Protected Cultivation

PRCATICAL MANUAL:

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Protected Cultivation
Practical No.: 01

TITLE: STUDY DIFFERENT TYPES OF PROTECTED STRUCTURES

Objective: To study different types of protected structures based on shape construction and cladding material and collect information about the following.

Material: peg, rope, measuring tape, bamboo stick/ 6 mm GI rod, insect proof net, notebook, pen, pencil, etc

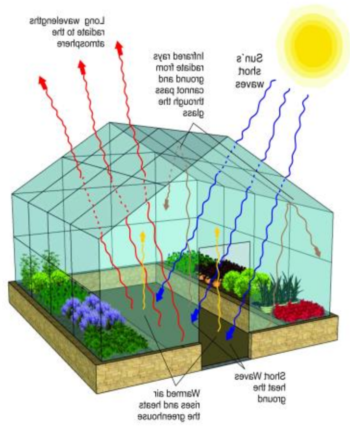
Introduction: In India, protected cultivation technology for commercial production is hardly three decades old. In a country like ours, where most of the structural designs have been adopted from different countries, the designs have been amply modified to suit the local conditions and requirements of different agro-climatic areas. **The commonly used protected structures are as follows:**

Low Tunnel: Also called 'miniature greenhouses', low tunnels (approximately 4 feet tall and 3 to 6 feet wide) generally cover rows of plants in field and, therefore, they are also known as row covers. Clean plastic films or nets are stretched over low wire hoops (high, steel wires or bamboo strips or cane) to protect plants against frost, wind, insects and pests. These hoops are covered by polythene sheets of about 50 microns thickness and are provided with ventilation holes on the side opposite to the solar movement. Low tunnels provide a passive control of plant micro climate, i.e., use of specific plastic material to control radiation and provision of natural ventilation. Plastic mulches and drip irrigation may be used in conjunction with low tunnels.

Walk-in tunnel: It is a temporary structure made by using GI pipes or bamboo, and is covered with different cladding material depending upon the season in which the cultivation is proposed Optimum size of the walking tunnel is 60–75 sq m, with 2–2.5 m width and up to 30 m length with a 2–2.5 m central height. Overall, the height is enough for the worker to walk comfortably during operation.

Net Houses: Depending upon the cladding (covering) material used, the net houses may be classified as insect-proof net houses and shade net houses. An insect-proof net house can be fabricated as a temporary or permanent structure in different designs. It can be in a walkin tunnel design and shape, with double door facility at one end of the structure. It is covered with UV-stabilised insect-proof net of 40–50 mesh for effective control of pests and diseases. The minimum size of insect-proof net house is 100 sq m.

Shade Net House: It is primarily constructed to protect plants from highly intense solar radiation. The structure is made of wood, stone, bamboo or GI pipes. When wood or bamboo are used, the poles are treated with turpentine and tar on one side before inserting them in the ground. Cladding material used on the top and sides of the structure is generally a shade net. The shade nets are available in different colours with different percentages of shade factor.



Greenhouse: It is a framed or covered structure with a transparent or translucent material which permits ample sunlight for crop production and has provisions for at least partial control of plant environment. As a result of this, a part of the solar energy is continually retained in the greenhouse, leading to a temperature increase. During summers, the greenhouses are cooled as per the crop requirement. Air humidity in the greenhouse can also be increased or lowered.. In general, crops in greenhouses are either grown on beds or in pots irrigated by micro-irrigation systems.

Mist Chamber: The main purpose of such a structure is to create high humidity and droplet-free presence of water for propagating delicate soft wood cuttings, vegetable crops, root plants and shrubs, etc. A mist chamber of 15–25 sq m is sufficient for a nursery. The frequency of misting depends upon ambient temperature and type of plant material being propagated.

Exercise: Activity 1: Describe different types protected structure

Sl. No.	**Name of the structure**	**Advantages**	**Material require**	**Area (Dimension)**

Activity2: Prepare a low tunnel with locally available materials.

Procedure: 1. Mark the area as per layout. 2. Insert peg as per demarcation. 3. Fix bamboo stick/GI rod. 4. Covering with cladding materia

Conclusions:

Practical No.: 02

TITLE: STUDY OF DIFFERENT KINDS OF GREENHOUSES

Objective: To study different types of greenhouse based on shape construction and cladding material and collect information about the following.

Materials required: measuring tape, notebook, pen, pencil, etc

Agro climatic conditions vary according to geographical locations. It is necessary to ensure the design of greenhouse meets the requirement of the peculiar agro climatic conditions. Therefore the type of greenhouse varies according to the climatic conditions of the area and utility of greenhouse. **Greenhouses can be classified based on different parameters.**

1. Classification based on shape: i. Lean to design, ii. Even span design, iii. Uneven span design, iv. Ridge and furrow, v. Quonset design, vi. Saw tooth design

1.1 Lean to design: Lean to design greenhouses are categorized as attached greenhouses and are placed against the side of existing wall preferably south wall of a building. This design maximizes the availability of sunlight with minimum constructional materials as the roof supports required are less. The roof of the building is extended with appropriate greenhouse covering material and the area is properly enclosed.

1.2 Even span: This design involves the two roof slopes of a greenhouse with equal pitch and width are attached to make a single roof. Construction of small greenhouses can follow this design. Several single and multiple span types are available for use in various regions of India. By using this deign the rainwater can slide off the roofs automatically.

1.3 Uneven span design: This type of design can be adopted to construct greenhouse on hilly terrain. The two roof slopes of different width form the single roof of the greenhouse.

1.4 Ridge and furrow: Design of ridge and furrow type greenhouse involves connecting two or more A-frame along its length of the eave. The eave serves as the furrow or gutter to carry rain water away. The side walls at the joints are eliminated which provides large interior space inside the greenhouse.

1.5 Quonset design: This type of greenhouse is constructed by using pipe arches or trusses for support. The pipelines run along the length of greenhouse. The greenhouse is covered by polyethylene sheet. These houses are connected either in free standing style or arranged in a interlocking ridge and furrow.

1.6 Saw tooth design: Green houses with Saw tooth design have rooftops in the shape similar to teeth of a saw. It is similar to ridge and furrow type except there is provision for natural ventilation in this type greenhouse.

2. Classification based on cladding material i. Glass green houses ii. Plastic film greenhouses iii. Rigid panel greenhouses

2.1 Glass greenhouses: Glass as covering material has the advantage of greater interior light intensity. These greenhouses have higher infiltration air rate, which leads to lower interior humidity and better disease prevention. Lean to type, even span, ridge and furrow type of designs are used for construction glass greenhouse.

2.2 Plastic film greenhouses: Flexible plastic films including polyethylene, polyester and polyvinyl chloride are used as covering material in this type of greenhouses. Plastics as covering material for greenhouse have become popular, as they are cheap and cost of heating is less when compared to glass greenhouses. The main disadvantage with plastic films is its short life as the covering material. For example, the best quality ultraviolet stabilized films can last for four years only.

2.3 Rigid panel greenhouses: Polyvinyl chloride rigid panels, fiber glass-reinforced plastic, acrylic and polycarbonate rigid panels are employed as the covering material in this type of greenhouses. These panels can be used in the Quonset type frames or ridge and furrow type frames. This material is more resistant to breakage and the light intensity is uniform throughout the greenhouse compared to glass or plastic. High grade panels have long life even up to 20 years. The main disadvantage is that these panels tend to collect dust as well as to harbor algae, which results in darkening of the panels and subsequent reduction in the light transmission. There is significant danger of fire hazard.

3.1 Classification based on construction i.Wooden framed structures ii. Pipe framed structures iii. Truss framed structures

3.1 Wooden framed structures: In general, for greenhouses with span less than 6 m, only wooden framed structures are used. Side posts and columns are constructed of wood without use of a truss. Pine wood is commonly used as it is inexpensive and possesses the required strength. Timber locally available, with good strength, durability and machinability also can be used for construction.

3.2 Pipe framed structures: When the clear span is around 12 m, pipes are use for the construction of greenhouse. In general, the side posts, columns, cross ties and purlins are constructed using pipes. Trusses are not used in this type of greenhouse also.

3.3 Truss framed structures: If the greenhouse span is greater than or equal to 15 m, truss frames are used. Flat steel, tubular steel or angle iron is welded together to form a truss encompassing rafters, chords and struts. Struts are support members under tension. Angle iron purlins running throughout the length of greenhouse are bolted to each truss. Columns are used only in very wide truss frame houses of 21.3 m or more. Most of the glass houses are of truss frame type, as these frames are best suited for pre-fabrication.

Exercise

ActicityNo. 1: Identify and describe about the types of greenhouse:

Picture (1, 2,3,4,5,6)	Describe about the types
	

Activity 2: Visit any protected structure and note down the following information

Sl. No.	Types of greenhouse	Category	Area (dimension)	Ventilation	Drawing of Cross section	Enlist material used in different structure	Describe the utilities of each structure

Sl. No.	Types of greenhouse	Category	Area (dimension)	Ventilation	Drawing of Cross section	Enlist material used in different structure	Describe the utilities of each structure

Conclusion:

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Practical No.: 03

TITLE: DESIGN OF GREENHOUSE

Objective: To study the design considerations and materials of construction for structural design of greenhouse

Materials required: notebook, pen, calculator etc.

Introduction: A basic important point for designing a greenhouse has been that the structure should be able to admit the maximum possible amount of sunlight during the winter season. Other major considerations involve shape of the roof, the material of roof etc. the design should be such that the angle of incidence of solar radiation is never greater than 40ºC. The structural design of greenhouse must provide safety from wind and other loads while permitting maximum light transmission to the crops. The framing members should be minimum size consistent with providing adequate strength to resist anticipated loads over the expected life of the structure. The various load should be considered to produce structurally sound and economical useful greenhouse.

Design load calculations: It is essential to consider all loads while erecting the greenhouse. The design of greenhouse structure is mainly governed by the dead load, live load, wind load and snow loads.
1. Dead loads are the weights of all materials (such as frame, covering material etc.) used in the construction of greenhouse.
2. Live loads are the weights superimposed by use (in greenhouse would include hanging baskets, vine ropes etc.). The minimum value of this is taken as 50 kg/sq.m in non-snow zones. In cooler areas the snow load may be added to this.
3. Wind loads are those caused by wind blowing any horizontal direction i.e. load due to wind velocity. The minimum value of this is taken as 100 kg/sq.m on vertically project area below 9.14metre height.
4. Snow loads are vertical loads applied to the horizontal projection of the building roof.

Site selection
- ✓ The soil should have a pH of of 5.5 to 6.5 and EC of 0.5 to 0.7 ms/cm
- ✓ Availability of continuous source of quality water (pH of 5.5 7.0 and EC should be less than 1 ms/cm)
- ✓ The site of construction should be elevated than the surrounding land.
- ✓ Transportation facility
- ✓ Land availability for future expansion

Orientation: Orientation of greenhouse depends up on light intensity, wind direction and wind velocity.
- ✓ Single span – East west orientation
- ✓ Multi span – north south orientation
- ✓ The opening of the top vent should be towards leeward side.
- ✓ Lengthwise slope – 0 to 2%
- ✓ Maximum width of greenhouse – 40 m

Materials: The selection of materials depends on its density, allowable stresses and economics. Initially wood and woo piped structures were common. Trusses, columns, beams or purlins made of these materials have different load bearing capabilities and in most instances, if maintained would remain sound. There are various materials available for fabricating the structure of greenhouse. The most commonly used are 1) wood 2) Steel 3) Aluminum

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Wood: This is very common where the cost of wood is comparatively very low and is available in plenty. The construction of structure is also simple as local artisans are able to complete the jobs. It is easy to construct greenhouse with wood structure.

Steel: Today, in construction of greenhouse high tensile strength pipes and tubular steel pipes (galvanized) are widely used. There has been a considerable development in construction of greenhouse. Galvanized steel or zinc coated pipes are preferred to avoid corrosion. All parts of the structure are made with 2 mm thick galvanized pipe or galvanized iron.

Aluminum: It is light in weight, easy to handle and not adversely affected by most greenhouse conditions. Aluminum pipes, angles, channels and T sections are commercially available. These can be used for trusses, purlins and columns.

Specifications

- Polythene 1 kg = 5 sq.m
- IS code for pipe – IS 1239, IS 1165
- Steel requirement – 5.5 kg/sq.m
- Insect net proof
- ✓ 50 mesh 130 GSM
- ✓ 40 mesh 105-120 GSM
- GI pipe of B class

Cladding materials: Flexible greenhouse films are made from low density polyethylene (LDPE), linear low density polyethylene (LLDPE), ethylene-vinyl acetate copolymers (EVA) and similar polymers. UV stabilized 200 micron thick polyfilm should have 88 % light transmission and life expectancy of 3 years.

- ✓ Ultra violet – UV absorbers and stabilizers
- ✓ Anti fogging – avoids water drops
- ✓ Anti dust – avoids dust particles
- ✓ Anti petal blackening – UV block fill
- ✓ Anti algae – avoids algae in heavy rainfall area
- ✓ IR cool – heat reflective
- ✓ Colored shade nets – Special optical properties
- ✓ Shade net – Regulate light and temperature

Insect net: Insect net it is used for cop protection in greenhouses as well as in net houses. 50 mesh and 40 mesh are commonly used. Insect nets having the capability to withstand even worst weather conditions thus can be used for numerous seasons.

Exercise: Enlist the different components of a greenhouse structure with suitable line diagram. • Visit nearby greenhouse structure and observe different components of the greenhouse. • Note down the components and their use.

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Practical No: 04

TITLE: STUDY OF INSTRUMENT IN GREENHOUSE

Objective: To study about different instrument used in green house

Material required: humidity meter or hydro-thermometer, thermometer pen, notepad, etc.
Introduction:

Various instruments are used for measuring environmental parameters in Greenhouse. These parameters are :

1. Temperature. 2. Solar intensity 3. Humidity 4. Leaf area index
5. Photosynthesis rate etc.

Instruments for temperature measurement:

1.Thermometers :

Types:

A) Liquid in glass thermometers (e.g. Hg. Alcohol colour with dye)
Range-Minimum -37.5 ^{0}C for pentane.
Highest 340 ^{0}C Hg up to 560 ^{0}C by filling space above Hg with CO_2/N_2 at High pressure

B) Bimetatic Thermometers : In this, the unequal expansion of two dissimilar metals, that have been founded together into narrow strip and coiled, is used to move a pointer round a dial.

C) Gas Thermometer : It is more accurate than liquid-in-gas thermometers, it measures the variation in pressure of gas kept at constant volume.

D) Resistant Thermometer : It is based on the change in resistance of the conductor or semi-conductors with the temp. range. Platinum, nickel and copper are the metals most commonly used in resistance thermometers.

E) Thermister : It is a thermally sensitive variable resister made of ceramic like semi-conducting material. They exist in small thin disc/thin chip/Wafer/large rod. The oxides of Cu, Mn, Ni, Co. Li are blended in suitable proportion and impressed into desired shapes from powders and heat treated to recrysatlize them, resulting in a desired ceramic body with the required resistance temperature characteristics. These are extremely useful for dynamic temp. measurements. It's operating range is -100 ^{0}C to 300 ^{0}C with accuracy of $\pm$ 0.01 ^{0}C.

F) Thermocouple : It is also called as *thermo-electric sensor*. Two wires of different metals twisted and brazed or held together normally from copper and Constantine. The magnitude of thermo-electric motive force (e.m.f.) is related to the temp. difference. Which is measured by a mill voltmeter or can be connected to temperature indicator.

G) Digital Electronic Temperature Indicator :

It directly display the temperature measured with the help of thermocouples and are available in multi-channels so that more than one reading can be recorded for different locations (inside/outside etc.) One end of the thermocouple is placed at location and other end is connected to the digital electronic temp. indicator which is calibrated to measure the direct reading of temperature.

2. Radiation measuring instruments :

Instruments for measuring solar radiation are basically of two types. The accepted terms of these are as follows :-

A) **Pyrheliometer –** An instrument using a collimated detector for measuring solar radiation from the sun and from the small portion of the sky around the sun (i.e. beam radiation).

B) **Pyranometer –** An instrument for measuring total hemispherical solar (beam + radiation) radiation usually on a horizontal surface. If shaded from the beam radiation by a shade ring or disc a pyronometer measures diffuse radiation.

C) In addition, the terms, solarimeter and actinometer can be used. Soloarimeter can be interpreated to mean the same as pyranometer where as actinometer usually refers to a pyrheliometric instrument.

Sunshine Recorder :

It is used for measuring the duration, in hour of bright sunshine during the course of the day.

Photosynthesis Analyser :

Portable Photosynthesis System : This system extends the boundaries of gas exchange research by providing a portable instruments. It makes rapid simultaneous measurements of photosynthesis rates and stomatal conductance with typical CO_2 depletion of only 2 to 100 ppm and very small RH changes the measurements are made very near ambient conditions.

Leaf Area Index (LAI) :

Measurement the amount of foliage and its distribution is fundamental to radiation penetration. Direct measurements of canopy structure are tedious and labour intensive in small canopies and nearly impossible in large forest canopies. The instrument used to measure leaf index is LAI-2000.

Measurement of Humidity :

The amount of water (vapour) content in the atmosphere (Green house)i.e. humidity is an important parameter in the growth of the GH. Plants.

Absolute Humidity – It is defined as the mass of water vapour present in unit volume of moist air (gm/m^3).

Relative Humidity (RH) – The ration between actual water vapour content of air and the amount of vapour the air could hold at saturation at the same temp. expressed as a percentage. The R.H. is measured with the help of hygrometer.

$$RH = \frac{P}{P_s} \; x\,100$$

$$\textit{at same temperature}$$

Measurement of pH : It indicates the acidity and alkalinity of the soil.

Data logger : It is an instrument which can measure the various parameters simultaneously. It is equipped with different probes required for different parameters. The output is displaced on computer monitor or separate display unit.

Exercise:

Activity 1: Monitor humidity and temperature in greenhouse

Procedure:

- Visit a greenhouse in nearby area after consultation with a farmer.
- Measure the temperature and humidity of greenhouse immediately after entering.
- Open the side curtains and after 30 minutes measure the temperature and humidity.
- After that ask the farmer to operate the fogger for 30 seconds.
- Measure the temperature and humidity again.
- Observe the temperature and humidity values that you collected.

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Practical No.: 05

TITLE: COST ESTIMATION OF GREENHOUSE

Objective: To study the preparation of cost estimate of greenhouse

Prepare the detailed estimate of material requirement for simple Pipe framed low cost green house (4x20m)

Sl.no.	Item of work /Details of the materials	Requirement (Qty)	Rate / unit (Rs)	Total amount Detail of (Qty) (Rs)
Total				

Conclusion:

TITLE: BED PREPARATION AND PLANTING OF CROP FOR PRODUCTION

Objective: To acquaint with the method of preparation of bed and planting of crop by following scientific techniques to raise quality and disease free vegetable seedlings

Tools required: Paper sheet and pen to note down the instructions, different tools for land preparation (tillage implements, manual harrow,) farmyard manure, fertilizers, bavistin etc.

Introduction: Bed preparation in a greenhouse, polyhouse, net house or a tunnel is very important and it plays a crucial role while growing plants. First of all, it is important to select 'well drained' soil for growing plants (like loam, red soil). The height of the bed should be equal, about 30–45 cm from the ground, with a width of 74–100 cm. The width of the path between two beds should be 50 cm. These beds are good for better aeration and drainage and are more common in greenhouse cultivation.The beds can be any length, but it is convenient to break them up with crosspaths to facilitate access and to avoid the temptation to walk across them. In this way, each bed will be accessible from a path on all two sides. Raised beds are built up higher than the surrounding paths. In many ways this is a logical progression from the decision to go for no-dig cultivation. It is often referred to as intensive raised bed gardening, because it can result in significantly higher yields.

Bed Preparation Procedure:

- The soil in the bed may first be loosened with a fork, as a one-off cultivation. At the same time remove any large stone. Remember, the aim is to clear the topsoil only. Ignore stones below 6 inches (15 cm), as these assist drainage. The same applies to old roots.
- The paths around the bed are now created, defined with a string line attached to wooden stakes. Dig out 15-20 cm of soil and drop this on to the bed, which is thereby raised. As you do so, break this soil into a reasonable tilth. Do not dig the path too deeply, as this will make a trench, which will be difficult to work in and maintain. The beds can be given a convex slope or can be flat, but it is recommend for flat-topped bed because this will reduce moisture loss by limiting the surface area and will also make for ease of working and spreading of compost manure. Sloping sides tend always to be falling into the pathways.
- Finally, spread organic matter over the bed. With the bed system this will go further, since it is being confined to the intensively cultivated bed surfaces alone, not spread over the whole vegetable plot. In time the beds will slump a little, but you will never 'lose' them, and they will, of course, be raised annually by the application of organic mulch.

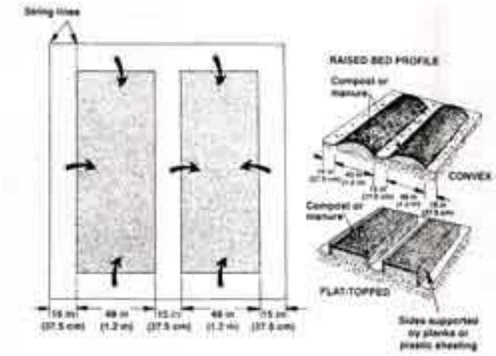


Fig.2.1: Layout of raised beds. Fig.2.2: raised bed for crop production

Planting of crop:

- Healthy and disease free seedlings of 30-45 days, 8-15cm height with 5-6 leaves are used for transplanting in the main field.
- Planting should always be done during evening
- Treat the saplings in 1% Dithane M- 45 solution for about 30 minutes to avoid fungal diseases.
- Mark the bed at row to row distance of 30 cm or any convenient distance.
- Plant the saplings in row to row and plant to plant spacing of 30cm or any convenient spacing.

Practical No.: 07

TITLE: RAISING OF SEEDLINGS AND SAPLINGS UNDER PROTECTED CONDITIONS

Objective: To study the method of raising seedlings and saplings under protected conditions

Theory: Nursery is prepared to raise saplings / seedlings as a pre-requisite for establishment of a garden. The nursery operations are specific and needs lot of care. A well prepared nursery can help in production of good saplings through stem cuttings or raising of seedlings through sowing of seeds. Nursery raised in rich soils can help in better growth of the saplings / seedling.

Materials Required: Bill hook / Secateur / garden implements / Measuring tape, Sand, Well decomposed Farm Yard Manure (FYM), Rope, Bavistin, (Dichlorovinyl Dimethyl Phosphate) DDVP, Gunny cloth.

Experiment procedure:

Stem cuttings / seeds have specific requirements for developing into saplings / seedlings. The advantage of raising saplings / seedlings in a nursery is that it is possible to develop rooted plants for taking up new plantation and also to raise grafts. More attention is required to grow saplings / seedlings in a nursery to get better survival and growth.

Steps:

- Select a land which is flat and near to the source of irrigation.
- Dig the land to a depth of 30 cm thoroughly and remove the weeds/ stone pebbles/old roots etc.
- Prepare raised beds of dimension 18 m (Length) x 1.06 m (Width) x 30 cm (Height) or any convenient size (Fig. 1.1).
- Apply about 60 kg sand and 30 kg FYM per bed and mix them with the soil thoroughly.
- Level the nursery beds with a piece of wood and make them ready for planting**.**
- Layout drip irrigation pipes

a) For Raising Saplings in the Nursery Beds :

- Healthy and disease free seedlings of 30-45 days, 8-15cm height with 5-6 leaves are used for transplanting.
- Planting should always be done during evening
- Treat the saplings in 1% Dithane M- 45 solution for about 30 minutes to avoid fungal diseases.
- Mark the bed at row to row distance of 30 cm or any convenient distance (Fig. 2.1).

- Plant the saplingsin row to row and plant to plant spacing of 30cm or any convenient spacing.

b) For Raising Seedlings in the Nursery Beds:

- In case seedlings are to be raised by sowing seeds, a line of 1 cm deep is drawn at 20 cm apart in the nursery bed and seeds are sown in the line at 3 cm spacing.

- Seeds can also be broadcasted in the nursery and covered with a thin layer of soil and sand mixture and later on thinning operation can be done to reduce the plant density**.**


Fig.1.1. Preparation of nursery bed; Fig.1.2: uniform and healthy saplings raised in nursery bed

c) Maintenance:

- Irrigate the nursery beds immediately after planting the cutting or sowing the seeds and subsequently as and when required depending upon moisture availability.
- Remove weeds manually from the nursery beds 30-45 days after planting of cuttings or sowing of seeds without disturbing the cuttings/ seedlings.
- Spray 0.1% Bavistin solution for controlling fungal diseases in the nursery.
- Spray 0.2 % Tafagor, Bavistineat 7-10 days intervals for controlling the pests.
- The saplings shall be ready for transplanting after a period of 30-45 days (Fig.2.2).
- Uproot the saplings carefully without damaging the root system. Irrigate the nursery before uprooting the saplings.
- Plant the saplings immediately in field after uprooting.
- If not planted immediately, keep uprooted saplings under shade and cover them with wet gunny cloth/sprinkle water at regular intervals..

Practical No.: 08

TITLE: USE OF PROTRAYS IN QUALITY PLANTING MATERIAL PRODUCTION

Introduction: The protrays raising technology is aimed to produce disease free, vigorous and season independent seedlings using protected environment. Depending on the objective, different types of protected structures like greenhouse, net house and portable low poly tunnels are used to take care of biotic and abiotic stresses during period of raising seedlings

Objective: To raise quality and disease free seedlings in protrays

Materials required: Paper sheet and pen to note down the instructions, seeds of crop, plugtrays/protrays, cocopeat, vermiculite, perlite etc.

Pro-tray for seedling raising

Advantages of Pro-trays: 1. Proper germination 2. Provide independent area for each seed to germinate 3. Reduce mortality rate 4. Maintain uniform and healthy growth of seedlings 5. Easy to handle and store 6. Reliable and economical in transportation

Rooting medium Ingredients:

- Mostly artificial soil-less media is used for raising healthy and vigorous seedlings of vegetable in plastic pro-trays.
- Combination of 3 ingredients like cocopeat, vermiculite and horticultural perlite are used as root medium for raising the nursery.
- These ingredients are mixed in 3:1:1 ratio before filling in the required containers.
- Media contains coarser textured peat provide better drainage and aeration promoting, therefore, better root development of transplants.

Procedure of raising seedlings in Protrays:

<u>A. Sowing of seeds:</u>

- Use true type seed.

- One seed per cell is sown.
- Sow seeds at shallow depth (0.5 cm) after pressing the media with finger in a gentle way into the potting plug or cells. The trays are filled with slightly moist media.
- After sowing, a layer of vermiculite is given to cover the seeds for better germination- good water holding capacity.
- The trays are shifted to polyhouse/net house.
- The trays are irrigated lightly every day depending upon the prevailing weather conditions by using a fine drip irrigation setup.
- Drenching the trays with fungicides as a precautionary measure against seedling mortality can also be done.
- Application of water soluble NPK fertilizer(25g/l) through drip irrigation setup on weekly interval.
- Seedlings are ready for transplanting after 20-30 days of sowing in trays. The internal environment of the polyhouses also affects the growth and development of the emerging seedlings. To get healthy seedlings the temperature should be maintained at 20-30°C. Growth regulators like cycocel @ 5-10 ppm can be sprayed at 3-4 leaf stage.
- The seedlings at right stage of planting are hardened by withholding irrigation before transplanting or selling to the growers.

Seedling in pro-trays

B. Disease control : ● Sanitation by controlling weeds inside the nursery greenhouse. ● Disinfect the trays by dipping in sodium hypochloride solution of 0.1 per cent before reuse of sowing has to be ensured. ● Ventilation is the best method of preventing damping off and foliar fungal diseases. ● Transplants can be treated with captan @ 0.2 per cent solution or by application of bavistin @ 0.1 per cent to the seedlings.

C. Hardening of seedlings: ● It is necessary to reduce transplanting shock. ● Plants should be gradually hardened by acclimatizing them to the anticipated growing conditions of the fields. ● It is done at least a week before planting. ● It can be done by slowing down their growth rate so that they can withstand chilling, drying winds, shortage of water, or high temperatures.

Practical No.: 09

TITLE: TRANSPLANTATION OF SEEDLINGS ON RAISED BED

Objective: To understand the transplanting process and assess the spacing of crops in greenhouse raised bed

Material required: measuring tape, khurpi, shovel and seedlings

Introduction: Transplanting is a process, wherein a seedling is uprooted from a nursery bed and transplanted to a permanent place, where it grows to produce yield.

Selection of seedlings for transplanting: In vegetable crops, 4–5 weeks old seedlings with 10–15 cm height (4–5 leaves) are suitable for transplanting (**Fig. 3.6 and 3.7**). Do not select weak, lanky and overgrown seedlings. Watering of the nursery bed is required just before uprooting.

During transplanting, a seedling must be:

• vigorous and sturdy • having a healthy root system

• free from insects, pests and diseases

• hardened in the nursery.

Fig. 3.6: Seedlings of chilli in pro-trays

Fig. 3.7: Seedlings of tomato in pro-trays

Ideal conditions for transplanting: Transplanting is done when the weather is cloudy, cool and moist. During sunny days, transplanting is preferred late in the afternoon to allow the seedlings to recover at the low temperature of the night.

Procedure for transplanting: Holes are made in the main field with the help of a khurpi or a shovel at a specified distance for a crop. One seedling is placed in each hole. Cover its roots with soil firmly. The seedlings of crops are transplanted on a flat bed or on sides of ridges. When planted on a flat bed, ridges and furrow are made after the seedlings set firmly. Irrigation should be done immediately after transplanting. In the initial stages, seedlings are transplanted at the side of ridges, and later, earthling up is done to bring the plant in the centre of the ridges. However, raised bed planting system is becoming popular. Beds of 15–20 cm height and 1.2 m width, irrespective of length, are prepared. These beds are either furrow irrigated or drip irrigated. Polythene mulching is another intervention to minimise weeds and save water. Irrigation is preferably localised along plant rows, leaving areas between the rows dry for transplanting operation. This is possible with furrow and drip irrigation but not with sprinkle irrigation. Irrigate the field 2–3 days before transplanting, if the soil is sandy or sandy loam. In case of clayey soils, irrigate 5–6 days prior to transplanting. Light irrigation is necessary immediately after transplanting for better field stand of seedlings.

Time of transplanting: In India, these can be grown throughout the year in areas where winters are less severe. Kharif season crops, like tomato, brinjal and chilli are sown in June– July and transplanted in the months of July–August. Rabi or winter season crops are sown in September– October and transplanted in November–December. For summer crops, seeds are sown in January–February and transplanted in February–March.

Transplanting shock: Transplanting shock means temporary retardation in growth or subsequent mortality of seedlings just after transplanting. This can be prevented by hardening of the seedlings by withholding water for 3–5 days before transplanting. Seedlings can recover easily if watered frequently for about a week after transplanting.

Exercise: Demonstrate the transplanting of seedlings

Procedure:

Activity 1: Prepare a suitable layout (flat bed or ridges and furrows) for planting.

Activity 2: Mark the location for planting seedings at suitable spacing

Activity 3: Make holes at the point of planting with the help of a khurpi or shovel

Activity 4: Place one uprooted seedling in each hole.

Activity 5: Cover it with soil and press the soil around the seedling firmly.

Activity 6: Water it immediately

Conclusion:

Practical No.: 10

TITLE: INTERCULTURAL TOOLS AND IMPLEMENTS OPERATIONS

Introduction: The main objective of weed control is to improve the soil condition for better plant growth. Weeds grow along with crops, thus competing for moisture, light and nutrients. Hence, it is essential to remove weeds. Following are some of the weeding devices used by the farmers.

Objectives: Overview on various intercultural tools and implements operations

Equipment requirement: Practical note book, pen, and pencil to note down the important points on intercultural operations etc.

1. Spade: A hand tool consists of flat iron blade and iron joint to fix the wooden handle and has a sharp front. It is available in different sizes and is used for: ● Lifting and turning the soil. ● Digging the pits, preparing channels for irrigation and drainage. ● Construction of field bunds.● Preparation of seed beds and hoeing of crops sown at wide row spacing and earthing up. ● Uprooting of bushes and stubbles. ● Harvesting of potato, sweet potato etc. by digging.

2. Small garden spade: Blade is smaller in size than the spade. It is most commonly used for making field bunds, seed bed preparation and hoeing (breaking and loosening of soil along with weeding) of crops.

3. Khurpa: It is widely used in hard soils for breaking and loosening the soil in addition to weeding, earthing up and digging small pits for transplanting vegetable seedlings. Potato and other vegetables can be harvested with it.

4. Digging-cum-weeding hoe: The iron blade which is slightly bigger than that of khurpa is fitted to a straight handle with its cutting ends downwards. It is used for giving deep hoeing about 2-5 cm deep so as to loosen the soil and remove the weeds.

5. Hand hoes: Mostly used for inter-cultural operations including removal of weeds, collection of stubbles and breaking of crusts to facilitate seed emergence. Spade SpadeKhurpa Digging-cum-weeding hoe 139 Practical Manual Olericulture-I

6. Garden rake: It is used for collecting stump and other residues of plant in the nursery. It also used in breaking clods and levelling of land.

7. Trowel: It is used for lifting nursery plants and also for transplanting seedling.

8. Hand leveller: It is used in small beds or nursery beds for levelling land and covering the seed after sowing. It can also be used for even distribution of manure.

9. Shovel: It is used for placing/lifting dug-out soil from one place to another.

10. Fork: It is used for loosening the soil in addition to weeding, mixing of compost in the soil.

11. Hoe-cum-rake: It is used for digging, hoeing, earthing up, levelling and collecting weeds.

12. Pronged hoe: It is available with two, three or four arms. It is used for digging of hard soil and also for digging crops like potato, turnip etc. It can also be used for mixing manures.

13. Hand cultivator/hand pronged hoe: It is a small hand fork type cultivator which is useful for loosening and aerating the soil without damaging the roots. It can be used for small scale vegetable growing.

14. Pick Axe/Mattocks: Pick axe has two edges with provision of axial hole in the centre for attachment with handle. One edge of pick axe is pointed and another is broadened. It is used for digging hard, compact and stony soils.

Exercise:

1. Visit local fruit greenhouse and make a schedule of intercultural operations practices.

2. Prepare cultural requirement of locally available crops and schedule different month wise cultural operations.

Practical No. : 11

TITTLE: MONITORING OF pH AND EC OF RAISED BED SOIL

Objective: To determination and monitoring of electrical conductivity and pH raised bed soil

Determination of soil electrical conductivity: The conductivity or more precisely the specific conductance of a soil at a given soil-water ratio is the reciprocal of the specific resistance offered by the solution at 25°C between the electrodes of 1 sq cm cross section kept 1 cm apart. Thus, the electrical conductivity of any solution depends on the amount of soluble salt present in it. Knowledge on the extent of salinity is important for management of saline soil including the choice of the crop suitable for that soil. Soluble salt content in saturation extract is more reliable index of salinity level than in soil: water ratio of 1: 2 or 1: 2.5 because it simulates the extent of salinity experienced by crop in field moisture condition.

Equipment's and Materials required: Conductivity meter with conductance cell, mechanical shaker, Buchner funnel, 100 ml conical flask, Whatman No. 42 filter paper.

Reagents: Standard potassium chloride solution, 0.01 N: Dissolve 0.7456 g of AR grade potassium chloride (KC1) and make up volume to 1 liter with distilled water. The EC_{25} of 0.01 N KC1 solution is 1.413 dS/m.

Principle: A simple Wheatstone bridge principle (except the type of current) is used for the measurement of EC of the soil solution, as EC of any solution is directly proportional to the concentration of soluble salt. Electrical conductivity is expressed as millimhos/cm (mmhos/cm) ordecisiemens/meter (dS/m).

Procedure

a) Preparation of Soil-Water Extract

1:2 or 1:2.5 soil-water extract

- Take 20g air dry soil in a 100 ml conical flask and add 40 ml (for 1:2) or 50 ml (for 1:2.5) distilled water.
- Shake on a mechanical shaker for 30 minutes and allow settling down for another 30 minutes.
- Filter the supernatant liquid through Whatman No. 42 filter paper into a beaker.

b) Determination of Electrical Conductivity

- Switch on the conductivity me ter and warm up it for 30 minutes.
- Adjust temperature at 25°C (if provided with the instrument) and cell constant (if known).
- if cell constant value is not known then calibrate the instrument using 0.01 N KCl solution with its

standard specific conductance value at room temperature.

- Thoroughly wash the cell with distilled water and then rinse with test solution.
- Measure the conductance of the solution directly from digital display and calculate specific conductance by multiplying electrical conductance with the cell constant value.
- Make necessary temperature correction at 25°C (if not provided with the instrument) by multiplying electrical conductivity with appropriate correction factor at room temperature.

Observation

Sl No	ECvalue
1	
2	
3	

Calculation: Electrical conductivity of the extract, mmhos/cm or dS/m = Conductance of the extract (mmhos) x cell constant (cm^{-1}) x temperature correction factor (ft) (if correction facility is not provided with the instrument).

Determination of soil pH:

Equipment's and Materials: pH meter with glass and calomel reference electrode, 100 and 500 ml beaker, glass rod.

Introduction: The soil pH value is the measure of hydrogen or hydroxyl ion activity in the soil solution and it indicates whether the soil is acidic, neutral or alkaline in reaction. The pH is the most important property of soil as it controls the availability of plant nutrients, microbial activity and physical condition of soil Since crop growth is affected both under very low (strongly acidic) and very high (strongly alkaline) soil pH, reclamation *of these soils* are necessary. Soil pH in fact indicates the extent of active *acidity* (activity of hydrogen ion in soil solution) of soil. Depending upon the purpose of measurement and soil condition, soil pH is measured in several soil-water or soil-salt solution ratios. The saturated *paste is used for* identifying specific soil problems like degree of acidity or *alkalinity*. The soil pH value is independent of dilution over a *wide* range of soil-salt solution ratio, thus more reproducible than those *obtained with* soil-water suspension.

Reagents: Standard buffer solutions: Certified buffer tablets are available for different pH values. Buffer tablets of pH 4.0, 7.0 and 9.2 are mostly used for pH meter calibration. Dissolve one tablet in specified volume (usually 100 ml) of water and preserve in refrigerator

Procedure

1) **Sample Preparation**

Soil - water suspension

- Take 20 g processed air dry soil in 100 ml beaker and add 40 mL(for 1: 2 soil - water ratio) or 50 mL (for 1: 2.5 soil - water ratio) of distilled water.
- Stir the soil with glass rod occasionally for about 30 minutes.

2) pH Determination

- Switch on the pH meter and allow it to warm up for half an hour.
- Set the temperature of the instrument at room temperature by turning temperature set knob.
- Calibrate the pH meter with three buffer solutions, one in acidic range (usually pH 4.0), one in alkaline range (usually pH 9.2) and other in neutral (pH 7.0) by using calibration knob.
- During each transition wash the electrodes thoroughly with distilled water and soak the adhering water with tissue paper.

- Repeat the calibration step 2-3 times till the instrument is completely calibrated at all the pH buffers.
- Carefully insert or dip the electrodes in the paste or suspension and measure the pH by pushing the pH measuring knob.
- Always withdraw electrodes from the solution when the instrument is in stand by position.
- Wash the electrodes thoroughly with distilled water.
- During rest keep the electrodes immersing in distilled water.

Observation

Sl No	pH value
1	
2	
3	

Conclusion:

- The give soil has a EC of …………
- The give soil has a pH of …………which belongs to the class…………

Rating

Soil Reaction Class	pH Range
Extremely acidic	<4.5
Very strongly acidic	4.6 - 5.0
Strongly acidic	5.1-5.5
Moderately acidic	5.6 - 6.0
Mildly acidic	6.1 - 6.5
Neutral	6.6 - 7.5
Mildly alkaline	7.5 - 8.0
Strongly alkaline	8.1 - 9.0
Very strongly alkaline	>9.0

Practical No. : 12

TITLE: LAYOUT OF DRIP IRRIGATION SYSTEM IN GREENHOUSE

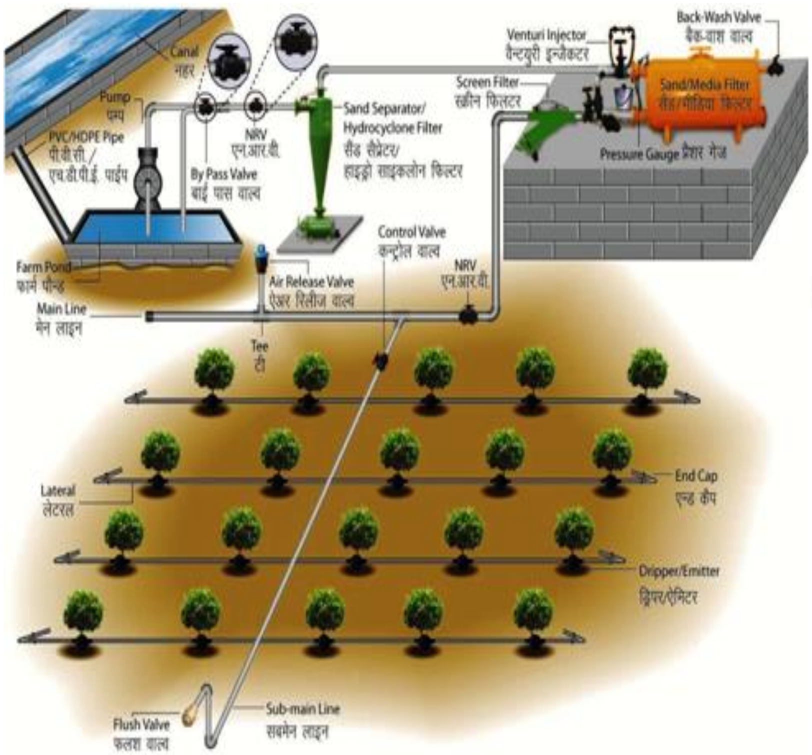
Objectives: To study about drip irrigation setup under greenhouse

Introduction: Drip irrigation system applies water in low volumes uniformly along with the fertilizers onto or into the soil near the plant root zone. This involves several components. These are the network of pipes (main line, sub mains, laterals), emitting device called as drippers or emitters, control head consisting of pumps, filters and fertigation units; and other accessories such as valves, gages etc.

Components of the drip irrigation system:

a) Pump and prime mover: The pressure necessary to force water through the components of the system including fertilizer tank, filter unit, mainline, sub main, laterals and provide at the emitters at the desired pressure is obtained by a pump of suitable capacity or the overhead water tank located at suitable elevation.

b) Water source: Water sources such as river, lake, reservoir/tank, well, canal water supply or connection to a public commercial or cooperative water supply network can be used.



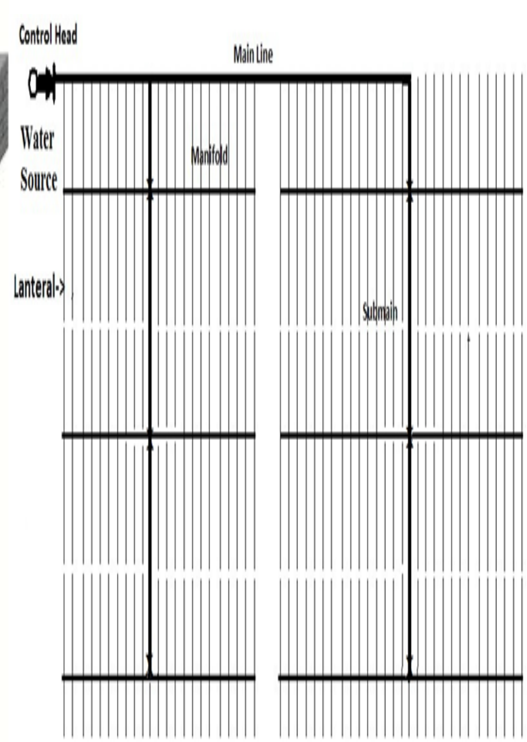


Fig.7.1. Component and layout of drip irrigation system. Fig.7.2. Typical layout of drip irrigation system.

c) Pipe network: Mainline, submains and manifolds (feeder pipes) and laterals.

d) Emitting devices: Emitters or drippers or the laterals integrated with drippers/emitters and line source with drippers.

e) Control devices: Valves, flow meters, pressure and flow regulators, automation equipment, backflow preventers, vacuum and air release valves, etc.

f) Filtration devices: Removal of suspended materials in the water. Media, screen and disc filters.

g) Chemical injectors: For application of plant nutrients and water treatment agents along with the irrigation water. Pressurized tank, venture injector, injection pump.

Control and Monitoring Devices:

Valves: Flow and pressure control valves are required for controlling water distribution and regulating pressure in the pipeline.

Gages: Pressure gauges monitor water pressure in the system and ensure operating pressure remains close to the recommended or desired values.

Water Meters:Water meters monitor and record the amount of water moving through a pipe where the water meter is installed.

Control Head: The main components of the control head are the filtration and chemigation units.

Filtration Systems: Filtration is the key to the success or failure of a drip irrigation system. The narrow water passage or pathways in the emitters of the drip irrigation system are susceptible to clogging by suspended matter and chemicals that precipitate from the irrigation water.

a) Preliminary separation of suspended solid particles by settling ponds, settling tanks and sand separators.

b) Complimentary chemical treatments for decomposition of suspended organic matter; to hinder the development of slime by microorganisms; to prevent chemical precipitates deposition and to dissolve previous deposited precipitates.

c) Filtration of the irrigation water: The media filters usually called as sand filters, screen filters or disc filters are used.

Chemical Injectors: Three categories of chemicals viz. fertilizers, pesticides and anti-clogging agents need to be injected into irrigation systems depending on the need.

i) Fertilizers are the most commonly injected chemicals. In drip irrigation system, it is possible to time the application of the fertilizers as per the requirement of crop growth stages. The fertilizers need to be water soluble.

ii) Systemic pesticides are injected into drip irrigation systems to control insects and protect plants from a variety of diseases.

iii) Chemicals that clean drippers or prevent dripper clogging: Chlorine is used to kill algae and different microorganisms and to decompose organic matter, while acids are used to reduce water pH and dissolve precipitates.

Emitters: Emitters, the core of micro irrigation system or made of plastic material.

Fig.7.3. Online non-pressure compensating drippers.

Exercise: Activity 1: Identify components of drip irrigation system.

Activity 2: Visit a greenhouse and note down plant spacing of different flower plants

Activity 3: Draw the layout of drip irrigation setup inside the greenhouse structure

Practical no.: 13

TITLE: REGULATION OF IRRIGATION

Introduction: Scheduling of irrigation based on soil moisture depletion approach to achieve better productivity, it is important to work out an efficient and economic irrigation schedule for water use under any given set of agro-climatic conditions. There are several approaches for scheduling irrigation based on crops, soil, atmosphere and plant water relations.

Objective: To study about regulation of drip irrigation

Equipment require: Moisture sensor, core cutter, scale, weight balance, pan evaporimeter

Methodology:

Estimation of Moisture Depletion:

According to soil moisture depletion concept, the water content at FC is considered 100 per cent available for crop growth and that at PWP is 0 per cent. The safe limit of allowable soil water depletion for a crop is determined by experimentation and taken as criterion for scheduling irrigation.

Values for FC and B.D. are determined layer wise of a soil profile to work out the moisture deficit with the formula:

$$d = \frac{FC - PWP}{100} \times B.D. \times \text{Depth of soil}$$

Based on this principle a large number of irrigation experiments have been conducted and it was observed that most of the crops like wheat, barley, maize, bajra and sunflower can resist the moisture stress upto 50% of available water in the root zone.

Example: In an irrigation trial on wheat, irrigation is to be scheduled at 20, 40, 60 and 80 per cent available soil water in 0-30 cm depth. If the FC is 28 per cent and PWP is 12 per cent, calculate the moisture present at which irrigations would be scheduled under different irrigation treatments.

Solution:

I1 = Irrigation at 20% ASW = (28-12) x 20 / 100 + 12 = 15.2%

I2 = Irrigation at 40% ASW = (28-12) x 40 / 100 + 12 = 18.4%

I3 = Irrigation at 60% ASW = (28-12) x 60 / 100 + 12 = 21.6%

I4 = Irrigation at 80% ASW = (28-12) x 80 / 100 + 12 = 24.8%

Scheduling of irrigation based on IW /CPE ratio approach: According to the recent concept water requirement of crops is dependent upon climatic parameters and therefore, the cumulative pan evaporation values are used for scheduling irrigation. It is well known that the consumptive use of water is a physical phenomena governed by the incident energy at a place and is not a physiological process. Based on this fact, the climatological approach of scheduling irrigation has been developed and it involves the depth of irrigation water (IW) and the cumulative pan evaporation (CPE). The ratio IW/CPE serves as a soil moisture stress index. The lower the ratio, the more will be the stress and vice-versa.

Example Taking experimental data, an example for scheduling irrigation based on pan evaporation is given below : Irrigation water to be applied = 7.0 cm

IW /CPE ratio = 0.9

Date of sowing of wheat = 15th November, 2007

Solution:

Ratio = IW/CPE

0.9 = 7.0 / CPE

$$CPE = \frac{7}{0.9} = 7.78 \text{ cm} = 77.8 \text{ mm}$$

It means we will irrigate the wheat crop when CPE reaches 77.8 mm. In the above table CPE reaches 77.5 mm on 12th December, 2007. Therefore, irrigation will be given on 12th December.

Table : Pan evaporation data

Month	Date	Pan evaporation / day (mm)	Cumulative pan evaporation (mm)
November	15	2.5	2.5
	16	2.4	4.9
	17	2.6	7.5
	18	2.5	10.0
	19	2.6	12.6
	20	1.3	13.9
	21	1.9	15.8
	22	1.2	17.0
	23	4.5	21.5
	24	3.6	25.1
	25	2.2	27.3
	26	1.9	29.2
	27	3.4	32.6
	28	2.4	35.0
	29	2.2	37.2
	30	2.7	39.9
December	1	1.6	41.5
	2	2.6	44.1
	3	3.9	48.0
	4	5.5	53.5
	5	4.9	58.4
	6	4.6	63.0
	7	2.2	65.2
	8	1.5	66.7
	9	1.8	68.5
	10	2.4	70.9
	11	5.1	76.0
	12	1.5	77.5
	13	0.8	78.3
	14	0.9	79.2
	15	1.7	80.9
	16	2.8	83.7

Protected Cultivation

Problem: **Calculate cumulative pan evaporation required for scheduling irrigation at IW/CPE ratio of 0.5,0.75 and 0.8 with 5 cm of irrigation water.**

Solution:

Parctical No. :14

TITLE: STUDY OF AGROCHEMICALS AVAILABLE FOR POLYHOUSE

Objectives:

Material required: notebook, pen, fertilisers and practical file

Introduction: Most greenhouse operations apply soluble fertilisers through irrigation systems, thus the use of the term ‘fertigation’. This is accomplished by drip (pipes) where soluble fertilisers are injected using injectors at a calculated quantity of concentrated solution (stock solution) into the irrigation line so that the water from the hose (dilute solution) carries as much fertiliser as planned. Fertigation provides not only greater resource optimisation, but also better adaptability for suitable placement and delivery of inputs, thereby increasing nutrient uptake efficiency, predictability, precision as per the requirement of the plant or the media formulations.

Fertilisers Suitable for Fertigation:

1. Nitrogen Sources: Nitrogen is the predominant element used in any kind of fertigation, including the ones used in greenhouses, as plants require it in large quantities besides being highly mobile across different phases of biogeochemical cycles.

Major sources of nitrogen, along with information on their use in fertigation are given below:

Ammonium Phosphate: It may lead to lowering of pH and soil acidification. High calcium or magnesium in the water for irrigation causes precipitate formations and it can choke the drip emitters and drip lines.

Ammonium Sulphate: It is an inorganic soil supplement that benefits especially in alkaline soils. It tends to be acid forming, which could be a disadvantage if greenhouse media is acidic.

Ammonium Thio-sulphate: It is used both as a fertiliser and as an acidulating (which makes it slightly acidic) agent.

Calcium Ammonium Nitrate: It is high in fast acting nitrate-nitrogen, low in lasting ammonium nitrogen, and supplies calcium. Calcium ammonium nitrate may be combined with ammonium nitrate, magnesium nitrate, potassium nitrate and potassium chloride.

Calcium Nitrate: It is soluble in water and causes only a slight shift in the soil or water pH.

Urea Ammonium Nitrate: Nitrogen is available in three forms — nitrate nitrogen, urea nitrogen and ammonium nitrogen. The nitrate portion is immediately available as soon as it reaches the root zone. The urea portion moves freely with the soil water until it is hydrolysed by the urease enzyme responsible for the formation of ammonium nitrogen.

Urea Sulphuric Acid: It is well suited for fertigation. Urea sulphuric acid is an acidic fertiliser, which combines urea and sulphuric acid.

2. Phosphorus Sources: Monoammonium phosphate, di-ammonium phosphate, monobasic potassium phosphate, ammonium polyphosphate, urea phosphate and phosphoric acid are some of the most common phosphate carrying water-soluble fertilisers

Ammonium Nitrate: It is a liquid fertiliser mainly used as a source of nitrogen in greenhouses. It is available in two forms of nitrogen — the nitrate-nitrogen form (mobile and instantly available) and ammonium-nitrogen (the longer lasting, as micro-organisms convert it to the nitrate form).

The major phosphorus sources along with information on their use in fertigation are as follows:

Ammonium Polyphosphate: If the water being used has high buffering capacity (high carbonate/bicarbonate content generally with high pH, i.e., > 8.0) along with a high calcium and/or magnesium content, possibilities of precipitation in drips becomes very high.

Diammonium Phosphate (DAP): DAP is a boon under situations of high alkalinity and indeed many greenhouses face this problem.

Mono-Ammonium Phosphate (MAP): It provides nitrogen in ammonia forms that is taken up by the plants readily.

Monobasic Potassium Phosphate: Also known as monopotassium phosphate, it provides good quantity of phosphorus along with potassium.

Phosphoric Acid: It can be used in many formulations of nitrogen, phosphorus and potassium mixtures. Being a good source of phosphorus, it provides additional advantage of keeping the pH of input injections low and helps in avoiding precipitation.

Urea Phosphate: It is a good source of both phosphorus as well as nitrogen. It provides nitrogen in the form of urea. It is basically acidic in nature and highly suitable for acidifying water and soil.

3. Potassium Sources: The potassium sources most often used in drip irrigation systems are potassium chloride (KCl) and potassium nitrate (KNO_3). Potassium phosphates are avoided for injection into drip irrigation systems.

Major sources of potassium sources along with their uses in fertigation are given below:

Potassium Chloride: Potassium is supplemented by using potassium chloride as it is highly soluble and inexpensive.

Potassium Nitrate: It is costly, but provides both nitrogen and potassium simultaneously. Potassium nitrate is advisable to use with irrigation water where salinity problems exist as it has a low salt index.

Potassium Sulphate: Notes It can easily be used in place of potassium chloride in high-saline areas and simultaneously presents a source of sulphur.

Potassium Thio-sulphate (KTS): Two grades of potassium thio-sulphate are available and are neutral to basic, chloride-free, clear liquid solution. It is blended with other fertilisers, but KTS mixed should not be acidified below pH 6.0.

Table 1.: Composition of major nutrients in different fertilisers commonly recommended for fertigation

Protected Cultivation

S. No.	Fertiliser (NPK)
1	Urea (46-0-0)
2	Ammonium Nitrate (34-0-0 3)
3	Ammonium Sulphate (21-0-0 4)
4	Calcium Nitrate (16-0-0 5)
5	Magnesium Nitrate (11-0-0 6)
6	Urea Ammonium Nitrate (32-0-0 7)
7	Potassium Nitrate (13-0-46 8)
8	Mono-Ammonium Phosphate (MAP) (12-61-0 9)
9	Potassium Chloride (0-0-60 10)
10	Potassium Nitrate (13-0-46 11)
11	Potassium Sulphate (0-0-50 12)
12	Potassium Thiosulphate (0-0-25 13)
13	Monobasic Potassium Phosphate (MKP) (0-52-0 14)
14	Phosphoric Acid (0-52-0 15)
15	NPK (19-19-19 and 20-20-20)

Table 2.: Solubility of Nitrogenous Fertilisers

S. No.	Types of fertiliser	Nitrogen content (%)	Solubility (gm/litre)
1	Ammonium Sulphate	21	750
2	Urea	46	1100
3	Ammonium Nitrate	34	1920
4	Calcium Nitrate	15.5	1290

Table 3.: Solubility of Potassic Fertilisers

S. No.	Fertiliser	K content (%)	Solubility (gm/litre
1	Potassium Sulphate	50	110
2	Potassium Chloride	60	340
3	Potassium Nitrate	44	133

Table 4.: Solubility of Micronutrient Fertilisers

S. No.	Fertilisers	Content (%)	Fertiliser Solubility (gm/litre)
1	Solubor	20 B	220
2	Copper Sulphate	25 Cu	320
3	Iron Sulphate	20 Fe	160
4	Magnesium Sulphate	10	710
5	Ammonium Molybdate	54	430
6	Zinc Sulphate	36	965
7	Manganese Sulphate	27	1050

Compatibility: Mixing the solutions of two or more water soluble fertilisers can sometimes result in the formation of a precipitate. Therefore, their solutions should be prepared independently in two separate tanks.

Table 5.: Combined nutrients (C = Compatible, NC = Not Compatible, LC = Limited Compatible)

S. No.	Fertilisers	Urea	Ammonium Nitrate	Ammonium Sulphate	Calcium Nitrate	Mono Ammonium Phosphate	Mono Potassium Phosphate	Potassium Nitrate
1	Urea		C	C	C	C	C	C
2	Ammonium	C		C	C	C	C	C

	Nitrate							
3	Ammonium Sulphate	C	C		LC	C	C	LC
4	Calcium Nitrate	C	C	LC		NC	NC	C
5	Mono Ammonium Phosphate	C	C	C	NC		C	C
6	Mono Phosphate Phosphate	C	C	C	NC	C		C
7	Potassium Nitrate	C	C	L	C	C	C	

Exercise: Visit a greenhouse and Identification of common fertilisers: Note down the components of irrigation/fertigation system, Identify fertilisers on the basis of appearance, Note down the content of each fertilizer, Note down the commonly used water soluble fertilizer, Observe difficulties faced during the operation.

Practical no.: 15

TITLE: FERTILIZATION CALCULATIONS FOR DRIP IRRIGATION

Introduction: Fertigationcal culations are done in PPM (parts per million) of various elements used as fertilizers. Fertilizer calculations also involve discharge rates of drip water and dilution rate of fertilizer injectors. Also it involves knowledge, self-acquired or from reliable sources, on the suitable PPM rates for particular crops.

Objectives: To study about fertilizer concentration requirement for crop through drip irrigation

Fertilizers solubility

Fertigation requires that fertilizer dissolves completely in irrigation water. Some highly soluble fertilizers appropriate for use in Fertigation are: Ammonium Nitrate, Potassium Chloride, Potassium Nitrate, Urea, Ammonium Monophosphate and Potassium Monophosphate.

The solubility of fertilizers also depends on the temperature. In summers higher density solutions may be made but in winters leaner solutions would need to be made.

Some factors to decide on the injector equipment required for regulating Fertigation in drips are:

- quantity of fertilizer to be applied
- duration of applications
- proportion of fertilizers
- starting and finishing time

Most growers use injectors of one type or other for applying fertilizers to greenhouse crops. Injectors “inject” a specific amount of concentrated fertilizer solution (stock solution) per increment of irrigation water that passes through the injector. An important attribute of each fertilizer injector is the injector ratio, which is defined as volumetric ratio of stock solution to dilute fertilizer solution. Injector ratio – the volumetric ratio of stock solution to dilute fertilizer solution.

Popular injector types:

1. Pressure differential (by-pass tank)
2. Vacuum injection (Venturi) – very popular
3. **Pump injection – very precise**

Methodology:

Determination of particular fertilizer quantity for required PPM at the root zone:

1. Step one in any Fertigation program is to first have a soil and water analysis done for determining the EC, pH and quantities that may be present of minerals in your water and soil.

2. Second step is to determine the nutrient rates your crop requires. You can use recommendations from the literature, or your own experience. If nutrient requirements are provided in units other than ppm or mg/l, it is recommended to convert the values to ppm (1ppm = 1 mg/l).

Deduct the soil water test results from the nutrient requirements of the crop for each required nutrient. For example, if magnesium requirement is 60 ppm and the source water contains 40 ppm, and then 60-40=20 ppm of magnesium has to be added to each liter of nutrient solution.

Fertilizer Selection: Farmer needs to go through all Fertilizers available with him or in nearby store. And then select ones which contain all nutrients needed to be added. Begin with the fertilizer that contains a unique nutrient that other fertilizers do not contain. For example, if the only available source of calcium you have is calcium nitrate, start the calculation with this fertilizer.Now we come to nuclear question. By now farmers has decided on what should be fertilizer ppm in the drip solution delivered to his plants.

Calculate Fertilizer Amounts: The formula allows you to calculate the amount of fertilizer needed to mix stock solutions. This formula can be used with any injector ratio, any desired concentration of diluted fertilizer solution and for all common units of measurement.

$$\textbf{Reqd amt of fertilizer} = \frac{\textbf{((PPM desired of N or P or K) X dilution factor))}}{\textbf{((\%N or P or K) X K)}}$$

ppm calculations

Note:

1. Dilution factor is the reverse of injector ratio i.e. if injector ratio is 1:100, the dilution ratio is 100.
2. K is a conversion constant depending on the units used.
3. K = 75 if units are ounces per gallon
4. K = 1200 if units are pounds per gallon and
5. K = 10 if units are grams per liter.

Example: Farmer has an injector with a 1:200 ratio and a fertilizer with an analysis of 20-20-20. He wants to apply 150-ppm nitrogen as a constant feed. How many ounces of fertilizer would he have to weigh out to make 1 gallon of stock solution?

1. Given

- Desired concentration = **150 ppm**
- Injector ratio = 1:200; **dilution factor = 200**
- Fertilizer analysis = 20-20-20 (**20-percent** nitrogen)
- Ounces of fertilizer to make 1 gal. of stock solution = X (unknown)
- Units: ounces per gallon. Use **75** as the conversion constant K.

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2. Perform calculation :X = (150-ppm nitrogen x 200) / (20-percent nitrogen X 75) =30,000 / 1500 = 20 oz. per gal.

3. Answer: Add 20 oz. of 20-20-20 to a stock solution bucket and fill to the 1-gal. Farmer can have as many gallons of stock solutions and feed it through his injector in the drip line till his crop is served. He will always have the same 150 PPM of N.

Practical no. : 16

TITLE: OPERATION AND MAINTENANCE OF FOGGER

Introduction: Fogging system, one of the developing technologies, is evaporative cooling technology. The most critical components of the system are the fog nozzles. Programmable logic controller (PLC) and high pressure pumps are used in addition to these components which are located in the air channels in the special formation.

Objective: To understand procedure for operation and maintenance of fogger.

Principal operation of fogger: The system works by feeding the inlet air with fine water droplets. Drips can be of different sizes depending on the duration of evaporation in the expected ambient conditions. These systems, generally between 20 and 40 microns, pass through high-pressure demineralized water atomization nozzles. Then the water is thrown from the tits. Fogging system is fairly effective and uniform method of greenhouse cooling that provides a reasonable increase in relative humidity inside greenhouse.

Materials and methodology:

Foggers are connected to lateral with micro-tube and it is hanging over iron wire in greenhouse (3 m above). Misters are attached to stakes in beds. Foggers and misters spray about 70 micron size of water in air and evaporated before falling onto the crop canopy. Foggers and misters are equipped with an anti-leak devices which does not allow flow of water droplets to fall down after the system is switched off. They have small discharge rate with small area coverage. The operating pressure of fogger and mister varies from 3 to 5 kg/cm2 .Generally the time of operation of foggers and misters are 30 to 60 sec, three or four times in an hour at specific time interval.

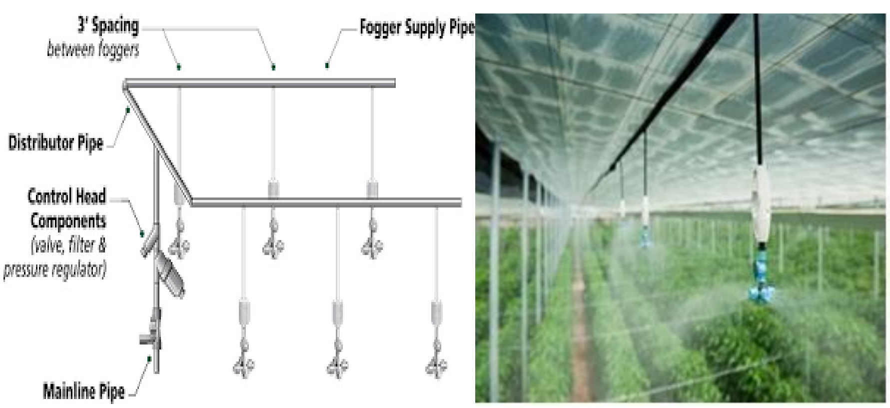


Fig: Components of foggers used for fogging in greenhouse.

Operating Procedure

- Plug the machine into an appropriate power source as specified on the machine identification label.

- Turn the machine power switch to the ON position to begin the application.
- Continue spraying until the correct amount of formulation has been distributed.
- To interrupt spraying turn power switches to the OFF position but do not close the metering valve. When spraying is finished, close meteringvalve before turning the switch to the OFF position. This will clear outlines and prevent chemicals from dripping from the nozzle.
- Prepare the disinfectant according to the requirement.
- Fill the tank of the fogger with the prepared disinfectant.
- Set the metering valve low to high according to the requirement.
- Switch on the main switch of the fogger and keep the fogger in the area to be fumigated for approximately 15 to 20 minutes

Maintenance Procedure:

- Periodically clean the formulation tank using a hot water/ detergent solution. Fully open the machine valve and operate the machine for 3 to 5minutes, flushing the solution through the valve, lines, and nozzle
- After 500 hours of operation, carefully remove the blower assembly and examine the brushes and the Commutator of the Blower motor.
- The brushes are worn or damaged, replace the brushes.
- If it becomes necessary to disassemble the foundation-metering valve of cleaning, be careful not to enlarge the metering orifice or damage the taper of the valve stem. Doing so will affect the calibration of the machine.
- After every use remove and clean the air intake filter on the rear of the blower housing using a hot water/ detergent solution.
- Allow the filter to dry completely before attempting to operate the machine.

Practical No. : 17

TITTLE: STUDY ABOUT MISTERS

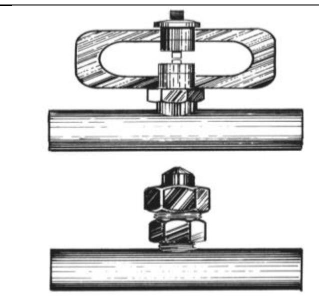
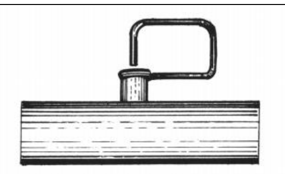
Introduction: Greenhouse misting systems use evaporative cooling to keep your greenhouse temperature perfect for growing plants. Water is sprayed through pressure-increasing, minuscule nozzles, filling the air with a super-fine mist. As that mist evaporates, heat from the air is “consumed, creating a cooler environment inside the greenhouse.

Objectives: To study about layout of mister system

Components of a Misting System:

Nozzle: A durable, fail-safe nozzle is an indispensable part of an effective mist system. You don’t want nozzles leaking and dripping onto your plants and the greenhouse floor. Going with a good-quality, rust-resistant brass and/or stainless steel nozzle will save you tons of frustration and repair/replacement money in the long run. Plastic nozzles are cheaper, but metal is a much more prudent choice.

Types of Mist Propagation Nozzles: Two basic types of nozzles are used in mist propagation systems:

1. Oil-burner nozzles, which have a whirling action.	
2. Deflection nozzles, which employ a small stream of water impacting against a small, flat plate.	

Compression Fittings: Compression fittings are sturdier pieces that connect your water-brining hose to water-misting nozzles. They come as T, elbow, and other shapes, to fit your needs.
The compression fittings directly connect your nozzles and your irrigation tubing, so check and double-check that the tube diameter and threading sizes match before you purchase these parts!

Tube or Hose: The water-carrying tube is the most easy-to-use and economical part of the mister system. Choose a ¼-inch or ½-inch delivery tube depending on your needs and the size of your compression fittings.

Filter: Mesh filter to the spigot that feeds your mister system is mandatory.

Operation of Greenhouse Misting System

Ventilation First: It’s essential that you already have a proper circulation/ventilation set-up in your greenhouse. Without sufficient circulation, a misting system won’t work. While a misting system will enhance ventilation, by encouraging air to move around as temperatures vary and preventing air stratification and shading, a mister does not replace vents and fans.

Watch Water: Misting nozzles vary according to the volume of water they spray. Many nozzles are adjustable. Nose nozzle can be tighten or loosen it to change how much water comes out. The tighter the nozzle, the more “misty” the water, and the less volume of water being released.

Placement: Misting placement differs for general greenhouse climate control and baby plant propagation. For maintaining overall greenhouse temps and humidity, you should install a misting system at the highest point in the house.

For starting seeds or cutting, place the misting system directly above the flats or containers. Position them at least 2-3 feet above the plants. This will likely mean you need to build a mounting structure on which to position the misting system (since the roof frame beams of the house will be much too high).

Nozzle Position: The nozzle should be spaced so that there are no dry areas on the bed and so the overlap is minimal. If excessive overlap occurs, excessive wetting may result. Most nozzle manufacturers recommend the nozzle spacing which they feel provides the best results. The most common recommended spacing is 3 to 4 feet. Be sure to follow the particular manufacturer’s advice. Nozzles are normally placed about 18 inches above the plant-bed surface. Some manufacturers may, however, recommend lower heights.

Controls for Misting Systems: Most mist propagation systems are controlled with two time clocks. The first is a 24-hour clock which turns the system on during the daylight hours and off at night. The second is a cycle timer which controls the duration of the “on” cycle and the interval between mist cycles. The clock should allow both of these intervals to be adjusted to correspond to the growing and environmental requirements. During bright, warm, summer days in Oklahoma, the optimum number of mist cycles can be as many as 20 per hour. Each “on” period should be as short as possible but long enough to fully wet all leaf surfaces.

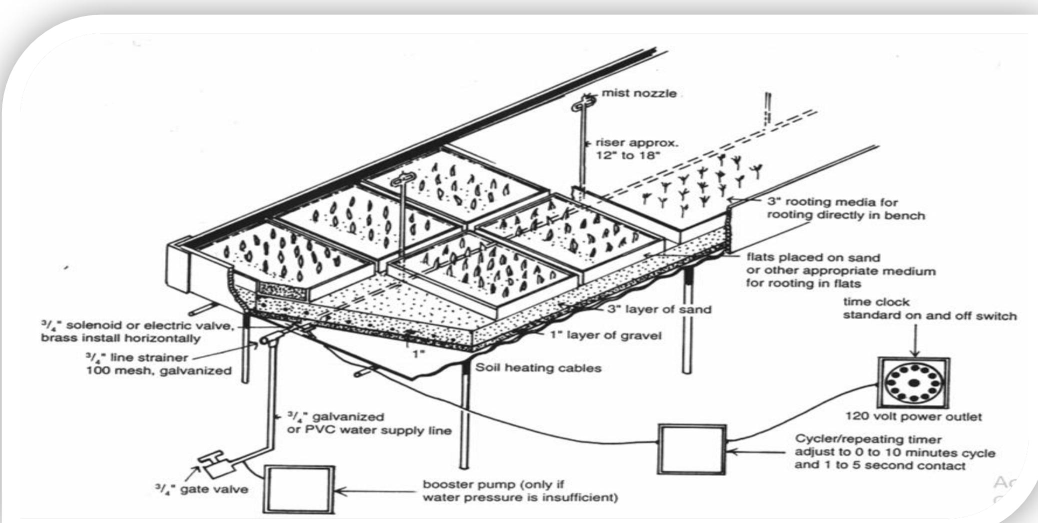


Fig.11.1. Layout for typical mist bench

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