 days)
Flavour	Harsh & Bitter
Vigour	More vigorous
Adaptability	Wider
Reaction to pest and disease	Tolerant

Characters	TRINITARIO
Evolution	Natural cross between Criollos x Forasteros, Bulk/Cultivated cocoa)
Pod colour	Intermediates/ Mixtures
Pod Shape	Husk texture- hard
Bean colour	Variable in colour, rarely white
Bean number	30 or more
Fermentation	Intermediate
Flavour	Mixture
Vigour	Intermediate
Adaptability	Wider
Reaction to pest and disease	Tolerant

Characteristics of different cocoa varieties

VTLCC-1

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCS-1

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCS-2

- Early, heavy bearer and both self and cross compatible clone.

- Green to yellow pods: 75/tree/year.
- No. of beans/pod is 36.
- Single dry bean weight is 1.05 g.
- Shelling percentage is 12 %
- Fat content is 52.5 %
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCH-1

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCH-2

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCH-3

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

VTLCH-4

- Early, heavy bearer and both self and cross compatible clone.
- Green to yellow pods: 75/tree/year.
- No. of beans/pod: 36.
- Single dry bean weight: 1.05 g.
- Shelling: 12%, Fat content: 52.5%.
- Dry bean yield: 1.33 kg/tree/year, 911 kg/ha.

Students activity

1. Describe three different type of Cocca on the basis of fruit and plant morphology.
2. Write down the characteristics of different varieties of Cocoa.

Exercise-4

Title: Selection of mother palm, seed nuts selection, nursery raising and selection of coconut seedlings for field plantation:

Objectives:

- ✓ To select the mother plant from well identified coconut plantation.
- ✓ To select the seed nuts from superior mother palm for nursery raising.
- ✓ To select the appropriate seedlings for field plantation of coconut**.**

Coconut is one of the most significant plantation crops in the world. Though coconut provides livelihood for more than ten million farm families in the country, productivity of coconut plantations is found to be low. Prevalence of old and senile unproductive palms, poor genetic base of the existing palms under cultivation are some of the important reasons for low productivity. Generally, coconut is a cross pollinated crop it is propagated only by seeds, the selection of planting material is of vital importance for regeneration of superior planting material and quality seed nuts and quality seedlings can be obtained through rigorous selections at various stages.

Importance of mother palm and seed nut selections

Coconut palm is a perennial crop with a life –span of over 70 years. It takes about 6 to 10 years to flower and another 5 years for yield stabilization. If the quality of the seedling used for planting is poor, the quality of the plantation will also be poor, producing low yield and less returns. This fact can be, however, realized only after long years when the palms start bearing.

Selection of Seed Plantation: For production of quality planting materials, it is essential to have good quality mother palms of the desired varieties. Hence, mother palm selection is a key factor in planting material production of coconut, in every coconut growing country certain areas of reputation in coconut production like Arasikere and Tiptur in Karnataka are identified as Centers of Coconut mother palm selection. The selected plantation should be

1) Having high proportion of heavy bearing palms,

2) Free from major pest and diseases

3) Avoid small plantation maintained under very favorable conditions as we cannot assess the inherent yield potential.

4). Avoid palms located near the cattle shed and compost pits.

Criteria for selection of mother palm:

The important features of superior mother palms are:

- ✓ Regular bearer.
- ✓ The age of the mother palm should be 15-40 years
- ✓ It should be high yielding with the yield record of 100 nuts/annum under irrigated condition and 70-80 nuts/annum under rainfed conditions.
- ✓ The crown should be spherical of semi spherical, dropping or erect crown should be avoided.
- ✓ A palm should have 30 or more fully opened leaved in the crown with strong petiole and wide leaf base.
- ✓ Every leaf axil should have one inflorescence with large number of spikes (30 to 35 spikes per inflorescence) and one or two female flowers per spike.
- ✓ Long and thin petioles are not desirable because they are liable to be weak and may easily bend or break under pressure.
- ✓ Bearing at least 12 bunches of nuts with short and strong bunch stalks. Bunches of medium sized nuts in sufficient numbers.
- ✓ A palm producing nuts of round and oblong shape with husked nuts weigh not less than 600 g and mean copra content of 150 g per nut or more should be selected.
- ✓ Palms producing barren nuts or those shedding large number of immature nuts should be discarded.
- ✓ A mother palm should be free from pest and diseases.

Criteria for seed nut selection:

- ✓ Collect the mature nuts of about 11-12 months old from the selected mother palm.
- ✓ Mature nuts produce a resonant sound and ringing on tapping which can be identified as immature nuts will produce dull sound.
- ✓ Seed nuts to be collected during December to May.
- ✓ Husked nuts should weigh not less than 600g with a mean copra content of 150 g per nut or more.
- ✓ Nuts with irregular shape and size and improper development should be avoided.
- ✓ Seed nut should be medium size and round or oval shape.
- ✓ Store the seed nuts in shade for minimum period of 30 days before sowing in the nursery.

Nursery raising

a) Selection and preparation of site for nursery

- ❖ Nursery sites should be well drained with light textured soil and with adequate but not too much shade.
- ❖ Irrigation water must be ensured.
- ❖ Provide shade during summer if raising in open condition.
- ❖ Prepare beds of 1.5 m width and of convenient (4-5m) length with 75cm space between beds.
- ❖ Before planting, examine seed nuts and discards those without nut water and with rotten kernels.
- ❖ To prevent termite attack, the beds are treated with chlordane, Aldrin or Lindane 10 % dust. Sandy soils do not require this treatment.
- ❖ Nuts soaked in water for about 2 weeks prior to sowing show early germination. Nuts are treated with 0.01 or 0.02 M potassium nitrate and sodium carbonate solution. This treatment results in early and higher germination and vigorous seedlings.

b) Time of sowing

- ❖ Sow the nuts in the nursery with commencement of southwest monsoon during May-June.

c) Spacing of Nuts

- ❖ Plant the seed nut at a spacing of 30cm (between rows) x 30cm (between nuts) with four or five rows per bed.

d) Method of planting seed nuts

- ❖ Plant the seed nuts in the beds in tranches 25-30 cm deep and cover with soil so that top portion of husk alone is visible.
- ❖ Vertical planting is preferable on account of lesser risk of seedling injury during removal form nursery and convenience in transporting.

Criteria for selection of seedlings

- ✓ Only 9 12 months old good quality seedlings should be selected based on early germination normally 2 to 3 months (8 to 10 weeks).
- ✓ The vigorous seedlings which are one year old, having minimum of 6-8 broad and dark green leaves and girth of 10-12 cm at the collar should be selected.
- ✓ Seedling should have short and straight stem and large number of roots.

- ✓ Early splitting of leaves is a good indicator of the rapid development and early bearing.
- ✓ The dwarfs should exhibit the petiole colour of the mother palm.
- ✓ The colour of the petiole and seedling vigour can be used as a selection criterion for dwarfs and hybrids. Hybrids usually exhibit hybrid vigour at the seedling stage itself. Seedlings of dwarf varieties can be easily identified by their early germination (3 months after sowing), short height, short and sturdy leaves with short and narrow leaflets.

Student's activities

1. Write down the criteria for selection of mother palm for coconut propagation.
2. Write down the steps for selection of seed nut and nursery raining of coconut.
3. How do you select coconut seedling from the nursery for field plantation?

Exercise-5

Title: Mother palm selection, seed nuts selection, nursery raising and seedlings selection for field plantation of Areca nut.

Objectives:

- ✓ To select the mother plant from well identified Arecanut plantation.
- ✓ To select the seed nuts from superior mother palm for nursery raising.
- ✓ To select the appropriate aracanut seedlings for field plantation.

5.1. Criteria for selection of mother palm:

- ✓ Mother palm should be healthy, early and regular in bearing.
- ✓ Dwarf to semi-tall in stature.
- ✓ It should have high percentage of fruit set.
- ✓ Large number of leaves on the crown.
- ✓ Palms having shorter inter nodes to be preferred.
- ✓ Select middle aged palm (15-35 years) with robust crown.

5.2. Criteria for selection of seed nut for sowing:

- ✓ Select fully tree ripe nuts from middle of the bunch.
- ✓ Heavier nuts to be selected with fresh weight of 35 g.
- ✓ The selected nuts should float vertically with calyx-end pointing upwards when allowed to float on water.
- ✓ Discard undersized and malformed nuts.

5.3. Nursery raising techniques:

Collected nuts may be kept in shade for about one week before sowing in the nursery bed. The nuts should be sown within a week after the harvest in soil or sand and watered daily to get early and good germination.

5.3.1. Primary nursery:

- ✓ Sow selected seed nuts in nursery bed with stalk-end up and with a spacing of 5-6 cm.
- ✓ Cover the seed nuts with sand and irrigate daily.
- ✓ Germination commences in about 40 days after sowing

and the sprouts can be ready for transplanted to the second nursery when they are about three months old. At this stage, the sprouts might have produced two to three leaves.

5.3.2. Secondary nursery:

- ✓ In the secondary nursery, beds of 150cm width and of convenient length are prepared for transplanting the sprouts.
- ✓ Select 90 days old sprouts having 2-3 leaves.
- ✓ Apply well decomposed manure @ 5 t ha-1 as basal dose.
- ✓ Transplant the sprouts at a spacing of 30cm x 30cm with the onset of monsoon.
- ✓ Polythene bags (25 x 15cm, 150 gauge) provided with 3-4 holes at bottom with a potting mixture (Top soil: Farmyard manure: Sand at 7: 3: 2) can also be used to raise seedlings in the secondary nursery.
- ✓ Partial shade to the seedlings can also be provided during summer by pandal or by growing banana to protect young seedlings from scorching heat.
- ✓ The nursery should be watered regularly in the summer and proper drainage should be provided in rainy season.
- ✓ The nursery should be kept clean by periodical weeding.

5.4. Criteria for selection of seedlings for transplantation in the field:

- ✓ Select healthy seedlings for transplanting in the main field when they are 12-18 months old.
- ✓ It is suggested to select the seedlings based on seedling index, because there is significant positive genotypic correlation of no. of leaves and negative correlation of height at the time of transplanting with yield.
- ✓ Seedling index = (No. of leaves x 40) – Plant height (cm).

  Example: Seedling height = 90 cm, Leaf number = 5 Selection index = (5 x 40)- 90 = 110

- ✓ Select seedlings with higher seedling index values. Seedlings with maximum number of leaves (five or above), minimum height and maximum girth are to be selected for planting.
- ✓ Uproot the seedlings with the ball of earth attached to them for transplanting.
- ✓ If the seedlings are raised in polythene bags, these can be straight way transported to any distance without much damage.

5.5. Planting of areca nut:

The site-selected for the main field should have well drainage and irrigation facilities. Planting is done by digging pits at a spacing of 2.7m x 2.7m. The pit size should be 90 cm x 90 cm x 90 cm and should be filled up to 60 cm height with top soil, FYM/compost and sand. Planting can be done during May-June in well-drained soil and in moistened clayey soil; it should be done in August-September. A shade crop of banana can be raised to give protection to the seedlings from sunscroch.

Exercise-6

Title: Raising of cocoa nursery and its management

Nursery establishment for raising of cocoa seedlings are given utmost importance as young seedlings require ample shading, adequate supply of clean water and drainage. Nursery activities should be targeted towards the growth of really well-grown and robust seedlings free from major pests and diseases.

6.1. Nursery site selection

- ✓ Cocoa is a crop of humid tropics. It comes up well in altitudes ranging from 300 m to 800 m above mean sea level.
- ✓ The nursery site should be accessible to good water source.
- ✓ The soil should be well drained soil with good source of growing medium.
- ✓ Clay loam, loam and sandy loam soil with optimum pH 6.5-7 is preferred.
- ✓ It should be readily located within the plantation are and
- ✓ The field to be planted; well secured from animals and theft and within easy monitoring range.

6.2. Establishment of seed gardens and clonal orchards

Presence of self-incompatibility is observed in many cocoa populations. Self-incompatible but cross-compatible genotypes are being utilised in hybrid seed production. The purpose of seed garden or clonal orchard is to produce seeds of known parentage and proven performance. Based on earlier progeny trials, best combining parents are selected, multiplied as clones and established as seed gardens or clonal orchards. These well designed gardens will produce hybrid pods through natural cross pollination. If, the orchards are assembled with two self-incompatible and cross-compatible parents they are called as bi-clonal orchards and if planted with multiple self-incompatible and cross-compatible clones they are designated as poly-clonal orchards. In a poly clonal orchard pollen parent is planted in a ratio of one to five female parent trees and seed is collected only from the self-incompatible parent. It has been estimated that one acre of such seed garden can produce enough seed to plant 400 acres and 1200 acres in the fourth and eleventh year, respectively.

6.3. Selection of mother trees and seed collection

If seed gardens or clonal orchards are not available selection criteria for mother trees should be strictly followed. The criteria for selection of mother plants for collection of seeds are given below:

1. Forastero type (green- immature, yellow- ripe) having medium to large pods of not less than 350 g weight, smooth or shallow furrows on the surface without prominent constriction at the neck can be selected.
2. A mother plants which bear 50-100 pods/tree/y ear after twelve years of age should be selected.
3. Husk thickness of pods should be less than 1 cm.
4. Pod value (number of pods to give 1 kg wet beans) should be less than 12.
5. Number of beans per pod has to be more than 35.
6. Bean dry weight to be more than 1 g.
7. The best seeds for sowing are those from the middle of the pod.

Mother tree of forester type

Extract middle beans

8. It is desirable to collect seeds from biclonal or polyclonal seed gardens to ensure quality of planting material.
9. Once pods are opened, seeds should be sown immediately after removing the mucilage.

6.4. Seed treatment and sowing

- ✓ When taken from the ripe fruit, the seed is surrounded by a mucilaginous pulp which contains a germination inhibitor.
- ✓ Germination can be speeded up by removing this pulp with the testa which is thin and leathery. The testa is usually called the skin or, when dry, the shell. A trained person can peel 200 seeds per hour.
- ✓ Rubbing of the beans carefully with dry sand or wood ash to remove the mucilage is practiced in India.

- ✓ Treating with fungicide Bavistin at rate of 2 g for 1 kg seeds may be practiced in adverse situations.
- ✓ Seeds should be kept horizontally or vertically with hilum end down and just covered with sand.
- ✓ Pushing of seeds deeply into the potting mixture should be avoided because lack of air may affect seed germination since it is epigeal where cotyledons are taken above ground in the process
- ✓ Healthy seeds from well matured pods usually give a germination of 90 to 95 per cent.
- ✓ Cocoa seeds will germinate at any time of the year with adequate irrigation.
- ✓ Sowing should be completed before the onset of monsoon otherwise continuous shower affects the germination.
- ✓ May sown seedlings will be ready for planting during September-October.

6.5. Polybag nursery

- ✓ To get better root and shoot growth, to make the planting and transportation easy sowing seeds in polythene bags can be followed.
- ✓ Black polybags of 6"x 9" size and 250 gauge thickness with drainage holes filled with potting mixture 2:1:1 Soil: Sand: FYM is recommended.
- ✓ Soil solarization by sun drying and covering of potting mixture with black polythene sheet during March-April will enhance seedling vigour and health.
- ✓ Top soil and sand should be sieved before filling.
- ✓ Organic manures like coir compost, vermicompost, neem cake, bean shell also been used in place of Farm Yard Manure.
- ✓ Vermicompost, coir compost, areca husk, cocoa husk/shell composts can also be used as potting mixture components.
- ✓ Poly bags should be arranged in rows of ten leaving 1.5 feet spaced path between the rows for monitoring. Support for the bags is usually provided by strips of bamboo or split areca stem. Shade nets or covering by thatches is needed.
- ✓ Seedlings will become ready for transplantations in about 5-6 months.

6.6. Vegetative propagation

- ✓ As the seedling progenies showed wider genetic variability, to maintain true to types, asexual or vegetative propagation is followed. Grafting and budding are being followed in multiplication of cocoa. It also ensures multiplication of identified high yielding clones in large quantities. Though vegetative propagation of cocoa by budding, rooting of cutting and grafting are feasible, the widely accepted methods in India are budding and grafting.

Vegetative propagation	Rootstock	Scions	Success (%)
Budding: Patch budding	10-12 month old seedlings	Bud patch of 2.5 cm length and 0.5 cm width from the bud wood	85
Grafting: Soft wood grafting	3-4 month old seedlings	Scion stick of 12- 15 cm length with 2- 3 buds	70

6.7. After care

- ✓ The emerging shoots from the rootstocks should be removed.
- ✓ October to December season will be the best for grafting and all other seasons are suitable with sufficient irrigation.
- ✓ Grafts will start yielding from the second year onwards.
- ✓ When budded or grafted plants are used select two or more clones for planting, as the use of single clone may not yield due to the existence of self-incompatibility in cocoa.
- ✓ Bud wood can be stored by dipping in benzyl chloride followed by washing in water and then sealing the cut ends using molten wax. Wrapping in moist cotton wool or wet tissue paper or blotting paper and packing in boxes by covering with polythene sheets will extend the storage life of the bud wood up to 10 days.

6.8. Selection of seedlings and transplanting

- ✓ Only vigorous seedlings are to be used based on height and stem girth.
- ✓ When seedlings are grown under heavy shade, hardening for 10 days by exposing to higher sun light may be necessary before transplanting.
- ✓ Watering of the nursery beds should be done before lifting seedlings for transplanting to avoid breakage of roots and should be taken along with little earth around the roots.
- ✓ If raised in polythene bags, the poly cover should be removed and the seedlings are planted with ball of earth into the pit.

- ✓ While planting grafts polythene strip tied over graft joint should be removed and the joint should be above the soil.
- ✓ The planting material may be of 4-6 month old seedling or grafted or budded plant.

6.9. Disease of cocoa nursery

Vascular Streak Dieback

Seedling dieback/seedling blight caused by Phytophthora palmivora Butl. is very common in the cocoa nurseries during rainy season. Younger seedlings are more susceptible to the disease and severe infections observed in grafted and budded plants also. It initiates from the collar region, cotyledonary stalk or leaves as dark brown to black discoloration. It spreads to the entire stem causing wilting, defoliation and ultimate death of the seedlings. Removal and destruction of infected seedlings from the nursery are very important to check the secondary spread of the disease. The disease incidence can be considerably reduced by improving the drainage facilities in the nursery and by providing proper shade. Drenching the seedlings with Bordeaux mixture (1%) just before the onset of monsoon and thereafter at frequent intervals will control seedling dieback.

Nursery pests

Myllocerus weevils (Myllocerus viridanus) skeletonise the foliage and its occurrence will be more during July to September. Spray under surface of the foliage with Fenthion 0.05%.

Exercise-7

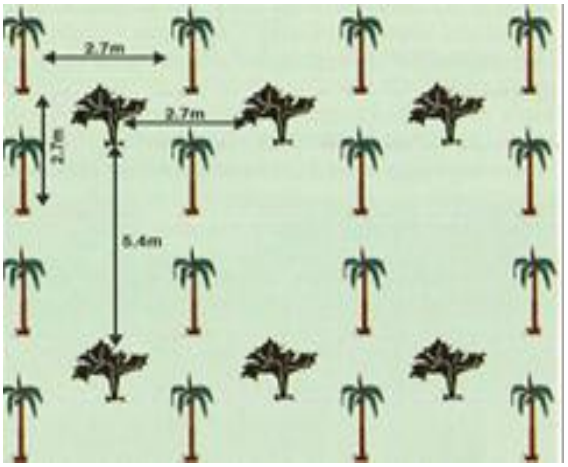
Title: Layout and planting of cocoa.

Cocoa is an important commercial plantation crop of the world. It is a popular beverage crop after tea and coffee. It is popularly known as ***"Food of the Gods".*** Cocoa is relatively a new crop in India which was introduced in early 1965. Commercial cultivation of Cocoa in India was started in a year 1970. This is mainly grown for its bean from which Cocoa solids and Cocoa butter are extracted. In India, 80 % of plantations are as a mixed crop in coconut and areca nut gardens. Cocoa is normally raised from seed as it is the easiest and cheapest.

6.1. Layout:

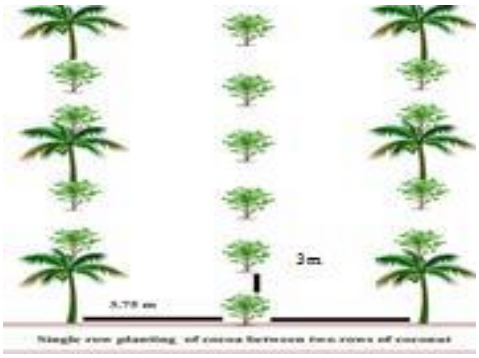
Cocoa is a shade loving plant. During its seedling period it requires about 50% shade and later the shade requirement is about 40%. The plant is grown as a mixed crop with other plants like spices and rubber mainly under rainfed conditions. Cocoa is generally planted as inter crop in coconut, arecanut and oilpalm gardens.

Cocoa under Arecanut



- ✓ Arecanut spacing 2.7 m x 2.7 m
- ✓ Cocoa in the centre of four areca palms at 2.7 m x 5.4 m (9 ft x 18 ft)
- ✓ Accommodates 686 plants/ha.
- ✓ High density multispecies cropping system Arecanut- 2.7 m x 2.7 m Cocoa- 2.7 m x 5.4 m Banana- 2.7 m x 5.4 m Pepper (trailed on arecanut)- 2.7 m x 5.4 m .
- ✓ Spacing of 3 m and above both for arecanut and cocoa can be followed if they are planted together in new plantation.

Cocoa under coconut



- ✓ Coconut spacing 7.5 m x 7.5 m.
- ✓ Cocoa in the centre of two rows of coconut at 2.7 to 3 m spacing in single hedge system.
- ✓ 3 m x 7.5 m (10 ft x 25 ft) = 444 trees/ha.
- ✓ When the spacing of coconut is more, double hedge of cocoa with 2.5 to 2.7 m may be followed. 800 trees/ha.

- ✓ 3 m away from palm is advised to avoid damage due to fallen fronds and 3 m between cocoa is also advised.

Cocoa under oil palm

- ✓ Oil palm spacing 9.9 or 10.5 m triangular plantings.
- ✓ Cocoa at 2.4 to 3 m spacing. 400 plants/ha
- ✓ Cocoa should be 2 m away from the base of palm.
- ✓ Shade in oil palm plantations is very high and so age of the palms/ wider spaced gardens/square plantings are to be considered.

6.2. Cocoa planting

Pits of 50 cm x 50 cm x 50 cm are dug, allowed to weather for one month and refilled with topsoil and 15-20 kg of compost of FYM to ground level. Tear off the polybags carefully, place the soil ball with the seedlings in the planting hole with minimum disturbance and press the soil around firmly. Planting should coincide with the onset of monsoon, but in places where irrigation is resorted to, flexibility in the time of planting is possible.



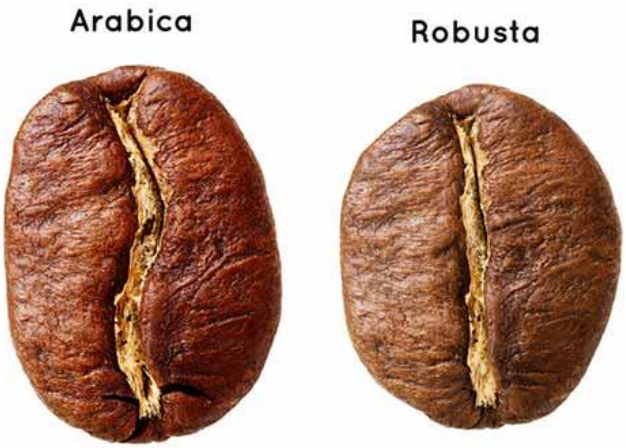
Exercise-8

Title: Description and identification of species and varieties in coffee

Coffee (*Coffea arabica* and *C. robusta)* cultivation is mainly confined to the States of Karnataka, Kerala, Tamil Nadu and Andhra Pradesh and on a limited scale to Arunachal Pradesh, Assam, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tripura and West Bengal. Coffee cultivation is confined mostly to the hilly tracts of Western and Eastern Ghats. The fruit are the essential part of coffee. Coffee is predominantly an export-oriented commodity and 65% to 70% of coffee produced in the country is exported while the rest is consumed within the country. Indian Coffees are earning high premium, particularly Indian Robusta which is highly preferred for its good blending quality. Arabica Coffee from India is also well received in the international market.

8.1. Important identifications features of Arabica and robusta coffee

Sl. No.	**Characters**	**Arabica coffee (*C. arabica)***	**Robusta coffee (C. *canephora)***
1.	Ploidy level	Tetraploid (2n =44)	Diploid (2n =22)
2.	Adaptability	Higher elevations (1000 to 1500m)	Comparatively lower elevations (500 to 1000 m)
3.	Plant stature	A small tree, shrub or a bush under training.	Bigger tree than Arabica
4.	Number of days for blossoming after the receipt of blossom showers	9 to 10 days	7 days
5.	Berries per node	10 to 12 per node but bigger	40 to 60 per node but smaller
6.	Fruit development period	8 to 9 months	10 to 11 months
7.	Root system	Small but deep	Large but shallow
8.	Pollination and fertilization	Self fertile and self pollination	Self sterile and cross pollination



8.2. Important varieties of coffee

Arabica varieties

Sln 795, Sln 7, Sln 9, Sln 10, Cauvery (Catimor x Hibrido de Timor)- Plants are dwarf, suitable for high density planting, Yield- 3000 kg/ha.

Selection-7 (San Raman): San Raman is a dwarf mutant from Costa Rica- An arabica type. Introduced into India in 1953. This mutant segregates into 70 per cent Dwarfs and 30 per cent Tall plants.

Chandragiri coffee:

It is a released during 2007-08 by Coffee Board with the original source from Portugal.

It was introduced in the year 1975 to CCRI Balehonnur from Portugal. Farm trials and intensive research trials were taken up at CCRI Balehonnur.

Features:

1) Bushy growth with slightly bigger leaves than Cauvery coffee

2) Bigger sized berries: It produces 25 per cent bigger sized berries compared to other varieties.

3) Resistant to leaf rust: Lower (5 to 7 %) leaf rust incidence in this variety is reported compared to other varieties (20 to 40 %).

4) Tolerant to drought

Improvement of robusta coffee (*Coffea canephora*)

Robusta selections from CCRI Balehonnur Karnataka are:

1) Selection –1 R (S-270 and S-274)

2) Selection –2 R (BR series 9, 10 and 11)

3) Selection – 3 R (C X R coffee)

Unlike arabica coffee robusta coffee has long productive life of 70 to 80 years and hence, farmers' do not replace the old varieties frequently.

1) Selection – 1R (S-270 and S-274)

It is a seeding progenies of two individual mother palm identified in robusta gene pool in India. It has 35 to 50 fruits per cluster.

Yield: 10 q per ha. Under rainfed condition.

S- 274 is preferred to S-270 on account of its bolder beans and wide adoptability. Among the robusta selections S-274 is most popular and is promising well in planters' field of all robusta tracts in India.

2) Selection 2 R (BR series 9, 10 and 11)

Based on individual performance of clones BR (Balehonnur Robusta) 9, 10 and 11 raised from S-274 were found to be promising and seed mixture of these clones was issued as Selection – 2 R. The population resembles S-274 in growth habit, yield potential and bean/cup characteristics.

Note: It is important to note that only seed mixture of these three clones BR –9, BR-10 and BR-11 should be used for planting. Individual clones should not be planted separately which may result in no fruit set due to incompatibility problems.

Exercise No. 9

Title: Nursery production of coffee

Coffee may be grown from seed or from cloned plants in the form of cuttings, grafts or tissue cultured plants. Arabica coffee is most commonly grown from selected seed unless there are special reasons for using clones. A number of steps are necessary for production of good seedlings.

9.1. Site selection Select and ensure that the site is:

- ✓ Level /gently sloped
- ✓ Bench terraced (where % slope is greater than 4 –5%)
- ✓ Weed free (especially perennial weeds)
- ✓ Sheltered from strong winds
- ✓ Accessible - for ease of transport
- ✓ Has permanent /reliable water source

9.2. Nursery bed preparation

- ✓ Select light loamy soil of good drainage with high organic matter content with water and shade facilities.
- ✓ Prepare raised bed of 15 cm height, 1m (3 ft) width and of convenient length for ease of nursery operations
- ✓ Incorporate 30 - 40 kg of well rotten compost, 2 kg of finely sieved agricultural lime and 400 g of rock phosphate to a bed of 1 x 6 m size. In heavy soils, it is necessary to add coarse sand for drainage and aeration.

9.3. Seed collection

Healthy and well developed fully ripe berries are harvested from specially identified plants for use as seed bearers. After discarding the floats, the sound fruits are depulped, sieved and mixed with sieved wood ash and dried in shade. The seed is then graded to remove all cut, triangular and elephant beans. Prior to planting, the seeds are treated with Agrosan or any Organomercurial compound to prevent fungal infection. To retain viability, stored seed should have a moisture content of around 41% and kept at 15^{o}C. 1 kg seed contains an average of 3,000 seeds.

9.4. Season

Planting spreads from June – December

9.5. Sowing of seeds in nursery beds

Water the seedbed before planting.

- Using a pointed stick, make furrows 12 mm deep across the bed and 100 mm apart.
- Plant seed flat side down, with seeds 25 mm apart within the row.
- Cover seed with soil mixture - seed should be about 12 mm deep after planting.
- Cover beds with rice straw mulch to give extra heat and to retain soil moisture. Water gently. Make sure the seed is not exposed when watering.

As germination time is highly dependent on soil temperature, it may take from 30 to 50 days before shoots appear. Use of plastic/polythene tunnels to retain heat will speed up germination.

Figure 1. Planting of seed (left) and covering with mulch (right)

Figure 2. Development of cotyledons and seedlings

9.6. Transplanting of seedlings into polybags

Depending on temperature, coffee seedlings are ready to be transplanted from the nursery bed into poly bags about two to three months after sowing. Polythene bags with adequate number of holes in the bottom half are taken and are filled with a prepared mixture containing jungle soil, FYM and sand in the proportion of 6:2:1. An area of 12 x 8 m can accommodate 5000 seedlings. Transplant coffee seedlings when it is at the matchstick or cotyledon (butterfly) stage before the taproot is well developed. Use the best seedlings with a straight tap root. Discard seedlings with either a bent taproot (J root) or those with few root hairs. Diseased and infested seedlings to be discarded.

9.7. After care:

- ✓ Remove weeds regularly.

- ✓ If soil becomes hard, soften it by using a trowel to break up big, hard clumps of soil into smaller pieces.
- ✓ Water as required to keep the soil damp. Don't over-water as this can cause damping-off - a disease caused by a fungus that will kill the plants.
- ✓ At three months, apply urea (46:0:0) at 60 g/10 L of water. This is enough for 100 seedlings. Apply every 15 days. If leaves become dark green, stop the procedure.
- ✓ If you do not use a chemical fertiliser, apply a small amount of finely crushed dry manure around the plants.
- ✓ Check seedlings every day to make sure they remain free from pests and disease. Remove bags with diseased, dead or damaged plants.
- ✓ Continue to keep plants in shade. Two months before field planting, gradually remove the shade to sun-harden the plants.
- ✓ As the plants grow, separate the poly-bags so there is sufficient space for the developing plant to spread. If bags are not separated, the plants grow tall and weak

Nursery diseases and pests

The two common diseases occurring in the nursery are:

1) Damping-off that appears as areas of dying plants. Damping-off is caused by a soil-borne fungi often found in old, diseased potting mixture, over-watering, too much shade or not enough space between plants. Damping-off can be avoided by proper preparation in the nursery. It is also important that new soil is always used in the nursery beds. If the disease is found, immediate drenching with either Benlate (Benomyl) or Captan can be carried out.
2) Cercospora (brown eye spot) is a fungus, which develops when plants are under stress caused by too much shade, too much sun, nitrogen deficiency, over-watering or over-crowding. This can be avoided by following good management practices. Immediate control measures involve using copper sprays.

Pest: Green coffee scale can also be a problem in the nursery. Scales severely affect plant health as the they suck the sap from the leaves. Keep the area free from ants and spray with spraying oils or Carbaryl or use traditional methods of control.

Exercise No. 10

Title: Harvesting and post-harvest management of coffee

10.1. Harvesting of coffee berry

Arabica coffee harvested from November to January and Robusta coffee from December to February. The crop will be ready for the first harvest in about 3 - 4 years but economic yields are obtained from 5 - 12 years onwards up to 50 years. The berries are harvested when they turn red to deep crimson colour. Coffee is just ripe when on gently squeezing the fruits the beans inside come out easily. Unripe fruits should be scrupulously sorted out before using the fruits for pulping. They may be dried separately as cherry. Harvesting is done in stages as follows:

1. **Fly picking:** Small scale picking of ripe berries during October to February
2. **Main picking:** Well formed and ripened berries are harvested during December. Bulks of the yields are obtained from this picking.
3. **Stripping:** Picking of all the berries left irrespective of ripening.
4. **Cleanings:** This is collection of fruits that have been dropped during harvesting. Unripe fruits should be scrupulously sorted out before using the fruits for pulping. They may be dried separately as cherry.

Note: Coffee fruits should be picked as and when they become ripe to get better quality. Arabica comes for harvesting earlier since they take 8-9 months for fruit development from flowering while robusta takes 10-11 months. Picking is done by hand. The first picking consists of selective picking of ripe berries and is called fly picking. Thereafter, there will be 4-6 main pickings at 10-15days intervals and final harvest.

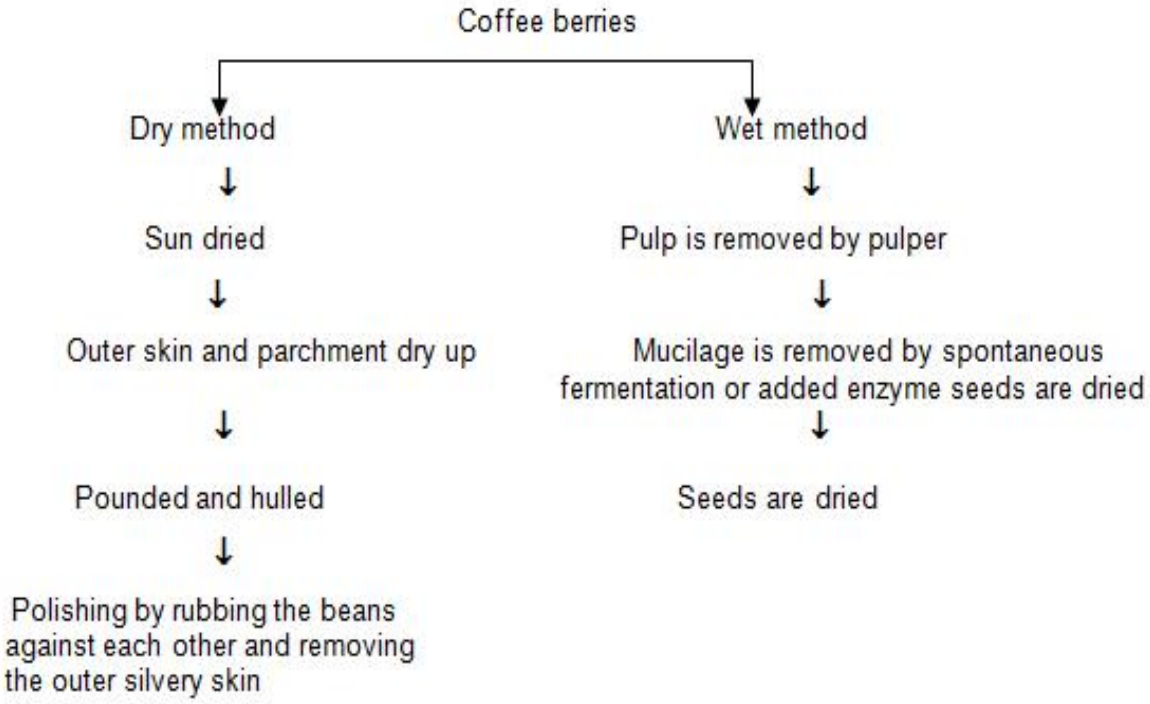
10.2. Post- harvest handling

i. Sorting: The cherry is sorted out before pulping. This helps to remove the immature, diseased, insect damaged and dry berries as well as the leaves, twigs and other foreign matter. The sorted out berries are processed by the dry method.

10.3. Processing Procedure

Coffee processing consists of removing the skin, pulp, parchment and silver screen. The quality of the final product depends upon the manner of processing. It is the curing process that prepares the coffee beans for market. Two methods are employed for processing- the dry and wet. In the dry method the beans are sun dried. In the wet method, known as the washed coffee process, pectin enzymes are used on selectively picked cherries to replace spontaneous fermentation.

Coffee curing process:



Note: **ii) Pulping:** Removal of outer skin of ripe berries by soaking in water. Pulp the ripe berries on the same day to avoid fermentation before pulping.

iii.) Demucilaging and washing: Demucilaging can be done by

a) Natural fermentation: Arabica = 24 to 36 hours

Robusta = > 72 hours because of thicker mucilage

Note: *Over fermentation = Leads to foxy beans while,

*under fermentation = Sticky mucilage is left out = Leads to absorption of moisture by beans = Mistiness.

*Proper fermentation = Mucilage come out easily beans when squeezed by hand.

b) Enzymatic fermentation = Pectinolytinc enzymes can be used.

c) Chemical Demucilaging: Treatment with Alkali. Here 10 % solution of Caustic Soda (Sodium Hydroxide) is used.

d) Removal of mucilage by friction:

iv). Washing: Washing in clean water after soaking for 24 hours (overnight) = Improves quality and appearance.

v) Drying: Seeds spread on the mats in the open for drying.

vi) Hulling: Removal of outer cover like epicotyl and parchment along with testa**.** The brittle, dry husk like parchment (endocarp) is removed by machines and the sliver skin is removed by polishing.

vii) **Polishing**: Removal of adhering testa

viii) **Sorting:**

ix) Bagging: Coffee beans readily absorb foreign taints (Blemish) and odour and hence, suitable care should be taken.

10.4. Grading

Cured coffee is graded according to sizes and shapes. The different plantation grades are:

- Pea berry (oval shaped beans)
- or A (first size in flats- bold, heavy and well formed)
- B (slightly smaller than O or A)
- C (slightly smaller than B)
- Triage (pale, discoloured, black spotted beans including bits)

The manufacture of coffee powder involves roasting, grinding, blending and packing.

Roasting

- During roasting many physical and chemical changes occur, which develops pleasant aroma, flavour, brown colour and good taste.

Grinding

- Roasted beans are ground to three sizes, namely, fine, medium and coarse. Coarse ground powder retains aroma and flavour better and longer than fine ground powder. Coarse ground powder is more suitable for preparing coffee decoction by percolation.

Blending

- Two types of coffee powder are marketed namely pure coffee prepared from coffee beans only and French coffee containing chicory. The proportion of chicory should not exceed 50%. Strength, flavour, aroma and acidity are the chief criteria in judging the quality of coffee and judicious blending of different grades brings out these qualities ot the best advantage.

Exercise No. 11

Title: Vegetative propagation and top working in cashew nut

Objective:

1. To perform epicotyl grafting in cashew nut
2. To perform soft wood grafting in cashew nut
3. Rejuvenation and top working in cashew nut

Cashew is a cross pollinated crop and exhibits wide variation in respect of nut, apple and yield of seedling progenies. Therefore, vegetative propagation has been advocated to mitigate this problem. Epicotyl grafting and softwood grafting are found to be successful because it is easy to produce large number of grafts in a short time. The percentage of field establishment is also reported to be high with these grafts.

11.1. propagation of cashew nut by softwood grafting

i. Preparation of rootstock:

- Disinfect the grafting knife by dipping them in fungicide solution.
- Raised the rootstock through seeds in nursery and keep them in shade.
- Remove the leaves by sharp knife leaving two pairs of bottom leaves.
- At the height of 15-20 cm from the ground level transverse cut is made on the rootstock and the terminal shoot is removed.
- A cleft of 6-7 cm deep is made in the middle of the decapitated stem by giving a longitudinal cut.
- A little portion of the wood is removed from the inner side of the cleft at the top for the perfect union of scion and rootstock.

ii. Preparation of the scion:

- Select a matching scion stick of same thickness as that of rootstock
- Wedge shape cut is given at the end of the scion stick by chopping the bark and wood from the two opposite sides.
- While preparing the wedge gum should not be disturbed.

iii. Grafting:

- The wedge of the scion is inserted into the cleft of the rootstock to see that the cambium layer of both the rootstock and scion come in perfect contact with each other.

- The joint should be tie with polythene tape firmly.
- A long and narrow HD polythene bags of 15 cm x 12.5 cm size and 100 gauge thickness is inserted on the grafted plant, tied at the bottom with a single knot in order to protect the scion stick from drying up.
- The freshly grafted plants are left in the nursery shed for about two weeks to encourage sprouting of the terminal buds.
- After 2 weeks the polythene cap is removed gently and the grafts are shifted to open condition in the nursery.
- Within 3-4 weeks, 70-80 % graft will sprout.
- Grafts will become ready for transplanting in about 4-5 months.

B 

Fig. 1. Steps involved in grafting

11.2 Propagation by epicotyls grafting:

In case of epicotyl grafting, tender seedlings of 10-15 days old with a height of 10-15 cm, having 3-4 coppery colour leaves are selected as rootstock and 'V' shaped cut is made after beheading it at a height of 6-8 cm from the collar region. For scion, no flowered lateral shoots of current season growth about 3-5 months old with pointed, dam apical buds should be selected for grafting. The grafted plants should be kept under shade for 8-10 days and afterwards may be shifted to open place.

11.3. TOPWORKING

Top working is nothing but replacing the crown of the tree with the shoots of high yielding varieties, taking advantage of the well developed root system to improve the productivity of poor yielding cashew tree which is other- wise quite healthy.

Procedure:

The procedure for top working mainly includes three steps:

1. Selection of trees for rejuvenation

- Low yielding trees

- Unproductive and small size fruits
- Susceptible to tea mosquito
- Age between 10-25 years.
- Trees should be free from stem borer infestation.

2. Beheading of trees:

- Time and season of beheading is December to February
- Remove branches
- Stumping: cutting stump at 0.50 to 0.75 m above ground level with saw to avoid bark splitting.
- Smear the cut portion with bordeux mixture 10 % paste or cow dung slurry and red soil.
- Prepare a basin of 1.50 m radius.
- provide shade.

3. Sprouting of beheaded trees:

- New sprouts appear in 30 to 40 days after beheading.
- Remove shade
- Retain 10 to 12 healthy shoots/sprout for grafting and remove others.

4. Selection of Scions:

- Select scions from high yielding varieties
- Pencil thick and 12 to 15 cm long scion stick with a sprouted bud should be selected from shoots of 3 to 4 months growth.
- Preconditioning: Remove all the leaves 7 to 8 days before grafting.
- Fresh scion is always preferred for better success.

5. Grafting:

- Select 10 to 12 sprouts for grafting
- Cut the sprout 5 to 6 cm from the top and split it in the middle to 3 – 4 cm depth with the help of a knife.
- Wedge grafting is practiced.
- Select the scion of the same thickness and give a cut to form a wedge or V Shape.
- Insert the scion: Firmly tie with the help of polythene strip.
- Cover the grafted portion with the help of polythene bags.

6. After care of the top worked trees:

- Die back of the shoots may occur during monsoon and this can be checked by spraying bavistin @ 10 g/10 L of water.
- Newly emerging shoots may get attacked by insects so spraying nuvacron @ 2ml/l of water will be helpful to obtain healthy normal shoots.

Exercise No. 12

Title: Propagation and nursery management of tea

The objective of Tea Nursery Management is to raise healthy, vibrant plants of uniform size of the appropriate cultivars [clones] with minimum casualties, properly trained and adequately hardened within a reasonably short time, eminently suitable for planting in the field. Tea is propagated by **seed** and also vegetatively by **single node cutting**.

12.1. Selection of Soil

Loamy soil with a pH of 4.5 -5.5, sieved from No. 3 and No. 4 meshes should be taken. Grass soil was taken which has the ability to hold up water with sands for easy draining by removing unwanted particles.

12.2. Nursery Site Selection

The site should be centrally located, proximate to water sources, soil and planting materials with a good drainage. Absence of overhanging branches of trees and protected from wind which should be the most probably concerned in regarding the selecting of nursery site. It should not have shade trees or overhanging branches of trees.

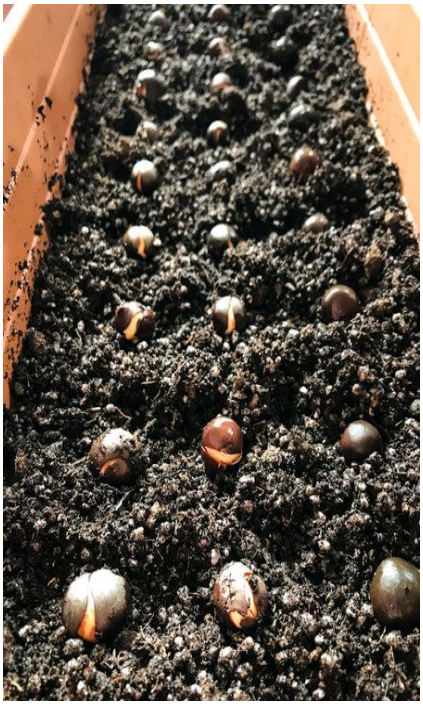
12.3. Fumigation and Bagging

Soil fumigation should be done to eradicate nematode infestation at the preliminary stage in the nursery by adding 800 ml of Metham Sodium or 500 g of Bazamid per 1 cube of soil after sieving from No. 4 mesh. Then it is covered for three weeks using 500 gauge black polythene. Soil solarization is also practiced as a soil treatment. The covered soil should be mixed well after the 9th, 12th, 15thand 21stdays. Bags were prepared from 150 gauge transparent polythene with a height of 9" and width of 5" and few holes were punched at the bottom of the sleeves. Bags were filled with moisten fumigated soil by gently pressurizing the soil towards the polythene sleeve without keeping air pockets in it. Then bags should be kept for 2 -3 weeks to settle down.

12. 4. Seed Propagation

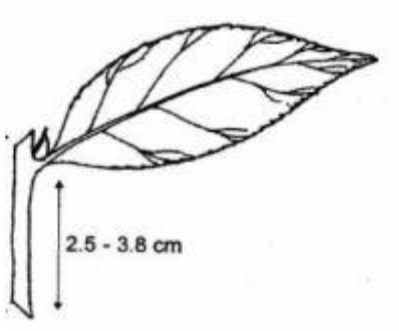
- Healthy, fresh and sound seeds should be sown.
- Heavy seeds have to be selected as the seeds may appear sound and hollow inside.
- To facilitate the drainage raised beds of 120 cm wide with path around are prepared.

- Shade has to be provided. Leguminous bush plants like *Tephrosia candida* are used in Assam as shade plants.
- Seeds are allowed to germinate in a bed of sand or in hips.
- They are then picked and planted in bamboo containers or baskets.
- After they attain proper maturity, they are planted in the main field.
- The life of the seedling in the nursery is aprox. 2 years.
- Transplanting of seedling is done with the ball of earth without damaging the root system.
- An alternate method is to stump the seedling. In this case seedlings are allowed to grow for 2-3 years and the stem is cut back to within a few centimeters above the ground level and the remaining root system is used for planting. In this method the bulk of the planting material is small and risk of damage of the plants is limited.



12.2. Vegetative Propagation

- Commercial method of propagation is through single node cutting.
- Elite clone should be selected with desirable characters like yield, quality, quick recovery etc.
- Cuttings are taken on April - May and August - September.
- Semi hard-wood cuttings are prepared with one leaf and an internode with a slanting cut at the bottom.
- Recommended length of a cutting is 2.5-3.8 cm.



- Cuttings with flower buds, over grown shoots and damaged mother leaf containing cuttings were discarded.
- The cuttings were dropped into a Cu fungicide solution container immediately after the cuttings were obtained. This was done for preventing the Blister blight attack initial stage in the nursery and dried out.

12.2.1 Features of mother bush

1) Compactness: Number of stems per unit area should be high and should be uniformly distributed.

2) Individual stem should be thick and uniform.

3) Bushes should have early filling tendency.

4) Bushes should have lateral spreading habit.

5) Main stem and primary branches should have upright growth after pruning.

6) Density of Plucking point/units should be high.

7) Flushes/leaves should have pubescence.

8) Bushes should be resistant to blister blight and free from other pests and it should be drought tolerant.

9) High yield, Yield per unit area of plucking table should be high.

10) Flowering tendency: Selected bushes should not have flowering tendency.

Shade Management

Cuttings should not be exposed to direct sunlight and therefore optimum shade was supplied. There are different types of shades such as low shade with bracken fern was used as shade-providing method and using a net that reduces the sunlight by about sixty percent.

Exercise No. 13

Title: Training and pruning of tea.

Normally tea bushes are established within a month after planting. Within a period of 12 to 18 months they reach a height of 60 – 75 cm (Field plucking stage) and after this stage pruning is taken up with following objectives:

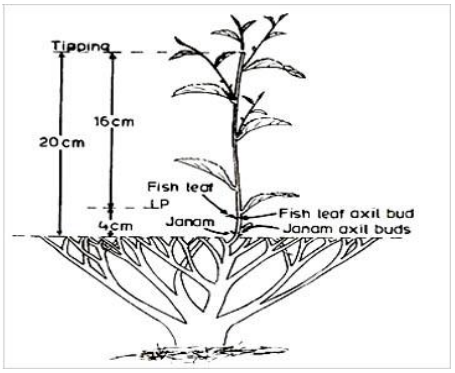
1. To minimize the height for purpose of easy plucking young buds, leaves and shoots.
2. To maintain the plant permanently in a vegetative phase.
3. To stimulate the production of young shoots.
4. To maintain sufficient volume of mature foliage to meet the physiological needs of the plants.
5. To promote rapid renewal of flush suitable for manufacture of quality tea.
6. To minimize pest and disease attack on tea bush.

Training

Training of young tea involves two operations viz., centering and tipping from planting to till first formative pruning.

1. Centering is done to arrest the apical dominance and to induce secondary's and is achieved by cutting of young plants as low as possible, leaving 8-10 mature leaves from bottom.

2. Tipping is done to induce side shoots. This involves tipping at 50-55 cm height from the ground level at green semi hard wood shoot level removing only 3-4 leaves and buds.



Further, training /pruning involv es regular plucking with hand. This aims at getting an inverted dome or cone shaped bush.

Pruning

Season of pruning: Pruning is carried out during the pre-monsoon or post-monsoon periods since adequate soil moisture is a pre-requisite for pruning.

Types of pruning:

1. Collar pruning/ Rejuvenation pruning

The whole bush is cut near the ground level to rejuvenate the bushes, which have grown out of hand. Since this is the severest form of pruning, causalities may be very high.

2. Medium pruning

To check the bush growing to an inconvenient height, this type of pruning is done in order to stimulate new wood and to maintain the foliage at lower levels less than 60 cm. Medium style of pruning refers to pruning between 45 and 60cm.

3. Fringe or lung pruning

Here all the criss cross branches are removed so that bush maintains a uniform height. Here all the leaves below the pruning level are left including peripheral branches. In this method dieback and death of plants is minimized.

4. **Skiffing**:

It is a lightest form of pruning. Here foliage is leveled off, only green stems are removed. Here top 5 – 8 cm new growth is removed so as to obtain uniform level of plucking surface. If the bushes are pruned about 75cm, it is referred to as skiffing. Skiffing may be repeated for 2-6 years.. However, skiffed bushes are more prone to drought and they get heavily infested by pests such as spider mite and tea mosquito bug.

Exercise-14

Title: Diagnosis and identification of physiological disorder of coconut.

Physiological disorder of coconut

1. Button shedding:

It is usual phenomenon in which dropping of nuts in their very initial stages of maturity (3 to 4 months stage). It is the natural phenomenon exhibited by plant to protect itself from exhaustion.

Reasons and Remedies for button shedding in coconut.

a) **Nutritional Imbalance / deficiencies:** NPK recommended for coconut is 500: 330: 1200 g per palm per year. Usually full dose of NPK is applied from 4th year onwards. Application of K and N minimized the incidence of button shedding in coconut.

b) **Unfavorable conditions:**

- Moisture: Deficiency / stress or water logging / excess of water promote button shedding
- Hard pan: A rocky strata at shallow (< 1.5 m) depth.

c) **Pathogen and insect:** Some pathogens especially fungi are known to be associated with the button shedding. They include Colletotrichum spp, Phytophthora spp.

2. Barren Nut:

Causes due to Insects viz.,

i) Coried bug (The attacked buttons do not develop resulting in immature nut fall. The nuts if developed may become barren. **ii) Eriophide mites** and **iii) Rodents problems** (Attack tender nuts resulting in immature nut fall.) are also results in nut drop.

iv) Defective pollination and fertilization: Many of the tall cultivar are cross pollinated. There may be inadequate pollination possibly due to high temperature or hot winds which cause desiccation or drying of the stigmatic surface. For this we can;

a) Keep bee hives b) Spray 2,4-D @ 60 PPM to improve fruit set and yield.

v) Inherent capacity / Genetic make-up (inborn nature) of the palm: We can resort to selective filling and replanting.

3. Crown choking:

Cause: Due to boron deficiency.

Symptoms: The leaves of the palm become shorter and crinkled. The leaflets show severe tip necrosis and fail to unfurls. The fronds exhibits choked appearance

Management: Application of borax at the rate of 50g per palm at half yearly interval during February-March and September-October along with recommended fertilizers will control this disease

4. Nut splitting:

Causes: due to boron deficiency.

Symptoms: One of the earliest symptoms of boron deficiency on coconut palm is leaf wrinkling and manifested as sharply bent leaflet tips, commonly called <hook leaf=. Leaves have a serrated zigzag appearance. One of the most common symptoms of boron deficiency is the failure of newly emerging spear leaves to open normally. In a chronic stage, multiple unopened spear leaves may be visible at the apex of the canopy. Boron deficiency also occurs in inflorescence and nuts. The inflorescence and nuts are become necrotic.

Management: Application of borax/sodium tetraborate 0.2% (2 g/l of water), (75-100 ml/seedling), borax/ sodium tetraborate/octaborate 15-20 g/plan.

Exercise-15

Title: Diagnosis and identification of physiological disorder of arecanut.

Physiological disorders arecanut:

1) Band or hidimundige: Band = barren (in marathi). This disorder is a major problem in Konkan Coast of Maharashtra. Diseased palms ceases to produce fruits. It is known as hidimundige disease in Karnataka In Sri Lanka = Pencil point disease and in Austrelia = Rosette disease

Symptoms:

1. Production of smaller leaves and ultimately crown forms a rosette shape
2. Reduction in internodal length and tapering of stem towards apex
3. Mostly unproductive nuts if at all produced are small and malformed.

Causes

1) Poor drainage and low fertility of soil
2) Sub soil pan / hard clayey pan

Control:

- Better soil management and improvement in drainage.
- Removal of hard pan on the sub soil and foliar application of micronutrients
- Correction of soil acidity and incorporation of mixture of copper sulphate and lime.

2) Nut splitting in arecanut:

A physiological disorder of universal occurrence in almost all gardens. The growth of pericarp does not take pace with the development of kernel inside and thus causing the splitting up of the pericarp and distal end. Then the split nuts drop. Infection of bacteria and fungus of the exposed kernel after splitting renders the nuts useless.

Symptoms: Premature yellowing of nuts when they are ½ matured. It is seen in patches in individual plantations and common on young palms.

Cause/ Reasons.:

- Excessive flow of sap in to the inflorescence or Excessive nutrient supply
- Prolonged drought followed by sudden irrigation

Control

1) Application of borax @ 2 g per liter of water (0.20 % spray) on bunches during early

stages of disease. and K2O at the base is found to check nut splitting to a certain extent.

2) Improvement of drainage and provide regular irrigation during drought

3) Sun scorch and stem breaking:

Cause: Due to adverse effect of solar radiation., i.e., palms exposed to the south western sun are affected.

Symptoms

Stem: Golden yellow spots will appear which later turn brown. In advanced stages fissures develop at these points. Further, saprophytic microorganisms and insects harbour in these portions leading to breaking of stem at later stages.

Management/Protection

1. Tying areca sheath or leaves on the stem being exposed to Western and southern sun.
2. Planting of quick and tall growing shade trees on the south – western side of the garden. Eg., Ever green trees like Kokum (*Garcinia indica*), Jack.
3. Adoption of proper alignment while planting to minimize the damage due to scorching.

Exercise-15

Title: Diagnosis and identification of physiological disorder of arecanut.

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Exercise-16

Title: Diagnosis and identification of physiological disorder of date palm.

1. **Blacknose:** Blacknose applies to the abnormally shrivelled and darkened tip of a date. Deglet Nour and Hayani seem to be the most susceptible varieties to this physiological disorder.

   Causes: excessive humidity and rainfall at Khalaal stage. Over thinning can also increase the incidence of checking and subsequent development of blacknose.

   Measures: The conditions to be avoided include excessive soil moisture and the presence of intercrops and weeds, especially at the susceptible stage of fruit development. Bagging the fruits in brown wrapping paper can inhibit the occurrence of blacknose disorder.

2. ***Whitenose***: Whitenose disease is commonly found in Iraq, Libya and Morocco. Dry and prolonged wind in the early Rutab stage causes rapid maturation and desiccation of the fruit resulting in whitish drying at the calyx end of the fruit. The affected fruit becomes very dry, hard and has high sugar content. Hydration may correct this condition in harvested fruits.

3. ***Black scald***: Black scald, different from blacknose, is a minor disorder of unknown cause occurring in the United States. It consists of a blackened and sunken area with a definite line of demarcation. The disease usually appears on the tip or the sides of the fruit, and affected tissues have a bitter taste. The appearance of the disorder suggests exposure to high temperature, but the exact cause is not defi nitely known.

4. ***Bastard offshoot***: This is a deformed growth of date palm vegetative buds especially of offshoots fronds. The bastard condition is due to infestation by the date palm bud mite *Makiella phoenicis* K. It may also be due to reduction in growth caused by an in equilibrium of growth regulators.

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