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1. AGRICULTURAL ENTOMOLOGYXTENSION EDUCATION

Entomophagy for Nutritional Security

Pasupathi E[1] and P. S. Geetha[2]

[1]Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Madurai-625104, Tamil Nadu. [2]Department of Differently Abled Studies, Community Science College and Research Institute, TNAU, Madurai - 625104, Tamil Nadu.

Food Security

Food Security Act (2013) states that, in India everyone should get sufficient quantity of nutritious food for the whole year. This is rather jeopardized due to increase in human population and decrease in crop productivity and food availability. The natural factors responsible for food insecurity such as climate change, soil health, imbalance of plant nutrient, pests and disease incidence, and manmade situations such as increased food prices, non-availability of foods, lack of purchasing power of consumers, disparity in food distribution etc,. To overcome this quandary searching for new available sources to substitute food can be a viable and obligatory step. For improving food supply through new viable technologies on a large scale would take longer time. As a global responsibility, at least for member countries, the Food and Agriculture Organization (FAO) of the United Nations took an initiative to create a policy and proposed the programme of feeding people with alternative sources including insects. Insects are environmentally friendly, as they can recycle waste, require little food and water for their growth, and have a rapid growth rate. For all these reasons, in recent years, entomophagy has reached global attention.

Entomophagy

Insects have played an important part in the history of human nutrition in Africa, Europe, Asia, and Latin America. Entomophagy is a not newly evolved concept, people are practicing from ancient times. The term Entomophagy (from the Greek words entomon, "insect" and phagein, "to eat") refers to the process of eating insects as food.

Diversity of Edible Insects in India

Over 1900 species of edible insects in 300 ethnic groups in 113 countries worldwide have been recorded by various authors to be part of human diet (MacEvilly, 2000). According to Chakravorty *et al.* (2011) 298 edible insects have been reported belonging to order coleopteran (34%), orthoptera (24%), hemiptera (17%), hymenoptera (10%), odonata (8%), lepidoptera (4%), isoptera (2%) and ephemeroptera (1%) and also stated insect diversity in Arunachal Pradesh (158 species), Manipur and Nagaland (41 species each), Assam (38 species), Meghalaya (16 species), Kerala (5 species) and Karnataka, Tamil Nadu, Odisha and Madhya Pradesh (1 species each).

Nutritional Values of Edible Insects

The insects have been well recognized worldwide as natural renewable resource nutritious food since insects provide carbohydrates, proteins, fats, essential fatty acids, minerals, vitamins, fibre and micronutrients.

Studies on the nutritional composition of edible insects should meet internationally recognized standards. The nutritional values of edible insects are highly variable because of its richness in species diversity. Even within same insect species also differences exist in nutritional values depending on the stage of the insects (egg, larvae, pupa and adult in case of holometabolous insects and egg, nymph and adults of hemimetabolous insects) and also the variation in nutrient composition is due to different analytical methodologies, the heterogeneity existing

between insects from different environments and different rearing and storage conditions. The international network of food data systems (FAO INFOODS) has recently published a database on food composition and in version 4.0 a total of 471 edible insects, with different methods of preparation.

In India, insect eggs, larvae/nymphs, pupae and adults are consumed probably because there is vast difference in the content of nutrients as per insect development period. Consumption of crickets, termites, grasshoppers and caterpillars yields a high energy value. Content of protein is significantly higher than or equal to animal foods such as, chicken, pork, eggs, beef or lamb. When five insects were compared for nutritive value, high protein content was found in dragon fly, *Crocothermis servilla* (Drury) larva (70.48%), short horned grasshopper, *Oxyahyla hyla* Serville adult (64.67%), surface grasshopper, *Oedaleus abruptus* (Thunberg) adult (60.00%) and eri silkworm, *Samiari cini* (Drury) pupa (71.9%).

Table 1. Commonly explored major edible insect species documented from India

Method of processing	Insect species	Order: Family	Insect life stage(s)	State
Baked	*Apis cerana indica*	Hymenoptera: Apidae	Egg, larva, pupa	Assam
	Antheraea assamensis	Lepidoptera: Saturnidae	Pupa	Assam
	Oecophylla smaragdina	Hymenoptera: Formicidae	Egg, adult	Assam
	Rhynchophorus phoenicis	Coleoptera: Curculionidae	Larva	Assam
	Rhynchophorus ferrugineus	Coleoptera: Curculionidae	Larva	Assam
Cooked	*Pentatomid* sp.	Hemiptera: Pentatomidae	Adult	Arunachal Pradesh
	Locusta sp.	Orthoptera: Acrididae	Adult	Arunachal Pradesh
Cooked + baked	*Polistes stigmata*	Hymenoptera: Vespidae	Egg, larva, pupa	Assam
	Samia ricini	Lepidoptera: Saturnidae	Larva, pupa	Assam
	Myrmica rubra	Hymenoptera: Formicidae	Larva, pupa	Assam
Dry/deep fried	*Reticulitermes flavipes*	Isoptera: Rhinotermitidae	Adult	Assam
	Dihammu scervinus	Coleoptera: Cerambycidae	Larva	Assam
	Meligethes aeneus	Coleoptera: Nitidulidae	Larva	Assam
	Batocera rufomaculata	Coleoptera: Cerambycidae	Larva	Assam
	Okanagan sp.	Diptera: Asilidae	Adult	Assam
Dry/deep fried + baked	*Megasoma elephas*	Coleoptera: Scarabaeidae	Larva	Assam
	Apis dorsata	Hymenoptera: Apidae	Larva, pupa	Assam
	Apis cerana indica	Hymenoptera: Apidae	Larva, pupa	Assam
	Apis florea	Hymenoptera: Apidae	Larva, pupa	Assam
Deep fried +	*Mantis religiosa*	Orthoptera: Mantidae	Nymph, adult	Assam

roasted				
	Melanopus sp.	Orthoptera: Acrididae	Adult	Assam
Raw/fresh	*Aeshna mixta*	Odonata: Aeshnidae	Nymph, adult	Assam
	Neurothemis fluctuans	Odonata: Libellulidae	Nymph, adult	Assam
	Apis dorsata	Hymenoptera: Apidae	Larva (hive)	Arunachal Pradesh
	Apis cerana indica	Hymenoptera: Apidae	Larva (hive)	Arunachal Pradesh
	Vespa mandarinia	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
Roasted	*Schizodactylus monstrosus*	Orthoptera: Gryllidae	Nymph, adult	Assam
	Gryllus campestris	Orthoptera: Gryllidae	Nymph, adult	Assam
	Gryllotalpa africana	Orthoptera: Gryllotalpidae	Nymph, adult	Assam
	Odontolabis cuvera	Coleoptera: Lucanidae	Adult	Assam
	Lucanus elsphus	Coleoptera: Curculionidae	Adult	Assam
	Cyrtotrachelus buqueti	Coleoptera: Dynastidae	Larva	Arunachal Pradesh
	Eurytrachelus titan	Odonata: Libellulidae	Adult	Assam
	Libellula carolina	Orthoptera: Acrididae	Adult	Assam
	Schistocerca gregaria	Hemiptera: Belostomatidae	Nymph, adult	Assam
	Belostoma indicus	Hymenoptera: Vespidae	Adult	Arunachal Pradesh
	Vespa tropica	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
	Vespa bicolor	Hymenoptera: Vespidae	Larva	Arunachal Pradesh
	Polistes sp.	Hymenoptera: Vespidae	Larva	Arunachal Pradesh

Table 2. Nutritional composition of commonly exploited edible insect species of India

Nutrient (%)	***Brachytrupes orientalis***	***Oxyahyla hyla***	***Oedaleus abruptus***	***Aspongopus nepalensis***	***Crocothermis sevilla***
Carbohydrates	15.18	28.17	30.00	-	1.18
Crude protein	65.74	64.67	60.00	10.60	70.48
Fat	6.33	2.18	15.00	38.35	4.93
Crude fibre	8.75	9.23	-	33.47	9.62
Ash	-	-	5.00	2.10	1.34
Calcium	0.24	-	5.00*	0.12	86.5
Potassium	-	-	10.35	26.80	-
Sodium	-	-	1.02	14.10	-
Phosphorus	-	1.75	0.075	-	-
Magnesium	0.54	0.084	6.00*	-	37.00
Zinc	2.10	0.017	2.50*	9.30	-

*mg/kg

Conclusion

With increasing awareness of nutritional security insects were used as a source of nutritional food and will be continue for future generations too. Insects, because of their high reproduction rate, high energy conversion rate,

high survival capacity, short life period and short space requirements will provide one of the viable alternative opportunities for food security. In future, information on nutritional aspects can effectively be used for better utilization of insects to combat malnutrition and undernourishment with insect protein. In this perspective, regulations established by FSSAI are to be rigorously respected in the production and processing of edible insects. Eventually, International, national and public private institutions have to be work together and develop new technologies related to entomophagy.

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2. SOIL SCIENCE

Role of Soil Physical Properties in Management of Soil Health

K.Sivakumar[1], M.Tilak[2] and K.Ramah[3]

Assistant Professor (SS&AC) (R-2744/2021), AC&RI, Coimbatore Assistant Professor (Agri. Microbiology)(02962/2021) Assistant Professor (Agronomy)(02961/2021) FC&RI, Mettupalayam Tamil Nadu Agricultural University

Soil is an important natural resource of the earth. The soil is characterized by its physical, chemical, physico-chemical and biological properties. Many properties affect soil health. Soil physical properties like texture, aggregation and structure are all inter-related and greatly influence root development, water and air movement in soil. Managing soils for physical properties along with other management strategies can improve soil health which result in uniform crop Strength and sustainability. Knowledge of the physical properties of soil is essential for defining and improving soil health to achieve optimal productivity.

The physical properties of the soil include

- Soil Colour
- Soil Texture
- Soil Structure
- Soil Bulk density
- Soil Particle density
- Soil Porosity
- Soil Consistency
- Soil Temperature
- Soil Aggregate stability

1.Soil Colour :

The colour of the soil is a result of the light reflected from the soil. Soil colour is inherited from its parent material. The red colour of the soil is due to iron oxide. The black colour of the soil is due to the presence of Montmorillonite clay mineral.

The soil colour is measured using Munsell colour chart. The soil colour is measured using three parameters like Hue, Value and Chroma (Fig.1).

Hue : It denotes the dominant spectral colour (red, yellow, blue and green).

Value : It denotes the intensity (i.e.) lightness or darkness of a colour (the amount of reflected light).

Chroma : It represents the purity of the colour (strength of the colour).

The Munsell colour notations are systematic numerical and letter designations of each of these three variables (hue, value and chroma). For example, the numerical notation 2.5 YR 5/6 suggests a hue of 2.5 YR, value of 5 and chroma of 6. The equivalent or parallel soil colour name for this Munsell notation is 'red'.

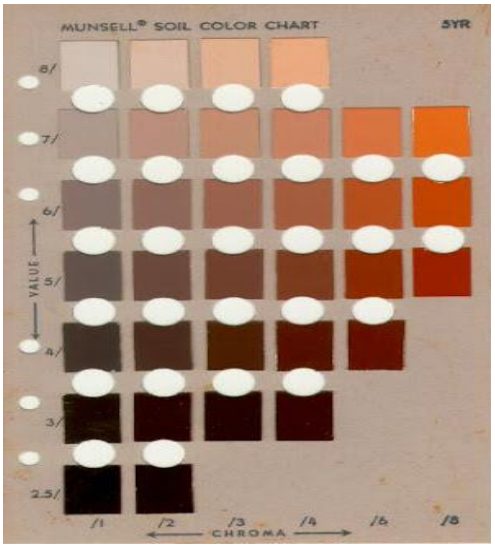


Fig.1.Munsell colour chart

2. Soil Texture :

The relative proportion (%) of particles of various sizes such as sand, silt and clay in the soil is called as soil Texture. There are 12 classes according to USDA *viz.,*

1.Sand (s) 2. Clay (c) 3. Loam (l) 4. Sandy clay (sc) 5. Silty clay (sic) 6. Sandyloam (sl) 7. Sandyclayloam (scl) 8. Siltyclayloam (sicl) 9. Siltyloam (sil) and 10. Clayloam (cl) 11. Loamysand (ls) and 12. Silt (si). The soil textural triangle (Fig.2) is used in mechanical analysis to identify the soil textural class.

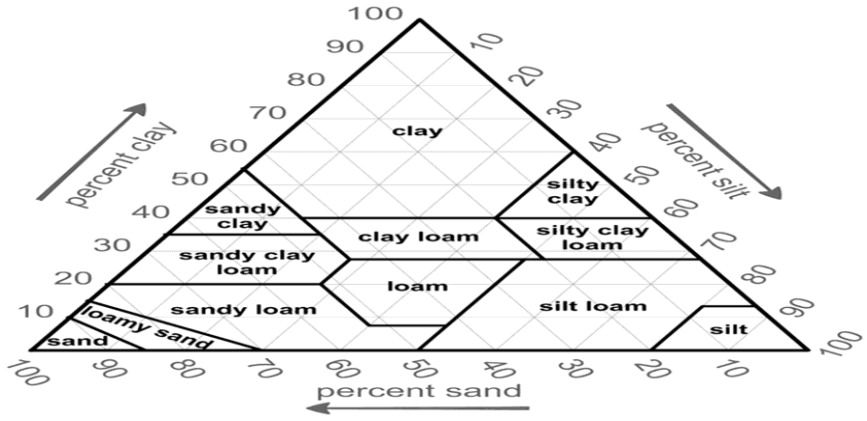


Fig.2.Soil Textural Triangle

3. Soil Structure :

The arrangement of primary particle within the secondary particle is called soil structure. The soil structure is divided into types, classes and grades (Fig.3)

1. **Types of soil structure :**The different types of soil structure are 1. Plate like 2. Prism like 3. Block like and 4. Spheroidal
   a. Plate like : when structural units are thin they are termed as platy structures. When the units are thin they are termed as laminar structures. Platy structures are mostly present in the surface layers of virgin soils. Platy structures are inherited from parent material.
   b. Prism like : The vertical axis is more pronounced than horizontal structure. When the top of ped is rounded it is termed as columnar. When it is flat it is termed as prismatic. This is seen in arid and semi arid regions.
   c. Block like : All the three dimensions are equal in shape.Then it is termed as Block like. When faces are flat and edges sharp it is termed as angular blocky. When faces are rounded it is termed as subangular blocky.
   d. Spheroidal : All rounded aggregates are placed under this category. In sphere like structures, infilteration, percolation and

aeration are not affected by wetting of soil. The aggregate of this group are termed as granular. This is less porous. The granules which are less porous are grouped as Crumby.

2. Classes of soil structure :

There are five different classes of soil structure *viz.,*

- Very fine (or) very thin
- Fine (or) thin
- Coarse (or) thick
- Very coarse (or) thick.
- Very Coarse (or) very thick

3. Grades of soil structure :

The different grades of soil structure are 1. Structureless 2. Weak structure 3. Moderate structure 4. Strong structure

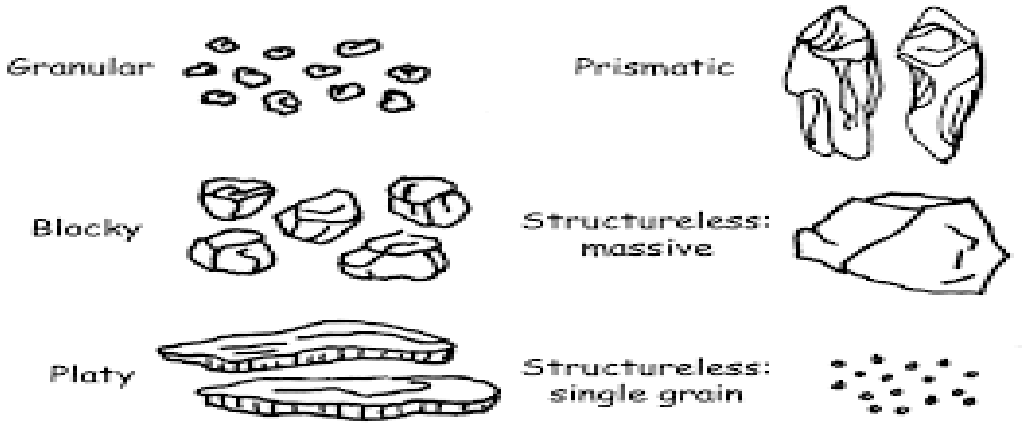


Fig.3. Types of Soil StructureTypes

4. Soil Bulk density :

The oven dry weight of unit volume of soil inclusive of pore spaces is called Bulk density (or) Apparent density. The bulk density of a normal soil varies from 1.25 to 1.60 Mg/m^3 (or) g/cc. When the bulk density of the soil is more addition of organic matter will reduce the bulk density.

Bulk density = Weight of the soil/Volume of the soil

5. Soil Particle density :

The weight per unit volume of the solid portion of soil is called Particle density (or) True density. The particle density of a normal soil is of the range 2.65 Mg/m^3 (or) g/cc.

$$Particle\ Density = \frac{\text{Weight of the Soil}}{(\text{Volume of the soil} - \text{Pore Space})}$$

6.Soil Porosity :

- Pore space : The volume of soil mass that is not occupied by soil particles is Pore space.
- Macro pores (or) Non capillary pores: These are large pores which do not hold much water.
- Micro pores (or) capillary pores: These are small pores which hold much water.
- Porosity : It is the percentage pore space.

The relationship between bulk density, particle density and pore space is given as

$$Pore\ Space\ (or) Porosity = \frac{1-\text{Bulk density}}{\text{Particle Density}} X10$$

Soil Consistence :

Soil consistence is the strength with which soil materials are held together or the resistance of soils to deformation and rupture. Soil consistence is measured for wet, moist and dry soil samples. For wet soils, it is expressed as both **stickiness** and **plasticity**.

At varying moisture conditions the degree and kind of cohesion (attraction between like particles) and adhesion (attraction between unlike particles) of soil materials varies. This is called as Consistence.

Consistence of soil at three moisture levels:

- Consistence when soil is wet
- Consistence when soil is moist
- Consistence when soil is dry.

Determination of wet-soil consistency

Testing is done when the soil is saturated with water, as, for example, immediately after a good rainfall. First, **stickiness**, is determined, that is, the ability of soil materials to adhere to other objects. Then, **plasticity** is determined, that is, the ability of soil materials to change shape, but not volume, continuously under the influence of a constant pressure and to retain the impressed shape when the pressure is removed.

Based on the stickiness the soil is rated as 0 – Non sticky 1 – Slightly Sticky 2- Sticky 3 – Very sticky

0 - Non-plastic, if no wire can be formed;

1 - Slightly plastic, if a wire can be formed but can easily be broken and returned to its former state;

****2 - Plastic**, if a wire can be formed but, when it is broken and returned to its former state, it cannot be formed again;

****3 Very plastic**, if a wire can be formed which cannot be broken easily and, when it is broken, it can be rolled between the hands and be reformed several times.

Determination of moist-soil consistency

Field test for moist-soil consistency

A small amount of moist soil shall be crushed by pressing it between the thumb and forefinger or by squeezing it in the palm of our hand. Moist soil consistency is rated as follows:

0 - Loose, if the soil is non-coherent (single-grain structure);

1 - Very friable, if the soil crushes easily under very gentle pressure but will stick together if pressed again;

2 - Friable, if the soil crushes easily under gentle to moderate pressure;

***3 - Firm**, if the soil crushes under moderate pressure but resistance is noticeable;

****4 - Very firm**, if the soil crushes under strong pressure, but this is difficult to do between the thumb and forefinger.

5 - Extremely firm, if the soil crushes only under very strong pressure, cannot be crushed between the thumb and forefinger, but must be broken apart bit by bit.

Non sticky - if no soil sticks to the fingers

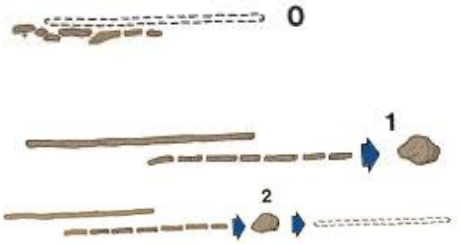
Slightly Sticky - if the soil begins to stick to your fingers but comes off one or the other cleanly and does not stretch when the fingers are opened

Sticky - if the soil sticks to both the thumb and forefinger and tends to stretch a little and pull apart rather than pulling free from your fingers

Very Sticky - if the soil sticks firmly to both thumb and forefinger and stretches when the fingers are opened.

Field test for plasticity of wet soil

A small amount of wet soil was rolled between the palms of your hands until it forms a long, round strip like a wire about 3 mm thick.



Determination of dry-soil consistency

Field test for dry-soil consistency

A small amount of dry soil may be broken by pressing it between the thumb and forefinger or by squeezing it in the palm of the hand. The dry soil consistency may be rated as follows:

Ratings of dry soil consistency

0 - Loose, if the soil is non-coherent (single-grain structure)

1 - Soft, if the soil is very weakly coherent and friable. breaking to powder or individual grains under very slight pressure;

2 - **Slightly hard**, if the soil resists light pressure, but can be broken easily between thumb and forefinger;

3 - Hard, if the soil resists moderate pressure, can barely be broken between the thumb and forefinger, but can be broken in the hands without difficulty;

4 - Very hard, if the soil resists great pressure, cannot be broken between the thumb and forefinger but can be broken in the hands with difficulty;

5 - Extremely hard, if the soil resists extreme pressure and cannot be broken in the hands.

Determination of soil consistency using the Atterberg Limits

The consistency of a soil sample changes with the amount of water present. Such changes in soil consistency may be accurately measured in the laboratory following standard procedures which determine the Atterberg Limits. These limits may then be used for judging the suitability of the soil,.

An Atterberg Limit corresponds to the **moisture content** at which a soil sample changes from one consistency to another.

The liquid limit (LL)

The percentage moisture content at which a soil changes with decreasing wetness from the liquid to the plastic consistency or with increasing wetness from the plastic to the liquid consistency.

The plastic limit (PL)

The percentage moisture content at which a soil changes with decreasing wetness from the plastic to the semi- solid consistency or with increasing wetness from the semi-solid to the plastic consistency.

The plastic limit is the lower limit of the plastic state. A small increase in moisture above the plastic limit will destroy the **cohesion** of the soil.

Both the liquid and plastic limits depend upon the **amount and type of clay** present in the soil:

- A soil with a high clay content usually has high LL and PL;
- Colloidal clays have higher LL and PL than non-colloidal clays;
- Sand, gravel and peat have no plasticity, their PL= 0;
- Silts have plasticity only occasionally, their PL being equal to or slightly greater than 0.

Field determination of the plastic limit - the thread method

A soil sample was taken and allowed to dry;

A little water is added to the soil sample and it was rolled on a flat surface like a small glass plate. A **thread of 3 mm thick and 10 cm long** was formed without breaking it;

8. Soil Temperature :

The main source of soil temperature is the energy received from sun's rays (radiant energy) that reach the earth after passing through the atmosphere. The exposure of the earth to the heat of the sun increases the surface soil temperature.

Soil temperature has direct (or) indirect influence on 1. Decomposition of organic matter 2. Absorption of soil water 3. Absorption of nutrients 4. Seed germination. 5. Plant growth 6. Soil formation 7. Other soil physical properties and 8. Plant diseases.

9. Soil Aggregate Stability:

Soil aggregate stability refers **to the ability of soil aggregates to resist disruption when outside forces** are applied. Aggregate stability is used for wind erosion prediction.

Soils that have a high percentage of silt often show lower aggregate stability. The stability of aggregates is affected by soil texture, the predominant type of clay, extractable iron, and extractable cations, the amount and type of organic matter present, and the type and size of the microbial population. Soils that have a high content of organic matter have greater aggregate stability.

The different methods used to estimate the soil physical properties are outlined in Table 1.

Importance of soil physical property on soil fertility

Texre: Sandy soils have poor fertility compared to clay soils and silty soils. Loamy soils which is a combination of all the three texture is highly fertile and supports all crops.

Structure: Crumby structure helps in drainage and provides optimum aeration, water holding capacity.

Deity: Soils with low bulk density is suitable for crop growth.

Porosy: A soil with equal amounts of macro and micropores is an ideal soil for all crops.

Soicolour: It has relation with temperature, organic matter, drainage and Parent material.

Soil physical property has significant role in providing favourable conditions like permeability, water holding capacity, aeration, consistence, aggregate stability thereby enhancing the soil fertility improving the soil health which will increase the crop productivity of the soil.

Table 1. Methodologies used to analyse the soil physical properties

Sl.No.	Soil Physical Property	Methodology
1.	Soil Colour	Munsell Colour Chart
2.	Soil Texture	Feel method (or) Mechanical analysis (or) International Pipette method (or) Hydrometer method
3.	Bulk density	Cylinder Method (or) Wax coating method
4.	Particle density	
5.	Porosity	
6.	Aggregate stability	Wet sieving method
7.	Soil temperature	Soil Thermometer

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3. HORTICULTURE: PLANTATION CROPS

Biotechnological Interventions in the Crop Improvement of Cashew

Dharini Chittaragi

Ph.D Scholar, Dept. of Spices and Plantation crops, HC and RI, TNAU, Coimbatore

Introduction

Cashew is hardy, drought resistant and comes up well in poor soil hence it is considered as **gold mine of waste land**. *Anacardium occidentale*, belongs to the family Anacardiaceae with chromosome number 2n=42. The main place of origin is Brazil. It was introduced to India by the Portuguese in the 16th century at Goa for the purpose of soil conservation. Commercial cultivation began in the early 1920s.

Biotechnology can be used in cashew for somatic embryogenesis and plantlet regeneration. It is useful for: Genetic transformation to introduce genes for resistance to Tea Mosquito Bug and stem & root borers, standardization of micrografting technique, developing haploids and isogenic lines and molecular characterization of existing genetic diversity.

1. **Micropropagation**: These techniques can be used for: Clonal propagation of elite lines, Production of clonal rootstocks, i*n vitro* conservation and International germplasm exchange.
   a. Tissue culture-Used for faster multiplication of cashew elite lines, useful selections and hybrids. Regeneration from mature tree explant is difficult due to:
      i. High rate of contamination
      ii. Browning
      iii. Slow growth
      iv. Poor rooting of microshoots
   b. Anther culture in cashew is useful for producing haploids and dihaploids-which in turn is used for genetic studies and for producing homozygous lines
   c. Cell culture or protoplast culture is useful for making somatic hybridization for transfer of characters from alien source
2. **Somatic Embryogenesis**: In plants,

embryo-like structures can be generated from cells other than gametes (i.e. somatic cells) by circumventing the normal fertilization process, hence the term somatic embryos (Parrott, 2000). As somatic embryos are formed without any fertilization event they are genetically identical to the parent tissue and are therefore clones. Somatic embryogenesis from maternal tissue like nucellus and leaf, Alternative for micropropagation and development of synthetic seeds, Somatic embryos can be used as target organ for transformation studies and as a useful organ for conserving germplasm.

3. **In-vitro:** Somaclonal variation in cashew trees is produced *in vitro* from cotyledonary nodes. Characters of *in vitro* produced trees (compared to seed grown trees):
   a. Slightly higher girth
   b. Lower height
   c. Early flower setting
   d. Strong tendency for apical dominance in initial growth
   e. Unstable immune system

Embryos from immature nuts of cashew are cultured *in vitro* to regenerate improved hybrid plantlets

Explants: Six weeks old or older show better germination and high survival percentage

Factors affecting germination:

a. Medium composition
b. Age of embryo
c. Genotype

4. **Micrografting**
   a. To rejuvenate mature cashew tree explant material
   b. Using *in vitro* germinated seedling as rootstock and shoots from stage II culture as scions
   c. Grafting success depends on: Method of grafting, size of scion and age of rootstock
5. **Molecular Markers**

They can be used for characterization of germplasm and for correlating markers with economically important characters

   a. Random amplified polymorphic DNA (RAPD)
   b. Random fragment length polymorphism (RFLP)
   c. Amplified fragment length polymorphism (AFLP)
   d. Biochemical markers (isozyme, protein)

Future Thrust

Application of next generation biotechnological tools will be helpful to identify a particular trait at gene level to improve the fruit quality.

Refernces

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4. PLANT PATHOLOGY

Importance of Seed Treatment in Eradicating Seed-Borne Diseases

Dr. Bindhu, K. G. and Zaheer Ahamed

UAS, Raichur, Karnataka

The core concept of seed treatment involves the usage of biological (or) chemical agents to control the seed or soil borne pathogens.Seed treatment plays an important role in protecting the seeds and seedlings from seed and soil borne diseases. Many of them are not familiar with these techniques, though familiar don't practice it.

Different types of seed treatment:

Seed treatment has to be carried out in different process using different products. So the right product when treated at the right time using right technique can improve the plant growth by reducing the disease.

Seed coating

In this method a binder particle is used with a formulation to enhance the adherence to the seed coating. This requires advanced treatment technology by the industries.

Seed dressing

Low cost method, the most renowned method of seed treatment is seed dressing. In this case the seed is dressed either with liquid (wet) or dry formulation. The seeds are spread on a polythene sheet and required quantity of chemical can be sprinkled upon the seed and its mixed up.

Seed pelleting

The most expensive method. This is said to be highly sophisticated seed treatment technology. This results in changing physical shape of a seed to enhance the palatability and handling this pelleting requires specialized application techniques with machineries.

Chemical method of seed treatment

The seeds are treated with the chemicals such as carbendazim @2g/kg seed, (or) chloropyripos@3g/kg seed (Insects), seed soaking in 0.2% monocrotophos for 6 hours. Thiram @2g/kg of seed (or) Captan @2g/kg of seed (or) carbofuron @3g/kg (or) tebuconazole @1.5ml/kf of seed.

Biocontrol agents

Trichoderma

The use of trichoderma as a biological agent seems to be an excellent approach. It is said to be a biocontrol agent in control of plant diseases also in bioremediation and natural decomposition. There are many strains of *trichoderma* but most widely used ones are *T. viridae*, *T. harzianum, T. hamatum* etc., for every 1kg if seed 4gm of trichoderma is used as seed treatment. It enhances the root growth of lateral roots.

PSB

Phosphate solubilizing bacteria are beneficial capable of solubilizing inorganic phosphorus from insoluble compounds. It serves as an inoculants to enhance the P availability to plants and crop yield. Its mainly used for direct soil application and also seed treatment. Dosage recommended is 5-10g/kg of seed for seed treatment.

Rhizobium

It is a beneficial bacteria helps in fixing nitrogen in leguminous plants. It attaches to the roots of the leguminous plants and produces nodules. These nodules fix atmospheric and convert it into ammonia. Its main role of legume-symbiosis. 5gm/kg seed can be used for seed treatment.

5. HORTICULTURE

The Green Plague of Pigeonpea: Sterility Mosaic Disease

Zaheer Ahamed and Dr. Bindhu, K. G.

UAS, Raichur

This disease is dubbed as the green plague as the infected plants remain in the vegetative state without flower production. Havoc of sterility mosaic disease (SMD) is a major threat to pigeonpea production in many pigeonpea growing area. Causal agent of SMD is PPSMV (*pigeonpea sterility mosaic virus*) is transmitted naturally by vector eriophyid mite (*Aceria cajani*) . it is transmitted by grafting but not by mechanical inoculation.

PPSMV –is a negative sense single stranded RNA belonging to the genus-emaravirus, family: Tenuiviridae and Bunyaviridae.

Aetiology and transmission :

SMD is characterized by typical symptom which shows stunting and bushy plants (fig.1) leaves which are of reduced size (Fig.2) with chlorotic or mosaic symptoms and with complete or partial cessation of flower production. This is –ssRNA is transmitted by an eriophyid mite in a semi-persistant manner. Both the virus and vector are highly host specific to pigeonpea and few of its wild relatives.

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Fig:1 Typical symptoms of SMD

Fig 2: Stunting with small leaves

Fig 3. Field view of SMD of pigeonpea depicting no flowering

Fig 4a: PPSMD chlorotic leaves

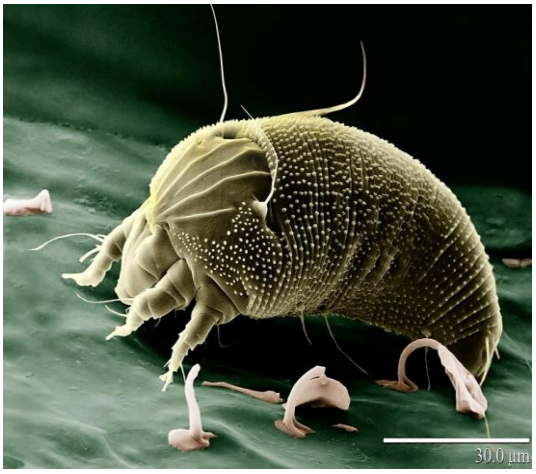


Fig 4b: Mite

Epidemiology

This PPSMV seems to infect several wild genotypes of pigeonpea also its cultivated hosts. This is said o be endemic in many areas (Fig 3). The epidemiology involves the virus, vector, host and environmental conditions. Volunteer plants serve as a source for both the

virus and its vector mites (Fig 4a & b).

Management

Usage of resistant varieties such as BSMR-736 varieties

To take off SMD affected plants and to burn them

Spray oomite/ecomite@ 1ml/litre of water (or) neem oil @2ml/lt of water (or) Difenthurium @2.5gm/lt (or) abamectin@1gm/lt of water.

6. AGRONOMY

An OvervieTomato Pomace as a Source of Nutraceuticals - An Overview

Swapna Sree Meduri[1], PS Geetha[2] and E Pasupathi[3]

Community Science College and Research Institute, Tamil Nadu Agricultural University, Madurai - 625104, Tamil Nadu.

Introduction

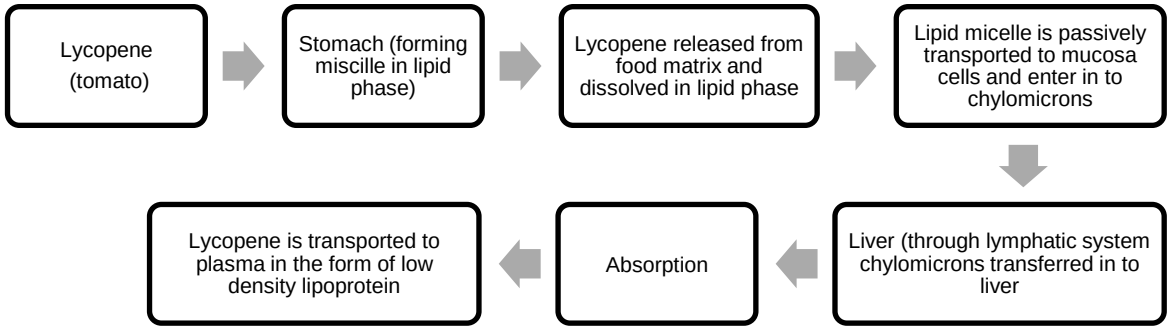
One of the major drawbacks of food manufacturing industries was food waste which contains high value components like polysaccharides, flavor compounds, proteins, phytochemicals which acts as functional ingredient in both pharmacologically and nutritionally. To minimize the cost of waste disposal several techniques for recovery were successfully applied in terms of tomato processing. Lycopene is a fat soluble compound (carotenoids) present in different foods for giving color with a molecular structure of $C_{40}H_{56}$. Important source of lycopene was tomatoes available at cheap cost and it has a huge demand in the market due to its carotenoids content. The pigment which contains conjugate double bond is responsible for absorbing light during process of photosynthesis. The factor which affects the lycopene content present in tomatoes is the water content of 50-75%. High amount of lycopene content was in cherry tomatoes. The cis-isomer of lycopene was absorbed in greater amount compare to tans-lycopene because of solubility in bile acids for making it bioavailable. Lycopene is an unsaturated acyclic carotenoid with 11 linear conjugated and two non-conjugated double bonds, its not a precursor of vitamin A. These are the important physico-chemical properties which are mostly seen when used in application of nutraceuticals.

Extraction of lycopene from food

The beneficial biological effects of lycopene it is used as nutraceuticals, functional food and supplements. Instead of usual extraction techniques new technologies were developed for improving the recovery rate from tomato peel. The extraction process of lycopene content may increase the bioavailability in human body. By using thermal processing also we can go for extraction of lycopene but it is done by controlled process it affects the sensory properties and health benefits of final products. The extraction methods of lycopene were broadly divided in to 2 types like green techniques and organic solvent extraction. The green house technique was used due to organic solvents are toxic to environment, the toxic traces in the final product may make the product unfit for consumption. In the organic solvent extraction the commonly used methods were soxhlet extraction, microwave assisted extraction, solvent extraction, enzyme assisted extraction, high hydrostatic pressure assisted extraction and ultrasound-assisted extraction and in green house technique most commonly used one is supercritical fluid extraction. After extraction, concentration process is carried out to create more stable extract in terms of physical, chemical and microbial characteristics. The concentration process eliminates the solvent from the sample, lowering its humidity and extending its shelf life while lowering transportation expenses. Hot air, spray dryer, rotating evaporator, lyophilization and far-infrared radiation are the most prevalent procedures for concentrations. The main disadvantage of some methods, such as hot-air and spray-drying because it causes degradation such color darkening, nutritional value loss, flavor changes. The rotating evaporator, lyophilization and far-infrared radiation are the best options. The concentration methods are also

use to prepare the sample for identification analysis. Before making the product available on the market, identification analysis determines if they obtained extract meets the quality requirement using lycopene measurement and purity determination. The most common method was high-performance liquid chromatography which was found in 76% of the retrieved items. Nuclear magnetic resonance came in second with 9%, followed by ultraviolet-visible and infrared spectroscopy both with 7%. The authors observed remaining 1% in other spectrophotometric techniques. With increased interest in the nutraceuticals advantages of these potential carotenoids, both food extraction and chemical synthesis have shown symptoms of slowing. More study has been done in this area in order to find other pathways, such as metabolic engineering.

Ingestion and absorption:



Therapeutic uses of lycopene

Tomatoes and tomato-based products are good providers of a number of phytochemicals that may have health advantages. Tomatoes are high in vitamin C, vitamin A, potassium and folate, among other nutrients. Lycopene was found to be the most powerful antioxidant. Carotenoids in mixtures were more efficient than single substances. When lycopene or lutein was present, the synergistic effect was strongest. Lycopene acts as a scavenger of singlet oxygen ($1O_2$) and peroxyl radicals (LOO•) in the body. In energy transfer reactions, lycopene's highly conjugated double bonds play the most crucial role. Diabetics have a high level of free radicals, which can cause difficulties, however antioxidants like lycopene can help to minimize complications and function as an anti-diabetic. Lycopene has inherent ability to reduce free radicals which is beneficial in several diseased conditions in old age. The impairment in memory in old age can be minimized by regular use of lycopene containing product. The treatment of lycopene using 3-nitropropionic acid-induced rats has significantly improved the memory and restored glutathione system functioning. Increased plasma lycopene levels have been linked to a lower risk of cardiovascular disease and breast cancer.

Nano carriers are being used to improve lycopene solubility, stability, and bioavailability

Although lycopene has numerous biological properties, its use presents some challenges due to characteristics such as high lipophilicity, insolubility in aqueous solvents, and stability and degradation issues. Solutions, such as its association with nanotechnology, are being sought to avoid these difficulties. Nanotechnology has been extensively researched as a means of increasing lycopene accessibility, bioavailability, and absorption because it can protect the molecule, improve properties such as solubility and bioavailability, and avoid toxicity issues. By use of nanoparticles it was came to know that there was low degradation of lycopene.

Anti-Oxidant Activity of Tomato Waste

Tremendous reactivity of lycopene long polyene chain with free radicals, lycopene is an excellent antioxidant, allowing singlet oxygen to be eliminated and reactive oxygen species to be reduced (ROS). Reduced ROS accumulation and

oxidative stress, inhibition of inflammatory pathways (TNF-, IL-6, and IL-1), NF-kB and apoptotic (caspase and Bbl-2), and activation of the nuclear factor E2-related factor 2 (NFE2L2)-antioxidant response element (ARE), increasing antioxidant enzymes levels like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (bMECs). There was an increase in heme oxidase (HO-1) mRNA expression in cardiac myo-fibroblast cells (H9c2), which was likewise induced by oxidative injury. Lycopene lowered levels of kinases over expressed in oxidative stress (p-ERK1/2, p-JNK, and p-p38), stress proteins (hsp70 and hsp90), and an indication of ROS-induced DNA damage in THP-1 cells exposed to H2O2 (8-OHdG). IKK activation/ phosphorylation, IkB implicated in NF-kB inactivation, and NADPH oxidase-4 expression linked to ROS generation were also suppressed. Other antioxidant mechanisms involving the NFE2L2 pathway include a decrease in interferon-gamma and IL-10 levels in C57BL/6 mice lungs after cigarette smoke exposure, and a reduction in malondialdehyde (MDA), myelo peroxidase (MPO), and caspase-3 in lungs and kidney tissues in Sprague-Dawley rats with thermal trauma (oxidative injury).

Utilization of tomato pomace waste as by-products

The principal component of the peel portion of tomato pomace is cutin, which is non-toxic, biodegradable, and water-proof. Tomato pomace is also a source of natural pectin (8 percent wt. on dry basis), a thickening agent utilized in the food sector, according to researchers. Due to its health-beneficial features, researchers studied the tomato peel composition and established its potential usage as a source of carotenoids, natural colors. Tomato pomace is the leftover cuticle (or peel), seeds, and small amounts of pulp from the processing of tomatoes. It's frequently used in animal feed as a source of dietary fibre, B vitamins, lycopene, and, to a lesser extent, vitamin A.

Conclusion

Many researchers have found that consuming lycopene-rich foods can help avoid degenerative illnesses in humans. Lycopene's interaction with other active chemicals is critical to its optimal function in human health. In the gastrointestinal tract, the isomer cis is more soluble, making it easier to absorb. On the other hand, this isn't a naturally occurring isomer; instead, it's usually the consequence of an isomerization. External variables, primarily high temperatures, trigger isomerization processes, which can degrade the final product, impacting not just its sensory quality but also its health advantages. Solvent extraction and supercritical fluid extraction were found to be the most popular extraction procedures in recent years. Centrifugation and evaporation, primarily using a vacuum rotary evaporator, were the most often utilized concentration methods. The most popular analytical procedures used by researchers were HPLC and UV–vis spectrophotometer. Another aspect to consider is that lycopene's insolubility in aqueous solvents, stability, and degradation make it difficult to employ as a nutraceuticals. Nonetheless, due to the lack of conclusive results on the role of lycopene in human health, more research into clinical aspects of lycopene, its mechanism of action in diseases, bioavailability, bioaccessibility, recommended intake, interaction with other compounds, and metabolites activities is required.

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Lycopene from Tomato Waste: A Potent Antioxidant with Endless Benefits. *Molecules*, *26*(15), 4495.

7. HORTICULTURE: PLANTATION CROPS

Crop Improvement in Palmyrah Palm

Dharini Chittaragi

Ph.D. Scholar, Department of Spices and Plantation crops, TNAU, Coimbatore-641003, India

Introduction

Borassus flabellifer, a tropical palm stands next to coconut. It is a versatile palm yielding many edible and non-edible products like sap, fruit, seed, leaf, fiber, timber etc. Still it is a least exploited of all palms. The distinguishing characters of palm in this genus are their palmate, fan like leaves and dioecious character *viz.*, male and female flowers are borne on separate trees.

Origin and Distribution:-Africa

Distributed in Tropical zones of Asia, Africa and Australia

Asia : India, Bangladesh, Sri Lanka, Myanmar etc.

India : Dry / sandy localities of A P, Kerala, Karnataka, TN, MP , Chattisgarh, Orissa , Rajasthan etc. In India Tamilnadu is having major area and production under palmyra.

Botany

Somatic chromosome number 2n =2x =36 n= 18. Even multiples of triploid-6x,12x,24x,48x,96x etc are also seen. This endopolyploidy was due to the result of a type of division comparable to c-mitosis

Family:-Palmae

Species

1. *B. flabellifer* : India, Srilanka and S-E Asian countries
2. B. aethiopum : Africa
3. B. sundaica : Indonesia
4. B. delag : Sudan
5. B. heiniana : New Guinea
6. B. madagascariencis : Madagascar
7. B. machadenis : Malaysia

Genus Borassus consists of many spp. Of which 3 spp are important

- Borassus flabellifer- Asian palmyra
- Borassus aethiopum-African palmyra
- Borassus sundaica- Indonesian palmyra
- Morphology-It is a tall unbranched palm, grows up to 20-30mt height and consists of 20-30 leaves per crown which are palmate
- Inflorescence –dioecious palm. Sex can be differentiated only during the flowering (after 15-20 years). Inflorescence is a branched spadix has 5-10 branches each branch is sheathed by spathe. Each branch has 2-3 spikes. Each spike is 30-40cm long and has 800-1000spikelets with 12-20 small flowers per spikelet. Flowers open 16-25 days after opening of spathe pollen shedding is simultaneous with flower opening. Female spadix has 1 or 2 branches covered by spathe 30-75 female flower per spadix. Flowers are large with 3 petals, 3 sepals, 6 staminodes (rudimentary stamen), globose ovary and trifid stigma.
- Pollination –when flower open done throught out the day but maximum between 8-11 am. Pollinating agents are wind, insect. Fruit takes 4-5 months from fertilization to maturity.
- Fruit-Fleshy drupe weighing 1-3kg, Epicarp creamy when young turns black or pinkish yellow at maturity. Mesocarp fleshy and fibrous when young. Endocarp hard and gelatinous at young and hardens at maturity forming cavity at centre.

Breeding Objectives

The long gestation period coupled with dioeciousness made difficult it for using in breeding programmes. Even it requires lot of land for maintainance of genetic resources.

- Higher yield of padaneera
- Dwarf stature

- Off season flowering
- High sugar content

Germplasm Conservation

Tamil Nadu Agricultural University
Kallikulam - 173 and
Pandirimamidi -176

Varieties

In India, there is no recognized variety. But palmyrah palms growing in Sri Lanka can be broadly classified into 2 varieties based on pigmentation of fruit skin. They are black and red skinned fruits.

Black-skinned fruits have comparatively less red pigment on their skin. Red skinned fruits have variable amounts of black pigments along with very liberal distribution of red in their skin. Fruits and nut number per tree are significantly greater in this variety. But pulp weight per nut is less; sugar, starch and protein constitute 77%, 10% and 2.5% of the pulp respectively. The alkaloids, amino acids and minerals are in greater amount in red skinned varieties. The other favourable fruit features, along with the sap-yielding characteristics of these varieties, seem to favour selection of red-skinned fruit variety for commercial exploitation.

Crop Improvement

The yield of padaneer in 38 palms was recorded for 3 consecutive years from 1982 at Srivilliputhur Palmyrah Research Station, Tamil Nadu. Of the 38 palms studied, 36.33%, 34.2% and 28.93% yielded padaneer in 1, 2 and 3 out of 3 years considered. The samples of trees observed for 3 years together reveal that 68.4%, 36.82%, 31.56% and 5.26% of the palms are poor, low, moderate and good yielders respectively.

Screening for dwarf types is a very important objective in palmyrah breeding. With this objective, 213 palms were observed for their height, among the mature palms available at the Palmyrah Station Srivilliputhur, Tamil Nadu. Nearly 43.7% were semi-dwarf palms. These trees can be utilized in hybridization programme to evolve dwarf plants.The palms have been classified based on percentage of jaggery recorded for padaneer. A total of 43 palms were considered. Considering the criteria, plantation is screened and 16 (9 male and 7 female) palms have been identified as elite palms for higher content of jaggery.

Released Varieties

SVPR-1: Palmyrah research station, Srivaliputhur (TNAU) has released one improved variety namely SVPR-1 Palmyrah palm.

Features

- Semi-dwarf type
- High padaneer yield of 298 litres per palm in a tapping duration of 95 days.
- Quality of padaneer : The padaneer of this variety has a high jaggery content (144 g per litre of padaneer i.e., 14.40 %) and a high brix content

Seed: Sex ratio

The seed sex ratio (primary sex ratio) was estimated by germinating seeds and growing seedlings under favourable conditions with minimal mortality until flowering. Early sex determination was done to assess the seed sex ratio of one-, two- and three-seeded fruits with a male-specific random amplified polymorphic DNA marker. The seed sex ratio (M: F) of seedlings raised from one, two- and three-seeded fruits were 57: 43, 35: 65 and 61: 39 respectively. There was no correlation between the number of seeds in a fruit and sex of the seedlings raised from them. The overall percentage of M: F was 52: 48, which was almost 1: 1 ratio. While comparing the sex ratio of one-, two- and three-seeded fruits individually, the sex-ratio of two-seeded fruits was 0.350 with probability 0.263. This indicated a female-biased sex ratio (M: F) in two-seeded fruits 35: 65. So Sex-linked molecular marker is a useful tool to learn the seed sex ratio of such plants in juvenile stages.

Future thrust

For sex identification there is a wide scope for using molecular markers so that identification becomes easy for the cultivation.

As their exist a wide variation in plant morphological characters need to be exploited for the crop improvement and germplasm collections is specified for certain locality that need to be widen to different parts of the country which will results in the better adaption and also for the better crop improvement in the palm

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8. AGRONOMY

Cultivation Practices of Bamboo

Ebeenezar S[1], Akhila Jabeen P A[2]

SRM College of Agricultural Sciences, SRM Institute of Science and Technology, SRM Nagar 603 203, Chengalpattu 603 201, Tamil Nadu, India

Introduction

Bamboo is one of the commercially cultivated crops in India, belongs to Gramineae and it is considered as the "Poor Man's Timber". India ranks 2nd in bamboo production next to China. Bamboo can be used as a substitute for wood and it is a versatile, strong, renewable and eco-friendly material that is a faster-growing woody plant. There are more than 136 species in India but only some of them are commercially viable, Bambusa nutans, B.balcooa, B.tulda, Ochlandra travancorica, Melocanna bambusoides, Dendrocalamus giantess and brandishing etc. The bamboo yearly production is estimated at around 3.23 million tons. It is mainly used as construction material, furniture, pulp and plywood. India is very fortunate to be blessed with good bamboo resources. Moreover, bamboo shoots are consumed as food and are considered a good source of nutrition. The northeastern states are the major bamboo producing states in the country.

Climate and Soil requirements

The bamboo plantation grows well in tropical hot to warm climatic conditions. However, it does not prefer a temperature under 15 °C in summer, since the bamboo has shallow (thin) roots. The bamboo growth is affected in the areas of cold wind regions because wind kills the tip of the bamboo leaves.

Bamboo can be grown in all types of soil but the depth of the soil should be 2 feet except in seashore and rocky regions. Bamboo plantation requires well-drained soil – clay soil and pH range from 4.5-6.0. Generally, sandy loams to loamy clay soil are suitable for the cultivation of bamboo. Annual temperature ranges from 8.8 – 36 °C and annual rainfall 1270 - 4050 mm. Bamboo can survive in frost during winter and is generally grown in 0 – 4000 m.MSL, however, 500 m is best for suitable bamboo cultivation.

Spacing and Intercropping In bamboo cultivation closely grown clumps create congestion and there will be less space for the intercultural operations, so 5×5 – 7×7 m spacing is followed for commercially bamboo species and the large clump species like D.giganteus 10×10 m spacing is practised. The average density of bamboo production is 200 plants/acre.

In bamboo plantations the gestation period is 5 years in between these periods some crops can be grown as an intercrop like turmeric, ginger, chillies and aromatic, medicinal or shade-loving plants. It can be practised for the first three years and increase the additional income to the producer.

Propagation and Planting material

For the establishment of a commercial bamboo plantation, the area should be cleared and ploughed. Bamboo can be propagated through clumps, Rhizomes or Seeds, but seeds are very rarely used for propagation. The

propagules are collected during the late part of February – May 1st part, just before the emergence of new clumps and delayed collection leads to the failure of plantations. The Bamboo seedlings are raised in a nursery bed and allowed to grow in poly pots for one year and then transferred to the main field. In the case of Rhizome planting, extra care is needed. Here one-year aged clumps along with roots should be dug and cut into 1 m in height size and planted in the rainy season. For Rhizomes and offsets, the size is 50×50×50 cm and 30×30×30 cm for seedlings or rooted cuttings.

Manuring and Irrigation requirement

Since the bamboos are heavy feeders, even the rich soil will be depleted in two to three years, if the fertilizers are not applied externally. It is recommended to apply fertilizer before Irrigation and after harvesting. Nitrogen and Potassium are the major compounds of fertilizers to which the bamboos respond well. The fertilizer can be given around the year in small quantities because the bamboo Rhizomes undergo continuous development except during the coldest part of the year. Green manures, vermicompost and ash can also be applied, the lime is applied @ 300-400 kg/acre to neutralize the acidity.

Frequent Irrigation is required while bamboos are in the nursery. One Irrigation is immediately given after transplanting, the plant should not suffer prolonged drought during the first year. In the first month after planting Irrigation should be given @ 2-3 days intervals. As bamboos are sensitive to logging make sure to drain out the soil incase of heavy rain or flooding, subsequent Irrigation should be given depending upon the climatic conditions. The drip Irrigation system can also be adopted for better utilization of water.

Weeding and Pest, Disease management

Regular and frequent Weeding is necessary for the first year, hand weeding and hoeing are carried out in weed control operations. Mulching the soil for 20 cm and 2 m diameter in a transplanted bamboo plantation will help control the weeds and retain the soil moisture.

Leaf biting and sucking insects are the common pests in young bamboo plantations, main diseases in bamboo are Fusarium moniliforme, var. intermedium, F.equiseti and culms blight which affects about 24 sp of bamboos especially in Kerala. Proper management practices should be taken at the initial stages. Thinning and pruning being practised to remove the malformed and damaged culms to ensure production without congestion.

Harvesting

In bamboo, the harvest can be done after 4 - 6 years of planting. Once the bamboo reaches the productive stage, proper harvesting techniques and schedules should be followed. The culms that are 4 years old should be harvested during November-January. In the 1st harvest 6th year 6 culms/clump can be harvested and 9 culms in the 9th year. The annual yield will depend upon the species and climatic conditions. An average yield is 9 – 10 tons/acre.

Conclusion

Continuous supply of bamboo is a key to the growth and development of bamboo-based industrial sectors. The current bamboo demand for various purposes is estimated at around 26.69 tons as against the supply of 13.47 tons. So it is important to boost bamboo production by involving more farmers in it so that the farmer can get more income and it results in the rise of small scale industries, which helps to boost the Indian economy.

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9. PLANTATION, SPICE MEDICINAL AND AROMATIC CROPS

Medicinal Properties and Active Constituent of *Terminalia chebula*

Suman Tamang

Ph.D. Research Scholar Department of Plantation Crops and Processing, UBKV, Pundibari Cooch Behar West Bengal.

Introduction

Since the early days of civilization medicinal plants are used in treatment of different ailments. Traditional Indian system of medicines like Ayurveda, Unani and Siddha is mostly based on the use of medicinal plants. There are number of literature and ancient knowledge of these medicinal plants show their success for the treatment of different ailments. This increased use of herbal medicines in today's era is credited to the fact that these are obtained naturally and is reliable, cheap and have higher safety margins with very less reported side effects (Sharma, 2009). It is a popular traditional medicine. Its widely use in homeopathy and other traditional medicinal system because of its wide therapeutic activities associated with its biologically active chemical components present in the plants. It is not only used in India but also in other countries of Asia and Africa. The fruits of *terminalia chebula* possess various health benefits and have been used in traditional medicine. It is an important ingredient in one of the most popular Ayurvedic preparations (Triphala) together with *Terminalia chebula, Terrminalia bellerica* & *Emblica officianallis*. constitute the preparation called Triphala. Triphala has been described in ancient Ayurvedic text as Tridoshic rasayna, a therapeutic agent with balancing the rejuvenating effects on three humors or constitutional elements in Ayurveda vata, pitta and kapha (Chattopadhyay, 2007).

Habitat: The *Terminalia chebula* tree may grow at places about 2000m from sea level and in areas with an annual rainfall 100-150cm and temperature 0.17 degrees terminalia chebula is mainly found in Nepal, Sri Lanka, Myanmar, Bangladesh and in Pakistan, Tibet, apart from Asia it is also found in countries like Egypt, Turkey and Iran. In India terminalia chebula or haritaki tree grows in deciduous forests of Himachal Pradesh, Tamil Nadu, kerala, Karnataka, Uttar Pradesh, Andhra Pradesh, West Bengal, Sikkim (Fundter *et al,* 1992).

Botanical Description

Botanical Name: Terminalia chebula
Family: Combretaceae
Genus: Terminalia
Species: Chebula
English: Black Myrobalan
India: Shilikha, haritaki, hirdo, hamija, harad, alale, katukka, manali, hirda, karadha, har, katak-k-kay, karaka, harejarad.

Major constituents: In *Terminalia chebula*, the fundamental phytoconstituents in it are hydrolysable tannins (which may fluctuate from 32-34%) phytoconstituents present in *Terminalia chebula* steroids, amino acids, fructose, gums, fixed oils, anthraquinone, starches, glucose, sorbitol and so on the plant is genuinely wealthy in hydrolysable tannins. (Kumar, 2006), (Juang, 2004) stated that *Terminalia chebula* contain 14 components of hydrolysable tannins like gallic corrosive, chebulic corrosive, punicalagin, chebulanin, corilagin, neochebulinic, ellagic corrosive, chebulagic corrosive, 1,2,3,4,6-penta-orgalloyl-β-D-glucose, 1,6-di-o-galloyl-D-glucose and Terchebulin.

Medicinal properties: *Terminalia chebula* possesses several medicinal properties and health benefits Some of them includes

Traditional value	**It is extensively used in Ayurveda, siddha, unani and homeopathic medicines in India. It is a**

	top listed plant in Ayurvedic Materia medica for treatment of asthma, bleeding piles, sore throat, vomiting and gout. (Malik et al, 2012).
Urinary System	Useful in Urinary tract infection (UTI) & urinary tract disorders, consuming of 1 tea spoon of Haritaki powder with a little honey twice in a day morning & evening helpd to control diabetes.
Skin diseases	Haritaki, which is useful in the serious bacterial infection in skin and other skin ailments, prevents pus accumulation in skin diseases and functions as a antiaging. Oil of haritaki is extremely useful for wound healing, particularly when burning. It helps enhance the complexion of the face.
Respiratory System	Haritaki releases rhinitis, cough, voice hoarseness, hiccups and dyspnoea, wheezing, breathing trouble as it decreases congestion.
Anti-Bacterial properties	Antibacterial properties of haritaki shows actively against gram positive and gram-negative bacteria such as salmonella typhi, staphylococcus epidermidisis, pseudomonas aeruginosa, bacillus subtilis. Gallic acid and ethyl ester, these two antibacterial compounds have been isolated from ethyl extract of *terminalia chebula* fruit. *Terminalia chebula* fruit extract had strong antibacterial activity against intestinal bacteria, clostridium perfringens and E. coli. Ethanol extract is effective against salmonella typhi, staphylococcus aureus, bacillus subtilis. Ether, alcoholic and aqueous extract has potent activity against helicobacter pylori (Kannan, 2009)
Anti-fungal properties	Aqueous extract of the plant shows antifungal activity against a number of dermatophyte and yeasts. The alcoholic ethyle acetate extract shows the activity against Aspergillus niger, aspergillus flavus, alternate. 70% of methanol ethylacetate, hexane, chloroform extract shows activity against fusarium oxysporum, phytopthora capsici, fusarium solani etc (Dutta,1998), (Mehmood, 1999).
Wound healing property	Topical application of alcoholic extract of the leaves of Terminalia chebula caused much faster healing of rat dermal wounds.

Conclusion

There are several evidences from literatures on the medicinal properties of *Terminalia chebula* such as Ayurveda, siddha, Unani in traditional system of medicines in India has reported the high therapeutic value. Terminalia chebula consists a several phytochemical or active constituents which are found to be associated with the plant extract that include mainly chebulic acid, gallic corrosive, chebulic corrosive, punicalagin, chebulanin, corilagin, neochebulinic, ellagic corrosive, chebulagic corrosive etc. All these compounds are found to be responsible for many of pharmacological activities. Terminalia chebula is an important herbal drug as it is used for treating many diseases.

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10. AGRICULTURAL SCIENCE

Moringa: The Herbal Green Gold to Combat Malnutrition

Pandidurai G [1], Aasif M [2] and Muruli N V [3]

[1, 3] Department of food science and nutrition, [2] Department of Agronomy, Research scholars
Tamil Nadu Agricultural University

Introduction

Moringa oleifera is the most widely cultivated pan-tropical species of a monogeneric family, the *Moringaceae*, which is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. *Moringa oleifera* is known by such regional names as benzolive, drumstick tree, kelor, marango, mlonge, mulangay, nébéday, saijhan, and sajna. The history of Moringa dates back to 150 B.C. Historical proofs reveal that ancient kings and queens used Moringa leaves and fruit in their diet to maintain mental alertness and healthy skin. There are 13 varieties of Moringa.

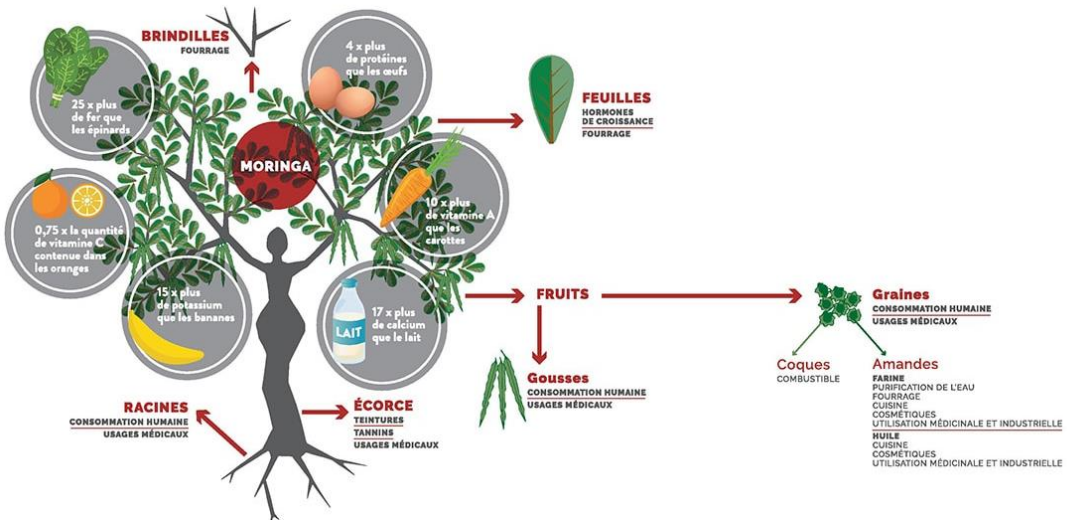
Moringa as a nutrient source

In developing tropical countries, Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers. The pods are extremely nutritious, containing all the essential amino acids along with many vitamins and other nutrients. The immature pod can be eaten raw or prepared like green peas or green beans, while the mature pods are usually fried and possess a peanut-like flavor. The pods also yield 38 to 40% of non-drying, edible oil known as Ben Oil. This oil is clear, sweet and odorless, and never becomes rancid. Overall, its nutritional value most closely resembles olive oil. The thickened root is used as a substitute for horseradish although this is now discouraged as it contains alkaloids, especially moriginine, and a bactericide, spirochin, both of which can prove fatal following ingestion. The leaves are eaten as greens, in salads, in vegetable curries, as pickles and for seasoning. They can be pounded up and used for scrubbing utensils and for cleaning walls. Leaves and young branches are relished by livestock. The Bark can be used for tanning and also yields a coarse fiber. The flowers, which must be cooked, are eaten either mixed with other foods or fried in batter and have been shown to be rich in potassium and calcium.

Treating malnutrition with Moringa

Ideally, good nutrition should be assured by

a varied diet rich in meat, root, grain, fruit and vegetable foods. In reality, for a majority of the world's population such variety in food is unaffordable or seasonally unavailable. Malnutrition is frequently characterized by this kind of restricted diet wherein a child consumes the same weaning pap every day. In this context, Moringa is a very simple and readily available solution to the problem of malnutrition. The edible leaves of the Moringa oleifera tree are already an occasional food source throughout West Africa and other regions of the tropics and sub-tropics. Micronutrient deficiencies are now recognized as an important contributor to the global burden of disease. Iodine deficiency in pregnancy has long been linked to intra-uterine brain damage and possible fetal wastage. Currently, although more than two billion people live in areas that used to be iodine-deficient, it is estimated that iodine deficiency is the cause of only 0.2% of the global burden of disease. Iron deficiency also affects about two billion people. Recent estimates find that iron deficiency anemia is responsible for one fifth of early neonatal mortality and one tenth of maternal mortality. Iron deficiency also reduces cognitive development and work performance.



Iron deficiency is the cause of about 800,000 deaths and 2.4% of the global burden of disease. Childhood and maternal mortality. Globally, 21% of children have VAD and suffer increased rates of death from diarrhea, measles, and malaria. The importance of zinc deficiency is being increasingly recognized. Trials have shown that zinc supplementation results in improved growth in children, lower rates of diarrhea, malaria, and pneumonia, and reduced child mortality. In total about 800,000 child deaths per year are attributable to zinc deficiency. Zinc deficiency is the cause of 1.9% of global burden of disease. According to WHO, 19% of the 10.8 million child deaths globally a year are attributable to iodine, iron, vitamin A, and zinc deficiencies. Recent estimates indicate that fortification or supplementation with iron, vitamin A, and zinc are among the most cost-effective interventions available, even in areas that are poor or have high HIV infection rates.

The advantages of using Moringa in malnutrition prevention programs

It is a drought-resistant and fast growing tree which is present in nearly all tropical and sub-tropical countries. Its edible leaves are already an occasional food source in West Africa regions and appear at the end of the dry season: a time when other greens are in short supply. As a source of good nutrition, its leaves are considered the best of tropical legumes with its high quantities of vitamin A and significant quantities of vitamin C, calcium, iron, protein, potassium, magnesium, selenium, zinc and a good balance of all the essential amino acids. Also, the leaves can be easily dried into powder form for use as a

nutritional supplement for sauces or as an addition to infant weaning foods. Moringa leaves can be produced intensively in a family-size small garden. The seeds can be spaced as closely as 10 cm apart. When the plants reach a height of a meter, they can be cut down to a height of 30 cm. The leaves can be stripped from the stems and used to prepared sauces or dried for long-term storage as a nutritious food additive, and the stems fed to livestock. The stumps survive the harvest and will re-sprout, allowing another harvest in as little as 50 days. Using this technique, a Moringa garden can continually produce green matter for several years with very little labor required.

Conclusion

The Moringa Oleifera plant is the most inexpensive and credible alternative to providing good nutrition. Moringa oleifera is the most nutrient-rich plant yet discovered. Not only is the Moringa oleifera tree extraordinary in that all parts of the tree are edible, but the most amazing aspect of the tree is its exceptionally high nutritional value. Moringa provides a rich and rare combination of nutrients, amino acids, antioxidants, anti-aging and -inflammatory properties used for nutrition and healing. The leaves of the Moringa tree are an excellent source of vitamin A (four times the amount in carrots), the raw leaves are rich in vitamin C (seven times the amount in oranges), and they are also a good source of vitamin B and other minerals. The leaves are also an outstanding source of calcium (four times the amount in milk), protein (twice the amount in milk), and potassium (three time the amount in bananas). The content of iron is very good as well and the leaves have purportedly been used for treating anemia in the Philippines. The content of amino acids such as methionine and cystine is also high. Carbohydrates, fats and phosphorous content are low making this one of the finest plant foods to be found.

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11. AGRICULTURAL SCIENCE

Nutritional and Therapeutic Uses of Green Gram [*vigna radiata* (L.) A Potential Interventional Dietary Component

Pandidurai G [1], Aasif M [2] and Muruli N V [3]

[1, 3] Department of food science and nutrition, [2] Department of Agronomy, Research scholars,Tamil Nadu Agricultural University

Introduction

In recent years, there is a sharp rise in the incidence of a variety of lifestyle disorders. Certain conditions such as cardio vascular diseases, diabetes mellitus etc. are threatening lives and have turned out to be major causes of death. Prevention of occurrence of such diseases has been a major global concern. Green gram, a principle pulse used as a daily food article, exhibits a potential to act against this. In this regard, Ayurveda recommends its use in daily diet and modern research also directs towards the same recommendation.

Green gram - An Ayurvedic Perspective

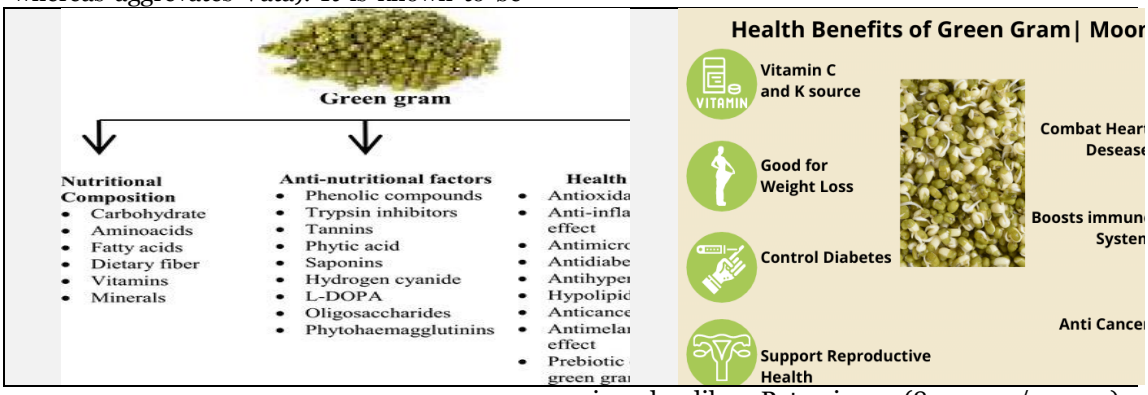
The word Green gram (Mung bean) in Sanskrit means "that which brings joy, delight and gladness". 1 All the pulses are known to produce flatulence with an exception of Mung bean. This property makes Mung bean complementary to health. There are evidences to show that Mung bean was used as a measurement parameter in Ayurvedic practice. It

has been used to explain the size of a mass of haemorrhoids. 2. It has been also referred to, in determining the outlet lumen of an enema nozzle for children. 3. (Used in basti or enema therapy) or a horn used in bloodletting therapy. 4. Further Mung bean has been used as a reference to describe the shapes of lesions of certain skin diseases [for e.g., Ajagallika. 5. (Diaper dermatitis), Upadamsha. 6.(Chancroid) and Masurika. 7. (Measles)]. These evidences show the familiarity of Mung bean to people at large.

In Ayurveda, the pharmacokinetics and pharmacodynamics of a drug are explained in terms of certain attributes viz., Rasa (Taste of the drug), Guna (Properties and effect it has on the body following consumption), Veerya (Potency of the drug, whether it has a catabolic or anabolic effect on the body), Vipaka (Post digestive effect on metabolism). Based on the above, the probable action of the drug can be understood in terms of its effect on the Doshas (Bioforces governing the body whose balance and imbalance determines health and ill health). The pharmacodynamics of mung in Ayurveda has been explained to be that as Madhura (Sweet) and Kashaya8 (astringent) in taste, Laghu8 (light for digestion), ruksha (Dry), sheetaveerya (cold in potency), katu vipaka8 (post digestive transformation into pungency) and it exhibits Kaphapittahara Vatakaratva 8 (pacifies kapha and pitta whereas aggrevates Vata). It is known to be drushtiprasadaka9 (improves quality of vision).

Botanical Illustration of Mung Bean

The mung bean (Vigna radiata) is a member of the legume family Fabaceae and commonly called as green gram (Figure 1). Mungbean originated in the plains of Peninsular India with its botanical origin, area of maximum genetic diversity and location of domestication being South India. 13 Mung bean is an annual, deep rooted herb, 25-100 cm tall with trifoliate leaves and short fine brownish hairs on the stem branches. Planted in early June, the crop begins to flower in 50 to 60 days which continues for few weeks and is ready to be harvested in early to mid-September. The matured pods are glabrous and consist of 8-20 globose seeds per pod. 14 Green gram is cultivated in several countries of Asia, Africa and the America. It grows best at an altitude of 0-1600 m above sea level and under warm climatic conditions (28-30°C). They are well adapted to red sandy loam soils and are drought tolerant giving reasonable yields with as little as 650 mm of yearly rainfall. Heavy rainfall results in increased vegetative growth with reduced pod setting and development. 15 The most important part of mungbean is the seed used in several food products, both as whole seed and in processed form. Like most legumes they are relatively high in proteins, around 25 % of the seed weight. The principal domestic use of mungbean is the production of bean sprouts which is seen commonly in Asian cooking and is used for dhals and soups.



Nutritional Facts of Mung bean

Green gram is known for its high nutritional value. 100 g of it produces 334 Kcal of energy. 17 It is rich in carbohydrates (56.7 g/100 g) and is a very good source for minerals like Potassium (843 mg/100 g), Magnesium (127 mg/100 g), Calcium (124 mg/100 g), Phosphorus (326 mg/100 g) and Iron (4.4 mg/100 g). Vitamins like Carotene, Thiamine, Niacin, Riboflavin, Ascorbic acid and

Folic acid are also present in Mung. It is considered one of the best sources for proteins and constitutes a number of essential amino acids such as Arginine, Histidine, Lysine, Tryptophan, Phenylalanine, Leucine, Isoleucine, Tyrosine, Valine, Threonine, Cystine and Methionine. Mung hence is considered to be a substantive source of dietary proteins and carbohydrates. Mung bean provides significant amounts of dietary iron to plant based diets in developing countries where Mung bean is consumed. 18 Certain chemical components such as flavanoids (Flavones, isoflavones and isoflavonoids), phenolic acids (Gallic acid, Vanillic acid, Caffeic acid, Cinnamic acid, protocatechuic acid, Shikimic acid, p-hydroxybenzoic acid etc), and organic acids isolated from Mung in recent years, supports its health promoting action as mentioned in the classics.

Mode of Action of Mung bean as per Ayurveda (Pharmacological Effects)

This property makes it a highly beneficial candidate for daily diet in the present scenario where in numerous lifestyle disorders are affecting people worldwide. Cardio vascular diseases and allied conditions (causal and risk factors) like Diabetes mellitus, Obesity, Dyslipidemia are leading threats to mankind globally. Dietary supplementation both preventive and supportive can help in combating these and usage of Green gram as staple will account for a valuable step. Mungbeans have been tested for several pharmacological activities worldwide. The Mung bean extracts were also found to have a potent scavenging activity against pro-oxidant species, including reactive oxygen species and reactive nitrogen species as well as an inhibitory effect on low-density lipoprotein oxidation. Regular consumption of Mung beans can regulate flora of entero bacteria, decrease absorption of toxic substances, reduce risk of hypercholestraemia and coronary heart disease, and prevent cancer.

Mung bean protein isolates improved the plasma lipid profile by normalizing insulin sensitivity and significantly reduced plasma triglyceride level. Mung bean (*Vigna radiata*) has been traditionally used in China both as nutritional food and herbal medicine against a number of inflammatory conditions since the 1050s. This when experimentally tested showed that Mung bean extract is protective against lethal sepsis by stimulating autophagic HMGB1 degradation. In the ant glycation assays, vitexin and isovitexin showed significant inhibitory activities against the formation of Advanced Glycation end products induced by glucose or methylglyoxal with efficacies of over 85 %. . It was found that the Mung extracts lowered blood glucose, plasma C-peptide, glucagon, total cholesterol, triglyceride, and BUN levels and at the same time markedly improved glucose tolerance and increased insulin immunoreactive levels suggesting a potent antidiabetic effect. 28 The above mentioned researches establish the potential of Mung bean in preventing the occurrence of certain chronic and life threatening disease conditions on daily consumption and also as a therapy in several diseased conditions.

Conclusion

Mung bean or *V. radiata,* one of the most commonly used components of Indian cuisine, is mentioned as the best among Shimbidhanyas (legumes) in Ayurveda. It is mentioned in both treatment and dietary aspects of life threatening conditions like cardiovascular diseases. Some of the researches of recent years have provided evidence on the validity and authenticity of the classical viewpoints about Mung bean. Hence Mung bean can be considered a potential interventional diet in lifestyle disorders. Further research is necessary for better understanding about Mung bean so as to throw more light on its pharmacological efficacy.

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12. SOIL SCIENCE

Nano Urea- An Efficient Source for Nitrogen Supplement

A. Premalatha[1] and S. Saravanakumar[2]

[1]Scientist (Soil Science), [2]Scientist (Agronomy), ICAR – Krishi Vigyan Kendra, MYRADA, Gobichettipalayam, Erode District, Tamilnadu

Background

Nitrogen (N) is the essential macronutrient needed for crop growth. Generally, Nitrogen is applied in the form of Urea. It contains 46 % of Nitrogen and accounts for >82% of the nitrogenous fertilizer applied to the crops. Globally 188 MT of urea is applied to crops every year. Excessive use of Urea causes environmental issues and deterioration of soil health. Nano urea therefore, stands as a promising, sustainable and environmental friendly solution to conventional bulk nitrogenous fertilizers like Urea. This nanofertilizer has been developed indigenously, for the first time in the world at IFFCO - Nano Biotechnology Research Centre (NBRC) Kalol, Gujarat through a proprietary patented technology.

Liquid Nano Urea

Nano Urea (Liquid) is a source of nitrogen which is a major essential nutrient required for proper growth and development of a plant. Nitrogen is a key constituent of amino acids, enzymes, genetic materials, photosynthetic pigments and energy transfer compounds in a plant. Typically, nitrogen content in a healthy plant is in the range of 1.5 to 4%. Foliar application of Nano Urea (Liquid) at critical crop growth stages of a plant effectively fulfils its nitrogen requirement and leads to higher crop productivity and quality in comparison to conventional urea. Application of 1 bottle of Nano Urea can effectively replace at least 1 bag of Urea. It has been tested on more than 90 crops across 11,000 locations in collaboration with ICAR-KVKs, Research Institutes, State Agriculture Universities and progressive farmers of India. When sprayed on leaves, Nano Urea easily enters through stomata and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from source to sink inside the plant as per its need. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant.

Properties of Nano Urea (Liquid)

It contains 4.0 % total nitrogen (w/v) evenly dispersed in water. Nano nitrogen particles size varies from 20-50 nm.

Rate, Time & Method of Application

- Mix 2 to 4 ml of Nano urea in one Litre of water and spray on crop leaves at active growth stages.
- When sprayed on the leaves initially it gets absorbed easily and also enters through stomata and other pores. It is translocated and metabolically assimilated as proteins, amino acids as per the plant's need
- For best results apply 2 foliar sprays* –
    - 1st spray at active tillering / branching stage (30-35 Days after Germination or 20-25 Days after Transplanting)
    - 2nd spray 20-25 days after 1st spray or before flowering in the crop.

Note– Don't cut nitrogen applied through DAP or complex fertilizer at the basal stage. Reduce only top dressed Urea applied in 2-3 splits; Number of sprays of Nano Urea can be increased depending upon crop and its nitrogen requirement

Application Instructions

1. Shake well the bottle before use
2. Use flat fan or cut nozzles for spraying on the leaves.
3. Spray during morning or evening hours avoiding dew.
4. If rain occurs within 12 hours of the spray of Nano urea, it is advised to repeat the spray.
5. Nano Urea can easily be mixed with biostimulants, 100 % water-soluble fertilizers and agrochemicals. It is always advised to go for a jar test before mixing and spraying for compatibility.
6. For better result Nano urea should be used within 2 years from the date of its manufacturing

Benefits of Liquid Nano Urea

- It effectively fulfills crop nitrogen requirement, increases leaf photosynthesis, root biomass, effective tillers & branches
- Enhances Farmer's income by an increase in crop productivity and reduction in input cost
- Because of higher efficiency, it can reduce the requirement of conventional Urea by 50 % or more
- Farmers can easily store or handle one bottle (500 ml) of Nano Urea
- It helps conserve soil, air and water quality
- Nano urea will help in improving soil health, improving aquatic life, reduces nitrate leaching losses and improves groundwater quality

Safety & Precaution Measures

Nano-Urea has been tested for biosafety and toxicity as per the guidelines of the Department of Biotechnology (DBT), Government of India and OECD international guidelines. Nano urea is safe for the user; safe for flora and fauna and is non-toxic, however, it is recommended to use a face mask and gloves while spraying on the crop. Store in a dry place avoiding high temperature and keep away from the reach of children and pets.

13. AGRICULTURAL EXTENSION

Zero Budget Natural Farming: System to reduce Farming Expenses

Peddi Naga Harsha Vardhan*

Research Scholar, Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal-736165.

Introduction

Indian agriculture need to reduce dependence on chemical fertilisers and should adopt chemical free agriculture. According to National Sample Survey Office (NSSO) data, almost 70% of agricultural households spend

more than they earn and more than half of all farmers are in debt. Privatized seeds, inputs, and markets are inaccessible and expensive for peasants. Indian farmers increasingly find themselves in a vicious cycle of debt, because of the high production costs, high interest rates for credit, the volatile market prices of crops, the rising costs of fossil fuel based inputs, and private seeds. In order to achieve the Central government's promise to double farmers income by 2022, one aspect being considered is natural farming methods such as the ZBNF which reduce farmers' dependence on loans to purchase inputs which they cannot afford. Under such conditions, 'zero budget' farming promises to end a reliance on loans and drastically cut production costs, ending the debt cycle for desperate farmers. Zero budget natural farming (ZBNF) is a method of chemical-free agriculture drawing from traditional Indian practices. Because of continuous incorporation of organic residues and replenishment of soil fertility this helps to maintain the soil health (Manish and Aksash, 2021). Zero-Budget Natural Farming (ZBNF) is a holistic alternative to the current concept of high-cost chemical inputs based agriculture (Manida, 2021). Zero Budget Natural Farming (ZBNF) is a set of farming methods, and also a grassroots peasant movement, which has spread to various states in India.

It was originally promoted by Padma Shri recipient Subhash Palekar, who developed it as an alternative to the Green Revolution methods driven by chemical fertilizers and pesticides and intensive irrigation. He argued that the rising cost of these external inputs was a leading cause of indebtedness and suicide among farmers. Without the need to spend money on these inputs cost of production could be reduced and farming made into a "zero budget"with the help of ZBNF. Mr. Palekar is also against vermicomposting, as it introduces the most common composting worm, the European red wiggler (*Eisenia fetida*) to Indian soils. He claims these worms absorb toxic metals and poison groundwater and soil. Organic farming is being promoted under the national programme of Paramparagat Krishi Vikas Yojana (PKVY) through farmer groups. Viability of organic farming is becoming a problem due to absence of input availability and output markets. It is argued that organic farming is suitable only for horticultural crops (Guruva et al., 2019). ZBNF farmers were growing more fruits and vegetables as their main kharif crop compared to their counterparts(Niti et al., 2020**)**

Instead of commercial chemicals inputs, the ZBNF promotes the application of following Bio-fertilizers (Biswas, 2020)

Jivamrita/Jeevamrutha: It is a kind of bio-fertilizer which adds nutrients to the soil for plants' uptake.

Preparation: In 200 litres of water 10 kg fresh local Indian bred cow dung and 5-10 litres of aged cow urine were added. Then, 2 kg each of jaggery and pulse flour and a fist of soil from chemical less area are added in to it and mixed thoroughly. Mixture should be kept in shade for 48 hours for fermentation.

Application: Soil application of 200 litres of Jivamrita/Jeevamrutha in irrigation water for 1 acre of land twice a month or foliar application of 10% solution.

Bijamrita/Beejamrutha: used as a treating the seed/seedling/planting material to reduce mortality rate and ensure good or vigorous crop stand on the field by checking various seed and soil borne diseases of younger seedlings.

Preparation: It is prepared same as Jivamrita/Jeevamrutha (local Indian bred cow dung and urine, lime, water and soil). Specifically, 5 litres of urine and 5 kg of dung of local Indian bred cow are put inside a container containing 20 litres of water. 50 g of lime and a fist of native soil are then added into it and thoroughly mixed.

Application: Coating and mixing the seeds by hand or leguminous seed dipping in Bijamrita/Beejamrutha solution followed by drying in shade and sowing.

Acchadana/Mulching: Protects the top soil from erosion. And also improves soil aeration and conserves soil moisture by checking evaporation water loss. Weed emergence can also be checked through mulching to some extent.

Types: Three types of mulching are used viz.

- Soil mulch (friable soil/dust coverage on top soil)

- straw mulch (dried resides of previous crops, dead materials of plants and/or animals) and
- Live mulch (symbiotic mixed or intercrops preferably with monocot and dicot such as cereal-legume cropping).

Application: Application of soil or straw mulch before sowing the seeds or sowing (cultivation) of crops to cover land spaces (live mulch).

Whapasa/Moisture: Focuses on improving water use efficiency by reducing the quantity and frequency of irrigation water applied as only a limited amount of water is needed (in form of vapour) for the crop growth. Therefore, it provides resilience from drought. Ideal situation to mix up of air and water molecules renders suitable soil aeration and reduces 90% water use which is helpful in rain fed agriculture.

Application: Irrigation during noon in alternate furrows to make air and water molecules to remain in soil.

For Plant protection following Bio pesticides was used

Bio-pesticides (*Neemastra*, *Agniastra, Bramhastra* etc.) were used which were made through natural or organic or bio-products. These bio pesticides are only permitted to use during the times of pest and disease outbreaks to protect the plants to reach economic injury levels.

Neemastra: Effective towards sucking insects, mealy bugs etc.

Composition: Indian breed cow urine (5lt) + Cow dung(5kg)= Neem leaves and pulp extracts (5kg) and ermented for 24hrs.

Bramhastra: Effective towards sucking pests, pod borer, fruit borer etc.

Composition: Neem leaves, Guava leaves, Papaya leaves, Custard leaves, Pomegranate leaves, White Dhatura leaves and *Lantana camara* leaves (crushed and boiled in Indian breed cow urine).

Agniastra: Effective towards Leaf roller, stem borer, pod borer, fruit borer etc.

Composition: Indian breed cow urine (5lt) + Tobacco leaf (1kg) + Garlic (500g) + Green chilli (500g) + Urine soaked neem leaves and pulp extracts (5kg).

Importance

- Reduces the farming costs by reducing dependency on chemical fertilizer, pesticides, etc., which are leading causes of indebtedness and suicide among farmers.
- Cost of production will be reduced and farming made into a "zero budget" exercise.
- Helpful in fighting against the impact of chemicals on the environment.
- ZBNF eliminates usage of chemical pesticides.
- Promotes good agronomic practices and improves soil conservation, seed diversity and quality of produce.

Conclusion

As a result of ZBNF farmers cost of production can be reduced because farmers need not to spend any amount on commercial chemicals and fertilizers. And farmers can be free from Loans and high interests this helps farmers to increase their income. Because the use of bio fertilizers and bio pesticides soil health can also be maintained.

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14. HORTICULTURE

Nyctanthes: Night Flowering Jasmine

Mahesh Reddy D.[1]

[1]*M.Sc. (Horti) Department of Floriculture and Landscape Architecture, CAU, Imphal.*

Nyctanthes is a small tree, growing to a height of 10 meters. The bark is rough flaky and grey. The plant native to Southern Asia, including habitats in Pakistan and Nepal. Northern India and Southern Thailand are also good places to look for it. The plant can be found growing as undergrowth in dry deciduous forests and on rocky soils in dry slopes. It grows in the outer Himalayas and on tracts of Jammu and Kashmir, Nepal, East Assam, Bengal, Tripura, and the Central area up to the Godavari in the south in India. The ideal conditions for their successful cultivation are warm summer and mild winter with ample water supply. It is well suited for rich sandy loam to clay soils and also grows in all types of soils with soil pH of 6.6 to 7.5 is good for more flower production.

Botanical Name	*Nyctanthes arbor-tritis*
Kingdom	Plantae
Order	Lamiale
Family	Oleaceae
Genus	*Nyctanthes*
Species	*arbor-tritis*

Other common names include Coral jasmine, Night jasmine in English, Harshinghar, Sihau, Seoli in Hindi,Parijata, Parijath, Sephalika in Sanskrit, Jayaparvati, Parijatak in Gujarati, Sephalika, Seoli in Bengali, Manjhapu, Pavala-malligai in Tamil, Kapilangadustu, Pagadamalle, Parijat in Telugu.

The leaves are opposite, oval or acuminate, and have an entire or serrated edge. Petioles are lengthy and hairy, measuring 5-7 to 7.7-10 mm in length and with an axial concavity. The venation is reticulate and unicostate. The lamina is elliptical in shape, with a pointed or acute apex. With thin, hairy, and short trichotomous cymes, the flowers are modest and fragrant. Calyx 6-8 mm long, narrowly campanulate, bracts broadly oval 6-10 mm long, apiculate, hairy on both sides. The corolla tube is orange in colour, and the corolla is glabrous. The fruits are heart-shaped, flat, brown, and have two portions, each with a solitary seed. It thrives on loamy soil. The seeds are exalbuminous, compact, and have thick testa. The outer layer is big, translucent, and has a lot of blood vessels.

Nyctanthes is planted in home gardens, in religious place for the numerous scented flowers which fall off and form a white carpet on the surface in the morning. It is popularly known as the 'Tree of sadness' because it blooms only at night. The flowers open toward the evening and drop off in the early morning; the area beneath the tree then gets covered with flowers. The flowers are used in the preparation of a dye. Flowers contain modified diterpenoid nyctanthin, flavonoids, anthocyanins and an essential oil. The orange tubular calyx of the flower contains carotenoids. Nyctanthine, an alkaloid found in Nyctanthes leaves. Seed kernels yield 12-16% of the pale-yellow brown fixed oil, which consists of glucosides of linoleic, oleic, lignoceric, stearic, palmitic acid and b-sitosterol.

Medicinal value

Besides, being an ornamental plant, valuable source of several unique products for the medicines against various diseases.

- The juice of the leaves is used as a digestive aid, a reptile venom antidote, a tonic, a laxative, a diuretic, and a diuretic.
- The powdered stem bark is used for treatment of rheumatic joints pain, malaria and also used as an expectorant.
- The flowers are bitter in taste and used as astringent, ophthalmic, stomachic and carminative.
- Leaves and stems are the potential source of natural antioxidants.
- Flowers are used in dyspepsia, flatulence, graying of hair and

baldness, astringent, stomachic, ophthalmic, gout treatment.

- Seed are used for treatment of Piles, baldness, scurvy and hair tonic.
- Oil from the leaves, seeds and bark possesses a wide spectrum of antibacterial action against gram negative and gram-positive microorganisms.
- Dry cough: Take the leaf juice with honey.
- Skin problems: Special herbal oil prepared by boiling fresh leaves in mustard oil is used.
- The leaf juice given with honey and sugar and mixed with common salt is used in treatment of intestinal worms mainly in children.
- The decoction of seeds is used as hair tonic and to get rid from dandruff and lice.
- Decoction of roots is used in enlargement of spleen.

Growing it in Nursery

The seed heads need to be dried on the plants to remove and collect seeds. Seedlings raised in April are transplanted in May/June. It grows to a height of 2 m by August and flowering starts in September/October of the same year. National Botanical Research Institute, Lucknow have been propagated by budding also practiced.

Planting Method: Pits of 45-90 cm3 are prepared depending on the type of soil and are exposed for a week. The pit is filled with top soil after mixing with about 10-15 kg of well rotten farmyard manure or compost and then watered to settle down the soil properly. Rainy season is best time for planting.

Spacing : They are planted at spacings of 8-10 ft. (2.4-3 m), 10-12 ft (3.3 – 4 m) and closer spacing of $2 \times 1.5 m^2$.

Intercultural operations: Proper training and pruning are necessary in order to make it grow in to a good shape. If not pruned regularly, it grows into a small tree. Pruning should be done in the last week of January.

Flowering: Flowering occurs in Late spring / early summer / mild summer / late summer.

Harvesting : The flowers are harvested when they are fully open. After harvesting, the flowers are packed in small and big bamboo baskets. The shrub bears a rich crop of flowers from September to November. The long woody branches are cut completely after the flowering is over if a bustier shape is required. Generally, the heading back is done to a height varying from 90-120 cm after the flowering is over.

Flower yield: A yield of 10-15 kg flowers / plant / year.

Pests and Diseases: Leaf blight is the severe disease in nyctanthes. Affected leaf margins show inward curling and become hard brittle. Spray Bavistin 0.1% a.i effectively controls the leaf blight.

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First figure shows nyctanthes plants the second shows its flowers and the third shows its seeds

15. AGRICULTURAL ECONOMICS

Labour Scarcity in Agriculture Sector: A Growing Challenge

Ashwini B C[1] and Bhavya A P[2]

[1]JRF, Department of Agricultural Economics, UAS, GKVK, Bangalore [2]Project Associate-I, ICAR-NIVEDI, Bangalore

Introduction

The importance of agriculture can never be over-stated. Although the share of agriculture in India's GDP has been declining, yet agriculture and its allied sectors like forestry and fishing (but not including mining and quarrying) contributes nearly 14% to India's GDP, accounts for about 11% of our exports, and supports half of our population's livelihood, besides also being the source of raw material for a large number of industries. Despite its declining relative share in GDP, several innovative steps and measures are being undertaken and the sector has done reasonably in the last few years. However, one of the major bottlenecks that has emerged and can become an insurmountable problem in the foreseeable future is the issue of shortage of agricultural labour (Anonymous, 2015).

Labor scarcity:

Even though India has the second largest man power in the world, all sectors of the economy have been affected by the scarcity of labour, the impact being felt more in the agricultural sector. Labourers constitute a vital input in agricultural production, but they are migrating to different parts of the country for earning a better livelihood, adding to the existing imbalance between labour demand and supply of labourers (Deshingkar, 2003).

The 2001 Census of India defined agricultural labour as any person who worked on another person's land only as labourer, without exercising any supervision in cultivation, for wage in cash or share such as share of produce (GOI, 2001). The portion of agricultural workers to the total workers has been declining over the years, while the corresponding ratio in the secondary and tertiary sectors is on the rise.

In 2011-12 out of the total workforce of 467 million, agriculture sector has constituted 228.3 million (48.9%). In agriculture, labour has remained very less productive as compared to other sectors. Worker's productivity in agriculture is growing at only 2.9 per cent, while in industry it is growing at comparatively higher growth rate of 6.7 per cent and in services at 5.3 per cent (Chand and Srivastava, 2014). Usually as an economy matures there is a movement of excess agricultural workers from low productivity agricultural sector to higher productivity sectors. Higher productivity implies higher wages in other sectors. So natural movement of workers take place, away from agriculture. Such shift should be coupled with technological advancement in the primary sector means adoption of lower labour intensive or higher capital intensive technology; otherwise agriculture productivity will be

affected.

Reasons for labour scarcity in agriculture

- Higher wages in other jobs available locally: Comparison of wages in farm and other sectors reveals that wages in other non-farm occupations are 15-20% higher than agricultural wages and industrial wages are 1.5 times higher than that of agricultural which clearly explains the preference for these sectors.
- Shifting to a regular / permanent job since agriculture job is seasonal: While the share of primary sector in rural employment reduced from 71 per cent to 64 per cent, the secondary sector gained more from this shift and its share went up from 15 per cent to 20 per cent, while a small increase was witnessed in the tertiary sector as well between 2005-06 and 2011-12.
- Migration to nearby city for higher wages
- Migration due to improvement in educational status
- Agriculture laboring is presumed to be a low esteem job
- Urbanization

Strategic options to address labour shortage

The problem of labour scarcity in agriculture has repercussions across states and needs to be addressed in order to contain its impact on the overall sector and the nation. A two pronged approach with respect to input factors and output factors has to be considered:

Input factors:

- Immediate Effect: Adopt techniques that can replace and/or reduce the requirement of human labour (Example: Farm mechanization, Seed technology, etc.).
- Long Term Effect: Increase returns from agriculture and arrest the migration of workforce from agriculture to other sectors (Example: Intensive farming, Sequential-cropping, etc.).

Output factors

- Agri-linkages factor (Example: Contract farming, Agricultural Co-operatives, etc.).

Conclusion:

The traditional belief of surplus agricultural labour, zero marginal productivity and opportunity cost of labour does not seems valid today. There has been a net reduction of 30.57 million agricultural labour from 2004-05 to 2011-12. Reasons for the labour scarcity are lesser remuneration in agricultural Sector, shifting to a permanent job in the non-farm sectors, this will lead to migration from rural to urban area. Impact can be seen in terms of changing cropping pattern, reduction in crop yield and cropping intensity, higher wages and higher cost of cultivation which is reflected in higher output prices thereby causing food inflation. So adequate measures to reduce labour requirement need to be taken up, otherwise productivity of farms may get affected and this may have spiraling effects on output prices, one of the mitigating measure is farm mechanization.

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16. PLANT PATHOLOGY

Cultivation Technology for Oyster Mushroom

Arjunsinh Rathava[1]. Dr. Vimal N. Patel[2]

[1.] Department of Plant Pathology. [2.] Department of Soil Science. College of Agriculture, AAU, Jabugam

'Oyster mushroom' or '*Dhingri*' as referred in India is a basidiomycetes and belongs to the genus '*Pleurotus*'. It is lignocellulolytic fungus that grows naturally in the temperate and tropical forest on dead, decaying wooden logs, sometimes on drying trunks of deciduous or coniferous woods. It can also grow on decaying organic matter. The fruit bodies of this mushroom are distinctly shell, fan or spatula shaped with different shades of white, cream, grey, yellow, pink or light brown depending upon the species. However, the color of the sporophores is extremely variable character influenced by the temperature, light intensity and nutrients present in the substrate. The name *Pleurotus* has its origin from Greek word, '*Pleuro*' means formed laterally or lateral position of the stalk or stem. The oyster mushroom is one of the most suitable fungal organism for producing protein rich food from various agro-wastes without composting.

This mushroom is cultivated in about 25 countries of far-east Asia, Europe and America. It is the 3rd largest cultivated mushroom in the world. The major producing countries are China, South Korea, Japan, Italy, Taiwan, Thailand and Philippines. At present, India produces annually 10,000 tons of this mushroom. It is popularly grown in the states of Odisha, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, Chhattisgarh and West Bengal and in the North Eastern States of Meghalaya, Tripura Manipur, Mizoram and Assam.

Mushroom are popular for their delicacy and flavored food value. It is well established fact that they are excellent source of vitamins and minerals. They also contain appreciable amounts of vitamins like Niacin and pantothenic acid, minerals such as calcium. Phosphorus and potassium and a fair quantity of iron. Folic acid which is of vital importance for treating anemic condition in the human body is available in large quantity. Their protein may be considered intermediate to that of animal and vegetables. Fresh mushroom contain about 80-90 % moisture, 3% protein, 0.3-0.4% fat and 1% minerals and vitamins. With the low carbohydrate and fat contents they constitute an ideal dish for diabetic patients.

The biology of oyster mushroom

Visually the basidiocarps or fruit bodies of an oyster mushroom have three distinct parts - a fleshy shell or spatula shaped cap (pileus), a short or long lateral or central stalk called stipe and long ridges and furrows underneath the pileus called gills or lamellae. The gills stretch from the edge of the cap down to the stalk and bear the spores. If a fruit body is kept on a paper directly (gills facing the paper) a dirty white or lilac deposition of powdery spores can be seen. The spore print color may be whitish, pinkish, lilac or grey. The spores are hyaline, smooth and cylindric. The spores are heterothallic and germinate very easily on any kind of mycological media and within 48-96 h whitish thread like colonies could be seen. The mycelium of most Pleurotus sp. is pure white in color. *P. cystidiosus* and *P. columbinus* forms coremia like stalked structures (asexual spores). Basidiospores on germination forms primary mycelium. Fusion between two compatible primary mycelia develops into secondary mycelium, which is having clamp connections and it is fertile. Primary mycelium is clamp less and non-fertile.

OYSTER MUSHROOM CULTIVATION

There are several *Pleurotus* spp., *viz.*, *P. ostreatus*, *P. flabellatus, P. sajor caju*, *P. florida* etc., well known for their delicacy and flavor. There species grow wild in the forests which can be cultivated in polythene, brick or stone houses.

Substrate preparation

Oyster mushroom can be grown on various substrates viz., paddy straw, maize stalks/cobs, vegetable plant residues etc. Since paddy straw is

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easily available and cheap, it is widely used. Paddy straw, should be fresh and well dried.

Soaking

Chop paddy straw into 3-5 cm pieces and soak in fresh water for 8-16 hours. If maize stalks/cobs are used, soaking period should be 24- 48 hours. Drain off excess water from straw by spreading on raised wire mesh frame.

Heat Treatment

Heat treatment of substrate results in minimizing contamination problem and gives higher and almost constant yields. It can be done in two ways i.e. by pastcuriz2tion and sterilization by chemicals.

- **(i) Pasteurization:** Boil water in a wide mouth container such as tub or drum. Fill the wet substrate in gunny bag or basket and close the opening. Dip the filled bag in hot water of 80-85 O C for about 10-15 minutes. To avoid floating, press it with some heavy material or with the help of a wooden piece. After pasteurization, excess hot water should be drained off from container so that it can be reused for other sets. Care should be taken to maintain hot water temperature at 80-85° C for all sets to achieve pasteurization.
- **(ii) Chemical sterilization technique:** Take 90 liters of water in a drum of 200 liter capacity. Slowly steep 10 kg of chopped paddy straw in the water. Mix l25ml of formaldehyde (37-40 percent) and 7 g of bavistin dissolved in 10 liters of water in another container and pour the solution slowly into the drum. Straw should be pressed and drum should be covered with a polythene sheet. Take out the straw after 12 hrs.

Spread the pasteurized or chemically sterilized straw on neat and clean cement flooring or on raised wire mesh frame, inside the chamber where bag filling and spawning are to be done.

Spawning

When the pasteurized substrate has cooled down to room temperature, it is ready for filling and spawning. At this stage, substrate moisture content should be about 70%. Polythene bags (35- 50 cm, 150 gauge) or polypropylene bags (35 x 50 cm, 80 gauge) may be used for its cultivation. One 500 ml bottle spawn (200-250 g) can be used for 10-12 kg wet straw (3 bags). Spawning can be done in layer spawning or through spawning.

In case of layer spawning, fill the substrate in bag, press it to a depth of 8-10 cm and broadcast a handful of spawn above it. Similarly, 2nd and 3rd layers of substrate should be put and simultaneously after spawning, the bags should be closed. In through spawning, pasteurized straw is mixed with 2% spawn and filled in bags. After gently pressing, close the bags for spawn running development.

Spawned bags should be stacked in racks in neat and clean place, in closed position. Temperature at 25 ± 5° C and humidity at 70-85% should be maintained by spraying water twice a day on walls and floor. It takes 20-22 days when bags will be fully covered with white mycelium.

Cropping and harvest

After 20-22 days, when bags are fully impregnated with white mycelium, transfer the bags into cropping room and remove polythene/ polypropylene covers. The open blocks should be kept in racks about 20 cm apart. Rack should be 60 cm wide with gap of 50-60 cm between two shelves. Mushrooms grow in a temperature range of 20°-33° C.

Relative humidity is maintained by spraying water twice a day on the walls and floor of the room. Spraying of blocks should be avoided for the first 2-3 days. A light mist spray of water is given on blocks as soon as the small pin heads appear. Once pinheads are 2-3 cm big a little heavier watering is to be done on blocks and further watering of blocks is to be stopped to allow them to grow. Mushrooms should be plucked before they shed spores to maintain quality. After 1st flush of harvest, 0.5 to 1 cm outer layer of the block should be scrapped. This helps to initiate 2nd flush which appears after about 10 days.

After harvest, the lower portion of the stalk must be cleaned with dry cloth. They should be

packed in perforated (5-6 small holes) polythene bags to keep them fresh. It loses freshness after about6 hours, which can be enhanced by keeping them in refrigerator. Oyster mushroom can be sundried for2 days and dried product marketed in polythene bags. Dried mushrooms should be soaked in water for 10 minutes before use.

Ventilation

During spawn run, ventilation is not important. However during cropping, fresh air is required. Hence, cropping rooms should be provided with proper ventilation.

Constraints

1. Non availability of suitable raw materials at the door step of the farmers such as quality substrate, spawn and organic supplements.
2. Dissemination of mushroom production technology is at a slower rate.
3. Mushroom spawn production is highly scientific and require more investment.
4. People of rural India possess indifferent attitude towards mushroom.
5. Mushroom is highly perishable, *i.e.* shelf life is shorter.
6. Environmental fluctuations create problem in successful cultivation of mushroom.
7. Problems associated with post-harvest handling, drying, pickling and canning.

17. HORTICULTURE

Crop Regulations in Fruit Crops

Priya Byadagi

Department of Horticulture, University of Agricultural Sciences, Raichur, Karnataka

Introduction

India is second largest producer of fruits in the world after china. India is rich in fruit diversity starting from tropical, subtropical to temperate region. Some of the fruits like guava, pomegranate, lemon, mandarin etc., if left without any treatment, give several light harvests of the variable quantities and qualities from the various flowering flushes throughout the year. There are three distinct flowering season i.e. February-March (ambe bahar), June-July (mrig bahar) and October-November (hasth bahar) with the corresponding harvest period during rainy, winter and spring season, respectively. A good quality production can be ensured by regulating the crop in such a way that they could produce only one crop instead of two or three in a year. Plants are forced to produce only one crop instead of two or three crops with good quality production. Some of the fruit crops bloom throughout the year without any resting period and produces two or three crops (bahar) in a year but yield and quality is not so good in all crop harvest. It is very essential to understand the flowering and fruiting behavior of crops and which bahar will give good crop with considering all the factors associated with a particular bahar.

Crop Regulation in different crops

The rainy season crop of guava is poor in quality and crop is affected by many biotic and abiotic stresses as compared to winter season crop. The winter season crops (mrig bahar) which ripen on October to January are superior in quality, free from diseases and pests and fetch higher income. This requires regulation of flowering (from ambe bahar to mrig bahar) to obtain most profitable crop by several methods. It depends on climatic factors, cropping pattern, cultivar etc. In pomegranate flowers continuously when watered regularly. The plants under such conditions may continue bearing flowers and bear small crop irregularly at different period of the year, which may not be desirable commercially. In tropical condition, there are three flowering seasons, *viz.,* January-February (ambe bahar) June-July (mrig bahar) and September-October (hasta bahar). The choice of flowering/fruiting is regulated taking into consideration the availability of irrigation water, market demand and pest/disease incidence in a given locality. The fruits of ambe bahar are ready for harvest in the month of June to September. As the fruit development takes place during dry months, they develop an attractive colour and quality thus suitable for exports. Similarly due to

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dry weather, the incidences of pest and disease attack are limited. However, ambe bahar can be taken only areas having assured irrigation facilities. Crop is harvested in the month of December to February. Usually this bahar is favoured as the flowering and fruiting period coincides with rainy season or immediately after rains, and the crop is taken without much irrigation. As the fruits develop during the rainy season and mature during winter, the colour and sweetness of the fruit is affected. The fruits from hasta bahar are harvested during the month of March to April. They have very attractive rind with dark coloured arils. Since the availability of the fruits during this season is limited, they fetch high value. Optimum water stress cannot be developed during this period as withholding of irrigation coincides with the rainy season. This leads to poor flowering and thus affects the yield. In case of acid lime major constraint faced by the growers is the peak and lean production in the same year. Acid lime trees flower thrice in a year in the months of January- February, June- July and September-October known as Ambe, Mrig and Hasta bahar, respectively. The fruits of the ambe, mrig and hasta bahar flowering becomes available in the month of June-July, November-December and April-May months, respectively. The flowering percentage of ambe, mrig and hasthbahar occurs 47 %, 36 % and 17 %, respectively. The fruits of hasthbahar flowering become available in the months of April-May when there is heavy demand and is sold at premium price. But hasta bahar (summer cropping) bear only 17 % flowering and fruiting is achieved in the uncontrolled condition because of the monsoon rains preceding flower initiation. Therefore, acid lime is forced to produces hasth bahar crop. Use of Gibberellic acid (GA_3) during stress period is known to reduce the intensity of flowering in the following flowering season. Cycocel (CCC) has been found very effective for imposing stress for inducing flowering.

Principle of crop regulation

The basic principle of crop regulation is to manipulates the natural flowering of the plant in desired season that contribute to increased fruit yield, quality and profitability.

Objectives of crop regulation

The main objective of crop regulation is to force the tree for rest and produce profuse blossom and fruits during any one of the two or three flushes. To regulate a uniform and good quality of fruits and to maximize the production as well as profit to the grower. To reduce cost of cultivation because uninterrupted continuous blossom would produce light crops over the whole year and require a high cost for the monitoring and marketing.

The selection of bahar at a location is mainly determined by

Availability of the irrigation water, quality of products, occurrence and extend of the damage by the disease and pests, market demands, climate of the area, availability of fruit in the market and comparable yields.

Methods of crop regulation

In order to get only appropriate season crop it is necessary to manipulate the flowering. The following practices can be adopted:

Deblossoming or thinning, withholding of irrigation, root exposure and root pruning, shoot pruning, chemical/PGRs application, nutrients application and shoot bending.

Deblossoming or Thinning

Different chemicals caused deblossoming in rainy season crop and subsequently increased the winter season crop. Rathore (1975) noted 96 per cent deblossoming with 100 ppm NAA in guava.

Withholding of irrigation

Induction of water stress by withholding irrigation from December to June or until the beginning of monsoon depending upon the prevailing conditions has been recommended (Cheema et al., 1954)

Root exposure and root pruning

Roots of the plant are exposed to sun by removing up to 7 -10 cm soil around 40-60 cm radius of tree trunk. The water is withheld for a month or two before flowering. As a result of water stress, leaves show wilting and fall on the ground. Before one month of commence of flowering of desired bahar, roots are again covered with a mixture of soil and FYM and irrigated immediately. Subsequent irrigations are given at suitable intervals. Consequently, plants give new vegetative growth, profuse flowering

and fruiting.

Shoot pruning

Terminal portion of the guava up to 20 or 30 cm length should be pruned during April to avoid Ambebahar and always avoid severe pruning.

Chemical/PGRs application

Bromouracil, 2, 4 D and paclobutrazol in variable doses are effective in inducing flowering in acid lime.

Nutrition application

To increase the quantum of winter crop the fertilizer schedule should be changed from April-May to May-June that will induce more vegetative growth that subsequently increases the winter cropping and also recommended that 10 % urea for better crop of Sardar guava and Allahabad safeda during winter.

Bending of shoot

Positive effect of shoot bending in guava. Branch bending was done during May by retaining 10-15 pairs of leaves at apex and removing all the leaves, flowers and developing fruits manually. Branches were bent dawn by applying pressure gradually from proximal to distal end of branch. They were kept at bent position by tying the tip of branches to the wooden pegs fixed on the ground with the help of rope till flushing completes i.e. for 40-45 days. They concluded that branch bending had shown positive influence on shoot growth, flowering intensity, yield and fruit quality.

Conclusion

Crop regulation in may be adopted successfully in various crops like pomegranate, guava, citrus and grape by various cultural and chemical methods by various techniques like withholding of irrigation, flower and fruit thinning, shoot pruning, and application of different chemicals like NAA, urea, Paclobutrozol, etc. offseason production is more profitable for fruit growers**.**

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18. HORTICULTURE

Role of Plant Growth Regulators in Horticulture

M.Prabu[1], K.Sivakumar[2] and M.Tilak[3]

Asst. Prof. (Hort.), Dept. of Veg. sci.,Asst. Prof. (SS&AC) Dept. of Soil Sci. & Agrl. Chem.,TNAU, Coimbatore
Asst. Prof. (Agrl.Microbiology) Dept. of Agroforestry,FC&RI, TNAU, Mettupalayam

The quantitative increase in plant body such as increase in the length of stem and root, the number of leaves etc., is referred to as plant growth, whereas, the qualitative changes such as germination of seed, formation of leaves, flowers and fruits, falling of leaves and fruits is referred as development. The two sets of internal factors, *viz*., nutrition and hormone control the growth and development of the plant. The raw material required for growth is supplied by nutritional factors which include the minerals, organic substances the protein, carbohydrates, etc. Utilization of these substances for proper development of the plant is regulated by certain "Chemical Messengers" called plant growth substances or plant growth regulators, which in minute amounts increase or decrease or modifies the physiological process in plants.

Phytohormones

- These are the hormones produced by plants which in low concentrations regulate plant physiological process.

- These usually move within the plants from a site of production to a site of action.

Plant Growth Regulators

- These are organic compounds other than nutrients, which in small amounts promote, inhibit or otherwise modify any physiological process in plant. Or It may be defined as any organic compounds which are active at low concentrations (1-10 ml) in promoting, inhibiting or modifying growth and development in plants.
- The naturally occurring (endogenous) growth substances are commonly known as Plant Hormones, while the synthetic ones are called Growth Regulators.

Plant Hormones

- It is an organic compound synthesized in one part of plant and translocated to another part, wherein very low concentration causes a physiological response.
- The plant hormones are identified as promoters (auxins, gibberellin, cytokinins), inhibitors (abscisic acid and ethylene) and other hypothetical growth substances (Florigen, death hormone, etc.).

Auxins

- Auxin is a greek word derived from Auxin which means to increase. It is a generic term for chemicals that typically stimulate cell elongation by loosening cell wall but auxins also influence a wide range of growth and development response.
- The chemical isolation and characterization was done by Kogi et al. (1934). Auxins are the first identified hormones of which IAA seems to be the major naturally occurring endogenous Auxin in plants and crops.
- Besides IAA, plants contain three other compounds which are structurally similar and elicit many of the same response as that of IAA, 4, Chloro indole acetic acid (CIAA), Phenylacetic acid (PAA), Indole butyric acid (IBA).
- The plant cell wall is made up of cellulose, proteins, and, in many cases, lignin. It is very firm and prevents any sudden expansion of cell volume (and without the contribution of auxins, any expansion at all).
- Crown galls are caused by *Agrobacterium tumefaciens* bacteria; they produce and excrete auxin and cytokinin, which interfere with normal cell division and cause tumors.

Site of Auxin Synthesis

- Auxins are synthesized in stem tips and in young tissues and move mainly down stem (Basipetal Movement) *i.e* from shoot tip to root.
- Synthetic compounds are classified into five major categories:
    - Indole acids
    - Napthalene acids
    - Chlorophenoxy acid
    - Picolinic acid.
    - Derivatives.

Role of Auxin

1. Cell division and enlargement: IAA + GA, example - cambial growth in diameter.
2. Tissue Culture: Shoot multiplications (IBA and BAP), callus growth (2, 4-D), root multiplication IAA and IBA (1-2 mg).
3. Breaking dormancy and apical dominance (inhibition of lateral buds): NAA
4. Shortening internodes: Apple trees (NAA) dwarf branch fruit.
5. Rooting of cutting: (10-1000 ppm-NAA, IAA, Phenyl acetic acid)
6. Prevent Lodging: NAA develop woody and erect stem.
7. Prevent Abscission: premature leaf, fruit and flower fall (NAA, IAA and 2,4-D).
8. Parthenocarpic fruit: Grapes, Banana and Orange (IAA).
9. Flower Initiation: Pineapple uniform flowering and fruit ripening (NAA) and delay flowering (2, 4-D).
10. Weed eradication: 2, 4-D. 2, 4 - Dichlorophenoxy Acetic Acid, 2- Methoxy,

3,6- Dichlorobenzoic Acid, 4-Amino, 3,5,6-trichloropicolinic Acid

Gibberellins

- It is the active principle isolated from the soil borne fungus *Gibberella fujikuri.*
- The concentration of GA_3 is usually highest in immature seeds, reaching up to 18 mg/ kg fresh weight in *Phaseolus spp*, but it decreases rapidly as the seeds mature.
- In general, roots contain higher amounts of GA_3 than shoots.
- Gibberellins have also been found effective in overcoming both kinds of dormancy in buds as well as seeds.

Role of Gibberellins

1. GA: Synthesis in leaf and induce shoot elongation (IAA + GA3), by effecting cell elongation or cell division or both.
2. Enhance metabolic activity: Mobilization of reserved food material, promote growth and height, increase root activity and kinetin production in root-translocate to growing bud.
3. Shoot elongation: GA3 spray increases height of seedlings.
4. Delay senescence: Increase photosynthetic and protein synthesis so decrease abscission.
5. Increase cambial growth and differentiation: Induce flower and fruit set (IAA+GA3).
6. Dwarf plant (genetically) to normal height: GA3.
7. Promote flowering in Long Day Plants: Substitute for long day condition and cold treatment (vernalization).
8. Induction of parthenocarpy in grapes: Three physiological events: Rachis cell elongation, flower thinning and berry enlargement.
9. Breaking dormancy and leaf expansion.

Cytokinins

- First endogenous cytokinin was isolated from maize kernels named as zeatin.
- Germinating seeds, roots, sap streams, developing fruits and tumor tissues are rich in cytokinins.
- Cytokinins imbibed seeds germinate better in dark than unimbibed lettuce seeds.
- Similarly cytokinins with gibberellins effectively breaks the photo-dormancy of celery (*Apium graveolens*) seeds.
- Synthetic cytokinins are: Kinetin, Benzyladenine and Ethoxy ethyladenine.
- The cytokinin zeatin is named after the genus of corn, *Zea*, in which it was discovered.

Role of cytokinin

- Cell division, elongation and enlargement.
- Tissue culture morphogenesis.
- Induction of flowering and fruit development.
- Parthenocarpy.
- Apical dominance overcoming.
- Breaking dormancy.
- Delay senescence.
- Improves N_2 metabolism.

Ethylene

- Neljubow (1901) is credited with having identified the active growth regulating component of the illuminating gas as ethylene.
- Ethylene is formed naturally in plants in amounts sufficient to bring about regulatory effect and it might be considered as plant hormones.
- Ethylene may be active in alleviation of secondary dormancy also. (Ross, 1984).
- Recently a synthetic chemical known as ethrel, ethephon, chloroethyl phosphonic acid (CEPA) has been reported to release ethylene when applied to plants.

Role of Ethylene

1. Breaking dormancy.
2. Induce ripening of fruits.
3. Induce abscission of leaves.
4. Inhibit elongation and lateral bud growth

Growth retardants

The term growth retarding chemical or growth retardant is that chemical slows cell

division and cell elongation of shoot tissues and regulate plant height physiologically without formative effects.

E.g: AMO 1618, Phosphon-D, CCC, Chloromequat and Alar.

- These do not occur naturally in plants and acts in retardation of stem elongation, preventing cell division.
- Plant growth retardants are defined as synthetic organic chemicals that cause a retardation of cell division steps in pathways of hormone biosynthesis without evoking substantial growth distortions.

Inhibitors

- These suppress the growth of plants.
- There are phenolic inhibitors and synthetic inhibitors and abscisic acid (ABA).

  Phenolic inhibitors: E.g. Benzoic acid, Salicylic acid, Coumaric acid and Chlorogenic acid.
  Synthetic inhibitors: E.g. Maleic hydrazide, Tri-Iodobenzoic acid (TIBA), SADH etc.
- An inhibitor from young leaves of Betula sps. prevent the growth of apical buds .

  Eg. ABA and Dormin.

Role of Abscissic acid (ABA)

1. To stop elongation.
2. Induce dormancy.
3. Delay germination.
4. Inhibit growth process.

Methods of Application

Growth regulators can be applied in different ways like

1. Spraying method.
2. Injection of solution into internal tissues.
3. Root feeding method.
4. Powder form.
5. Dipping of cuttings in solution.
6. Soaking in dilute aqueous solution.

Various Uses of Plant Growth Regulators

Propagation of Plants

- A number of plants are propagated by stem, leaf cutting and by layering. For promotion of rooting, the most commonly utilized hormone is IBA followed by NAA.
- Gibberllic acid causes inhibition of root formation in cutting. Cytokinins also help in quick and profuse root formation in cuttings and layers.
- By use of auxins, profuse root formation is observed in cuttings of guava, fig, pomegranate, crotons, rose, hibiscus, etc.

Seed Germination

- Many seeds have natural dormancy which can be got over by dipping the seeds in auxins.
- Soaking seeds of french beans and peas in 10-20ppm solution of GA for 12 hours before sowing, significantly improves the yield and quality.
- Dipping sweet potatoes in 5ppm GA solution for 5minutes before sowing increases sprouting and yield of potatoes.

Control of Plant Size

- In fruits and vegetables, application of higher doses of nitrogenous fertilizers spraying cycocel (growth retardant), the superfluous growth of leaves is checked.
- By spraying 10ppm solution of morphactin in potato, the growth of plant is reduced and thereby the size of tubers is increased.
- The growth retardants are useful in checking the growth of hedges in ornamental gardens there by reducing the cost of trimming the hedges.

Regulation of Flowering

- In Pineapple, due to later flowering the fruit get ready in rainy season.
- This deteriorates the quality of the fruit.
- This difficulty can be overcome by spraying 5-10 ppm solution of NAA before flowering.

- Application of 100-200 ppm GA in Dahlia plants induces early flowering.
- Sometimes, it is necessary to delay flowering. E.g. Crossing of varieties which do not flower simultaneously. Hence, the crossing becomes difficult.

Control of Sex Expression

- In number of cucurbits, such as ridgegourd, bittergourd, watermelon, cucmber and pumpkins which have proportion of male flowers is more than female flowers.
- For better yield, it is necessary to increase the number of female flowers.
- This can be achieved by application of auxins which increases the number of female flowers and decreases the number of male flower.
- The commonly used auxins are NAA and ethrel.

Control of Fruit Set and Growth of Fruit

- Spraying NAA, TIBA, and PCPA on flowers increases the fruit set.
- Dipping of grape bunches (young fruits) in GA solution increases the berry size in Thompson seedless grape.

Control of Fruit Drop

- In Nagpur Santra, the fruit drop can be controlled by spraying 10-20 ppm NAA or 10 ppm 2,4-D after fruit set.
- The fruit drop in mango can be controlled by these two auxins.

Thinning of Fruits

- Sometimes it is necessary to thin the fruits so as to bring a balance between the supply of nutrients and development of fruit.
- In such cases spraying with mild solution of ethrel or morphactin reduces the fruit load by 25-30 per cent.

Early Ripening and Development of Fruit Colour

- If the fruits could be brought in the market in early part of the season, they fetch good price.
- Spraying with 2,4,5-T and B-9 hastens maturity of apples by 1-4weeks.

Prevention of Sprouting

- In potatoes and onions, after harvest, in storage, the buds start sprouting which makes them unfit for cooking.
- Spraying of malic hydrazide (MH) solution before storing, prevents sprouting and these can be stored safely for 6 months.

Control of Weeds

• The conventional method of controlling the weeds is to remove them by uprooting manually. Successful control of weeds is obtained by spraying 2, 4-D in many crops.

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