Plant Nursery Management: Principles and Practices

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ISO 9001 : 2008

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भाकृअनुप
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उप महानिदेशक (प्रा सं प्र)

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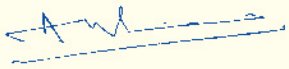
Foreword

Demand for seeds and seedlings of silviculture, horticulture and vegetable species has been is increasing over the years. The special plantation drives and greening activities have substantially increased the demand for tree seedlings. During the past decade, significant achievements have been made by plantation development and an area of > 5.7 Lakh ha has been brought under fruits, vegetables, spices, flowers, plantation crops, medicinal and aromatic plants. Ease of availability of quality planting material (QPM) at reasonable costs, however, is a challenge. At present only up to 30-40% demand for planting material is being met by the existing registered nurseries; the rest are met from the unorganized sectors, implying the need for establishing more nurseries in the organized sector.

ICAR through its network on hybrid seed production has intensified the work on production of quality planting material of different plants. A total of 1023 nurseries, 12,654 community tanks, 14,583 tube wells, 27 tissue culture units, 39,72,805 m^2 greenhouses, 27 model floriculture centres, 27 mushroom units and 21,055 vermicompost units were established during 11^{th} Plan. Clearly, such efforts targeting quality seedling production will go a long way in promoting sustainable agriculture. Nursery management is an important tool for the success of such entrepreneurships and will help nurserymen to run profitable businesses. The present bulletin on “Plant Nursery Management:

Principles and Practices" provides guidelines for nursery establishment and describes species specific propagation techniques, pest, disease, weed, water and nutrient management and economics.

I compliment CAZRI, Jodhpur and the authors for producing this bulletin which will help quality planting material production and nursery management in this country.



(Alok K Sikka)

August 2014

Preface

Trees Outside Forests (TOFs) are the main source of tree based fuel, food, fodder, fiber, etc. The quality and quantity of benefits expected from TOFs mainly depends on choice of species, seedling quality and their field management. The diverse Indian edapho-climatic condition offers the scope for planting a variety of species. *Poplar* and *Eucalypts* in Indo-Gangetic plains, *Casuarina*, Cashew and Coconut in coastal area, Tea, Coffee, aromatic plants and Rubber in mountains, Mango and Cashew in Deccan plateau, several vegetables and orchard trees in kitchen gardens are some well proven methodologies where quality planting materials (QPM) has been in demand. Due to the diverse edapho-climatic condition of India, the QPM requirement is vary and also everlasting. Meanwhile the species or variety or genotypes suitable for cultivation in one region may or may not be remunerative in another region. Hence, development of location specific quality seedlings has the potential to increase the agriculture productivity.

The availability of quality seedlings at lower cost offers ample scope for large scale planting. In this juncture, putting efforts on quality seedling production offers scope for sustainable agriculture. Nursery is pre requisite for producing quality seedlings in lesser input and nursery management is a potential tool to execute the activity in successful means. This bulletin is an attempt for narrating the nursery establishment guidelines, species precise propagation techniques, pest, disease, weed, water and nutrient management, economics and information system of plant nursery. We assure that this bulletin will be a valuable field guide for nursery practitioners.

- Authors

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Introduction

State of Indian Agriculture 2011-12 reported the increase in per capita availability of fruit (from 115 gram to 172 gram per day) and vegetables (from 236 gram to 312 gram per day) between 2001-02 and 2010-11. As per FSI (2011), the total forest cover increased and reached 692027 km^2 (21.05% of geographic area) while the total tree cover has been estimated to be 90,844 km^2 (2.76% of geographic area). Even though the agriculture production is in an upward trend, the increase in population, inflation and climate uncertainty warrant efforts towards sustainable agriculture. The greenhouse gas emission and its alarming consequences imply the need for carbon sequestration mechanisms while the carbon credit mechanism urge for green economy. At this juncture, perennials offer the possibility of climate change mitigation with additional advantage of products for consumption viz., fruits, spices, medicinal parts, fuel-wood, fodder, timber, pulp and paper, etc. On the other hand India has only 23.81% forest cover, which is far below the recommended 33% of our National Forest Policy, 1988. Increasing the area under natural forest has negligible scope, while Trees Outside Forests (TOFs) offer tremendous opportunity for productivity augmentation and sustainability.

Demand of Seedlings and Seeds in India per Year

The special plantation drives and environmental clearance compulsion by greening activity also increased the demand of seedlings. The quality and quantity of benefits expected from TOFs mainly depend on choice of species, seedling quality and their field management. Inadequate availability of quality planting material is one of the important determining factors in development of a sound horticulture, pulp and paper industry. The annual requirement of forest tree propagules viz.,*Eucalyptus, Poplar*, other MPTs is calculated as 10 million each while the requirement of *Casuarina* is 8 million. The availability of best quality seedlings at lower costs offers ample scope for large scale planting. In order to facilitate the availability of quality planting material, the data on demand is the must. The Table 1 presents the per year demand of fruit, vegetable seedlings and seed.

Seedling Supply Chain

The main suppliers of perennial tree seedlings are the departmental/government and industrial nurseries. They are producing seedlings and vegetative propagules to meet their own seedling demand and also supply them to public to meet their raw material demand. Mostly the vegetable and ornamental seedlings are produced by the farmers themselves, due to the market availability of improved seed and requirement of minimum inputs to establish them. Since the price of ornamental seedlings mainly depends on the

Table 1. Yearly demand of fruit, vegetable seedlings and seeds in India

Crop	Seedling (millions)	Seed (kgs)
Banana	3151	*
Mango	10	*
Papaya	576	*
Grapes	80	*
Cashew nut	31	*
Pomegranate	21	*
Gauva	20	*
Coconut	2.5	*
Sapota	1.6	*
Arecanut	1	*
Tomato	13028	600
Brinjal	200000	635
Chilli	14157	195
Onion	695000	2779
Cabbage	22963	101
Cauliflower	12669	87

(* - No data available)
(Source: *Resource Book on Horticulture Nursery Management, NAIP, ICAR, 2012)*

buyer's interest, size of planting material, the small private nurseries mostly concentrate on the ornamental seedling/propagule production to fetch more profit. The industrial nurseries are well equipped with infrastructure, manpower, automation and target to produce seedling/propagules of short rotation tree species to meet their factory raw material demand such as pulp and paper, plywood, small timber for furniture, juice, jam and pickle making. Hence, different kind of nurseries target various end products. But nursery is pre requisite for meeting the quality seedlings demand and nursery management is a potential tool to execute the activity in successful way.

What is a Nursery?

A nursery is a managed site, designed to produce seedlings grown under favorable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy the needs of users. In the existing infrastructure, there are just over 100 big nurseries. At present 30-40% demand for planting material is being met by the existing infrastructure. As per the report of the working group on Horticulture, Plantation crops and Organic farming for the XI five year Plan (2007-12), Planning Commission, Government of India (GoI), there are about 6,330

registered nurseries under public and private sectors. The state-wise details of nurseries are given in the Table 2.

Table 2. State-wise details of nurseries

State	Number of nurseries under			
	Public Sector	SAUs/ ICAR Institutes	Private sector	Total
Andhra Pradesh	57	-	913	970
Arunachal Pradesh	20	-	37	57
Assam	4	-	82	86
Bihar	127	27	126	280
Chhattisgarh	106	1	-	107
Gujarat	23	14	335	372
Haryana	25	1	36	62
Himachal Pradesh	78	-	648	726
Jammu & Kashmir	77	-	348	425
Jharkhand	157	2	-	159
Karnataka	28	-	15	43
Kerala	64	26	30	120
Maharashtra	136	42	1300	1470
Madhya Pradesh	270	-	-	270
Manipur	12	-	41	53
Meghalaya	31	-	-	31
Mizoram	9	-	8	17
Nagaland	2	-	15	17
Orissa	92	-	62	154
Punjab	24	7	39	70
Rajasthan	27	6	22	55
Tamil Nadu	76	-	285	361
Tripura	41	-	9	50
Uttar Pradesh	79	-	-	79
Uttrakhand	23	12	176	211
West Bengal	6	-	80	86
Total	**159**	**138**	**4,607**	**6,330**

(– no data available)

Importance of Nursery and its Role

Seedlings and grafts are produced in nursery from which the fruit orchards and ornamental gardens can be established with minimum care, cost and maintenance

The nursery planting materials are available at the beginning of the planting season. This saves the time, money and efforts of the farmers to raise seedlings

There is a wide scope for fruit orchards, ornamental, vegetable, and landscape gardens at public places, highways and co-operative housing societies

It assures the production of genetically improved quality planting material

It provides employment opportunities for technical, skilled, semi-skilled, unskilled labor

They are an important source supplying the seedlings for meeting the fruit, pulp and paper, fuel wood, timber and other demands of the industries

Guidelines for Nursery Raising

Time of sowing/initiation of propagules production depend on how long the seedlings will take to have an optimum size of a seedling (with good rooting and about 20 cm tall) and coincidence of its ready availability at the time of initiation of monsoon (July for South West monsoon and October for North East monsoon areas).

The number of plants required to be produced from a nursery can be calculated as below.

Number of plants required for the season = W

Mortality in nursery = X

Transportation/culling loss = Y

Seedling required of buffer loss = Z

Total seedlings required to be produced from the nursery = W + X + Y + Z

In case of vegetative propagules, the success percentage also needs to be considered. Generally, it is assumed that the area of nursery should be 0.25% to 2.5% of the area to be planted or the area of nursery should be about 1 acre for every 30,000 seedlings. It also required daily supply of water @ 200 l per 1000 seedlings.

Components of a Good Nursery

The nursery site should be located in the nutrient rich/medium soil, near to water source, free from soil pathogens and insects, availability of cheap and skilled labors and has good access to the main road for easy transportation. The site should be on gently sloping area and away from other tall crops: this is important for good drainage as well as to encourage air circulation. An appropriate site must be selected for the most effective, efficient, and economical design of a nursery. The purpose and target of plants to be produced will decide the site selection and its improvement. Careful observation of site conditions and an assessment of past and present climatic records are important. If desired, make a list of potential nursery sites and compare them using a decision matrix.

Layout

No standard blueprint for designing a plant nursery exists. On the contrary, each nursery will have a unique design based on distinct needs, resources, and requirements. Generally a good nursery should consist of water tank/pond, water pump/pump house, seed and fertilizer store room, implement shed, germination/mother bed area; potting/container filling area, seedling raising area, worker mess/hall, office room, propagation structures, compost area, etc. A nursery is usually arranged in a series of beds with pathway between them. An open area is needed at one end, where work such as sieving of soil and filling of containers can be done. Usually a room/shelter is required for staff and the watchman, and where equipment can be securely stored. Layout should be in a way that enables operations to flow logically through the nursery so as to save labor and time. Roads and paths within the nursery should be carefully planned. The nursery facilities should be kept clean. Every effort should be made to control weeds in and around the nursery as weeds may host insects and pathogens. The general layout of a nursery is given below in Fig. 1.

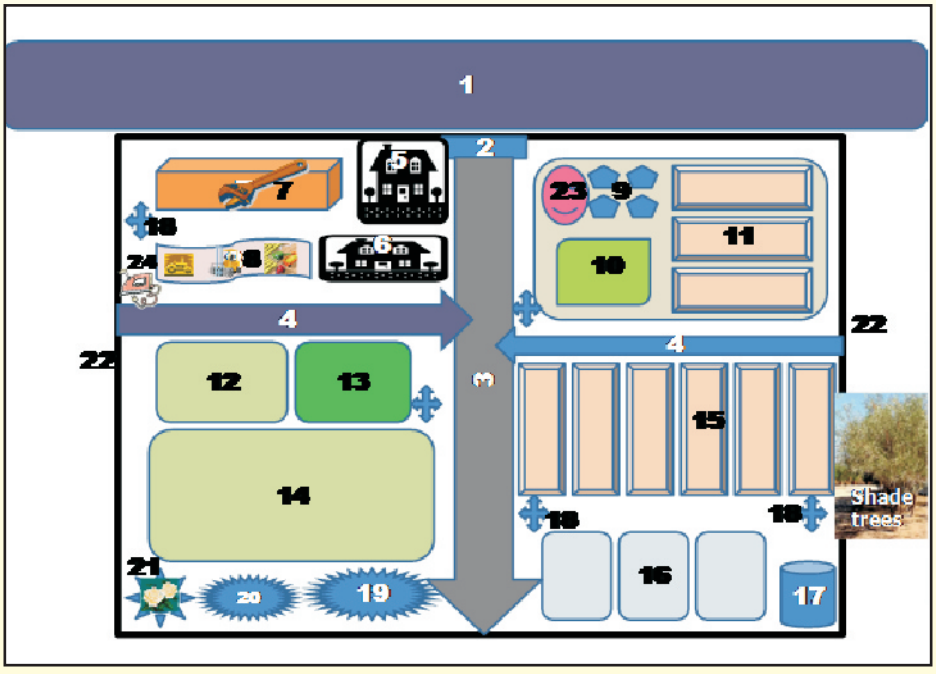

Fig. 1. General layout of nursery

(1: Main road, 2: Gate, 3: Nursery road, 4: Path, 5: Office, 6: Labor shed, 7: Store rooms, 8: Vehicle shed, 9: Potted plants, 10: Saplings, 11: Seedlings, 12: Propagation/mist chamber, 13: Shade net house, 14: Poly house, 15: Seedling beds, 16: Mother beds, 17: Well/water source, 18: Water pipeline, 19: Soil dumping, 20: Compost area, 21: Mother plants, 22: Fencing, 23: Plant library, 24: Generator/Electricity room).

Inputs

Containers, nursery media, propagules, water, fertilizers, chemicals, electricity, tools, equipment, machineries and labor are the major input to nursery.

Containers: Made up of polythene (bags, pots, and root trainers), clay (pots) or iron material. Polybags are the cheap containers, while root trainers are user friendly, easy to handle and transport.

Nursery Media: The growth medium must be sufficiently firm to hold the seedling or propagules during rooting and supply food and water for the successful growth of young seedlings.Soil is a very common easily available and comparatively cheaper medium used in nursery. Sand is generally used in mother bed and vegetative plant propagation media. The other media used in nursery are peat soil, sphagnum mass, vermiculite, perlite, leaf mold, saw dust, grain husk and Coco peat. Among them vermiculite is mostly used for cuttings while sphagnum mass is used for air layering. Generally, availability of all mineral nutrients is affected by the pH of the growing medium. In growing media such as organic soils, maximum availability occurs between 5.5 and 6.5 pH.

Propagules: Seed, cutting, rootstock, scion, explants, etc.

Water and Fertilizers: water for irrigation and fertilizer for major and minor nutrient supply.

Chemicals: Pesticides, fungicide, herbicides and growth regulators.

Tools: Axes, crow bar, wheel barrows, boxes, plastic buckets, watering cans, wire cutters, digging forks, hammer, nails, hoes, hand pruning knives, budding knives, respiratory masks, sprayers, saws, scissors, secateurs, budding and grafting knives, budding and grafting tape, germination trays, khurpis, iron pan, spade, forks, etc. The general nursery tools are presented in Fig. 2.

Electricity: For operating power machineries and to provide control environment in nursery.

Equipment and Machinery: The nursery operations like transporting, watering and sales depend on the vehicle and machineries and equipments in the nursery. Among them tractor with trolley, disc plough, water tanker are necessary. The nursery potting media filling machine or automated container filling machines (Fig. 3) for nursery mixture preparation and filling, grafting machine facilitate the speedy operation of nursery in cost effective way.

Fig. 2. General nursery tools

Fig. 3. Automated container filling machine

Labor: Nursery is a labor intensive activity. Skilled and permanent labor engagement ensures quality seedling production and their maintenance in nursery.

Inputs Management

Water and nutrients are the two important inputs having direct relationship with quality of seedlings. Water quality and its proper availability to plants ensure better growth of seedlings. It may be used effectively by sprinkler irrigation system. Irrigation of seedling with the required quantity alone reduces the occurrence of weed, pathogens, etc. Availability of nutrients to seedlings depends on the pH of the media, watering and character of species. Proper solarisation of media, mixer media preparation, container filling, filled container arrangement, using well decomposed farm yard manure (FYM), quality water and crystal colloids will ensure minimum input cost.

Mother Bed: They are seed sowing beds prepared with fertile and clean nursery mixtures (Soil, sand and FYM). Generally they are rectangular in shape with 1 to 1.8 m width and 1.8 (in hills) to 12 m (in plains) length. The lengthy side of the bed should be oriented towards the sun (east-west) so that shading can be done.

Types of mother beds:

Raised bed: They are prepared by dumping soil about 10 to 15 cm above ground level. They are common in high rainfall areas to prevent water logging. These beds

are good for the species which don't require more moisture for germination as Teak, Fir, *Spruce*, vegetable seedling, etc. Fig. 4 is the picture of a raised bed

Fig. 4. Raised bed

Sunken bed: They are prepared by excavating the soil in bed area. These beds are usually 10-15 cm deeper than the normal ground level. It prevents the out flow of water and conserves moisture. Seeds with hard coat (*Acacias, Acer*, Karonda, etc.) are sown in these beds. Fig. 5 is the picture of sunken bed

Fig. 5. Sunken bed

Level beds: The surface of this bed is perfectly flat or has a slight camber. Stones, wood or a line of pucca bricks are placed at the edges of bed to prevent crumbling in dry season

Germination bed, transplant bed, storage bed, seedling bed and cutting bed are the other kind of beds used in nursery for seedling stock preparation

Plant Propagation Structures

For propagation, framed structures such as green house, poly tunnels, culture room, hardening chamber and mist chamber are some important structures. A greenhouse is a framed, infrastructure covered with a transparent material in which crops can be grown under at least partially controlled environment. Various designs of greenhouse viz., shade net house, plastic film green house, glass house and natural green houses may be designed according to the need and resource availability.

Shade Net House: A shade net nursery usually has 20 m x 10 m dimensions. It is erected using GI pipes as a support. UV stabilized HDPE green or black colour shade net of 50 to 75% shade intensity is used to cover the nursery area at a height of 6.5 feet. Wire grid is provided at the top of the structure as support for shade net. To prevent insect entry, 40 mesh UV stabilized nylon insect proof net is fitted on all the four sides of the nursery. Provision is also made to pull polythene sheet over the pro-trays in the event of rainfall by way of making low tunnel structure. For preparing low cost polytunnel structure, 3/4" LDPE pipes and 400 gauge UV stabilized polyethylene sheet are used. Sometime bamboo poles and polysheets may also be used.

Glass/Greenhouses: Glass house is preferred when the greenhouse is to be placed against the side of an existing building. It makes best use of sunlight and minimizes the requirements for roof supports. Consolidation of interior space reduces labor, lowers the cost of automation, improves personnel management, and reduces energy consumption. Glass greenhouse is seldom used today because they are not adaptable to automation. The construction cost of glass house is more than that of plastic film greenhouses. Several styles of glass greenhouses are designed to meet specific needs.

How to Assess Quality of Seedlings?

Nursery is an area where young/infant seedlings are maintained under intensive care for upto their planting. Quality seedlings production starts from the collection of quality seed, nursery establishment and maintenance after its germination. Even though

quality is a qualitative gradable trait it can be measured indirectly by its correlation with growth, productivity, vigour and quality index. If the quality of a specific group of seedlings is to be assessed, destructive sampling through random selection of some seedlings of the group and computing Dickson Quality Index (DQI) as below is quite useful.

$$DQI = \frac{\text{Total seedling dry weight (g)}}{\{\text{height (cm)} / \text{stem diameter (mm)}\} + \{\text{shoot dry weight (g)} / \text{root dry weight (g)}\}}$$

The limitations of this index are

It will be useful to evaluate the quality of even age seedlings; comparison of different age groups doesn't exist

DQI will be derived after destructive sampling. Hence, its implication on live seedlings may be suitable only for academic purpose

Bureau of Indian Standards (BIS-2008) Related to Nursery

Different systems and standards of nursery are available for control the quality measures. Since agricultural practices are highly localized occupations they display a lot of variability in cultural practices and varietal preferences across regions. Further, with the opening up of the world market, there is a flow of trade in the agricultural products. It is, therefore, necessary to define and assign certain common minimum standards to facilitate trade in these products and to win the confidence of the consumers within the country and outside. This draft Indian Standard (Part 1) (Doc: FAD 22 (1949) C) is first in a series of Indian Standards on Good Agricultural Practices (GAP) to be developed. Table 3 depicts some of the provisions mentioned in BIS specific to nursery.

General Quality Standards for Nursery Plants

The shoot and root development of nursery plant should be in proper ratio. The nursery plants should be free from weeds

Color of leaf, morphology of leaf should be in proper standard in accordance to variety and species

The nursery plant should be free from disease and pest and have a vigorous growth

Table 3. Provisions in BIS specific to nursery

Item	Level	India GAP requirements– related to nursery	Compliance criteria
Propagation	Minor	Has the recommended technology both in primary and secondary nursery, as applicable, followed in raising the seedlings in the open or under protected conditions? Is the source of technology documented?	Verify for quality control systems, viz., raised seedbeds, soil solarization, granular application of insecticides, drenching soil surface with fungicides etc. Documentation should be maintained to verify claim.
Nursery protection	Minor	Are the preventive measures against pests and diseases taken? Are crop protection treatments applied in the nursery or during plant propagation recorded? Is a record of approved products and treatment methodology used during seedling growth in the nursery, maintained?	Check if the planting material is protected against pests and diseases in the nursery before release. Necessary documentation should be maintained to verify the claim.
Stock scion compatibility	Recognition/ Critical	Is the selection of root stock and scion appropriate and graft compatible?	Check the records for appropriate age and growth of stock & scion used and the percentage graft taken in the nursery and visible compatibility.

(Source: India GAP Part 1 Crop Base, 2008, BIS, New Delhi, Doc: FAD 22 (1949) C, p 28).

The graft union should be healthy and the size of scion and rootstock should be equal

After shifting and transporting, seedling should not show symptoms like leaf drying, yellowing, stress, etc.

At present, there is no legislation to regulate production and sale of seedling and vegetative propagules by nurseries. A mechanism to ensure the quality of planting material needs to be developed through registration and quality control. Table 4 depicts the present status of adoption of nursery act by different states.

Table 4. The present status of adoption of nursery act by different states of India

Particulars	States and their responsible mechanism
States where some system of registering/monitoring exists for nurseries or process has been initiated	1. Andhra Pradesh: Horticulture Development Agency in1990. 2. Assam: Certification through Zonal Joint Director and committee of scientists from AAU, Jorhat. 3. Bihar: Process initiated. 4. Goa: Certification Committee exists. 5. Gujarat: Department of Horticulture issues certificates for nurseries. 6. Haryana: Issue of license for three years. 7. Karnataka: Deputy Director of Horticulture, a scientist from UAS-Bangalore/Dharwad and a representative from nurserymen Association/Farmers Association are members of reg. committee. 8. Kerala: District Collector, Co-chaired by Principal Agriculture Officer, Deputy Director (In-charge of farms) and a scientist from Kerala Agricultural University examine the plant material before certification by any agency. 9. Tamil Nadu: Seed Certification under Seed Control Order 1983 which was enforced in 1994.
States where some nursery registration act exists	1. Punjab: Punjab Fruit Nurseries Act, 1961. 2. Maharashtra: Maharashtra Fruit Nurseries (Regulation) Act, 1969. 3. Himachal Pradesh: The Himachal Pradesh Fruit Nurseries Registration Act, 1973. 4. Uttar Pradesh: Fruit Nursery Act, 1976. 5. Uttrakhand: Fruit Nursery Act, 1976. 6. Jammu & Kashmir: Fruit Plant Nursery Registration Act, 1987. 7. Orissa: Orissa Fruits Nursery's Act (OFNA), 2001. 8. Tamil Nadu: Tamil Nadu Horticulture Nurseries (Regulation) Act, 2006 needs approval.

Quality Propagules Production

Following are the steps to produce quality propagules.

Seeds should be collected from seed orchard. If no seed orchard is available for the species, selection of candidate plus tree has to be done by comparison tree method and seed should be collected from the Candidate Plus Trees (CPTs) only

Well mature pod/fruits should be collected just prior to falling and seeds should be extracted as early as possible without damage to the seed. Using fresh seed for seedling raising purpose is generally advocated. If seed has the viability period it can be stored and used. In case of vegetative propagules fresh scion or buds should be collected from the identified mother plant and used for grafting or budding within 12 hours

The seedling germination energy or grafting/budding success per centage needs to be increased by following appropriate pre-sowing and growth regulator treatments of seeds and vegetative propagules respectively

Follow the standardized propagules management practices by placing them in nursery beds or under shade net house

Table 5 is the criteria which assures quality of planting material production of some important plant species

Good Practices of Fruit Collection, Seed Extraction and Storage

Fruit/pod/seed collected directly from trees is of high quality because they are healthy and not been exposed to soil moisture or soil microorganisms. Selecting seed from many parts of the crown, assures broad genetic base of the seed collected

If seed extraction and processing can not be conducted immediately, place sacks or containers of seed in a dry and cool room with good air circulation. Place the sacks or containers on a shelf or rack to facilitate air movement. Sacks may also be hung from the ceiling

Mature fruits should be processed for seed extraction. Fruits that are undeveloped or infected with insects and disease should be discarded. Proper extraction methods should be conducted carefully to avoid damaging seed. Normally, 2-3 days of drying is enough. Rubbing and crushing the fruits will expedite seed extraction

Some common tools used during extraction include sacks, tarps, trays, buckets, tanks and sandpaper (or other abrasive material). Many species have wings pod/seeds that should be removed. Most wings can be detached by crushing or rubbing the seed. Large, firmly attached wings can be removed by hand and discarded

If seed is to be sown immediately after extraction and cleaning, no further processing is required. However, if it will be stored, even for a short period, the seed of most species require drying in order to maintain viability during storage. Whether seed requires drying or not depends on its classification as recalcitrant or orthodox

Broadly seeds can be classified as recalcitrant and orthodox. Recalcitrant seed must retain high moisture contents to remain viable and generally can be stored for only a few days or weeks. If stored under humid conditions, such as wrapped in a moist cloth or paper, recalcitrant seed may remain viable for a slightly longer period. Species with recalcitrant seed include *Artocarpus heterophyllus* (jackfruit), *Azadirachta indica* (neem),

Table 5. Criteria for quality planting material of some important plant species

Tree	Propagation method	Quality standards
Silviculture species		
Acacia auriculiformis	Seed	15-30 cm tall
Acacia nilotica	Seed	5 months old
Albizia lebbeck	Seed	5-6 months old
Azadirachta indica	Seed	1 yr old
Casuarina equisetifolia	Seed/nodal cutting	35-45 cm tall, 5-6 months old
Dalbergia sissoo	Seed	60 cm tall, 3-4 months old
Dendrocalamus strictus	Seed	45-60 cm tall, 1 yr old
Eucalyptus spp.	Seed, two leafy cutting	30-45 cm tall, 6-8 months old
Gmelina arborea	Seed	20 cm tall, 6 months old
Prosopis cineraria	Seed	1 yr old
Prosopis juliflora	Seed	1.5 m tall, 1 yr old
Sesbania grandiflora	Seed	60 days old
Tectona grandis	Seed	1-2 cm collar dia, 3-4 months old
Horticulture, ornamental species and vegetables		
Aonla	Budding	6-12 month old seeding
Areca nut	Seed	15-18 month old
Banana	Sucker/Tissue culture	2-3 month old seedling
Ber	Budding	1 year old budding seedling
Black Pepper	Cutting	120 day propagules
Brinjal	Seed	4-5 week old, 12-15 cm height, 6-8 leaf stage
Broccoli	Seed	4-6 week old
Cabbage/cauliflower	Seed	3-5 week old seedling
Carnation	Seed	20 days old
	Cutting	2 month old propagules
Cashewnut	Epicotyl/Softwood grafting	5-6 month old propagules
Chilli	Seed	6-7 week old seedling, 15-20 cm height
Citrus	Grafting	1-2 year old graft, 75-90 cm in height
Coconut	Seed	1-1.5 year old, stem girth-10-12 cm, leaf stalk thick and short
Custard apple	Seed	5-6 month old seedling
	Grafting	1 year old graft
Fig	Cutting	8-12 month old, 4-6 buds, 30-40 cm height, 1-1.25 cm in diameter propagules
	Layering	2.5-3 month old propagules
Gaillardia	Seed	3-4 week old, 4-6 leaf stage
Gerbera	Seed	2 leaf stage, 5-6 week old
	Sucker/Tissue culture	5-6 leaf stage propagules
Grape	Cutting/Grafting	15-20 cm long, 3-4 buds, 2.5 cm dia stock
Guava	Layering	6-9 month old propagules
	Tongue layering	45 days after removal from mother plants
Jasmine	Cutting	60-65 days old propagules
Marigold	Seed	3-4 week old, 5-6 leaf stage
Onion	Seed	6-8 week old, 20-25 cm height
Papaya	Seed	15-22.5 cm tall1.5-2 month old
Pomegranate	Air layering	20-25 cm height, 3-6 month old
Santra, Sweet orange	Budding	150 days old
Sapota	Softwood and approach grafting	60 days after removal from mother plants, leaves fully turn green
Rose	Budding	3-6 month old propagules
Tomato	Seed	3-4 week old, 12-15 cm height, 4-6 leaf stage

Calamus species (rattans), *Durio zibethinus* (durian), *Eusideroxylon zwageri* (ulin), *Theobroma cacao* (cacao) and many dipterocarps (*Shorea*, *Hopea*, *Palaquium,* etc.). Orthodox seed must be dried to a low moisture content before they are stored. The orthodox seed of many species can be stored for one year at room temperature or several years in cold storage with little loss of viability. Orthodox seed stores best at moisture contents of 5-8%, species with orthodox seed include *Acacia mangium* (mangium), *Eucalyptus* species, *Tectona grandis* (teak), *Paraserianthes falcataria* (falcata) and *Gliricidia sepium* (gliricidia).

Sexual Plant Propagation

Sexual plant propagation means developing plant from seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself. When a mature seed is exposed to favourable environment, it germinates and begins its active growth.

Seed Pre-sowing Treatments

Pre-sowing treatments are methods applied to overcome seed dormancy to ensure rapid, uniform and timely seed germination that facilitates seedling production. Pre-sowing treatments are applied to seeds immediately before sowing. Most methods require only a few minutes to 24 hours. However some pre-sowing methods require a few to several days. Appropriate pre-sowing treatment methods depend on the dormancy characteristics of the seed being treated. The most common pre-sowing treatment methods are:

1. Soaking in cool water
2. Soaking in hot water
3. Boiled water treatment
4. Scarification (acid, mechanical, manual) methods
5. Fire or heating methods
6. Soaking in chemicals
7. Alternate wetting and drying

Advantages of Sexual Plant Propagation

It is the easiest and least expensive method of plant propagation

Seedling trees are harder and have longer life span

Plants which are difficult to propagate by vegetative method e.g. papaya, phalsa, coconut, etc. can only be propagated by seed

The rootstocks for budding and grafting are obtained by means of sexual propagation

Sexually propagated plants are more resistant to pests and disease

Polyembryonic varieties (give rise to more than one seedling from one seed) can be propagated by seed

Disadvantages of Sexual Plant Propagation

Seedlings take more time to bear fruits (late bearing)

Quality of existing plants cannot be improved by sexual propagation

Plants propagated sexually are large in size, thus the cost of manuring, pruning and spraying increases

Due to cross pollination and segregation, there is no assurance about genetic purity of plant

Identification of sex in seedling is not possible

The main requirement of this method is the fresh, viable and quality seeds. Mother bed (raised/sunken), containers (Polybags / pots / dona / root trainers), nursery mixture (Forest soil, sand, FYM @ 2 :1 : I ratio) are the other requirements. The table 6 represents the trees generally propagated by seeds, and its number of seeds/kg, best seed collection period, viability, pre-sowing methods to break dormancy and germination per cent. Table 6 is the details of sexual propagation of some important tree species.

Asexual Plant Propagation

Vegetative parts of plants such as leaves, stems, and roots are used for propagation. These plants may be taken from single mother plant or other plants. The vegetative methods most often used to produce trees are cuttings, air layering, grafting and micro-propagation. It requires the explants from the improved/selected mother tree. Fig. 6 is the rose plants propagated by cuttings.

Fig 6. Rose cuttings

Table 6. Details of seedling propagation through seeds

Species	No. of seeds per kg	Best seed collection period	Pre-sowing treatment	Viability	Germination per cent
Acacia nilotica	7000-11000	April-June	Fresh, 40-50 min H_2SO_4 scarification	> 2 yrs	88
Adenanthera pavonina	3750	Dec-Feb	Overnight hot water (70ºC) soaking	2 yrs	75
Ailanthus excelsa	9500	March-June	De-winking, Water soaking 12-24 hrs	6 months	70
Albizia lebbeck	9200	Nov-Dec-Feb	Water soaking for 24 hrs	4-5 yrs	40-60
Alnus nepalensis	18 lakhs	Nov-Dec	Stratification	3 months	58
Anthocephalus chinensis	16 lakhs	Jan-Feb, Oct-Nov	Overnight water soaking	6 months	76
Azadirachta indica	1750-4000	June-July	Fresh, De-pulping and sowing	2 weeks	50
Canarium strictum	300	Nov- Jan	Hotwater treatment	18 months	90
Casuarina equisetifolia	7,60,000	June-Dec	Fresh, Mixed with ash and BHC	1 yr	70
Elaeocarpus sphaericus	450	Dec-Jan	Mechanical/Acid scarification–15 min	3 months	41
Eucalyptus hybrid	>3,57,000	Sep-Dec	Fresh, Mixed with ash/sand and BHC	2 yrs	90
Hardwickia binata	3900	April-May	Fresh, No treatment	1 yr	60-80
Jatropha curcas	1200-1800	Feb-Mar,Oct-Nov	Fresh, Water soaking 12-24 hrs	I yr	>90
Leucaena leucocephala	8000-10000	April	Hot water treatment for 2-3 min	2 yrs	90
Mesua ferra	230	Aug- Sep	24 hrs cold water soaking	4 months	70
Pongamia pinnata	800-1500	Mar-May	Fresh, No treatment	12 months	80
Prosopis juliflora	12500	May-June	20 min H_2SO_4 scarification	18 months	80-90
Sapindus emarginatus	470	Nov-Dec	Mechanical picking on top of seed	12 months	74
Simarouba glauca	1000-1500	Jan-April	Fresh, No treatment	1 yr	>80
Syzygium cumini	1200	June-Aug	Fresh, No treatment	1 month	50
Tamarindus indica	1000-1200	Oct- Dec	Fresh, 15 min. H_2SO_4 scarification	3 yrs	>60
Tectona grandis	2500-3000	Mar-April	Alternate wetting and drying for 7 to 10 days	<2yrs	30-60

Advantages of Asexual Plant Propagation

Plants propagated by this method are true to type and uniform in growth, yield and quality of fruits

Some fruits such as banana, pineapple, seedless guava and seedless grape varieties can only be propagated through vegetative means

Vegetative propagated fruit tree comes into bearing earlier than seed propagated plants and have assured genetic configurations

Plants produced are of manageable size and have uniform fruits making harvesting easy

Some diseases can be avoided in susceptible varieties by grafting them on a resistant rootstock e.g. use of Rangpur lime as rootstock for budding Mandarin orange to avoid gummosis disease

Repairing of damaged portion of plant is possible by asexual methods through bridge grafting or buttressing. These methods can be used for healing of the wounds caused by rodents

Inferior quality crown of the existing plants can be improved. For example, side grafts and crown grafting in mango

It is possible to grow multiple varieties on the same plant. One can grow numerous varieties of roses and mangoes on different branches of the same stock

Number of plant per hectare is more due to its small canopy and restricted growth

Vegetative propagation helps in rapid multiplication with modern techniques like tissue culture and other micro propagation techniques

Disadvantages of Asexual Plant Propagation

Plants propagated by this method are not hardy and fall easy prey to adverse conditions of soil, climate, diseases, pests, etc.

It is difficult and more expensive method of propagation in some plants like papaya, coconut, etc.

Plants are generally not so vigorous and long lived as seedling plants and they require special skill for propagation

Hybridization in these plants is not possible because there is no variation in the progeny; these methods are not suitable for development of a new variety

The required propagation structures for this method are: green house, mist chamber with cooling pad, polytunnels/screen house, tissue culture room with

temperature and light control. The required hardware are root trainers (Composite/block/single cell), other containers, grafting machine, secateurs, cutting knife, scissors and vermiculite. Following Table 7 lists the vegetative propagation methods of some MPTs and Table 8 on fruit trees respectively.

Table 7. Vegetative propagation methods of some MPTs

Species	Type of propagation	Best month	Treatment
Acacia mangifera	Semi hardwood cutting	May-June	2000 ppm IBA
Azadirachta indica	Cutting, grafting, air-layering	Feb-March	4000 ppm IBA
Capparis decidua	Cutting	July-Sep	-
Casuarina spp	Softwood/nodal cutting	All months	3000 ppm IBA
Cordia myxa	Budding, seed	Aug-Sep, May-June	-
Eucalyptus camaldulensis	Softwood/mini cutting	Aug-Sep	6000 ppm IBA
Eucalyptus hybrid	Coppice shoots and 2 leafy cutting	All months	400 ppm IBA
Hardwickia binata	Stem cutting	Jan-March	4000 ppm IBA
Morus spp	Cutting	June-July	-
Pongamia pinnata	Young shoot with heal cutting	April	4000 ppm IBA
Populas deltoides	Entire transplant (ETP) cutting	All months	Aldrex 30EC
Prosopis cineraria	Hardwood cutting	All months	Auxins
Simarouba glauca	Grafting, air-layering	Oct-Jan	4000 ppm IBA
Syzygium cuminii	Budding, seed	June-July	-

Grafting

Grafting is the joining of parts of plants together in such a way that they unite and continue to grow as a single plant. The part of the plant that becomes the upper portion or top of the new plant is called the scion and the part which becomes the lower portion that includes the root is called the stock or root stock. All methods of joining plants are called grafting. Several grafting methods viz., cleft, saddle, veneer, approach, root, whip and tongue methods are practiced, while cleft or wedge grafting is the most common field level practice which assures more success. Now a days mini grafting in vegetable seedlings are popular to impart abiotic stress tolerance in propagules. Grafting requires experience and practice and the following six requirements to improve the performance.

Table 8. Vegetative propagation methods of fruit trees

Name of fruit crops	Propagation method	Time of propagation	Important cultivars
Mango (*Mangifera indica*)	Grafting	May-June	Keshar, Alponsa, Sindhu, Ratna
Ber (*Ziziphus mauritiana)*	Budding	June-Sep	Gola, Seb, Kaithli, Mundia, Umran, Banarasi Karaka, Goma Kirti
Pomegranate (*Punica granatum)*	Cutting, air-layering	July-Aug	Ganesh, Jalore seedless, Mridula, G-137, Arakta, Bhagwa, Sinduri
Aonla (*Emblica officinalis)*	Budding	June-Aug	Kanchan, Krishna, Chakaiya, NA 6, NA 7, NA 10, Balwant, Anand-2
Custard apple (*Annona squamosa*)	Seed, budding	June-July	Red Sitaphal, Arka Sahan, Mammoth, Local varieties
Guava (*Psidium guajava*)	Budding, air-layering	June-July	Allahabad Safeda, L-49, Red flesh, L-49, Chittidar, Lalit, Shweta, CISH-G-5, CISH-G-6
Datepalm (*Phoenix dactylifera*)	Suckers/offshoots	Feb-March, Aug-Sep	Medjool, Zahidi, Barhee, Halawy, Khadrawy, Khunaizi
Ficuscarica	Hardwood cutting	Dec-Feb, June-July	Puna fig, Brown Turkey, Dianna, Excel, Conadria, Dinkar, Black Ischia
Phalsa *(Grevia subinaequalis)*	Cutting/seed	Mar-April June-July	Sharbati and local PKM-1, Pratisthan
Bael (*Aegle marmelos)*	Budding	June-Aug	NB 5, NB 9, Pant Nagar Selections
Sapota	Approach grafting	Feb-March	Kalipatti, Cricket ball
Cashew nut	Epicotyl grafting	Feb-March	Vengurla-4,5,6,7 and 8
Grapes	Cutting/grafting	Feb-March	Sonaka, Shared seedless, Thompson seedless

The stock and scion must be compatible or they will not unite. Graft only closely related species or plant family

Cambial regions of scions and stock must be in intimate contact. Cut surfaces should be held tightly for proper healing and flow of water and nutrients

Grafting can be done at any time of the year but March through August is considered ideal if the stock and scion are at the right size and growth stage. Some months like August and September are however too wet and the scions show a tendency to rot unless special precautions are taken

After grafting, all cut surfaces must be protected from desiccation or dryingout. This can be done by covering the graft area with wax or tape or some moist material like sphagnum moss

Proper care must be given to the graft until it unites. Shoots from the stock must be removed as they can choke out the scion. Shoots from the scion can grow so vigorously that they break the scion off unless staked or tied

The grafting knife should always be kept razor sharp during grafting operations

In cleft or wedge or V grafting, the top of the root stock is cut off square and a vertical cut made in the centre using a heavy knife or special grafting tool. The scion is made by cutting a long, gradually tapering wedge. Holding the split open with a screw driver or similar tool, one or two scions are inserted into the split so that the cambial layers are lined up with each other at least on one side or both sides in the case of small plants of equal size. Wrapping and subsequent care is the same as for veneer graft but the root stock does not require cutting back and hence wound healing is faster. Make sure the scion and buds are not upside down.

Budding

Budding differs from grafting in that only a single lateral bud is used instead of a portion of a stem with several lateral buds as well as a terminal bud. The principal advantage in budding is that one terminal scion will furnish five or more buds for as many trees. For doing budding a vertical cut 4 to 8 cm (1-1/2 to 3 inches) long is made on the stock and a second horizontal cut is made at the bottom of the vertical cut. The bud is prepared by cutting into the scion 13 mm (1/2 inch) or more above the bud and cutting downward, going under the bud and coming out well below it, leaving a long handle on the lower part which is cut off after the bud is inserted. The shield can be 6 to 13 mm (1/4 to1/2 inches) or more wide and 4 to 8 cm (1-1/2 to 3 inches) long with the bud being located in the centre. The bark of the inverted T-cut of stock is raised at the corners and along the vertical split to admit the shield. The bud is forced into the cut and under the edges of the bark, being careful not to split the bark. After insertion, the protruding handle of the shield is cut off with a horizontal cut at the bottom so that the shield can fit and slide completely into the cut made into the stock. Buds are wrapped in 13 mm wide vinyl strips covering the bud completely. Examine buds in two or three weeks and rewrap leaving the bud exposed if considered necessary. Cut back top of root-stock gradually when bud begins to grow as well as any new growth below the graft.

Air-layering

In air-layering, the branch to be propagated is girdled by removal of a ring of bark 25 to 38 mm in width. It is advisable to scrape the surface of the wood in the girdled area to remove the cambium, otherwise the area can heal over quickly and fail to make roots. The girdled area is then covered with a ball of sphagnum or coir dust which has been soaked in water and squeezed by hand. The wet sphagnum or coir dust is covered with a sheet of plastic tied at each end with twine or with a sheet of aluminium foil tightly twisted closed at both ends. Callus and roots will form at the upper end of the girdled area in six to eight weeks. When the roots are well formed, the air-layered branches are cut from the tree and either planted direct in the field or first planted in containers of soil and later set in the field.

Micro-propagation

Micro-propagation is vegetative propagation under *in vitro* conditions wherein plants are propagated using miniature plant tissues called explants grown aseptically in test tube or other container. Micro-propagation offers a rapid means for producing planting stock on a mass scale from a single nodal explant or seed or callus raised from explants. Micro-propagation has the advantages of small space requirement, high multiplication rate, freedom from seasonal influences and freedom from microbes. In micro-propagation, generally, nodal shoot segments or shoot tips are exploited to form multiple shoots on appropriate nutrient medium. The growth controls that operate in an intact plant can be broken down or eliminated under *in vitro* conditions, leading to profuse production of shoots from a single initial explant. The shoots can be separated and rooted to give rise to entire plantlet. Generally, micro-propagation is approached in three ways-enhanced axillary bud break, adventitious bud differentiation and somatic embryogenesis. Regeneration from fascicular meristems has been achieved from juvenile as well as mature tissues in many species. Propagation via adventitious meristems involves the induction of unipolar shoots on explants followed by shoot excision and induction of root meristem.

Stimulation of axillary meristems into shoots, the most commonly used method for mass propagation of plant species, is accomplished by hormonal treatment of explant. The process involves four major steps namely induction/establishment, multiplication of shoots, rooting of shoots and hardening and acclimatization of plantlets. Establishment is the most important and crucial step determining the success of the protocol. Usually nodal segments containing quiescent axillary buds are collected from young actively

growing branches followed by sterilization and culture on synthetic nutrient medium. Explants from trees of different age groups exhibit difference in their *in vitro* response. Living plant materials from the environment are naturally contaminated on their surfaces (and sometimes interiors) with microorganisms, so surface sterilization of explants is done using chemical solutions (sodium or calcium hypochlorite, mercuric chloride). In case of severe contaminations, seeds can be raised aseptically or if possible, the mother plants can be transferred to green house at least 2 months before explant collection. The sterilized explants are inoculated on semi-solid agar gelled/ liquid medium containing organic and inorganic nutrients, carbon source, growth regulators, etc. In addition to providing nutrients the medium provides access to atmosphere for gas exchange; dumping ground for plant metabolites; support for erect growth and maintains osmotic potential. Many nutrient media have been formulated by various research groups while working on different plant systems in the past. To name a few important ones are- Murashige and Skoog's medium, Gamborg's medium, Nitsch and Nitsch medium, Woody Plant medium (Lloyd and McCown's) and White's medium. High mortality may be observed upon transfer of microshoots to *ex-vitro* conditions if proper hardening and acclimatization is not done. Tissue culture protocol of Fruits (banana, grapes, pineapple, strawberry, sapota), Cash crops (sugarcane, potato), Spices (turmeric, ginger, vanilla, large cardamom, small cardamom), Medicinal plants (*Aloe vera*, geranium, stevia, patchouli, neem), and Ornamentals (*Gerbera*, carnation, *Anthurium*, lily, *Syngonium, Cymbidium*) have been perfected and used commercially.

Common Possible Errors in Nursery Activities

Containers not filled properly

Cylindrical shape of container not maintained

Container not in upright position

Soil or sand used in germination beds not changed after each production cycle

Sowing seed too deep

Lifting transplant seedlings individually and wrenching them

Exposure of seedlings to air after lifting

Bad transplanting and delayed transplant to container beds

Leaving air space around the root of the young seedling after transplanting

Bad root pruning while transplanting

Inadequate attention paid to root pruning in transplanted containers before transporting to field

Same knapsack sprayer used to apply weedicides and fungicides

Hardening off process starting too late or neglected

Dumping of seedlings in nursery without placing them as per species, size, etc.

The following Fig. 7 depicts some of the good nursery practices to be followed and wrong practices to be avoided in nursery.

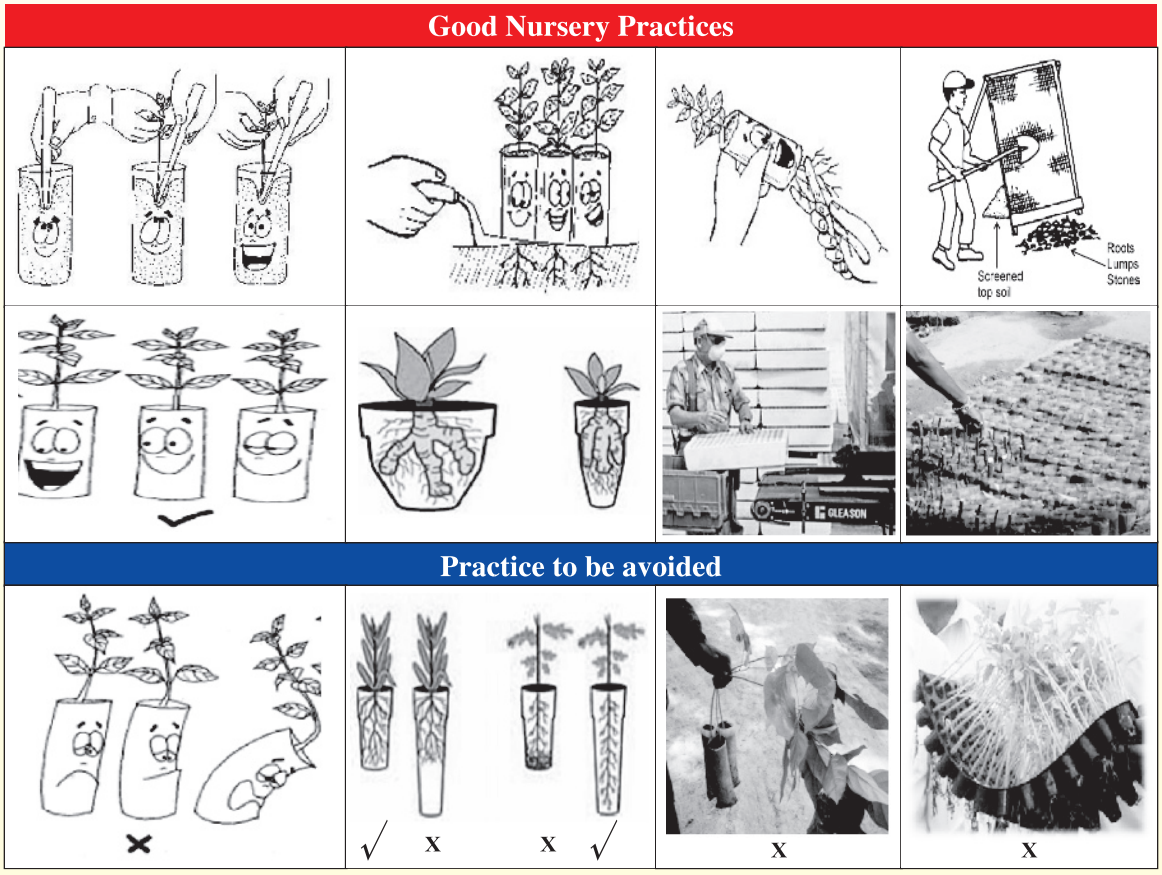

Fig. 7. Good nursery practices to be followed and wrong practices to be avoided

Nursery Technology for Some Important Tree Species

Following are the standard propagation procedure of important Indian trees.

Timber and Industrial Wood Tree Species

***Acacia nilotica*:** Freshly collected seeds are sown in polybags (after pre-sowing treatment) at 1.5cm depth during Feb-March. Shading is necessary to prevent surface

drying. Avoid excessive watering in the first month. Seedlings are fit for planting out in July-August of the same year. Any way one year old seedlings are good for planting in the field.

***Ailanthus excelsa*:** Fresh seed is sown in well worked raised nursery beds, in drills about 20 cm apart, and lightly covered with finely pulverized soil; depth of sowing being not more than 5 mm. Seed being minute is mixed with ash or fine soil to ensure even sowing. Seed beds are irrigated regularly but lightly as the seedlings are liable to damping off. Germination commences in about 10-12 days and taken about 50 days to complete. Young seedlings are susceptible to insect and rat damages. In order to avoid it, porcupine proof fencing of nursery is helpful. Seedlings raised in the containers attain 15-25 cm height in the first growing season, while the subsequent growth is more rapid.

***Albizia lebbeck*:** Seedlings can be raised by sowing in drills 15 cm apart in the nursery beds in March, or in containers. Germination commences in 4 days and is complete in 17 days. Prick out seedlings into polybags when they attain 7.5 cm tall. Seedlings growth is fast and is susceptible to insect attack also. Seedlings reach plantable size in July of the same year.

***Azadirachta indica*:** Depulped, fresh, dried seeds are sown in nursery raised bed, in lines 15- 20 cm apart at 1 cm depth. Nursery beds are watered sparingly; weeded, hoed and protected against frost in winter. Germination starts in about a week and continues for 3 weeks. Plantable size seedlings (20-30 cm tall) are produced in 2-3 months. But the pricked out seedlings are maintained in the nursery for one year to increase its field performance.

***Bamboo* spp.:** Bamboo reproduce themselves naturally from seed fallen on the ground after sporadic or gregarious flowering, also from the rhizome buds, throwing up culms as annual shoots. Bamboo can be propagated in the nursery by direct sowing of seeds, planting nursery raised container or bare rooted seedlings, and by vegetative means. Most common method of vegetative reproduction is by rhizome or offset planting; other methods are layering, nodal cuttings and culm cuttings.

***Dalbergia sissoo*:** Broken pod segments (dewinged pods) or clean seeds are sown about 1.25 cm deep in nursery beds, 0.9 m to 1.2 m wide, flat, or sunken beds during Feb-March. Sowing may be done any time between mid-February and September, but late sowings give lesser growth. Bed needs to be irrigated at least twice in a month. For planting out, 3-4 months old entire plants, when about 60 cm tall are suitable; for making stump 12-16 months old stocks are preferred. Before digging out plants, most of the lower leaves are stripped off to reduce transpiration.

***Dendrocalamus strictus*:** Seed is broadcast in raised nursery beds, 10 m x 1 m, in September - October; seed rate being approximately 1.5 kg per bed. Germination takes 10-20 dates; seedlings when about 3 months old and 4-5 cm tall, are pricked out in polythene bags. Seeds may also be sown direct in polythene bags. Seedlings with 45-60 cm tall are fit for planting out during following July.

***Eucalyptus* spp.:** For raising container plants seed is first sown in raised nursery beds and then pricked out into polythene bags, after germination. About 200g seed is sown per germination bed of 10 m x 1 m size, during September-October or after Feb-March after winter frost. To avoid dense sowing, seed is mixed with fine sand or earth, and given a light covering of fine sand; Chlorpyriphos @ 100g per bed is advised to protect seeds from insect damage. Germinating beds are covered with thatch grass to prevent drying out and minimize bird's damage, or direct impact of water spray of a chance shower of rain. Germination takes place within 5-15 days, and then thatch is removed. Seedlings are pricked out into polythene bags when about 5-10 cm tall, normally 4-6 weeks after germination. These bags are placed in sunken beds and watered regularly to its 30-45 cm height and are fit for planting in 6-8 months. Eucalyptus is also propagated by two leafy cuttings which require mist chamber and other propagation hardware. This ensures true to type propagules and higher productivity.

***Gmelina arborea*:** Seed is sown in drills, as soon as it ripens, in nursery beds; shading is necessary. Germination starts in 2-3 weeks. Seedlings are transplanted in to polybags and maintained up to 6 months for its height growth till > 20 cm.

***Tectona grandis*:** Commonest type in moist area is the temporary nursery, while dry and irrigated nursery is recommended, for dry and drought prone areas. The soil is well dug up, mixed with ashes, in a well-drained site. Standard size of bed is 12 m x 12 m raised bed in moist localities to avoid water logging and flat or slightly sunken bed in dry zone is advised. Pre sowing treated seeds are sown in broadcast or 7.7 x 7.5 cm lines, about one cm deep, between February and May. Seedlings are pricked out in transplant beds during the first rains and one year old seedlings are suitable for the stump preparation. 1.0 to 2.0 cm collar diameter; 3-4 months old seedlings are suitable for planting.

Fuel Wood Tree Species

***Acacia auriculiformis*:** Seeds requires pre-treatment, either 24-48 hours immersion in water at room temperature or boiled water for 24 hrs. Sowing in bed/polythene bag (20 cm x 15 cm size) during March to early April is suggested. Seed is sprinkled with kerosene oil to protect against ants. Germination starts in 30-35 days. A thatch barrier on

one side of bed is needed to protect the young seedlings against hot winds. 15-30 cm tall seedlings are ready for planting in the fields.

***Acacia senegal*:** Seeds are sown in polythene bags filled in with a mixture of good loamy soil and FYM in the ratio of 2:1 during June-July. One year old entire seedlings are planted out in the following monsoon. Seedlings should be protected against drought and frost by regular watering.

***Casuarina equisetifolia*:** Nursery soil should be inoculated with soil collected from *Casuarina* plantation, and quinalphos sprinkled around beds to prevent ant damage, seed is sown broadcast @ 10 g/sq. m size bed, usually in November, and lightly covered. Beds are mulched with straw and watered daily till germination is complete (20-30 days). Seedling are fit for planting when 35-45 cm tall in 5-6 months.

***Pongamia pinnata*:** Seed is dibbled in the nursery beds any time after collection, preferably in the beginning of hot weather at a spacing of 7.5 cm x 15 cm. Mulching of sown beds is helpful. Germination commences after about 10 days and completes in a month. Pricking out improves growth. Seedlings attain a growth of 25-30 cm by the end of first growing season, and of about 60 cm by the beginning of the next rainy season, when they may be planted out entire, with ball of earth, or in the form of stumps.

***Prosopis cineraria*:** Pre-sowing treated (acid scarification for 12-15 minutes) seed is sown in soil filled perforated polythene bags; 2 seeds in each, I cm deep, in June-July. Regular watering is necessary, but excessive watering is harmful. Seedlings are regularly weeded; if two emerge, one of the two seedlings is removed. They reach planting size after one year.

Thorn-less and sweet pod *Prosopis* variety: Hand extracted seeds from well ripened yellow colour pods of non-thorny sweet pod *Prosopis* plant type has to be presowing treated by acid scarification by H_2SO_4 for 15-20 minutes. Seeds will start germinating after 4^{th} day and germination is upto 80-85%. The seedlings raised by the seeds collected from the non-thorny *Prosopis* mother plants will also produce about 13-15% of thorny *Prosopis* plant type too. The seedlings will attain the field plantable size (more than 30 cm height) within six months of seed sowing. In order to raise sweet pod plant type plantation, the non-thorny seedlings only should be used for planting.

Fodder Tree Species

***Acacia leucophloea*:** Seeds soaked in cold water for 24 hrs are used to sow in nursery. Germination starts after a week and is complete within a month, then they are

transplanted to the polybags. The seedlings are ready for planting after six months of nursery period.

***Albizia procera*:** Treated seeds (hot water or cold water soaking for 12 hrs) are sown in nursery beds in drills 7.5 x 7.5 cm during May. Light watering is given for about a week. Germination commences in 3 to 4 days and completes in 3 weeks. Seedlings attain about 13-15 cm height in July of the same year, are fit for planting out, with or without ball of earth, during rains.

***Leucaena leucocephala*:** Seeds require inoculation with *Rhizobium* culture to ensure nodulation and nitrogen fixation. Plants may be raised in nursery beds or containers. Preferably inoculated seeds are sown in beds in March-April, in lines spaced 30 cm apart and seeds 5 cm apart in lines and about 1.2 to 1.5 cm deep. Nursery soil should be neutral to mildly alkaline. Beds are irrigated regularly but lightly. Germination commences in 4-6 days and the seedlings attain plantable size by July-August.

***Moringa oleifera*:** Seed is sown in June, in sunken nursery beds, in lines 20 cm apart, seeds about 2 cm apart in lines and just, about 1 cm deep. Addition of well rotten compost to the nursery bed is beneficial. The required seed rate is 30-35 g/sq. m of bed. Germination starts in about 8-10 days and takes 4 weeks to complete. The seedlings are fit for planting out, and also for making stumps after one year.

***Sesbania grandiflora*:** Seeds are sown in polythene bags after collection in May and watered regularly. Germination starts on the third day of sowing and will complete within a week to ten days. Seedlings grow very rapidly and are fit for planting out in about one to two months.

***Ziziphus* spp.:** Treated seed are sown broadcast, or in lines in nursery beds, or directly into containers, in February-March, and covered with soil to a depth of 1.5 to 2.0 cm. Seedlings are pricked out into transplanted beds/containers at the 4-leaf stage, at a spacing of 30 x 15 cm. Plants attains plantable size (>30 cm) in the first or second rains. Cultivated varieties are usually propagated by ring grafting or budding on wild root-stocks, either *in-situ* or in the nursery seedlings.

Nursery Disease and their Management

The seedling stress symptoms like damping off, wilt, root rot, rust and powdery mildew are caused by pathogen infection and results in stunted growth of seedlings. These pathogens may be soil, seed or air borne in nature. Nurseries established in the

recently cleaned land hardly invite parasitic organisms. Stunted growth of seedlings indicates the loss of soil fertility, excess watering and dumping of seedlings in shady areas.

As a preventive measure sterilization of nursery mixture, pre-treatment of seeds with fungicide such as Captan can control the disease. If the disease occurs, the casual pathogen may be identified by expression of symptoms and accordingly fungicide may be applied. Table 9 listed the important nursery diseases and their control measures.

Table 9. Important nursery diseases and their control measures

Symptoms	Affected seedling species	Control measures
Wilt, root rot, collar rot	Sisham, neem, *Casuarina*, *Eucalyptus*, tomato	Soil drenching with 0.1% Carbendazim
Leaf spot	*Eucalyptus*, pomegranate	Spraying Dithane M 45 or Fytolan 0.2% or Copper oxychloride 0.2%
Leaf rust	Teak, sisham, ber	Spraying 0.2% Zineb Spraying 0.2% wetable sulfer
Leaf blight	Neem, *Eucalyptus*	Spraying Carbendazim 0.2%
Powdery mildew	Teak, neem, *Casuarina*	Spraying 0.2% Dithane Z-78 or Bordeaux mixture 0.1%

Integrated Nursery Disease Management

Selection of apparently healthy seeds/propagules for seedling production

Seed dressing with 0.2% Carbendazim/Methyl thiophanate/Benomyl/Thiram

Sowing in sterilized/fumigated, clean beds and adequate watering

Using sterilized budding knife, secateurs, and scissors during budding and grafting

Transplanting seedling after root dip for 3-5 min in 0.02% Carbendazim solution

Healthy planting material maintenance by keeping them under proper sunlight, watering and clean environment

Frequent examination of seedling health and removal of diseased stocks

Foliar spray of 0.2% Carbendazim/Dithane M-45 at regular interval

Nursery Pests and their Management

A major injury to nursery stock is also caused by various groups of insects. These insect pests have been divided into three categories viz., major nursery pests (white grubs, cutworms, termites and crickets), minor nursery pests (defoliators, sapsuckers, grasshoppers) and non-insect pests (nematodes and vertebrate pests). Generally the damage caused by the insects may be controlled by maintaining better sanitation of the nursery area, adoption of suitable cultural practices and need based application of chemical and biological pesticides.

White Grubs: The adult white grubs feed on leaves and larval stage of the grub (during monsoon months feed on roots. It is a major pest in Teak, Mango, Sal and leguminous seedling at Bihar, Gujarat, Maharashtra, Madhya Pradesh and Tamil Nadu states. Deep ploughing, soil solarisation, poisoning and using light traps are some control measures against white grub attack. Application of 200 g phorate or 50 ml of chloropyriphos mixed in 50 ml water may be used to spray for one bed. Foliar spray of host trees available in the nursery vicinity with 0.05% monocrotophos or 0.03% quinalphos can also helpful in controlling the adult population.

***Cutworms*:** It damages the young seedlings soon after germination and is also a feeder of young leaves. Seedlings of Pine, Cedar, mango, sapota and *Casuarina* species are the most preferred by cutworms. Nursery site flooding and collection of cutworm after heavy rains are some preventive measures to avoid cutworm damages. Dusting of seed bed with a mixture of quicklime and ash or 1.5% quinalphos will control the insect.

***Termite*:** They cause damage to seedlings either by primary attack (tap root destroy), secondary attack (follow up attack after draught, pathogens, etc.) or complementary attack and damage the seedlings which make it weak and subsequently it is susceptible for other pathogen and pest attacks. The termite attack can be controlled by keeping the nursery cleared of wood debris, using well decomposed FYM and application of termiticides such as chlorpyriphos.

***Crickets*:** The nymphs and adult stage cricket come out at night and cut off all the seedlings, low branches and drag the piece to their tunnels for feeding the young crickets. Ficus, *Casuarina*, Eucalyptus, Sisham, teak, rubber and mango seedlings are commonly affected by crickets. Deep ploughing during nursery site preparation, application of 200 g phorate or fenitrothinon 5% dust per bed can control the pest.

***Minor and Non-insect Pests*:** Defoliators (beetles, weevils and caterpillers), grasshoppers and sapsuckers (green leaf hopper, white flies, thrips) are the minor pests. They can be

controlled by the application of 100 g dose per bed of phorate 10%, or spray of formulation of any systemic insecticide eg. dimethoate 30 EC.

Nematodes, rat, squirrel, hare, deer, mite and birds are some important non-insect pests. Poison bating by rodenticide such as Zinc phosphide, proper fencing and manual scaring are the best methods to reduce damage by them. Other than the disease and pest damages, the natural events like frost, chilling, drought, fire and non-availability of nutrients also cause stunted growth/death of seedlings.

Watering, Weeding and Nutrient Management in Nursery

The single most important factor in germination and seedling production is water but too much water can be just as harmful as too little water. The quantity of water required depends on the size of the nursery, the kind of soil, the species, the number of seedlings and the irrigation method practiced. More water is needed in arid region nurseries because the sandy soils have a low water holding capacity. For a nursery of about one hectare area, the estimated water requirement is about 60,000 l per day during the dry season. To avoid drying of seedlings, a reliable and continuous supply of water should be ensured by the facility of storage of water for at least 3 days supply. It is also necessary to ensure the quality of water used for irrigation. Normal pH water area the best suited, while water with more than pH of 7 favors attacks of 'damping off' fungi. Watering preferably in the mornings and avoiding the mid-day period when the sun will cause excessive evaporation. The visible symptoms of over watering are slight to severe yellowing and stunted growth. Sometimes large groups of seedlings exhibit 'wave' formations where the watering system is not supplying water uniformly to all the plants. This condition should not be confused with blocks of plants with stunted growth which is normally caused by a deficiency of nutrients. Wilting is one of the early signs of under watering. Hand watering with cans fitted with a rose spray or knapsack mist nozzles are the obvious methods for small nurseries. The ideal system for large nurseries is overhead sprinkler irrigation as it is easily controlled and provides the most uniform method for the application of water.

Weeds are any plants present in the cultivation area which is out of our interest. They compete with the seedlings for nutrients, water and light. and suppress the growth of young plants because the weeds are usually more vigorous and grow at a faster rate. The most troublesome are grasses or dicotyledonous plants that grow from a root stock. If such a weed is cut off at the ground level, it will sprout again and continue to grow from the carbohydrates stored in its root tissue hence the need to remove the whole plant. Since it is more difficult to eradicate weeds after they have invaded seedlings growing in

containers and in transplant beds, both the potting soil and the pre-filled containers may be watered in advance so that the germinated weeds can be removed in advance of transplanting. For this purpose, containers should be filled up to 4 weeks in advance of transplanting or direct sowing operations if weed free potting soil is not available. A thick hedge around the nursery helps keep out weed seeds that is otherwise brought in by wind.

Sixteen plant food nutrients are essential for proper seedling development. Each is equally important to the plant, yet each is required in vastly different amounts. Among them the primary (macro) nutrients (nitrogen, phosphorus, and potassium) are most frequently required in nursery. Any deficiency of nutrients will be expressed by seedlings through deficiency symptoms; accordingly the relevant fertilizer should be applied as per requirement. For general nutrient support, FYM and compost are mostly used in nurseries where the available soils are either too sandy or too heavy and of low quality. It helps to build a good soil structure, improves water holding capacity of the soil and provides nutrients for plants. It greatly reduces the need for chemical fertilizers and, when mixed with small amounts, dilutes the fertilizer, making it available in much larger useful quantities. It is therefore an economic way of using available chemical fertilizers and is itself a natural fertilizer, very similar to humus. The leaves of seedlings planted with unfinished compost usually turn yellow because the plant cannot acquire all the nutrients it needs whilst the immature compost continues to absorb what little nitrogen that might be available. Adding of well decomposed manure in the nursery mixture will assure the production of quality and healthy seedlings. In order to boost the rhizome growth, phosphorous must be added while application of urea will resulted foe good vegetative/ foliar growth of seedlings. Meanwhile, using of bio-fertilizers such as *Azatobactor, Azospirillum* and *Phosphobacteria* @ 5 to 10 g and vermicompost, VAM @ 10 to 50 g per container raised seedlings are also suggested to boost the growth of seedlings.

Planning and Scheduling of Nursery Activities

The successful establishment of quality seedling and propagules depends upon the proper planning and timely execution of activities. Even though seed storage facilities, propagation structures for external environment control are available, doing the nursery activities as per natural season will enhance the field planting success of the propagules. Preparation of species level nursery activity calendar will facilitate the seedling production. Following are important points to be remembered for planning of nursery activity.

Mature pod/fruit has to be collected just prior to its falling and subsequently seed should be extracted without damage to the seeds

Sowing of seed/propagules should be carried out during early morning (7 to 9 am) or evening (3 to 5 pm) hours

Transplanting, watering, weeding and shifting operations in nursery needs to be done at fixed interval

Hardening of vegetative propagules and dispatch of grown up seedlings should be in proper time

Engaging only the skilled and trained labor in nursery activities to assure the success

Water storage for lean available period, mother plant maintenance for seasonal collection of material is some important resource management activities

Timely availability of nursery inputs (soil, sand, FYM, bio-fertilizer, chemicals, water, etc.) and their collection in cheap cost period can reduce the seedling production cost

Each plant species has its own season of establishment. Hence, sowing, transplanting and distribution of each species should be scheduled accordingly

The following Fig. 8 depicts the relative quantity of seedling requirement in arid, coastal and temperate regions of India. It may be consider for nursery operation planning by which availability of the quality seedlings at right season.

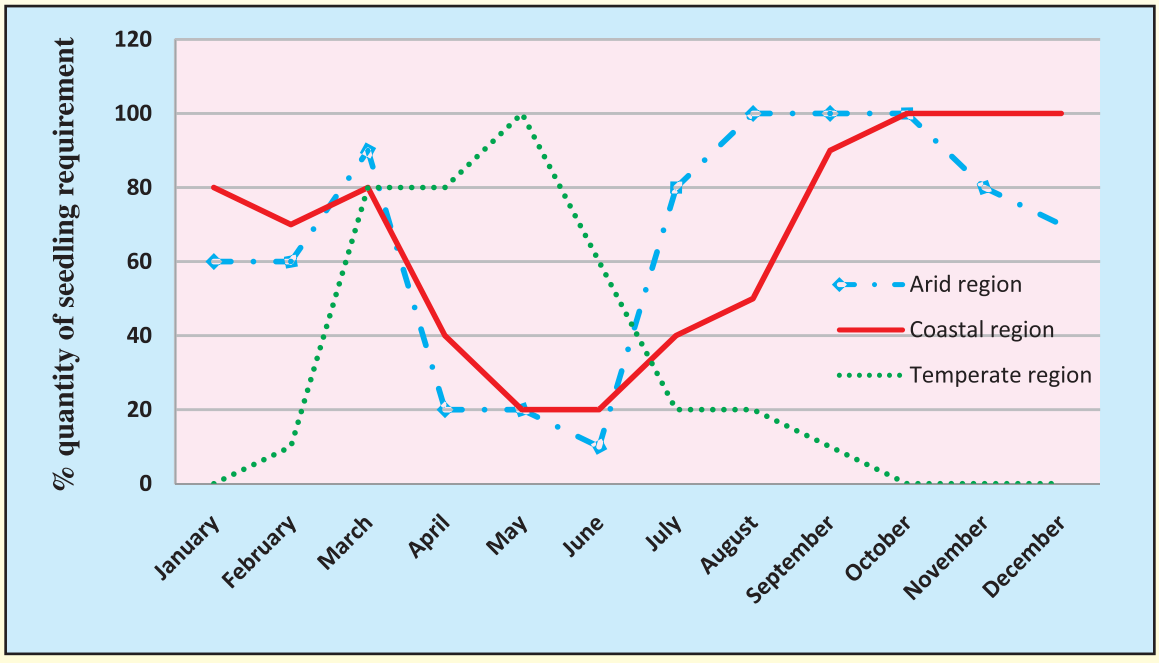

Fig. 8. Relative seedling requirement in arid, coastal and temperate regions (month-wise)

Following are some general scheduling of seedling production in nursery:

Seed Collection: Fresh and fully matured fruit/pod at its available season.

Propagules Collection: As per standard season and method of scion, bud collection specific to the species.

Seed Sowing and Transplanting: During physiological active period (just after winter).

Seedling Dispatch: Starts with the onset of monsoon.

Avoidable Periods: Severe winter, summer, labor shortage, pest and disease outbreak seasons.

Examples of Successful Model Nurseries

The need of increasing the tree cover at least one third of our geographical area and increasing demand on fuel-wood, timber, pulp and paper develops more dependency on plantations establishment. Since success of any plantation depends on the quality of seedling stocks used for planting. Attempts were made by Indian government to develop departmental nurseries in several places. Due to the limitations with the system and the increasing demand, scope exists for the beginning of private, co-operative and Kisan nurseries.

Pragathi biotech Ltd., Jalandhar and Barathi grow more biotech Ltd., Bangalore are some examples of successful private owned nurseries feeding the demand of Eucalyptus saplings in north India and Banana, Bamboo, rose, other tissue culture plants in South India

Profit functioning ITC, WIMCO, TNPL, JK, Star and Seeshasayee corporate nurseries used to meet the pulp and paper seedling requirements. The field nurseries established by them in villages under contract farming ensure the continuous supply of raw material

The Kisan nurseries established in watershed areas eg. Puja nursery and Bhati nursery in village Bujawar, Jodhpur are some successful nurseries established to ensure livelihood and socioeconomic improvement of the people

Departmental nurseries are serving the purpose of meeting local demands. Eg. CAZRI horticulture nursery is mainly producing budded ber saplings for distribution

Participatory Nursery Technology

Quality seedling production is aimed for enhancing the overall agricultural productivity, livelihood improvement and socioeconomic enhancement of people. The major aim of nursery management training is training the personnel with suitable nursery seedling production technology in cost effective way. Implementation of nursery technology in participatory mode (consortia of persons from research and development agencies, private organizations and public) as field/kisan nurseries development has potential to provide win-win situation to its stakeholders in watershed programmes.

Benefits of Participatory Nursery Development

The seedlings developed in the field nurseries will be in good demand; because they will show interest to develop their more desired/preferred species only

The success of plantation will be increased due to the improvement in quality of seedlings

Reduction in production and transportation cost of seedlings ensure profit to the producer

It increases the societal awareness and improves the socio-economic status of stakeholders due to its assured employment and profit

It motivates the women participants in developmental activity and empowers them

Provide additional employment and livelihood opportunity during lean agricultural operation period. It assures win-win situation to its stakeholders

Limitations

Lack of trained personnel and skilled labors for doing nursery activities in villages

Initial establishment and maintenance cost for nursery needs to be met by the people, which they presume as a risk bearing activity

Risk on marketing of seedlings, pest and disease damage incidences

Non availability of improved varieties in trees, seeds of promising horticultural and vegetables at the village door steps

Economics of Nursery Development

Presently nursery is considered as a small entrepreneur activity. When this venture provides profit to the investors, then only it will be considered for practicing. The following fixed (Table 10) and variable costs (Table 11) associated with establishment of nursery and expected return (Table 12) by seedling production activity will be helpful to assess the cost benefit ratio of this activity.

Table 10. Fixed cost of development of nursery in one hectare area

Particulars	Quantity	Rate (Rs.)/unit	Cost (Rs.)		
			Year I	Year II	Year III
Fencing	400 sq. m	600	240000	-	-
Work shed	20 sq. m	1100	22000	-	-
Mother plant block	6000 sq. m	5	30000	9000	6000
Irrigation with pipeline	10000 sq. m	13.5	135000	4000	3000
Office cum store	25 sq. m	1100	27500	-	-
Shade net house	400 sq. m	350	140000	-	-
Polyhouse	200 sq. m	600	120000	-	-
Polytunnel	100 sq. m	300	30000	-	-
Preparation of land, nursery beds, internal roads, pathways	2000 sq. m	20	40000	-	-
Water storage	1 unit	125000	125000	-	-
Nursery tools	required	-	15000	-	-
Root trainers, pots	10000 no	3	30000		
Propagation kit	required	-	3500	-	-
Electricity/generator	1 unit	27000	20000	-	-
Total			**978000**	**13000**	**9000**

Table 11. Variable cost of seedling production
(For 50000 seedlings and 15000 graft/cutting propagules)

Particulars	Required quantity	Rate (Rs.) / unit	Cost (Rs.)
Cost of poly bag	200 kg	150/kg	30000
Vermiculite/Sphagnum mass	200 kg	25/kg	5000
FYM, compost	10 trolley	800/trolley	8000
Soil	20 trolley	600/trolley	12000
Growth regulators	25 grams	600/5gram	3000
Bag filling labour charges	65000 bags	1/bag	65000
Cutting / grafting charges	15000 grafts	5/graft	75000
Watering, seedling maintenance cost	12 months	5000/month	60000
Electricity, water and protection cost	12 months	3000/month	36000
Total			**294000**

Table 12. Expected return from nursery per year

Particulars	Quantity and rate	Cost of return (Rs.)
Sale of seedlings	50000 nos, Rs. 5 each	250000
Sale of grafts/cuttings	15000 nos, Rs. 15 each	225000
Total		**475000**

Record Management

Records of all purchases (seed, chemicals, media, etc.), observation of data (sowing, germination dates and germination per cent, growth, etc.), labor engagement and attendance, sales, pest and disease outbreaks, permanent and temporary stocks (including species wise seedling stocks) and movement register are required to be maintained upto date. Various records of expenditure and income are recorded in different book viz., purchase book, sales book, ledger, cash book, dispatch register, etc.

It is advisable to maintain books of accounts for the following reasons:

They provide up-to-date nursery business information and guideline for planning

They help to analyze the performance of the nursery activity

Online Nursery Information and Sales Systems

The Nursery Management Information System (NMIS) was first designed in 1970s to support the nursery programs in USA, mainly for tracking the seed collection, storage, sowing of seed, seedling inventory, seedling lifting, grading and culling, packing of seedlings for storage, shipment and distribution of seedlings. NMIS consists of a source subsystem for managing and maintaining source material for products and a products subsystem for managing and maintaining product inventories. Source (includes seed as well as other types of plant propagation materials) was originally developed as a means of tracking information received through processing. At the end of the day, the data recorder will downloaded to NMIS and a daily inventory checklist of report is produced for execution of activities by the nursery manager. The system has the provision of orders entered by the clients along with their contact details, grading specifications, special services, job codes, and amount of request. After an order is entered, an order confirmation report will be sent to the client for review. When all orders have been entered, a surplus for sale report will be created. Currently an Oracle® version of the source subsystem is in use, while some nurseries have been using a MS Access® version. Recently nursery systems are designed with Active Server Page (ASP), VB as front-end and MS-Access as back-end. Interactive mode with customization of modifications, updates, revision, inventory e-learning, etc. are also linked with the system due to the GPS and real time data transfer technology.

Much software for nursery sale, inventory and management are available in the market. Nursery Sales and Inventory Management (http://www.nurserysoftware.com) is one of the most comprehensive software for managing a wholesale plant growing or re-

wholesales operation in Oregon City, USA. Likewise, www.enuresry.in is an Indian web platform provides websites or web stores for landscapers, plant nursery owners and gardeners to showcase and sell plants over web. One can use this software to support their nursery. There are web sites act as a platform which gives a "smart availability list" service for growers and suppliers of plant material. By signing up for an account, one can quickly publish the plant material for sale through this portal. This service provides not only a public availability list in which the plants are published in a large alphabetical list organized by Latin name, but also the private availability list particular to one nursery. The public availability list allows any customer to find the available plants and easily send a request for quote, whereas the private availability list can be sent to the already registered customers to keep them updated while also preventing them from browsing over to a competitor's list. Meanwhile the private availability list can be linked to the concerns web site, signature file in emails, blog, business card, mailings, etc. It has the feature viz., unlimited number of content plants to store, multiple marketing formats for sales, multiple labelling formats, accommodates poor man's laminating and icon pricing boxes, e-bay made automatically, integrate map quest into pages with screen capture utility, editing features with cut and paste from the web directly into nursery management database, upload and download to picture share and information library, lifetime membership to library uploading and downloading, many plant care tracking features, complete records and logs for all plants, fertilizer, tonic and organic pesticide recipes, store videos, streamlined collection and storage of plant information and use of this in all marketing and labelling purposes, etc.

Other than the above common platforms for nursery information management, several private owned (http://www.hccnursery.com of HCC Nursery, Bostic, North Carolina, USA; http://www.indiannuresry.net of The Indian Nursery, Howrah, West Bengal, India), government departments (http://stg3.kar.nic.in/forest_enursery of Karnataka Forest Department) managed and specific species wise portals (http://www.manakcitrus.co.in for citrus plants; http://www.rose-gardening-made-easy.com for rose plants) were also available online. They are designed as online nursery store to exhibit seedling availability, pricing, ordering, etc with the core aim of connecting the nurserymen and the buyers to perform selling. But the nursery level record and resource management is mainly done manually, which is time, energy consuming and offers scope for inaccuracy. The development of nursery management system (NMS) for stock management has been underway under a DST funded project at CAZRI, Jodhpur. The following Fig. 9 shows the home and mange stock pages of administrator in NMS.

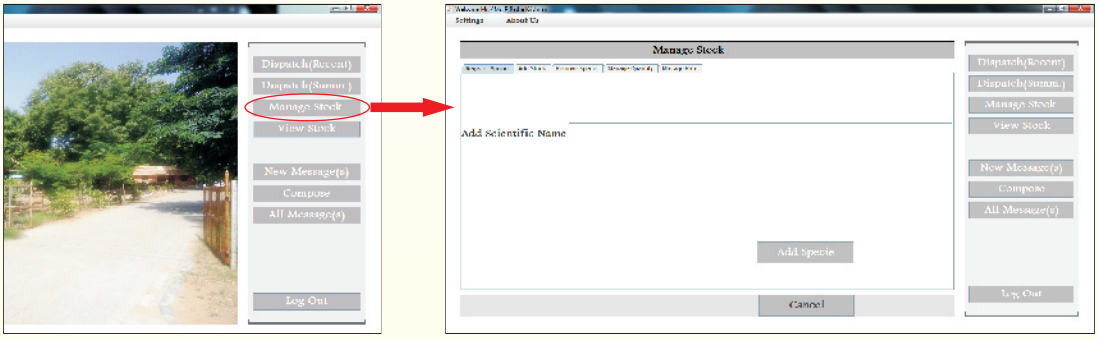

Fig 9. Home and mange stock pages of administrator in NMS

Likewise, setting-up of a Indian "Horticulture Information System" (HIS) through a network using Information and Communication Technology (ICT) from District level linked to state Horticulture department and at national level with Ministry of Agriculture as focal agency to coordinate, organize, analyze and consolidate the data is proposed by the National Horticulture Mission. It is to have horticulture information service centre at district level to collect data and linked it with State and Central organizations to collate the data. A uniform methodology should be evolved by various agencies in all the states regarding process for collection of data, use of same format, so that the data will be collected in uniformity for its completeness, updating reliability and validity at all levels. For this purpose, NHM has proposed to establish a "National Institute of Horticultural Management and Data base". Besides providing academic inputs and training at apex level, the proposed institution will undertake research and consultancy assignment on policy issues specially related to WTO and international business, data collection, maintaining the portal, data analysis, sharing, etc.

Live Plant Library at Nursery: An Awareness Concept

It is one of the recent important concepts to establish a live plant library to emphasize the importance, value, fascination and diversity of plants among the public. Detailed notes including common names, botany, location, habitat, uses and cultivation aspect of seedlings and plants may also be communicated to the visitors through this library. In other words, plant library can be defined as an exhaustive collection of plants and specimens in different forms preserved and placed to provide information about plants to beginners, professionals, and nurserymen in a relevant way. The information displayed in the plant library should be organised in a way to encourage the visitors towards conservation of nature by providing awareness and education services. Space for this kind of live plant library establishment may be allocated near the entry gate of nursery which will attract attention of visitors and potential for proper dissemination of information.The plant library space may also be used for the display of rare and important propagules available in the nursery for sale.

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