The Planta RBS: Vol.-1 Issue-1 (October) 2020: 52 - 83
(Research Book Series – www.pgrindias.in)

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A REVIEW ON HI-TECH NURSERY MANAGEMENT OF HORTICULTURAL CROPS#

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Abstract

Hi-tech nursery management includes aspects of Hi-tech greenhouse, Micro-irrigation, Fertigation, Hi-tech plant propagation and automation in nursery. Hi-tech nursery enhance physiological and physical activities due to which plant perform well it also enhance seed germination rate, higher germination percentage, increase grafting success, prolong the period of propagation, successful propagation is possible in extremely harsh and adverse climatic conditions and insect free planting material. Improving the availability of healthy planting material of improves or recommended verities supported by a network of regional nurseries equipped with distribution out fits will help in scientific development of horticulture. The infusion of latest technology has become essential for increased productivity. Unless uniform planting material of desired type is available, increased productivity levels cannot be achieved, so adaption of hi-tech nursery management is the basic need for preparation of quality planting material and supply to nurserymen across the country.

#Review Article

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Introduction

After independence country has made considerable progress in horticulture. The productivity of fruits and vegetable has increased from 86 t/ha and 7.5 t/ha and 7.5 t/ha (1950) to 11 t/ha to 16.1 t/ha (anon., 2009), respectively, besides other factor, the phenomenal growth in horticulture was mainly due to use of quality seed and planting material. The availability of genuine planting material at the doorsteps of the farmer is one of major bottlenecks that come in the way of horticulture development at commercial venture.

Present fruit production is 59.36 Million tonnes, where as projected demand of fruit for 2011-12 is 81 million tonnes (Anon., 2008).to achieved this demand we required planting material 1414 millions in number. This can only be possible with the establishment of nurseries in the areas, where planting material are required there is a need to develop a long chain hi-tech nurseries coupled with trained manpower for mass multiplication of quality planting for fulfilling the demand of the end users, but not only planting material can fulfill our demand we required quality, disease and pest free planting material which can be produce in Hi-tech Nursery due to following reasons

- Controlled over plant microclimatic parameter, irrigation and fertigation due to which physiological and physical activity of propagula get activated so that plant performs well in Hi-tech nursery.
- Hi-tech nursery enhanced seed germination rate and higher germination percentage is obtained.
- Hi-tech nursery increase grafting success and also prolongs the period of propagation.
- High return per unit area is possible in Hi-tech nursery.
- Successful crop propagation is possible even in extremely harsh and adverse climatic conditions in Hi-tech nursery.
- Disease and Insect free planting material is obtained in Hi-tech nursery by adopting practices like soil Solarization, use of soil less media, strict supervision and timely control over disease and pest.

Hi-Tech Nursery

Nursery is the place where seedling, sapling or any other planting material are raised and sold for planting in the garden or orchard, Whereas, Hi-tech nursery is a place where plants are raised from seeds/other vegetative methods for production of new plants under protected and controlled conditions. All the operations starting from soil preparation to seedling packing in Hi-tech nursery are done with the use of technical knowledge and thus they are expected to deliver good success. Since the propagula get appropriate conditions for growth and development and the practical skill of the grower is assured, hence seedlings and plantlets perform well in Hi-tech nursery. Protected cultivation is intended to mean some level of control over plant microclimate to alleviate one or more of a biotic stresses for optimum plant growth. The microclimatic parameters are temperature, light, air composition and nature of root medium. Success in multiplication under protected conditions increase even in unfavorable agro climatic conditions than open field conditions.

(Singh, H.P., Gorakh Singh., J.C. Samuel and R.K. Pathak (2003):Precision Farming in Horticulture.)

Therefore, there is an urgent need for strengthening the concept of hi-tech nursery, where propagation is done under protected condition. Hi tech nursery management includes aspect of micro propagation, Micro-irrigation, fertigation, Hi-tech Greenhouse, Hi-tech plant protection, etc.

Greenhouse

A greenhouse is a framed or inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions at least partially controlled environment and which is large enough to permit a person to work within it to carry out cultural operations.

Historical Development of Greenhouses

In the 1st century Cultivation of off season cucumber under transparent stone by the foe emperor. Tiberius is the earliest reported in protected agriculture. In the 16th century glass lanterns, bell jar and hot beds covered with glass are used to protect horticultural crops against cold. In Japan Straw mats are used along with oil paper 17th century low portable wooden frame covered with an oiled translucent paper Were used to warm the plant environment, also use of glass on one side only as Slopping roof was started in this century. In 18th century Use of glass on both side as slopping roof was started along with the development of glass house in England. Protected agriculture was fully established with the introduction of polythene as a greenhouse cover in 1948, when Professor Emry Myers Emmert at the University of Kentucky, first time used the less expensive polythene as a greenhouse cover material in place of more expensive glass. Today in 20th century with the development of Hi-tech greenhouse. Almost every aspect of the production system is automated, with the artificial environmental control and growing system under nearly total computer control.

Principle

The productivity of a crop is influenced not only by its heredity but also by the microclimate around it. The components of crop microclimate are light, temperature. Air composition and the nature of the root medium. Which can be controlled under greenhouse and also known as the principle of greenhouse

1) Light

Light is the sole source of energy provided to plant to built tissue (i.e. to grow). Excess light is not a problem in itself but the excessive heat associated with the high radiant energy can cause high temperature problems. During these problem periods, shading of the greenhouse to be practiced. Shade cloth can be manually opened and shut or that can be operated automatically through some controller operating through some a pyranometer. Light is provided in the form of incandescent, tungsten, halogen, and fluorescent and high intensity discharge lamps (HID) during winter.

2) Temperature

Temperature management is very important for successful greenhouse crops. Poorly controlled temperature regimes can increase disease and lead to poor quality planting material. Temperature control is achieved by the use of various systems including heating furnaces, exhaust fans, evaporative cooling pads, and shade cloths. .

3) Humidity

In order to maintain desirable relative humidity levels in greenhouses, efforts are made to use humidification or dehumidification. Humidification in summer can be achieved in conjunction with greenhouse cooling by employing appropriate evaporative cooling methods such as fan-pad and fogging systems. During rainy seasons the ambient relative humidity is high along with that of the greenhouse. In this situation the ventilation cannot lower the humidity of greenhouse air so Chemical dehumidification system are use which are technically feasible but expensive at present.

4) Water and Nutrients

Nursery plant in greenhouses requires ample amounts of water. Water is the universal solvent in plant cells and is involved in many biochemical processes. Drip or ring emitters are placed at the base of each plant to provide water and nutrients to the plants.

5) Carbon Dioxide

Research in northern climates has shown that raising the CO2 level from the normal ambient level of 350-1000 ppm often results in increased yield. Effective use of this technology requires that houses be closed for long periods each day.

6) Pest, Disease and Plant Health Management

Greenhouse sanitation and well-timed applications of properly selected pesticides are all important in managing pests and disease in the greenhouse. Hi-tech greenhouses have mechanism for effective monitoring of insect pest or disease attack on plants. Suitable equipment and chemical formulations are then employed to control the plant health related problems. In recent times, biological control systems have found more acceptances for plant protection in greenhouses.

7) Control Systems

In typical greenhouses, controls are a mix of manual adjustments, timed events and theoretically regulated actions but now a day's computerized environmental control allows integration of the different greenhouse components into an efficient and profitable system. Automatic control systems to provide consistent favorable environmental conditions. Automation of irrigation systems that are labour saving, allow precision in regulating the timing and amount of irrigation. In the same manner controllers has provided flexibility in regulating heaters, ventilation fans and wet pads. Computerized control systems can help the development of a grower's overall management strategy by providing consistent, detailed data about the greenhouse environment.

Different Protected Structure

There are different protected structure varying from cloches, frames to Hi-tech greenhouse which are describe as fallows.

1) Cloches

Cloches provide congenial micro-climate which can be used to benefit plant at the same stage of life. Plant grown under cloches will make an earlier start to life and grow more quickly than if they grown completely unprotected out of doors.

Types of cloches

There are several types of cloches and whatever size or shape is used; they should always be anchored firmly to the ground.

i) Glass or Plastic

Most cloches used to be made of glass but, because of high risk of breakage, rigid, white translucent polypropylene sheeting is now often used instead. Thin plastic tubing or sheeting is also used. Glass also traps reflected long waves from the sun whereas plastic does not and this means that climate under glass cloches is warmer, on average than under plastic ones.

ii) Tent

These have two sheets of 24 gaze glass measuring about 22 x 60 cm^2 (9 x 24 Inch) clipped together by special galvanized wires. Such an arrangement only gives a 30 to 38 cm (12 to 15 inch) width at the base and is very restrictive in cropping.

iii) Barn

These are shaped like a barn. Basically, two sheets of glass about 60 x 30 cm^2 (24 x 12 inch) from the roof, with two sheets 60 x 15 cm^2 (24 x 6 inch) forming the sides. Again wires are used to clip the glass together. This design gives cloches with a width of 60 cm (24 inch) and height in the center of 23 cm (9 inch) End section are generally available and extra side pieces can be fitted to some barn cloches to raise the height to 36 cm (14 inch).

iv) Plastic tunnel

These are made by stretching clear plastic sheeting over wire hoops. The hoops are made of heavy gauge fencing wire cut into lengths of 150 cm (5 ft). An 'eye' is made 15 to 20 cm (6 to 8 inch) from each end and the hoop is bent into a semicircular. To make the cloche, space the hoops 60 cm (2ft) apart in a straight line. At both ends of the row drive a 38 to 45 cm (15 to 18 inch) long wooden stake into the ground at an oblique angle and about 40 cm (2ft) from the end hoops. Tie one end of a 120 cm (4ft) wide sheet of 38 micron transparent plastic to one stake, loosely stretch the plastic over the hoops and tie it to the second stake. Hold the plastic in position at each hoop by threading light wire through the eyes. In windy position heap up the soil around the edge of the plastic sheeting.

2) Frames or Miniature Greenhouse

Frames are like miniature greenhouses, they admit light and trap heat from the sun and are used to forward, produce and propagate plants from seed or cuttings. They may be used both out of doors and inside a greenhouse. These structures are often used for propagation. The base of a frame is usually made of wood, brick or metal alloy and is taller at the back than at the front. Dutch frame which measure about 155 x 63 cm (62 x 25 inch) Dutch lights have a single sheet of 24 gaze glass held in a wood frame. The glass can be slid over the bottom rails and the top rail. It is held in position by a small spar secured by galvanized nails. There are no precise criteria for size of frame, although 150 by 80 cm (5 by 2 ½) is usual. The base for frames can be made of brick, composition blocks, wood or asbestos. Brick and composition block walls provide better insulation than wood and should be used for frames which are to be heated for much of the year. The ideal height for the base for low –growing vegetable, Such as lettuce, flower crops and bedding plants is 30 cm at the back and 23 cm at the front. For taller growing plants height at the back 45 cm and at the front to 38 cm. A more ideal frame can generally be made by setting the angle of the light much more vertically To do this you need two lights one set at the ideal angle to catch the sun's rays and the other set horizontally at the top of the frame to increase its overall depth. It is usual to have frames facing south for most activities. The exceptional is when the frame is to be used exclusively for shade loving plants.

3) Lean to Greenhouse

Such types of greenhouses are attached to the side of a building and should be placed on the south side of the building. so that plant make the best use of sunlight and owner can minimizes the requirement of roof supports. The roof of the building is extended with appropriate greenhouse covering material and the area is properly enclosed.

4) Tunnel Type of Greenhouse

Whenever plants are to be protected from cold and frost for very short periods tunnels of about 6 feet height can be made by bending steel tubes or bamboo and covering with polyethylene sheets. The polythene cover can be removed once the weather conditions become favorable.

5) Shade Net House

This type of greenhouses is used to cut down solar radiation and prevent scorching and wilting of the leaves caused by marked increase in temperature and from strong sunlight.

6) Quonset Type Greenhouse

The roof of this type of greenhouse will be semi-round. The roof and sides can be covered with polythene, fiberglass or polycarbonate sheets. The ideal size of the greenhouse is 96-120 feet in length 29 feet wide 8 feet sides and 12 to 14 feet height at the centre. It is a detached greenhouse with a simple frame. The frame basically consists of pipe bent into an arc, forming the truss and Quonset outline of the greenhouse.

7) Even Span Greenhouse

These kinds of greenhouse are constructed in plain regions of India. Such small sized greenhouse is designed when owner is to use leveled ground. In this type this greenhouse is constructed with the two roof slopes of equal pitch and width. These may be of several single and multiple span types. For single span in general, Varies from 5 to 9 m, whereas the length is around 24 m. The height varies from 2.5 to 4.3 m.

8) Uneven Span Greenhouse

This type of greenhouse is constructed on hilly terrain. The roofs of the greenhouse are of unequal width, so that owner can make use of the side slopes of hill. They are well adaptable to the hilly regions. These are not adaptable to automation.

9) Ridges and the Furrow Type Greenhouse

This type of greenhouse consists of a number of structures joined together along the length of the eave. The eave serves as a furrow or gutter to carry rain and melted snow away. The side wall is eliminated between the greenhouses, which result in a structure with a single large interior. Ridges and furrow greenhouse are commonly used in northern countries of Europe and in Canada and are well suited to the Indian conditions.

10) Saw Toothed Type Greenhouse

These are also similar to the ridge and furrow type greenhouses, except that there is provision for natural ventilation. Specific natural ventilation flow path develops in a saw tooth type greenhouse.

11) Naturally Ventilated Greenhouses

This category of greenhouses does not have any environmental control systems except, the provision of adequate ventilation. The purpose of protecting the plant material from the untimely rain, frosts, hails, insects and diseases is served by these greenhouses

12) Partially Environmental Controlled Greenhouse

There is partial control over the plant micro climate. In this type of green houses 2 or more than 2 microclimatic components are controlled by using various controlling systems. Example of this type of greenhouse is Mist house, Fan and pad type of greenhouse etc.

13) Hi-tech Greenhouse

These greenhouses consist of controlling system, sensor, computer control and operator as the name itself indicate that in this greenhouse advance new technologies and systems are employed depending upon the level of sophistication, the environment control system in a greenhouse may include partial or complete control of microclimatic parameters. For efficient management of the environmental control equipment.

A general list of equipment for greenhouse environment control is given in Table

Component	**Parameter controlled/modified**
Lighting system	Supplemental light, photoperiod and temperature (indirectly)
Fan-pad cooling system	Temperature and humidity
Air conditioners	Temperature and humidity
Shading/thermal screen system	Temperature, light and photoperiod
Fogging/misting system	Temperature and humidity
Heating equipment	Temperature
Humidifiers	Relative humidity and temperature
Fertigation equipment	Moisture content and nutrient status of soil
CO2 generators	Air composition
Controllers	Operation of all other equipment

It is assumed that a high tech greenhouse would include most of these equipment and controlling systems.

Different protected structure

Glass Cloche

Tent

Barn

Plastic tunnel

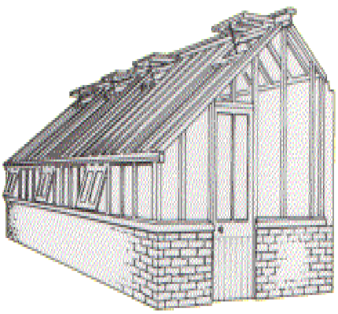
Frames

Lean to type Greenhouse

Tunnel Greenhouse

Shade Net House

Even Span



Uneven Span Type

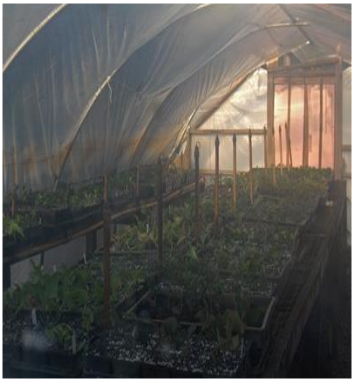
Ridges and Furrows

Saw Tooth Type

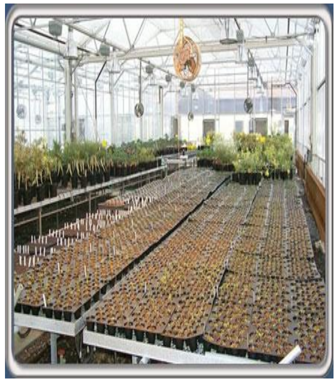
Naturally ventilated

Fan Type

Pad type



Mist house



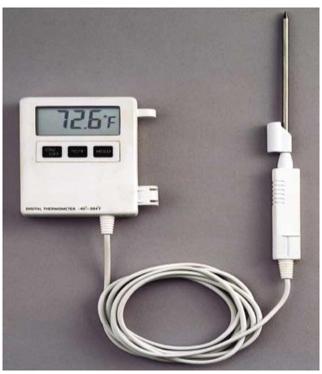
Hi-tech Greenhouse

Different Equipments use in Hi-Tech Nursery

Co 2 Analyzer

Lux Meter

Thermostat



Temperature Sensor

Oxygen Sensor

Co 2 Generator



Soil Moisture and Automatic Irrigation Dehumidifier Temperature Sensor Quality Measuring Device

Plant Multiplication under Greenhouse Conditions

Horticultural crop propagation is hampered by weather variations and occasional vagaries like storm, drought, floods etc. These tend to have adverse effect on production of the crop. Greenhouse technology is most modern and intensive form of mass multiplication of quality planting material. In our country ample scope exists for protected multiplication of horticultural crops. Round the year propagation can be practised for deriving higher financial benefits. At IARI, New Delhi, round the year propagation of fruit tree nurseries was attempted in a greenhouse. During April-June and July-August, kinnow, aonla, ber and lime cuttings were prepared, while during September-November seeds of papaya, mango and jackfruit were germinated. Again in February-March papaya cv. Coorg Honey Dew was germinated fairly well. The results of various research studies undertaken at different PFDCs for the last few years are as given below.

Enhancement seed germination of papaya under bamboo polyhouse

Observation	**Germination (per cent)**					
	Greenhouse			**Open field**		
Year	**2000-01**	**2001-02**	**Mean**	**2000-01**	**2001-02**	**Mean**
No. of days for germination	12	16	14	14	28	21
Germination (%)	78.4	62.7	70.55	48.7	14.6	31.65
Days taken to attain optimum height	48	63	55.5	61	83	72
Healthy seedlings before transplanting (%)	90	74	82	71	32	51.5

Source: Mishra 2001-02 Samstipur

Relative performance of mango grafting under greenhouse in comparison to open field condition at various PFDCs

Months of grafting operation	Success Percentage At Various Places					
	Uttaranchal (Pantnagar)		Orissa (Bhubneswar)		Andhra Pradesh (Hyderabad)	
	Green house	Open field	Green house	Open field	Green house	Open field
Apr, 2001	-	60	30	-	-	-
May, 2001	46.67	24.47	50	35	-	-
Jun, 2001	64.47	33.33	60	50	-	-
Jul, 2001	100	100	100	100	-	-
Aug, 2001	97.80	93.33	100	100	-	-
Sep, 2001	93.33	51.13	90	80	100	80
Oct, 2001	60.00	53.33	80	70	100	80
Nov, 2001	44.70	31.13	75	50	100	80
Dec, 2001	51.30	8.87	60	30	80	70
Jan, 2002	60.00	8.87	60	30	80	60
Feb, 2002	77.80	17.80	75	45	60	40
Mar, 2002	75.53	28.87	75	40	40	10
Apr, 2002	80.00	84.47	-	-	-	-

Source: Shukla, Mishra, Shankar; 2001-02; Pantnagar Bhubhneswar and Hyderabad

Comparison of propagation of cashew nut, guava and pomegranate under greenhouse and open field conditions at Bhubaneswar and Hyderabad

Month of Grafting Operation	Crop-year Of grafting Operations /sources percentage					
	Cashew nut		Guava		Pomegranate	
	April 2001 – March 2002		Sept2000- March2001		June 2000– March 2001	
	Green house	Open field	Greenh ouse	Open field	Green house	Open field
Apr	60	35	-	-	-	-
May	50	35	-	-	-	-
Jun	65	55	-	-	90	85
July	90	90	-	-	100	80
Aug	90	90	-	-	100	80
Sep	70	70	100	85	80	60
Oct	80	60	90	85	70	50
Nov	70	40	80	80	65	50
Dec	60	30	70	70	60	45
Jan	50	25	70	70	50	40
Feb	70	50	65	65	40	20
Mar	70	50	60	60	30	20

Source: Mahapatra ; Mishra 2001-02; Bhubneswar and Hydrabad

Advantages

1) Uniformity and Purity of Propagated Plants

The horticultural crops like mango, guava, litchi, papaya etc. are heterozygous and out crossing. Due to this, conventional seed propagation methodology result in multiplication of a large population of plants which lack the desirable attributes. Ironically the perennial nature and long gestation period of these trees make initial screening difficult. Similarly, due to strict control over edaphic and environmental conditions, layering and grafting of plantlets are more successful and losses due to mortality of seedlings can be avoided. The control over temperature of rooting medium and air temperature allows high rate of adventitious root formation thereby increasing number of propagated plantlets. The movement of cell sap accelerates the callus formation which after fusion forms cambium and intermingling of two cell lines (scion and rootstock). Accelerated vascular connection results in faster growth and bud emergence. Strict control over sanitary conditions allows for good growth, uniformity and purity of propagula.

2) Genuineness of Planting Material

The genuine planting material can be best supplied by the grower himself. Hence, adoption of hi-tech nursery for production of genuine planting material is gaining importance with passing time. The potential benefits of the planting material well tapped by knowing genetic makeup of the mother plant by the grower. Therefore, he may use only superior mother plants for production of nursery. Strict supervision and control can be well exercised in the greenhouse structures, which is otherwise not possible in the field due to which genuineness of planting material can be maintained.

3) Acclimatization of Micro propagated Plantlets

The transfer of micro propagated plants from culture vessel to soil requires a stepwise hardening procedure which requires protected or greenhouse facilities. Due to the control over microclimate, uniformity of planting material is brought about. The plants are protected from unpredictable weather conditions and they are more vigorous than plants grown under open field conditions.

4) Economy

The growing commercialization and consumerialistic tendency of society in globalized economy has made impact in traditional areas of nursery and plant propagation. In case of hi-tech nursery high input cost is easily overcome by huge productivity due to minimal mortality. The bulk production also minimizes the provisions for manuring, soil, irrigation etc. At Pantnager, it was found that cleft grafting percentage was higher in Polyhouse condition throughout the year in comparison to open field. The economic evaluation of plastic house for the year round grafting revealed that a net return of Rs 39,295 from 75 m2 low-cost polyhouse is obtained in four months.

5) Disease and Insect-free Planting Material

Under protected cultivation the plants are raised under strict supervision and timely treatments to check the disease and insect infestation. Careful nurturing of plants since very beginning is responsible for availability of vigorous and healthy plants in abundant quantity.

B) Micro-Irrigation

Micro-irrigation refers to low-pressure irrigation systems that spray, mist, sprinkle or drip. The term "micro-irrigation" describes a family of irrigation systems that apply water through small devices. These devices deliver water into the soil surface very near the plant or below the soil surface directly into the plant root zone. Nursery growers have adapted micro-irrigation systems to suit their needs for precision water application. Micro-irrigation is used extensively for greenhouses and nurseries.

Micro-irrigation Systems Components

Micro-irrigation components include pipes, tubes, water emitting devices, flow control equipment, installation tools, fittings and accessories. Irrigation pipeline systems are generally described as branching systems. Various branches are given names such as main, sub main, and lateral. Choosing the right size main, sub main, and lateral pipe to match the flow rates from the water source is important. Basic components can include a pump and power unit, a backflow prevention device if chemicals are used with water, a filter, a water distribution system, and some devices for controlling the volume of water and pressure in the system. If the water source is from a city/municipal/rural water supply, a direct connection is possible. The water distribution system is a network of pipes and tubes that can range in size from 1/2 inch to 6 inches in diameter. Water from the pump may be carried to the edge of the field by a single large main. Smaller sub mains may then carry the water to laterals and ultimately to the emitters. Control components the control portion may include a combination of the following devices: pressure regulator, valve, vacuum relief valve and timing clock or controller. A flow meter should be used to measure the amount of water. Pressure gauges monitor the water pressure at the pump and other locations. Equipment to inject fertilizers into the water line is also frequently used. Backflow prevention devices are used to prevent contamination of the water source.

Emission Devices

The emitter is a metering device made from plastic that delivers a small but precise discharge. The quantity of water delivered from these emitters is usually expressed in gallons per hour (gph). These emitters dissipate water pressure through the use of long-paths, small orifices or diaphragms. Some emitters are pressure compensating meaning they discharge water at a constant rate over a range of pressures. Emission devices deliver water in three different modes: drip, bubbler and micro-sprinkler.

In **drip mode**, water is applied as droplets or trickles.
In **bubbler mode**, water 'bubbles out' from the emitters.
in **micro-sprinkler mode** Water is sprinkled, sprayed, or misted.

Drip Irrigation

In this system water is applied as droplets or trickles. Depending on how the emitters are placed in the plastic polyethylene distribution line, the drip mode can be further classified as a line source type or a point source type.

The **line source** type emitters are placed internally in equally spaced holes or slits made along the line. Water applied from the close and equally spaced holes usually runs along the line and forms a continuous wetting pattern.

The **point source** type emitters are attached external to the lateral pipe. The installer can select the desired location to suit the planting configuration or place them at equally spaced intervals. Water applied from the point source emitter usually forms a round deep wetting spot. This is suited for widely spaced plants in orchards, vineyards, for landscape trees or shrubs. and for closely spaced row crops in fields and gardens.

Bubbler Irrigation

Water from the bubbler head either runs down from the emission device or spreads a few inches in an umbrella pattern. The bubbler emitters dissipate water pressure through a variety of diaphragm materials and deflect water through small orifices. Most bubbler emitters are marketed as pressure compensating. The bubbler emission devices are equipped with single or multiple port outlets. Most bubbler heads are used where deep localized watering is preferable. The typical flow rate from bubbler emitters is between 2 and 20 gph.

Micro-Sprinkler Irrigation

In this system water is sprinkled, sprayed, or misted. Micro-sprinklers are emitters commonly known as sprinkler or spray heads. There are several types. The emitters operate by throwing water through the air, usually in predetermined patterns. Depending on the water throw patterns, the micro sprinklers are referred to as 1) mini-sprays, 2) micro sprays, 3) jets, or spinners.

The sprinkler heads are external emitters individually connected to the lateral pipe. Which is very small (1/8 inch to 1/4 inch) diameter tubing. The sprinkler heads can be mounted on a support stake or connected to the supply pipe. The flow rates of micro-sprinkler emitters vary from 3 gph to 30 gph depending on the orifice size and line pressure.

Drip irrigation

Bubbler irrigation

Different Micro-Sprinkler Irrigation System

Advantages of Micro-Irrigation

1) **Water Savings -** Conveyance loss is minimal. Evaporation, runoff and deep percolation are reduced as compared to other traditional irrigation systems.
2) **Energy Savings -** A smaller power unit is required compared to sprinkler irrigation systems.
3) **Weed and Disease Reduction -** Because of limited wetted area from non-spray type of micro-irrigation, weed growth is inhibited and disease incidences reduced.
4) **Can be Automated -** Fertilizers and chemicals can be applied with water through the irrigation system. Micro-irrigation systems can be automated which reduces labour requirements.
5) **Improved Production on Marginal Land.** On hilly terrain, micro-irrigation systems can operate with no runoff and without interference from the wind. The fields need not be levelled. Pumps and power unit

Micro Irrigation in Greenhouse and Nursery

Plants under environmentally controlled conditions found in greenhouse and nursery systems generally require more water for growth. The widely used non soil mixes quickly drain and require frequent watering. Manual watering is time consuming and may not be practical for large operations.

Fertigation

Application of fertilizer along with water is known as fertigation. Proper scheduling must be planned as to provide nutrients at a time when required by plants. Fertigation requirement water-soluble fertilizer All chemicals applied through irrigation system must avoid corrosion, softening of plastic pipe and tubing, or clogging any component of the system. It must be safe for field use, must increase or at least not decrease crop yield, must be soluble or emulisifiable in water and it must not react adversely to salts or other chemicals in the irrigation water. In addition, the chemicals or fertilizers must be distributed uniformly throughout the field. Uniformity of distribution requires efficient mixing, uniform water application and knowledge of the flow characteristics of water and fertilizer in the distribution lines. To avoid clogging, chemicals are applied through micro irrigation systems to dissolve the deposits in drip lines. The solubility of some of the fertilizers are given in Table 1.

Table 1. Fertilizer solubilities of conventional fertilizer (at 20°C)

Fertilizer	Solubility (g-1)
Potassium chloride	340
Ammonium sulphate	750
Urea	1,060
Potassium sulphate	110
Potassium nitrate	320
Mono ammonium phosphate	370
Magnesium sulphate	250

Equipment and Methods for Fertilizer Injection

Fertilizers can be injected into drip irrigation systems by selecting appropriate equipment like pumps, valves, tanks, venturies and aspirators.

Fertigation Injection System

Pumping is the most common method of injecting fertilizer into a drip irrigation system. Injector energy is provided from electrical motors, internal combustion engines, water-driven hydraulic motors and pumps, and impeller driven power units. The positive injection pumps include single or multiple piston, diaphram, gear, and roller pumps. In case of two or more different types of fertilizers multiple pump units can be used to avoid/reduce precipitation problems

1) Pressure Differential Injection System

The PD unit takes advantage of the system's pressure-head differences. Pressure differences can be developed by valves, venturi, elbows, or pipe friction. The main advantage of the PD applicators is the absence of moving parts. They are simple in operation and require no electric and gasoline, or water powered pumps. The primary disadvantage of the PD units is that the rate of application is not constant and changes continuously with time; thus, a uniform concentration of a nutrient cannot be maintained

2) Venturi Injection System

Some Venturi injection system allows fertilizer to be added directly into the system form open tanks without being diluted. A portion of the irrigation water is by passed through a Venturi, which functions as an aspirator to pull the solution into the system. Because of high pressure losses, larger venturis may require booster pumps. Solution injection rates are regulated by flow meters and valves.

Application of Fertilizers

Nitrogen: Nitrogen, the plant nutrient most commonly deficient for crop production, is often applied through micro irrigation system. Nitrate nitrogen moves readily in soil with irrigation water and can be applied separately or in mixture with such compound as ammonium sulphate, urea, calcium ammonium nitrate and ammonium nitrate. Calcium nitrate can also be used when bicarbonates are low. Anhydrous ammonia, aqua ammonia and ammonium phosphate in most instances cause clogging problems. Nitrogen source selection should be based on its possible reactions with the irrigation water and the soil Rolston and Boradbent found that little denitrification occurred in a clay loam soil, if the soil tension was higher, than 10 bars. Miller *et al*. indicated that nitrogen is used more efficiently when applied through drip in tomato.

Phosphorus: Phosphorus has not generally been recommended for application in drip irrigation because of its tendency to cause clogging and its limited movement in soil. If, irrigation water is high in calcium and magnesium precipitate of insoluble calcium and magnesium phosphate may result from the application of inorganic phosphate. Rauschkolb *et al.* applied phosphoric acid along with short pulses of sulphuric acid to keep the water pH low in drip irrigation system without precipitation or clogging problems. Organic phosphate will not participate unless compound is being hydrolyzed to inorganic phosphate in the water or the water pH is high. The orthophosphoric acid lowered enough the pH of irrigation water to minimize clogging problems from phosphate precipitation over 3 and 24 days of irrigation period.

Potassium: Common K sources are potassium sulphate, potassium chloride and potassium nitrate, which are readily soluble in water. These fertilizers move freely in soil and some of the potassium ions are exchanged on the clay complex and are readily leached away. However, Urei *et al.* were not able to demonstrate it but there was some movement after the potassium ions concentrated in soil near the emitter.

Micronutrients: Micronutrients such as iron, zinc, copper and manganese can be applied as chelates or sulphate salts in drip irrigation system. Normal plant requirements for these nutrients are very low and their application through drip irrigation requires careful and precise metering. McElhoe and Hilton found that zinc EDTA applied through drip irrigation for pecan trees cost less than foliar application but leaf concentration of zinc were generally lower with drip than the foliar applications

Advantages of Fertigation

1) Uniform Application of Fertilizer*:* In fertigation, fertilizer is applied along with irrigation water, i.e. through dripper. Normally, uniformity in drip irrigation system is above 95 per cent and thus fertilizer application also achieves higher uniformity.
2) Placement in Root Zone: Fertigation provides the opportunity to apply fertilizers/ chemicals in the root zone only as it is possible to have a control through drip irrigation system.
3) Quick and Convenient Method: The fertigation is quick and convenient as it provides management of time and quality at control unit of drip irrigation.
4) Saves fertilizer*:* The nutrients supplied through fertigation increases their availability, limit the wastage of their being leached out below rooting depth and consequently improve fertilizer-use efficiency.
5) Frequent Application is Possible: Fertigation provides an opportunity to apply fertilizer more frequently than conventional methods. However, a mechanical spreader is costly, causes soil compaction, may damage the growing crop and always not accurate.
6) Micronutrients Application along with NPK : Fertigation provides an opportunity to mix the required micronutrients along with conventional NPK and can be applied to soil/plant systems.
7) Save Groundwater Pollution: The excessive use of fertilizer through conventional methods lead to the leaching of fertilizer material beyond the root zone depth. At a number of locations it has been observed that it pollutes the groundwater of the area. The fertigation provides an opportunity to prevent these environmental hazards.

Hi-Tech Plant Propagation

(A) Soilless Media: Use soilless media is used in Hi-tech nursery instead of soil base media due to following reasons. Soil base media have Contamination of pathogen, weed seed and Variable composition, CEC and Porosity and it is not easily sterilized

Function of Media
Media Provide Anchor, moisture, Permit air exchange, Provide nutrients

Properties:
Density, Porosity, Aeration, CEC are the properties of media

Characteristics of Ideal Media:
The media must be sufficiently firm to provide anchorage to seed or cuttings
It should be decomposed material with high C/N ratio.
It volumes must be fairly constant when either wet or dry.
It should have better water holding capacity (45-65 %).
It should be porous (Porosity 55-85 %) to drain excess water.

It should be free from weed seeds and harmful pathogens.
It should be readily available, reusable and cheper
Ideal media should have air space 10-30 %

Components of Soilless Media

A) Organic

a-1) Peat Moss

Peat consists of the remains of aquatic, marsh, bog or swamp vegetation which has been preserved under water in a partially decomposed state. There are three types of peat as classified by U.S.Bureau of mines moss peat, reed sedge and peat humus. Moss peat usually referred to in the market as peat moss and is derived from sphagnum or other mosses. It varies in color from light tan to dark brown. It has a high moisture holding capacity 15 times its dry weight, has a high acidity pH 3.2-4.5 and contains a small amount of nitrogen about 1 per cent but little or no phosphorous or potassium. Reed Sedge peat consists of the remains of grasses, reeds, sedges and other swamp plants e.g. Florida Peat. color, ranging from reddish brown to almost black. Peat humus is originate from either hypnum moss or reed sedge peat. It is dark brown to black in color with a low moisture-holding capacity but with 2.0 to 3.5 per cent nitrogen.

a-2) Sphagnum Peat Moss

Commercial sphagnum moss peat or sphagnum peat is the dehydrated young residue or living portion of acid-bog plants in the genus Sphagnum such as S. capillaceum and S. palustre. its high cost limits it commercial use. It is relatively pathogen free, light in weight, and has a very high water holding capacity, being able to absorb 10-20 times its weight of water. It contains small amounts of minerals, but plants grown in it for any length of time require added nutrients. Sphagnum moss has pH of 3.5-4.0. It may contain specific fungistatic substances, including damping off of seedling.

a-3) Pine Bark – Soft Bark

Pine bark is usually stripped from the trees, milled and then screened into various sizes. Composting bark involves moistening the bark, adding 1 to 2 pounds N/yd^3 from either calcium nitrate or ammonium nitrate, forming a pile and then turning the pile every 2 to 4 weeks to ensure proper aeration. Composting bark typically takes 5 to 7 weeks. Aging is a cheaper process, but aged bark has less humus and a greater nitrogen draw-down in the container than composted bark.

a-4) Composted Hard Wood Bark

The pH of fresh hardwood bark is usually less acid (pH 5 to 5.5) than peat moss or pine bark. Composted bark may be rather alkaline (pH = 7 to 8.5). Hardwood bark typically contains toxic compounds and, for this reason, should be composted before use.

a-5) Sawdust

These materials are by products of timber mils. They can be very well used in soil mixture. Nitrogen is added in sufficient amount by decomposition of saw dust. in general, sawdust or wood products are not recommended for a container media. The carbon to nitrogen ratio is extremely high, requiring adequate amounts of nitrogen and composting to avoid negative effects on plant growth.

a-6) Coconut Coir

The raw material, which looks like sphagnum peat but is more granular, is derived from the husk of the coconut fruit. The typical pH range for coir is 5.5 to 6.8, and the average dry bulk density is 4 lbs/ft^3.It contains significant amounts of phosphorus (6 to 60 ppm) and potassium (170 to 600 ppm) and can hold up to nine times its weight in water. Since coir contains more lignin and less cellulose than peat, it is more resistant to microbial breakdown and, therefore, may shrink less. Coir is easier to re-wet after drying than peat moss.

B) Inorganic component

b-1) Perlite

Perlite, a gray-white silicaceous material, is of volcanic origin, mined from lava flows. Perlit holds three to four times it weight of water. It is essentially neutral with a ph of 6.0 to 8.0 but with no buffering capacity. It has no cation exchange capacity and contains no mineral nutrients. Leached out by watering heavily. It is most useful in increasing aeration in mix. Perlite in combination with peat moss, is a very popular rooting medium for cuttings.

b-2) Vermiculite

Vermiculite is a micaceous mineral that expands markedly when heated. Chemically, it is a hydrated magnesium aluminum- iron silicate. When expended, Vermiculite is very light in weight (90-150 kg per cubic meter) neutral in reaction with good buffering properties, and insoluble in water. It is able to absorb large quantities of water 40-54 liters per cubic meter. Vermiculite has a relatively high cation exchange capacity and thus can hold nutrients in reserve for late release it contains magnesium and potassium, but supplementary amounts are needed from other fertilizer sources. Horticultural vermiculite is graded to four sizes No 1 has particles from 5-8 mm diameter; No 2, the regular horticultural grade from 2-3 mm; No 3 from 1-2 mm; No 4 which is most useful as a seed germinating medium from 0.75 to 1 mm.

b-3) Sand

Sand consists of small rock particles, 0.05 to 2.0 mm in diameter, formed as the result of the weathering of various rocks, its mineral composition depending upon the type of rock. Quartz sand, consisting chiefly of silica complex, is generally used to propagation purposes. Sand is the heaviest of rooting media used, a cubic foot of dry sand weighting about 45 kg (100lb). Sand contains virtually no mineral nutrients and has no buffering capacity, or cation exchange capacity (CEC). It is used mostly in combination with organic materials.

b-4) Rock Wool (Mineral Wool)

This material is prepared from various rock sources, such as basalt rock, melted at a temperature of about 1600℃, then, as it cools, is spun into fibers, and pressed into blocks with a binder added. Horticultural rock wool is available in several forms Shredded, prills (pellets), Slabs, blocks, cubes or combined with peat moss as a mixture. Rockwool will hold a considerable amount of water, yet retains good oxygen levels.

(B) Soil sterilization

Steam Pasteurization

Expose steam (212° F) for 30 to 45 minutes. All sections reach at least 180° F. involves blowing a mixture of steam and air through the media. Aerated steam (140° to 175° F)

Chemical Fumigation

Chemicals methyl bromide and vapam are used commonly for fumigation

Solarization

Soil and bed condition-Loose and friable soil with no large clods or other debris on the soil surface

Plastic Tarp-Clear, UV-stabilized plastic tarp of 0.5 to 4 mils thick. The tarp material stretch across the soil surface. Using two layers of thin plastic sheeting separated by a thin insulating layer of air increases soil temperatures and the overall effectiveness of a Solarization treatment. The edges of the sheets must be buried to a depth of 5 or 6 inches in the soil to prevent blowing or tearing of the tarp by the wind.

Timing-Long, hot, sunny days are needed to reach the soil temperatures required to kill soil borne pests and weed seed. The longer the soil is heated, the better and deeper the control of all soil pests and weeds will be. 2-week trapping period proved only moderately effective

(C) Micropropagation for Production of Disease-Free Planting Material

Micro propagation plays a significant role in production of virus-free plants of horticultural crops. Most of the horticultural crops are multiplied asexually and therefore once the plant is infected with viruses, the disease is transmitted from one vegetative generation to other. Many methods are being used to recover virus-free plants, viz. meristem tip culture, nucellar embryogenesis, micro grafting and even chemo and thermotherapy.

a) Method's of Micro Propagation for Production of Disease Free Planting Material

1) Meristem Tip Culture

The Meristem is a dome of about 0.1 mm in diameter and 0.25 mm long and protected by developing leaves and scales. The defoliated stem segments are first surface sterilized using good sterilant, e.g. ethanol, sodium hypochlorite. The Meristem dome is then dissected under a microscope inside laminar airflow. The exposed meristem tip, which appears as shiny dome, is then severed with the blade and transferred to liquid or solid medium. Murashige and Skoog is most commonly used medium for meristem culture of important horticultural crops due to high concentrations of potassium and ammonium ions and meso-inositol. The pH of the media may be a limiting factor for growth of meristem. The pH should range between 5.5 and 5.8. The technique of Meristem culture has successfully been used to obtain virus-free plants of a number of horticultural crops.

2) Nucellar Embryogenesis

Nucellar embryogenesis is another technique for mass production of virus-free plantlets in crops like citrus and mango, which are highly polyembryonic in nature. In citrus embryos arise from nucellus or integument adventively which is taken advantage for producing true-to-type plants. In citrus there are some species, which are highly polyembryonic and certain species are monoembryonic. It was found that nucellus taken from fertilized ovules of all monoembryonic cultivars would not develop. Pollination and fertilization are essential for the induction of nucellar embryogenesis even though there are reports of success in induction of embryogenesis using unfertilized ovules. Nucellar embryoids were formed only in polyembryonic Trovita ovule in culture. About 8-10 weeks old ovule of *Citrus reticulata* have been found as best explant for initiating nucellar embryogenesis under in-vitro condition. MS medium fortified with malt extract and/or paclobutrazol was found to be best for induction of nucellar embryogenesis in citrus. The inorganic salts such as ammonium nitrate, calcium chloride, potassium phosphate and potassium iodide showed significant association with embryogenesis

3) Thermotherapy

Thermotherapy is especially useful in treating viral and mycoplasmal infection in fruit trees. This has been found to be extremely useful in case of fruit trees where meristem culture is difficult. The technique involves exposer of a branch to constant or alternating temperature of 37-38 ^oC for 20-40 days. The potential virus-free bud is then excised and grafted on virus-free rootstock. Thermotherapy along with meristem culture is being practised in strawberry at commercial scale. The exact mechanism of virus-free plant production through thermotherapy is not known. However, it has been postulated that heat inactivates the virus present in the system, blocks the viral RNA synthesis and reduces translocation of viruses.

4) Micro Grafting or In-Vitro STG

Micro grafting or in vitro shoot tip grafting is being utilized to eradicate viruses from important woody perennial fruit trees. For the first time it was attempted in citrus.

Navarro *et al*. modified the technique in citrus. Citrus graft transmible diseases produced by virus, viroids, bacteria, spiroplasm and phytoplasm produce economic losses in most citrus growing areas. They causes declining loss of vigoour and short commercial life of trees, low yeilds and poor fruit quality, thus they are the potential to become primary limiting factor for production.The procedure used in the past include Nucellar embryony, Thermotherpy which are not useful due to some of their diadvatages in this situation, a method to recover citrus plants tree of all graft transimisible pathogen and without juvenile characters was required to produce healthy trees for commerial plantings.

The technique named shoot tip grafting In Vitro was developed by Navarro *et al* (1975)that allow a 30-50 per cent incidence of successful graft that were transplanted to soil with over 95 peer cent survival. The resulting plant did not have juvinile characters and most of them were free of graft transmible pathogen

Techniques for Shoot Tip Grafting In Vitro It Includes the Following Steps

1) **Root Stock Preparation**

   Seedling recovered by seed germination in Vitro are used as rootstock seeds are peeled, removing both seed coats, surface sterlized and sown in 25 × 150 mm culture tube containing 25 ml of the plant cell culture salt solution of Murashig and Skoog (1962). Solidified with 1 per cent Bacto agar cultures are incubated at 27 ° C in continuous darkness for 2 week. The heighest rate of succeful grafts was obtained with 2 week old seedlings. Stem height 3-5 cm tall with diameter of 1.6 to 1.8 mm at the grafting. Troyer citrange is the most commonly used rootstock for STG. However fallowing rootstocks have been succesfully used for In- vitro STG, Rough lemong, sweet orange, soure orange, Rangpure lime and cleopatra mandarin.the rootstock seedling is recommended for the test tube under asceptic conditions and it is decapitated, leaving about 1.5 cm of the epicotyl. The root is cut to a length of 4-6 cm and the cotyledons and axillary buds removed.

2) **Scion Preparation**

   Shoot tips can be excised from growing vegetative flushes of field or greenhouse plants or from budwood cultured in vitro also can be excised from dormant buds field trees have the disadvantage of the seasonal flushing and the lower rate of elimination of some pathogens. Greenhouse plants have the advantage that flushes can be induced when necessary and they can be subjected to warm pretreatment to improve the efficiency of elimination of pathogen. Budwood cultured in vitro at constant 32°c and exposed 16 hr daily to 80 μm /m^2s illummnation in culture medium Murashige and skoog an excellent source of shoot tip for STG

3) **Grafting**

   Flushes 3 cm long or shorter are collected, stripped of larger leaves, cut to about 1 cm long and surface sterlized by 0.25 per cent sodium hypo chloride solution. Shoot tip composed of the apical meristem and tree leaf primordia and measuring 0.1 -0.2 mm in length are then excised with a razor blade. The shoot tip is placed inside the incision of the rootstock with its cut surface in control with the exposed by the horizontal cut of the incision made at the top of the decapitated epicotyle size of the leaf primordium varies from 0.1 -0.2 mm gives a realistic degree of grafting success with highest possible number.

4) Culture In-Vitro of Grafting Plants

Micro grafted plants are cultured in a liquid nutrient medium composed of the plant cell culture salt solution of Murashige and Skoog / modified whites is distributed in to 25 × 150 mm test tube in 25 ml aliquotes. A folded paper platform, perforated at its center for insertation of the root portion of the rootstock is placed in the nutrient solution. These cultures are kept at constant 27 ˚C and exposed 16 hr daily to 40 – 50 µE/M^2S illumination five days after grafting the callus was completely developed at graft union, Imitation of vascular differentiation was observed seven days after grafting. There was complete vascular connection 11 days after grafting 4-6 week after grafting the successful grafts are ready and they can be transmitted to soil.

5) Transplanting to Soil

Scion of successful grafts should have at least two expanded leaves before being transplanted to soil. This stage usually reached 4-6 week after grafting .

Application of In-Vitro STG

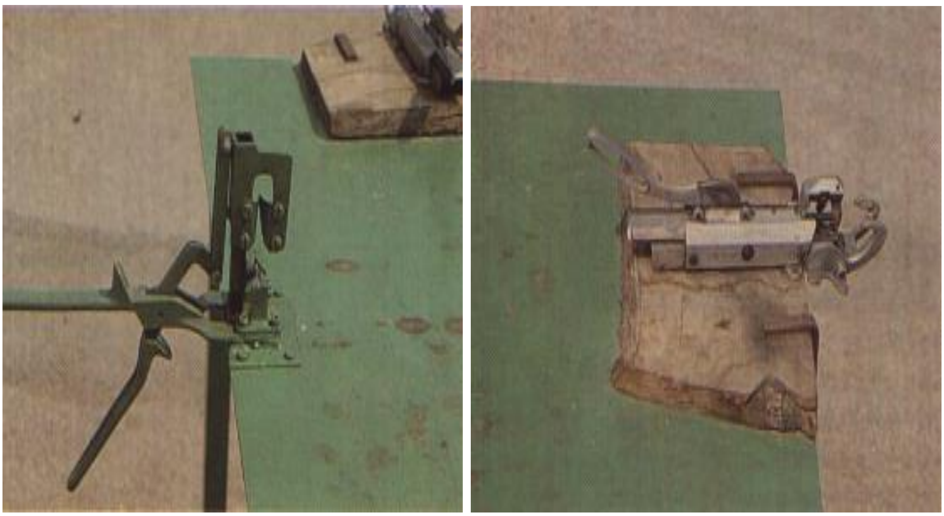
1) Control of graft transmissible pathogen.
2) Sanitation programmes.
3) Quarantine procedures.
4) Regeneration of somatic hybrids.
5) Regeneration of plants from irradiation shoots.
6) Regeneration of haploid plants.
7) Production of stable tetraploid plant of monoembryonic genotype.
8) Regeneration of plants from somaclonal variation experiments of adult material.
9) Regeneration of transgenic plants.
10) The technique for micro grafting has also been developed in peaches, plum, cherries, apricot, grape, apple, mandarin orange, cashew, tea etc.

Automation In Hi-Tech Horticulture

a) Nursery Mechanization

The necessary root media can be pulverized, mixed, pasteurized and filled in pots or trays but required equipment for the purpose needs development. The root media can be mixed in batches by modifying the concrete mixer. The pasteurization can be done by applying steam to rooting media by maintaining the media at 60-82oC for required duration. Portable steam generator should be used to generate steam and aerated steam may be passed through perforated pipes buried below the media beds. The potting media may be filled in seedling trays/pots for transplanting, using screw augur. The seeds can be sown using planters. A frequency domain sensor with 4 cm long electrodes was calibrated for measurement of volumetric water content and EC for use in growing media for horticultural crops.

Automatic pot filling machine fill up, fertilized and potted exactly 4800 pots per day at South Gippsland Victoria



Grafting machines

b) Sowing and Transplanting

Pricking out and replacing seedlings in trays is expensive in terms of experienced manpower. The development of automation in horticulture is briefly considered and a computer controlled machine for the automatic planting of seedlings in boxes was developed by Trentini. It lifts the seedlings with a plug of soil from the trays and transplants them at the required spacing. It can transplant 2,000 seedlings in a hectare with a single grip, and 5,800 when the actuator is fitted with 3 grippers. A worker manually picking and transplanting seedlings can handle 900-1,200 plants over an 8 hour shift. The transplanting of nursery in field is labour intensive. The raising of seedlings in block and transplanting increase the accuracy and efficiency of transplanting.

c) Soil Moisture Measurement

The continuous and precise measurement of soil water content is often a key for the interpretation of results measured in field and greenhouse experiments. This is especially true for studies on water consumption by plants and its role in the scheduling of irrigation. Several moisture-measuring devices are available including resistance block, tensio-meter and neutron moisture probe. A sensor which continuously monitors leaf thickness in field with an accuracy was developed and field tested over a period of six growing seasons. The suitability of three different electrical components was investigated as transducers of linear changes in leaf thickness to a measurable electrical signal. Concurrent research demonstrated that there is a linear and significant correlation between leaf thickness and leaf turgor potential (R2 > 0.9), which in turn has been shown to be an accurate and sensitive measure of plant-water status as it affects plant metabolism

d) Irrigation

The increase in understanding of soil-plant relationship has given rise to the concept that the best use of available water resources and optimum plant performance can be realized by prevention of moisture stress. Information on soil water potential to be used to automatically control the operation of a micro irrigation system. Granular matrix sensors may be used to provide soil-water potential data. A data-logger to be programmed to maintain soil water potential at constant level by high frequency irrigations (up to 8 times/day) using controllers connected to solenoid valves. Soil-water potential measurements would provide the feedback necessary to automatically schedule high frequency drip irrigation. The feedback allows the maintenance of nearly constant soil water potential in root zone. Maintenance of constant soil-water potential in root zone could result in optimum crop growth with a low leaching potential. Over and above these, appreciable amounts of useful irrigation water could be lost due to percolation beyond the root zone. Automated irrigation equipment certainly appears to be a valid concept, given our shrinking water resources and the surface and groundwater pollution problems that could occur with excess water application. Farmers need to apply water only when it is needed and in the required amount. The concept of applying irrigation water at various rates in pockets of the field would further improve water-use efficiencies. Low lying areas usually do not require as much water as hilltops but our present technology applies water uniformly which need to be made site-specific Use of different sensors to collect data on soil parameters, weather, crop and fertilizer concentrations to assist in automation of micro irrigation system was advocated by Ehlert *et al*. An algorithm for preparing fertilizer solutions based on soil characteristics was suggested by Savvas and Adamidis. Benami and Offen (3) suggested some basics for possibility of different levels of automation of sprinkler irrigation. Micro irrigation systems have potential to register very high irrigation efficiency up to 97 per cent. To achieve this precision control and automated operation through use of computers are required. Further emphasis will be to increase the production by accurate application of nutrients and irrigation water according to physiological growth of crop and prevailing agro climatic conditions. The know-how of production, operation and maintenance of automated micro irrigation systems is almost nil in India. This technology packages are bought at exorbitant costs from countries such as Israel and United States. In all such instances, the technical know-how is not revealed to Indian users. Therefore, efforts need to be made to develop indigenous automated micro irrigation system to supply the irrigation and nutrients on the basis of soil moisture distribution and level of nutrients concentration in plant root zone on real time basis.

e) Fertilizer Application

The technology for application of fertilizer is reasonably well-developed, at least from a hardware and software viewpoint. Perhaps the main missing link, at this time, is to develop the process for making a fertilizer recommendation based on each soil and crop type. Application of fertilizers through drip irrigation requires special fertilizer applicators so as to maintain specific concentration and application rates with respect to irrigation water and crop needs. Though venturi of ¾ inch size and fertilizer tanks are available in the country but there is a strong need to have more precise fertigation pumps for efficiently applying the fertilizers along with irrigation water. Appropriate concentration of nutrients may be mentioned in the root zone soil by way of application of required amount of nutrients through irrigation water.

f) Insect Pest Management

Mostly spraying is being done by manual sprayers. These operations is labour intensive and can be mechanized by using power operated sprayers. The detection and identification of insect pests is often carried out manually using trapping methods. However, recent advances in signal processing and computer technology have introduced the possibility of automatic identification species by several means including image analysis and acoustics. Insects can generate sound either deliberately as a means of communication or as a byproduct of eating, flight or other movement, which may be employed for detection and identification. Scientists at Hull University, Hull, UK, are investigating techniques for automatically identifying Orthoptera (grasshoppers and crickets) with time domain signal processing and artificial neural networks. Twenty-five species of British Orthoptera have been selected as a test set. The preliminary results indicate very high classification rate approaching 100 with extremely low misclassification rates. The technique is widely applicable to many insect pests and other phyla such as birds. The electronic probe insect counter (EGPIC) system was developed to provide automated real-time monitoring of insects. Insect counts from an array of electronic grain probes distributed throughout a storage volume are transmitted to a central computer for display and temporal analysis. Thus, by providing early detection of emerging infestations, EGPIC system can allow managers to initiate targeted control measures on need basis but before substantial losses occur.

Economics of Hi-Tech Nursery

Economic Estimation for Preparation Of 10,000 Santra Bud Grafts

Sr.No	Input items	Cost Required (Rs)
1.	Cost of Jamberi / Rangapur lime fruits	700.00
2.	Extraction of seed	150
3.	Raising of rootstock	
3a.	40-50 raised beds preparation cost 80 baskets F.Y.M. application and mixing 5 male @ Rs 22	125 80
3b.	Sowing of seeds and immediate hand watering (5 female) @ Rs 25	125
3c.	Hand watering twice a day till germination upto 30 days(30 female)	750
3d.	Weeding till transplanting and simultaneous soil stirring 20 female	500
3e.	32 irrigation from November to June 32 male @ Rs 25 each	800
4.	Transplanting and after care	
4a.	Preparation of nursery beds including land preparation, layout, addition of F.Y.M.20 male laborers	500
4b.	Transplanting, Marketing, Holding, Pressing – 50 laborers	1250
4c.	Weeding 15 times @ 10 female per weeding. 10 times removal of sides shoots 10 female each time. Total 250 female	6750
4d.	Irrigation from October to June, repairing beds, spraying, etc, one male throughout.	6750
5	Budding	
5a.	Budding charges for 20,000	1500
5b.	cost of Rs. 75 per @ 1000 polythene paper for tying	200
5c.	Bud stick charges	1000
6	Other inputs	
6a.	Cost of F.Y.M. for nursery beds	1000
6b.	Fertilizer, Urea, Insecticides	1500
6c.	Labour charges for spraying pesticides E	250
6d.	Electricity charges	800
7.	Lifting of grafts, packing, etc for sale from time to time @ Rs 20 for 100 grafts	2000
8.	Uncovered items such as depreciation on machinery, tools, transport, taxes, etc. @ 10 of the expenditure.	2650
	Total expenditure	29,150

Unit cost for construction of low cost polyhouse (100' x 15' x 10')

The design and cost estimation details of construction of a poly house covering an area of 1500 Sq.ft (140 Sq.m) is given below.

S. No.	Material Physica l requirement	Area(sq.m)/ length(m) /number/ volume(m^3)	Rate per sq.m or m or cubic m	Cost (Rs.)
1.	Roof, front and back	312 Sq.m	35	10,920
2.	Agro-shade net for sides	130 Sq.m	25	3,250
3	Bamboo	120 posts	50	6,000
4	Rope	25 m	65	1,625
5	Land levelling	240 m^3	21	5,040
6	Labour	40 man days	62	2,480
7	Cost of making beds (bricks, sand and cement)		lumpsum	1,000
8	Door with fittings			506
9	Foundation A.Earth work for 40 posts B. Cement Concrete, 1:3:6	3.8 m^3 3.8 m^3	62.00 1550.00	236.00 5890.00
10	Storage tank	(1000 Lt Capacity)	2.2 per ltr.	2,200
11	Siphon tube	70'	1	
	Total			**39,217**

Proposals of Government Departments / Public Undertaking / Universities in India for Hi-tech Nursery establishment

Sr. No	State	Organization	No of Hi-tech nursery Recommended	Total Cost
1.	Mizoram	FDA Aizawal FDA Lunglei, Mizoram	Two	20,00,000
3.	Haryana	Pinjore Research Nursery, Pinjore Forest Research Complex, Panchkula.	One	10,00,000
4.	Haryana	FDA Kaithal, Haryana.	One	10,00,000

5.	Haryana	FDA, Bhiwani, Haryana	One	10,00,000
6(a).	Madhya Pradesh	Conservator of Forest, R & E Circle,Gwalior(FDA Gwalior)	One	10,00,000
6(b).	Madhya Pradesh	Conservator of Forest, R & E Circle,Khandwa(FDA Khargone)	One	9,98,000
6(c).	Madhya Pradesh	Conservator of Forest, R & E Circle,Bhopal (FDA Sehore)	One	10,00,000
6(d).	Madhya Pradesh	Conservator of Forest, R & E Circle,Khandwa(FDA Khandwa)	One	10,00,000
6(e).	Madhya Pradesh	Conservator of Forest, R & E Circle, Jhabua(FDA Dhar)	One	10,00,000
6(f).	Madhya Pradesh	Conservator of Forest, R & E Circle, Betul (FDA Hoshangabad)	One	10,00,000
6(g).	Madhya Pradesh	Conservator of Forest, R & E Circle, Ratlam(FDA Ujjain)	One	10,00,000
6(h).	Madhya Pradesh	Conservator of Forest, R & E Circle, Sagar (FDA Panna)	One	10,00,000
6(i).	Madhya Pradesh	Conservator of Forest, R & E Circle, Jabalpur(FDA Mandla East)	One	10,00,000
6(j).	Madhya Pradesh	Conservator of Forest, R & E Circle, Gwalior (FDA Sheopur)	One	10,00,000
6(k).	Madhya Pradesh	Conservator of Forest, R & E Circle, Jhabua (FDA Jhabua)	One	10,00,000
6.	Uttaranchal	Ghadiwali, Shyampur Range, FDA Haridwar.	One	10,00,000

Conclusion

- Improving the availability of healthy planting material of improve or recommended verities supported by a network of regional nurseries equipped with distribution out fits will help in scientific development of horticulture.
- The infusion of latest technology has become essential for increased productivity.
- Unless uniform planting material of desired type is available, increased productivity levels cannot be achieved hence adoption of frontier technologies like Hi- tech nursery for raising plantlets has to be encouraged .

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