A practical manual on Protected Cultivation and Secondary Agriculture

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Experiment 1: Study of different type of green houses based on shape.

Green House:

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

Greenhouse type based on shape

Greenhouses can be classified based on their shape or style. For the purpose of classification, the uniqueness of the cross section of the greenhouses can be considered as a factor. As the longitudinal section tend to be approximately the same for all types, the longitudinal section of the greenhouse cannot be used for classification. The cross sections depict the width and height of the structure and the length is perpendicular to the plane of cross section. Also, the cross section provides information on the overall shape of the structural members, such as truss or hoop, which will be repeated on every day. The commonly followed types of greenhouse based on shape are lean-to, even span, uneven span, ridge and furrow, saw tooth and quonset.

1 Lean-to type greenhouse

A lean-to design is used when a greenhouse is placed against the side of an existing building. It is built against a building, using the existing structure for one or more of its sides. It is usually attached to a house, but may be attached to other buildings. The roof of the building is extended with appropriate greenhouse covering material and the area is properly enclosed. It is typically facing south side. The lean-to type greenhouse is limited to single or double-row plant benches with a total width of 7 to 12 feet. It can be as long as the building it is attached to. It should face the best direction for adequate sun exposure. The advantage of the lean-to type greenhouse is that, it usually is close to available electricity, water, and heat. It is a least expensive structure. This design makes the best use of sunlight and minimizes the requirement of roof supports. It has the following disadvantages: limited space, limited light, limited ventilation and temperature control. The height of the supporting wall limits the potential size of the design. Temperature control is more difficult because the wall that the greenhouse is built on, may collect the sun's heat while the translucent cover of the greenhouse may lose heat rapidly. It is a half greenhouse, split along the peak of the roof.

2 Even span type greenhouse

The even-span is the standard type and full-size structure, the two roof slopes are of equal pitch and width. This design is used for the greenhouse of small size, and it is constructed on level ground. It is attached to a house at one gable end. It can accommodate 2 or 3 rows of plant benches. The cost of an even-span greenhouse is more than the cost of a lean-to type, but it has greater flexibility in design and provides for more plants. Because of its size and greater amount of exposed glass area, the even-span will cost more to heat. The design has a better shape than a lean-to type for air circulation to maintain uniform temperatures during the winter heating season. A separate heating system is necessary unless the structure is very close to a heated building. It will house 2 side benches, 2 walks, and a wide center bench. Several single and multiple span types are available for use in various regions of India. For single span type the 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.

3 Uneven span type greenhouse

This type of greenhouse is constructed on hilly terrain. The roofs are of unequal width; make the structure adaptable to the side slopes of hill (Fig. 2). This type of greenhouses is seldom used now-a-days as it is not adaptable for automation.

4 Ridge and furrow type greenhouse

Designs of this type use two or more A-frame greenhouses connected to one another along the length of the eave (Fig. 2). The eave serves as furrow or gutter to carry rain and melted snow away. The side wall is eliminatedbetween the greenhouses, which results in a structure with asingle large interior, Consolidation of interior space reduces labour, lowers the cost of automation, improves personal management and reduces fuel consumption as there is less exposed wall area through which heat escapes. The snow loads must be taken into the frame specifications of these greenhouses since the snow cannot slide off the roofs as in case of individual free standing greenhouses, but melts away. In spite of snow loads, ridge and furrow greenhouses are effectively used in northern countries of Europe and in Canada and are well suited to the Indian conditions.

5 Saw tooth type Greenhouse

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

6 Quonset greenhouse

This is a greenhouse, where the pipe arches or trusses are supported by pipe purling running along the length of the greenhouse. In general, the covering material used for this type of greenhouses is polyethylene. Such greenhouses are typically less expensive than the gutter connected greenhouses and are useful when a small isolated cultural area is required. These houses are connected either in free, standing style or arranged in an interlocking ridge and furrow. In the interlocking type, truss members overlap sufficiently to allow a bed of plants to grow between the overlapping portions of adjacent houses. A single large cultural space thus exists for a set of houses in this type, an arrangement that is better adapted to the automation and movement of labour.

Experiment 2. Determine the rate of air exchange in an active summer winter cooling system.

Air flow calculation

The airflow leaving an inflated tube through a smooth circular opening can be calculated according to the equation: Airflow (cfm) = Constant * Coefficient of Discharge * Area in Square Feet * the square root of the static pressure within the tube in inches of water.

$Q = 4005X\ CX\ AX\ P^{1/2}$

Q = Airflow in cfm for circular openings (0.60)

C = Coefficient of discharge for circular openings (0.60)

A = Area of opening in square feet (for a circle: πd2/4)

P = Static pressure in inches of water

4005: Constant for air at standard temperature and pressure

Air Exchange Capacity of a Ventilation System

One way to calculate the air volume being moved by a ventilation system is to measure air speed and cross sectional area through which air is moving.

Air speed (feet per minute, fpm) x Area (sq. ft.) = ventilation rate (cubic feet per minute, cfm)

The air speed moving through the fan and/or inlets should be measured. To determine cross-sectional area, the fan airflow opening should be measured, which is usually the fan diameter, or sum the total inlet areas.

Experiment 3. Determination of drying rate of agricultural products inside green house.

Drying process can be divided in to three periods:

(i) Constant drying rate period and

(ii) (ii) First falling drying rate period and

(iii) (iii) Second falling rate period.

(i) Constant drying rate period

In a constant drying rate period, a material or mass of material contain so much water that liquid surface exists will dry in a manner comparable to an open faced body of water. Diffusion of moisture from within the droplet maintains saturated surface conditions and as long as these lasts, evaporation takes place at constant rate. When a solid is dried under constant drying conditions, the moisture content $\times_t$ typically falls The graph is linear at first, then curves and eventually levels off. Constant rate drying period will proceed until free moisture appears from the surface, the moisture removal rate will then become progressively less. The moisture content at which the drying rate ceases to be constant is known as the critical moisture content. During the constant rate period, the moisture from interior migrates to the surface by various means and is vapourised. As the moisture content is lowered, the rate of migration to the surface is lowered. If drying occurs at too high temperatures, the surface forms the layer of closely packed shrunken cells which are sealed together. This presents a barrier to moisture migration and tends to keep the moisture sealed within. This condition is known as ‘case hardening’.

The constant rate period is characterized by a rate of drying independent of moisture content. During this period, the solid is so wet that a continuous film of water e×ists over the entire drying surface, and this water acts as if solids were not there. The temperature of the wetted surface attained the wet bulb temperature.

Web bulb Temperature (WBT)

WBT is the steady state temp shown by the thermometer whose bulb is covered with a wet wick and from which water is evaporating into a high velocity air stream. The quantity of water evaporated is not high enough to alter the temperature and humidity of the air stream.

The air blown at high velocity (minimum recommended is 300 m/min). It causes evaporation of water from the wick. Evaporation requires latent heat. This heat comes from surface of glass bulb of thermometer. So the temperature of the glass bulb decreases. The the heat comes from the temperature difference between Tw and Ta (large). It is the case of simultaneous heat and mass transfer. This heat is latent heat for phase change of water to water vapor.

q = amount of latent heat transfer

q = Mw Nw λw A----------------- (i)

Mw = mol. Mass of water kg/kg mol

Nw = molar flu× of water vapour, kg mol m-2 s-1

λw = Latest heat of vaporization kJ/kg

A = surface area of the bumb m2

$N_w = k_y (y_w - y)$

k_y = mass transfer coefficient kg mol m^{-2} s^{-1}

y_w = mole fraction of water vapour in the stagnant air layer adjacent to the wet cloth

y = mole fraction of water vapour in the air stream, some distance away from the wet cloth

$(y_w - y)$ is the driving force.

Where,

w = kg of moisture

Ø = time

h = heat transfer coefficient between air and moisture kcal/ kg hr °C

t_a = dry bulb temperature of air, °C

t_s = surface temperature, °C

A= area, m^2

ΔH_v = heat of vapourisation at t_s ,Kcal/ kg

k_a = mass transfer coefficient (kg/ hr m)

H_s = humidity of saturated air at the surface temperature

H_a = humidity of air

The constant rate period ends when the migration rate of water from the interior of the surface becomes less than the rate of evaporation from the surface. The period subsequent to the critical point is called 'the falling rate period'. Beyond this point, the surface temperature rises, and the drying rate falls off rapidly. The falling rate period takes a far longer time than the constant rate period, even though the moisture removal may be much less. The drying rate approaches zero at some equilibrium moisture content.

Drying in falling rate period involves two processes:

a) movement of moisture within the material to the surface
b) removal of the moisture from the surface

The method used to estimate drying rates and drying times in the falling rate period depends on whether the solid is porous or non porous. In a non porous material, once there is no superficial moisture, further drying can occur only at a rate governed by diffusion of internal moisture to the surface. In a porous material other mechanism appears, and drying may even takes place inside the solid instead of at the surface.

(ii) First falling drying rate period

Point B, the moisture content at the end of the constant rate period, is the ‘critical moisture content’. At this point the surface of the solid is no longer saturated, and the rate of drying decreases with the decrease in moisture content. At point C, the surface moisture film has evaporated fully, and with the further decrease in moisture content, the drying rate is controlled by the rate of moisture movement through the solid.

(iii) Second falling drying rate period

Period C to D represents conditions when the drying rate is largely independent of conditions outside the solid. The moisture transfer may be by any combination of liquid diffusion, capillary movement, and vapour diffusion.

11.2 Estimation of Drying Time

In order to determine the time required to achieve the desired reduction in product moisture content, the rate of moisture removal or drying rate must be predicted. The rate of drying depends on properties of drying air (the dry bulb temperature, RH, and velocity of air and the surface heat transfer coefficient), the properties of food (moisture content, surface to volume ratio and the surface temperature) and rate of moisture loss. The size of the pieces has an important effect on the drying rate in both the constant and falling rate periods. In the constant rate period, smaller pieces have a larger surface area available for evaporation where as in falling rate period smaller pieces have a shorter distance for moisture to travel through the food. Other factors which influence the rate of drying include:

1. The fat content of the food (higher fat contents generally results in slower drying, as water is trapped with in the food).

2. The method of preparation of food (cut pieces lose moisture more quickly than losses through skin.

3. The amount of food placed in a dryer in relation to its size (in a given dryer faster drying is achieved with smaller quantities of food).

For constant rate drying period the following general expression would apply:

Rc = dw / dt = wo – wc / tc -------------- (1)

Where,

wc = Critical moisture content (kg water / kg dry solid) and

tc = Time for constant rate drying

During falling rate drying, the following analysis would apply.

- dw/dt = Rc / wc (w) or

wc / Rc ò - dw /w = ò dt

Where the limits of integration are between critical moisture content wc or end of constant rate drying, tc and some desired final moisture content, w.

On integration:

$t - t_c = w_c/R_c \ln(w_c/w)$ or time for falling rate becomes

$t_f = w_c/R_c \times \ln (w_c/w)$ ------------(3) and

The total drying times becomes

$t = (w_o - w_c) /R_c + W_c/R_c \times \ln (w_c/w)$ ----------(4)

The above equation indicates that the time for complete drying from some initial moisture content w_o to a desirable final moisture content w depends on knowledge of critical moisture content w_c, the time for constant rate drying t_c, and the rate for constant drying R_c.

Experiment 4. Study of green house equipments.

List of greenhouse equipments:

1.Screens: It helps control the amount of light, humidity and temperature inside the facility, which turns to an improvement of the crop conditions and a reduction of the energy costs.

The screen has a flexible and easily-folding structure that once folded takes up minimum space and allows entering the maximum amount of light.

It may be automatically run by means of a solar radiation sensor.

Hot air heating: The hot air generators are especially recommended in those cases where there is not an important requirement for continuous heating and as an occasional defence against freezing temperatures. The purpose of this system is to increase the productivity of the crops and their maturity in cold weather, using medium level technology.

The distribution of hot air is carried out using fans and hoses.

Water heating: This is a Centralised heat generation system using natural gas, diesel, biomass, geothermal heat. Water circulates through metal or PVC-Polyethylene pipes as a heat transporting agent, depending on the temperature of the hot water source, the temperature increase requirements and the crop.

We offer a wide range of solutions in this area, from basic systems, to the most sophisticated systems with Open Buffer heat storage systems and use of CO_2 coming from combustion gases.

Extractor fan: The extractor fans allow forcing the ventilation inside greenhouses when the natural ventilation using roof and/or perimeter vents, does not allow reaching the desired rate of air renewal, which is an innate need for producing crops as well as livestock farms.

They are often used in combination with evaporative cooling panels or water misting systems for the purpose of obtaining a certain level of cooling.

Air circulation fan: The air circulation fans or recirculation fans help obtain a suitable air movement contributing to maintain a homogeneous interior climate, avoiding hot air accumulation at the upper section of the greenhouse, reducing substantially the degree of water condensation and favouring the crops' transpiration and CO_2 absorption.

They may be used as support for the extractor fans or as humidifier systems or for applying treatments.

Cooling: This water evaporation cooling system is comprised of extractor fans and cooling panels installed on opposite walls of the greenhouse to create a negative pressure area inside the greenhouse. This forces the outside air flowing through the dampened panels becoming charged with water molecules and cooled down and thus decrease the temperature inside the greenhouse.
Fertigation: Fertigation consists of applying simultaneously water and fertilizers through the irrigation system, supplying the nutrients required by the crops to the soil or substrate. Fertigation is especially useful in the case of drip irrigation. By means of automatic high technology fertigation equipments the water and the nutrients are perfectly placed in the absorption area of the roots, improving the rate of growth and quality of the crops.

This system allows carrying out a more rational use of the water and fertilizers, respecting the environment and minimizing the environmental impact.

Growing benches: The growing benches may be fixed, mobile or transportable.

Fix benches have a standard working height of 80cm.

The transportable benches include multi-direction wheels with brakes. Mobile benches allow moving the bench platform sideways on the structure, which facilitates creating aisles to access the benches, thus optimising the surface used for the growing.

Depending on the purpose for which the bench is used, any of the above-mentioned models can be selected with metallic grid bottom or an ebb and flow bottom.

Fog system: Consists of incorporating a large number of micro-particles of water to the ambient air, which remain suspended in the air inside the greenhouse long enough to evaporate without wetting the crops. The water is added in the form of fog using special nozzles distributed uniformly all over the surface of the greenhouse.

The Fog system is very useful for humidifying and cooling down the greenhouse in a controlled manner and carrying out disinfection treatments using soluble plant protection products.

Inflatable roof: The double inflated film system consists of creating an air chamber between two layers of plastic. The air chamber is kept inflated using small fans that inject air into the chamber via PVC and flexible pipes.

This air chamber reduces the heat transmission coefficient towards the outside, achieving a considerable energy savings and temperature control.

This system may be used on roofs as well as along the perimeter.

Climate control: offers a wide range of climate controllers for the automated management of all the systems that are installed in our greenhouses.

The controllers are guided by the information collected by the different sensors installed, in order to maintain suitable levels of solar radiation, temperature, relative humidity and CO_2 concentration for the crop; thus achieving the best evolution of the crops regarding their performance, early maturity and quality.

Experiment 5. Visit to various Post Harvest Laboratories.

Visit to RKM, Morabadi (Ranchi)

Experiment 6. Determination of Moisture content of various grains by oven drying & infrared moisture methods.

Moisture: Moisture content was estimated using A.O.A.C. (2006) method. Accurately weighed 5 g sample was taken in previously dried and weighed petri dish. The petri dish along with sample was placed in the oven maintained at 85±1°C for 3 to 4 h, by repeating the process of drying, cooling in the desiccator and weighing at 30 min intervals, until the difference between consecutive weights was less than 1mg. Then it was transferred to desiccators and cooled and weighed. The percent moisture content was calculated as:

$$\text{Moisture content (\%)} = \frac{W_2 - W}{W_1 - W} \times 100$$

Where; W = Weight of empty petri dish

W_1 = Weight of petri dish with sample before drying

W_2 = Weight of petri dish with sample after drying to constant weight

Infra-Red moisture meter:

The near infrared reflectance, NIR or IR, technique is a widely used technology for online moisture testing. Its popularity is due in large part to the ease with which it can be applied.

A light source (typically quartz halogen bulb) is collimated and filtered into specific wavelengths. The filters, mounted in a rotating wheel, chop the light into a series of pulses of specific wavelength. The filtered beam is directed onto the surface of the product to be measured. A portion of the light is reflected back to a detector (usually lead sulfide). Specific wavelengths of light are absorbed by water. If the filters are chosen such that one wavelength will be absorbed by water (sample beam) and one wavelength will be unaffected by water (reference beam), then the amplitude ratio of the two reflected wavelengths will be proportionate to the amount of water in the product. The ratio technique eliminates effects of product distance and source aging.

- Ease of application. Typically mounted 6 to 10 inches above product. Moderate product height variations have little influence on measurement.
- Small spot measurement area in conjunction with scanning frame provides product profile.
- Specific wavelengths may be chosen to measure variables other than moisture.

Experiment 7. Determination of engineering properties (shape and size, bulk density and porosity of biomaterials).

1. **Grain size and shape**

Grain size and shape (length-width ratio) is a very stable varietal property that can be used to measure the varietal purity of a sample. Comparing the length-width ratio of the sample with a published ratio for the variety will give an indication of varietal purity of the grain sample. A significant deviation means that the sample is impure – that is, it is either a different variety or a mixture of varieties.

Scale (length, mm)
Extra long (more than 7.5)
Long (6.6 to 7.5)
Medium (5.51 to 6.6)
Short (5.5 or less)

Scale	Shape	Length-width ratio
1	Slender	3.0
3	Medium	2.1 – 3.0
5	Bold	1.1 – 2.0
9	Round	Less than 1.1

Obtain a random sample from the seed batch.

Collect 20 grains at random from this sample of seed.

Use a Vernier caliper or photographic enlarger to measure the dimensions of each grain.

2. **1000 grain weight**

Each variety has a published weight for 1000 grains. If the 1000-grain weight calculated from the sample departs from this, it may be an indication that the sample contains a mixture of varieties.

Select a random sample from the seed batch

Count 1,000 whole grains from the sample.

Weigh the 1,000 grains.

3. **Bulk Density**

Bulk density was determined by liquid displacement method. Fifty ml distilled water was taken in the measuring cylinder and volume was noted. Fifty g seeds were weighed accurately and transferred to the cylinder. Increase in volume of water was recorded to calculate bulk density and expressed as g/cc.

4. **Hydration Capacity**

Seeds weighing 10 g were counted and transferred to a measuring cylinder. To this 30 ml water was added and cylinder was covered with aluminum foil and left overnight at room temperature. Next day, seeds were drained, superfluous water was removed with filter paper and swollen seeds were reweighed.

$$\text{Hydration capacity (\%)} = \frac{\text{Increase in weight x100}}{\text{Weight (g) of seeds}}$$

$$\text{Hydration capacity (per seed)} = \frac{\text{Increase in weight}}{\text{Number of seeds}}$$

5. **Hydration index**

Hydration index was calculated using the following formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity per seed}}{\text{Weight (g) of one seed}}$$

6. **Swelling capacity**

Seeds weighing 10 gm were counted and their volume was noted and soaked overnight. The volume of soaked seeds were noted in graduated cylinder.

$$\text{Swelling capacity (\%)} = \frac{\text{Increase in volume x100}}{\text{Weight (g) of seeds}}$$

$$\text{Swelling capacity (per seed)} = \frac{\text{Volume after soaking-Volume before soaking}}{\text{Number of seeds}}$$

7. **Swelling index**

   Swelling index was calculated using the formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Seed volume (ml)}}$$

8. Porosity: (inter granular space):

Introduction and Definition: Total porosity is defined as the fraction of the bulk rock volume V that is not occupied by solid matter. If the volume of solids is denoted by Vs, and the pore volume as Vp = V - Vs, we can write the porosity as:

$\phi = V – V_S/V = V_P/V$

Pore Volume/Total Bulk Volume

The porosity can be expressed either as a fraction or as a percentage. Two out of the three terms are required to calculate porosity. It should be noted that the porosity does not give any information concerning pore sizes, their distribution, and their degree of connectivity. Thus, rocks of the same porosity can have widely different physical properties. An example of this might be a carbonate rock and a sandstone. Each could have a porosity of 0.2, but carbonate pores are often very unconnected resulting in its permeability being much lower than that of the sandstone.

Laboratory Determinations: There are many methods for measuring porosity, a few of which will be discussed below. Several standard techniques are used. In themselves these are basic physical measurements of weight, length, and pressures. The precision with which these can be made on plugs is affected by the nature (particularly surface texture) of the plugs.

1 Direct Measurement Here the two volumes V and Vs are determined directly and used in Eq. (1). This method measures the total porosity, but is rarely used on rocks because Vs can only be measured if the rock is totally disaggregated, and cannot, therefore, be used in any further petrophysical studies. This measurement is the closest laboratory measurement to density log derived porosities.

2 Imbibition Method The rock sample is immersed in a wetting fluid until it is fully saturated. The sample is weighed before and after the imbibition, and if the density of the fluid r is known, then the difference in weight is r Vp , and the pore volume Vp can be calculated. The bulk volume V is measured using either vernier callipers and assuming that the sample is perfectly cylindrical, or by Archimedes Method (discussed later), or by fluid displacement using the saturated sample. Vp and V can then be used to calculate the connected porosity. This is an accurate method that leaves the sample fully saturated and ready for further petrophysical tests. The time required for saturation depends upon the rock permeability.

Experiment 8. Determination of Moisture content of various grains by moisture meter.

Moisture meters: All commonly used methods are based on electrical property of beans. An electrical current unit, resistance or capacitance, is measured and then converted into moisture content.

Resistance: the meter measures the electrical resistance of beans when a current is applied between two electrodes. Beans are placed in a constant and known volume.

Capacitance: the meter measures an electrical current between two plates of a condenser which constitute the walls of a recipient. A precise weight of sample is required. In both techniques, temperature corrections are required for accurate measurements. Most of moisture meters are equipped with temperature correction software.

Limits of the method: calibration charts must be established for each grain type. This means that a meter must be calibrated separately for robusta beans and arabica beans, but also for cherries and parchment to obtain accurate measurements. Accurate measurements are obtained within a range given by the manufacturer. Over this range, readings have no meaning.

LOSS ON DRYING MOISTURE METER METHOD (LOD):

The original primary moisture measurement method was Loss On Drying (LOD). In an LOD test, the sample is weighed, dried, and weighed again. The difference in the two weights (Loss on Drying) is then compared with either the original weight (Wet-base test) or final weight (Dry-base test) and the moisture content calculated. Tests can be manually conducted (weigh, oven dry, weigh) or automated (integrated weight and heating unit) with systems called Moisture Determination Balances. Depending on the balance and heating mechanism, a wide array of precision and accuracy is available. Today there are even micromoisture analyzers, using microbalances that can provide moisture measurement to the PPM level, consistent with the limits of KF testing.

Drawbacks of LOD test method are that it is destructive, meaning the sample is altered by the heating. In addition, it may be time-consuming with some tests taking 30 minutes or more to complete. Further, the test makes the assumption that all weight loss is due to water. In cases where substantial other volatiles (organics) are also available, this may not be the truth. Therefore, the results will overstate the moisture content and the test temperatures must be kept low to avoid excessive loss of these “non-water” based components. Lowering the temperature increases the test time. Finally, the samples are dried with people involved. Where there is heat involved, safety and labor costs may become a concern.

Experiment 9. Field visit to seed processing plant

Visit to ICAR-RCER, (Palandu, Ranchi)