M.Sc. AGRICULTURE LAB MANUAL

2nd Semester

Prepared By

Biological Science Dept.

Agriculture

MIDNAPORE CITY COLLEGE

AGRONOMY OF OIL SEED, FIBRE AND SUGAR CROPS- AGR-201

EXERCISE 1

Sowing of Sugarcane crop

Efficient care and precautions should be taken while selecting the cuttings, treating it with chemicals at the time of planting.

a. Selection of stem cuttings: Sugarcane crop is propagated by stem-cutting. The upper- half-portion of the plant bears buds of high viability and is best for raising new crop. Cane setts of two or three nodes, bearing 3 or 4 vegetative buds are made from the healthy, free from insect pests and diseases, top portions of the plants after hand peeling. About 35,000 sets are required for one hectare.

b. Sett treatment: Cane-seed-setts are wet and sugary, therefore, while in soil, before sprouting into new plant, these are mostly damaged by insects (termites) and fungus. To avoid these losses, the sets, before planting, are dipped into 0.5% Agallol (3%), or 0.25% Aretan or Tafasan (6%) for 2-3 hours.

c. Time of planting: The best time of planting the sugarcane setts for spring crop is the period when the atmospheric temperature records an average of 25°C. Therefore, the time of sowing in Tamil Nadu, Andhra Pradesh, Maharashtra and Karnataka is earlier (December -January) than the time of sowing in Punjab, Haryana, Uttar Pradesh (February -March). The crop can be sown round the year. Crop planted before winter season gives less sprouting and tillers due to cold weather, during early sprouting stage.

Method of Planting of Sugarcane

1. **Planting in flat beds**

- Low rainfall areas generally optimum for this planting method, which is simplest as well as cheapest of all.
- Shallow furrows(8-10 cm deep) are opened with a local plough or cultivator at a distance of 75 – 90 cm.
- There should be adequate moisture in the field at the time of planting and two blind hoeings are given to replace the insect damaged setts.
- Setts are planted at end to end taking care that one three budded sett falls in each running 30 cm length of furrow.
- After germination, two to five inter row cultivation may be given at proper intervals to control the weeds and to facilitate the tillering.
- Generally, earthing is not done but some times, if it is necessary the crop may be given one earthing during July-August to protect the crop from lodging and to provide drainage in the field.

2. **Ridge and furrow method**

The method is generally adopted in areas with moderate rainfall but have drainage problems.

- The furrows are made in ‘v’ shape about 80-100 cm. Apart and about 20-25 cm deep.
- The setts are placed in horizontal position, usually in end-to-end system but if the seed stalk is not good and inter-nodes are longer eye-to-eye system of planting setts may be done.
- To minimize the border effects of gaps, doubling of setts is done at the ends of the furrows.

- As the canes start growing, the furrows are partly filled with soil and inter-row cultivation is carried out. This repeated inter-row cultivation results in leveling of the land by end of May or Mid of June which is called as first earthing.
- Further repetition of inter-row cultivation transforms the furrow into ridges by putting soil around the plants and inter-row space become furrow automatically, through which irrigation or drainage is provided. This transformation of furrows into ridges is called as second earthing.

3. Pit method of sugarcane under drip fertigation system

- Pit to pit spacing- 1.5x1.5m
- Number of pits/ha- 4,444 pits
- Pit diameter – 0.9 to 1.2 m
- Pit depth – 0.38 to 0.45m
- Number of budded setts / pit – 32 (Single budded setts) or 16 number of single budded setts.
- Fill the pits to a depth of 15 cm with compost and native soil and mix it well. Place the healthy setts in circular fashion leaving 10 cm from the outer boundary of the pits with equal spacing between each setts and cover the setts with the soil. On 50 to 60 days after planting give partial earthing up by sliding the soil from the outer boundary of the pit and full earthing up should be given leaving a depression of 2.5 cm from the ground level at 90 to 100 days after planting.
- Fertilizer dose- 275:62.5:112.5 kg NPK/ha
- The entire phosphorous dose can be applied as basal at the time of planting.
- The nitrogen and potassium as urea and MOP (White potash) should be applied through fertigation system in 14 equal splits starting from 15 DAP upto 210 DAP
- Drip design- lateral to lateral spacing 3.0 m (alternate rows)
- 8 mm micro tubes on either side of the lateral to a length of 1.0 m with one 8 LPH
- Irrigation – daily or in alternative days

4. Wider or dual row planting

- To facilitate mechanisation in sugarcane cultivation, wide row planting adopting a spacing of 150 cm is becoming popular. Further improve the cane yield under wide rows, a new technology, 'dual row planting' has been developed.

•Broad furrows are formed at a spacing of 150 cm and in the middle of the furrows sugarcane setts are planted in two rows adopting a spacing of 30 cm between them.

•In a comparative study of two different methods of wide row planting, the dual row system gave a cane yield of 136.3 t/ha compared to 126.7 t/ha recorded by the single row system.

- In plant crop, variety Co 94005 recorded the highest cane yield under dual row planting. Among the spacing, the dual row planting and the normal 90 cm were on par and were significantly better than the other spacing.
- In the ratoon crop, variety Co 94005 was best for wide row spacing followed by Co 91010.

5. Spaced transplanting (STP) method with single eye set

- Recently in STP (Spaced transplanting) method single eyed sets are used for planting. Either direct sets or seedlings raised in polybag nurseries are transplanted into the field after 50-55 days.
- For this STP or single eyed set method 750-1MT seed per acre is required.

- For both furrow and flat method rows are made 90cm apart and settlings are spaced at 45 – 90cm.
- If any settlings fails to establish it is required to replace by the extra stock maintain in the nursery
- This method saves seed cost by 60-70%. In this method distance between two sets kept at 30cm.

6. Poly bag seedling transplanting

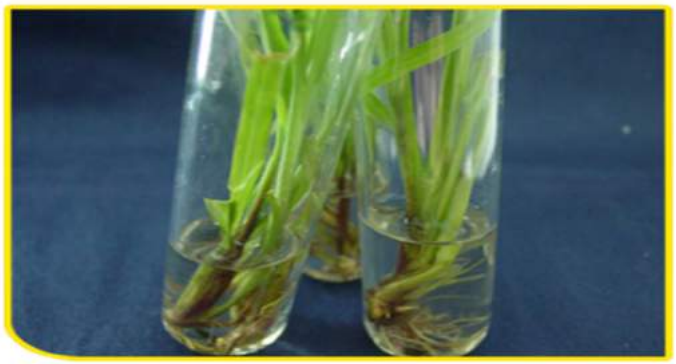
- This technique is also more or less same as STP technique.
- Here the seedlings are raised in perforater plastic bags of size 10x15 cm filled with FYM or pressmud, soil and sand 1:1:1 proportion.
- In this technique field establishment of seedlings is better, around 95-99%, as there is no damage to the root system.
- In this method, a small pit is dug out at specified spacing (45cm).
- A small quantity of phosphatic fertilizer is placed and covered with some soil. Then the settling is planted after clipping the green leaves.

7. 'Chip-bud' or 'bud-chip' technique

- In this technique the bud along with a portion of the nodal region is chipped off using a bud chipping machine.
- The bud chips are treated with fungicide and planted in the raised bed nursery or in polythene bags filled with FYM/press mud, soil and sand in 1:1:1 proportion.
- Seedlings are transplanted as in case of STP technique.
- The advantages are that the quantity of seed material (chip buds) required is only around 1 to 1.5 tonnes and the cane after taking chips can be sent for milling.

8. Tissue culture

- Micropropagation of seed cane through Tissue Culture technology is useful in developing large scale production of true to type and disease free sugarcane plantlets using apical meristem culture technique.faster multiplication of a sugarcane variety can be done.
- Apical meristem (growing part of sugarcane) is dissected and inoculated on a growth medium having definite nutrient composition.
- The apical meristem starts producing tillers in the laboratory after about 45 days of incubation in temperature and light controlled conditions.
- one apical meristem one can develop millions of plantlets in a period of seven to eight months.
- The plantlets well established and hardened in plastic bags are transplanted to field condition.
- Apply 16.5 Kgs. of granular lindane per hectare in the soil after fifteen days of transplantation and irrigate the field. This helps in preventing early shoot borer infestation.
- If necessary main shoot may be removed 35-40 days after transplanting.
- The major earthing up needs to be done at 90-100 days after transplanting.
- A seed multiplication ratio of 1:25 (planting material for 25 hectares is obtained from one hectare seed nursery) is obtained from the seed nursery planted with tissue culture plantlets.
- The well hardened plantlets developed when used give 98 to 100 % survival under field condition.



Other planting methods

1. Sablang or sprouting Method

Plants are grown in fertile soil with wide spacing, shallow planting, frequent irrigation, and adequate fertilization. The tillers are removed carefully from the mother plant as soon as they develop their own roots and are transplanted in the main field. The mother plant continues tillering and the tillers are planted in the main field in the same manner.

2. Rayungan Method

Seed stalks are decaptivated (topped off) about 4-6 weeks before planting time. As a consequence, lateral shoots develop into tailed Rayungan which are cut off and planted out in the trenches made ready for the purpose. Thus by removing the upper rayungans, the lower buds also sprout which are similarly used.

3. Distance Planting

In this method the top setts are collected and put in nursery and after they sprout and roots come out, they are transplanted in the main field at a spacing of 90 cm x 50 cm.

4. Tjeblock Method

Tjeblock is an improvement over the Rayungan method because it takes care of proper availability of nutrients and energy to all the buds where as in Rayungan method, there is considerable stress on nutrients supply on lower buds. In Tjeblock method the stalk is cut off at its half length and planted vertically with one node under the soil for rooting. The planted ones and mother stalks are adequately irrigated and fertilized.

Tying, Wrapping and Propping of Sugarcane

Tying, wrapping and propping are done in sugarcane just to provide mechanical support to the growth up cane plants to prevent lodging. By wrapping the distribution of CO_2 become easy and proper to all the plants throughout the field. The dried leaves are removed from the plants the green leaves on plants are wrapped together by taking all the canes of one bundle. After wrapping the clumps in adjacent rows are tied together (crosswise). When wrapping and tying is over in entire field these tied clumps are given further support of bamboo poles from outside (on two opposite sides) of the field.

EXERCISE 2

Criteria of harvesting of cane at right time

Crop Age

Harvesting is done based on maturity (age) group. Farmers who grow a particular variety are usually conversant with the harvesting time. Even most sugar factories give cutting orders to farmers based on crop age. This is not a scientific method since, planting time, crop management practices, weather conditions etc influences maturity.

Visual Symptoms

Yellowing and drying of leaves, metallic sound of mature canes when tapped, appearance of sugar crystal glistening when a mature cane is cut in a slanting way and held against the sun are some of the visual indices of assessing maturity of cane.

Quality Parameters

Important sugarcane quality parameters for assessing cane maturity are the juice Brix, pol or sucrose percentage and purity.

- **Juice Brix:** Juice Brix refers to the total solids content present in the juice expressed in percentage. Brix includes sugars as well as non-sugars. Brix can be measured in the field itself in the standing cane crop using a Hand Refractometer or Hand Refractometer Brix or HR Brix. In the field using a pierce collect composite juice samples from several canes. Then place a drop of the composite juice sample in the Hand Refractometer and measure the Brix reading. The circular field gets darkened relative to the Brix level, which could be easily read. The HR Brix meter has graduations from 0 to 32 per cent. The HR Brix readings can be separately taken from both top and bottom. A narrow range indicates ripeness of the cane, while a wide difference indicates that the cane is yet too ripe. While, if the bottom portion of the cane has lower Brix value than the top, it means that the cane is over-ripened and reversion of sugar is taking place.
- **Juice Sucrose Or Pol Per Cent**: The juice sucrose per cent is the actual cane sugar present in the juice. It is determined by using a polarimeter, hence sucrose per cent is also referred to as pol per cent. For all practical purposes pol % and sucrose % are synonymsNow a days an instrument called sucrolyser is also available for determining sucrose % in juice.
- **Purity Coefficient**: It refers to the percentage of sucrose present in the total solids content in the juice. A higher purity indicates the presence of higher sucrose content out of the total solids present in juice. The purity percentage along with sucrose percent aids in determining maturity time.
- **Purity Percentage = (Sucrose %/HR Brix)×100**
- A cane crop is considered fit for harvesting if it has attained a minimum of 16% sucrose and 85% purity.

- **Reducing Sugars:** The reducing sugars refer to the percentage of other sugars (fructose and glucose) in the juice. A lower reducing sugars value indicates that much of the sugars have been converted into sucrose.
- **Commercial Cane Sugar:** The commercial cane sugar (CCS) refers to the total recoverable sugar percent in the cane. This could be calculated by the following formula**:**

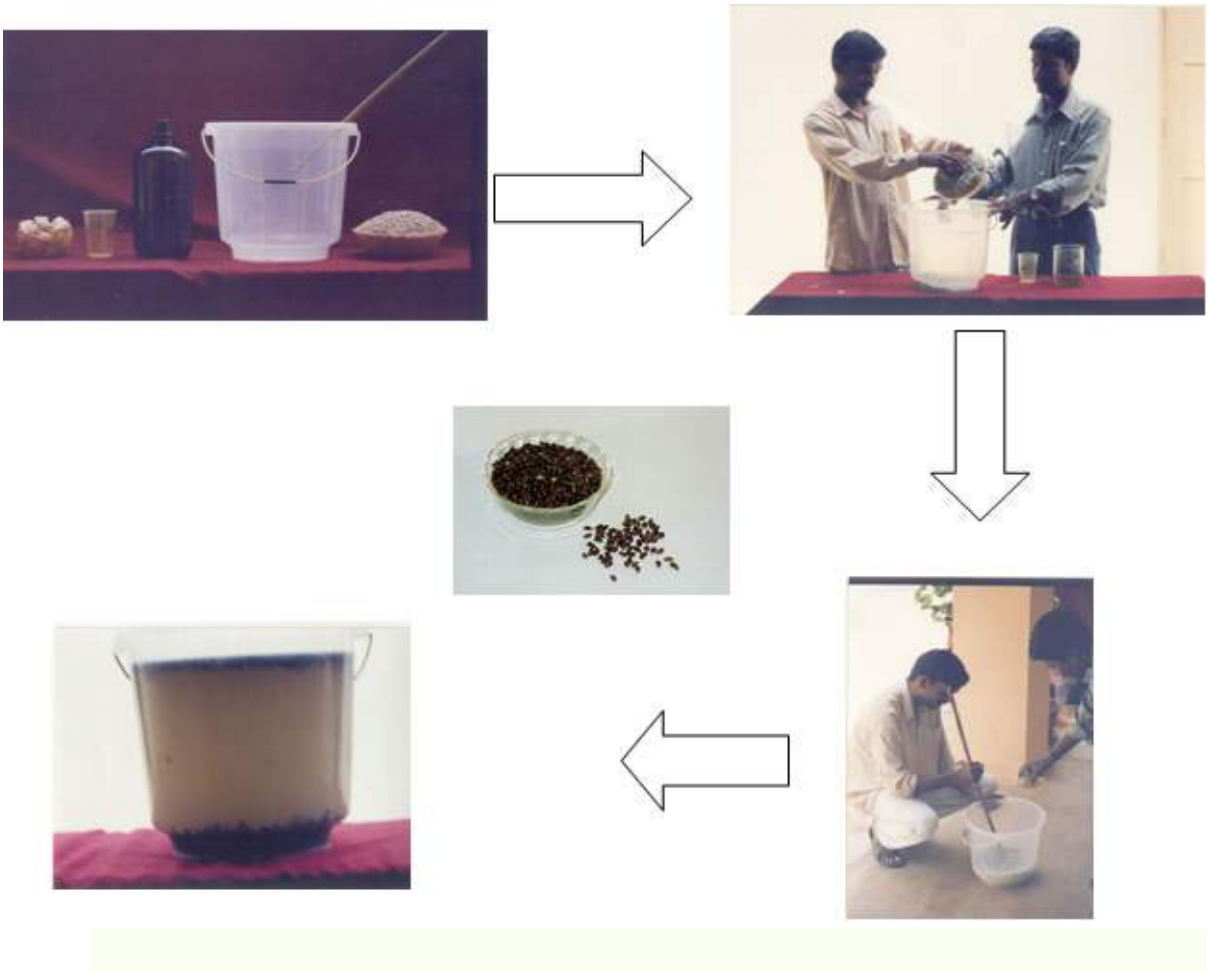
CCS (tons/ha) = [Yield (tons/ha) x Sugar Recovery (%)] /100

Sugar Recovery (%) = [S - 0.4 (B - S)] x 0.73

Where, S= Sucrose % in juice, and B= Corrected Brix (%)

EXERCISE 3

Cotton seed treatment



ACID DELINTING IN COTTON

In cotton, seeds are removed from kapas the fruiting body which has both seed and lint. In the separated seed, seed coat will have hairy outgrowth and this is the genetic characteristic feature of the seed. These seeds are known as fuzzy seed as the hair like growth is known as fuzz.

Normally these fuzzy cotton seeds are used for sowing purpose and these seeds creates problems on sowing as

- Maintenance plant population in the field mainly due to difficulty in recognition of contaminates, broken seeds, diseased seeds, insect infected seeds, immature seeds etc.
- Non free flowing nature of the fuzzy seed make the sowing difficult
- More seed rate
- Lesser storability

Hence separation of seed from the lint to increase the free flowing nature of the seed proper removal of the fuzz, the external hair from the seed coat is necessary, which could be

obtained through the process known as delinting. Delinting is the process of removal of fuzz from the seed coat in cotton i.e. it is a crop specific seed management technique.

Methodology

- Take one kg of the cotton (fuzzy seeds) in a plastic bucket
- Add concentration H2SO4 at the rate of 100ml / kg of seed
- While additions it should be constant stirring by using wooden stick for 2-3 minutes to facilitate uniform coverage and better treatment effect.
- After 3 minutes all seeds will turn into coffee brown in colour
- Wash the seeds immediately for 4-5 times with cold water until the acid nature of the seed is removed.
- Care should be taken while washing the improper washing will affect the viability of the seed.
- After thorough washing the entire seed should be placed in water in 1: 10 ratio to remove floaters.
- For complete removal of acid seeds can be dipped in 0.5% calcium chloride solution for 10-15 minutes.
- The sinkers seeds can be used for sowing purpose.
- For large scale delinting of cotton, cotton delinting machine can be used.

Factors influencing

- Type of acid
- Seed size / varietal character
- Efficiency of persons
- Washing
- Neutralising

Precautions

- Don’t use hand while mixing use wooden poles
- Use plastic bucket only
- Mix the seeds for only 2-3 minutes and not more than that as excess acid will kill the seed
- Give through washing
- Dry the seed to low moisture content for longer storability
- Remove the broken and immature seed

Advantages

- Seed borne pathogens are eliminated
- Destroyed boll worm eggs on the seed coat
- Remove the inhibitors in the pericarp
- Increase seed germination and vigour

- Reduce the seed rate
- Make seed free flowing
- Make mechanical sowing feasible
- Storability is more

EXERCISE 3

Working out growth indices

GROWTH ANALYSIS

Growth analysis can be used to account for growth in terms that have functional or structural significance. The type of growth analysis requires measurement of plant biomass and assimilatory area (leaf area) and methods of computing certain parameters that describe growth.

The growth parameters that are commonly used in agricultural research and the name of the scientists who proposed the parameters are given below.

- LAI - Williams (1946)
- LAR - Radford (1967)
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i. Leaf Area

This is the area of photosynthetic surface produced by the individual plant over a period of interval of time and expressed in cm2 plant-1.

***ii. Leaf Area Index (LAI)**

Williams (1946) proposed the term, Leaf Area Index (LAI). It is the ratio of the leaf of the crop to the ground area over a period of interval of time. The value of LAI should be optimum at the maximum ground cover area at which crop canopy receives maximum solar radiation and hence, the TDMA will be high.

$$LAI = \frac{\text{Total leaf area of a plant}}{\text{Ground area occupied by the plant}}$$

Total dry matter production (TDMP) and its distribution:- The TDMP is the biomass accumulated by the whole plant over a period of interval of time and its distribution (allocation) to different parts of the plant such as roots, stems, leaves and the economic parts which controls the sink potential.

iii. Leaf Area Ratio (LAR)

The term, Leaf Area Ratio (LAR) was suggested by Radford (1967), expresses the ratio between the area of leaf lamina to the total plant biomass or the LAR reflects the leafiness of a plant or amount of leaf area formed per unit of biomass and expressed in cm-2 g-1 of plant dry weight.

$$LAR = \frac{\text{Leaf area per plant}}{\text{Plant dry weight}}$$

iv. Leaf Weight Ratio (LWR)

It was coined by (Kvet *et al.*, 1971) Leaf weight ratio is expressed as the dry weight of leaves to whole plant dry weight and is expressed in g g –1.

$$LWR = \frac{\text{Leaf dry weight}}{\text{Plant dry weight}}$$

v. Leaf Area Duration (LAD)

To correlate dry matter yield with LAI, Power *et al.* (1967) integrated the LAI with time and called as Leaf Area Duration. LAD takes into account, both the duration and extent of photosynthetic tissue of the crop canopy. The LAD is expressed in days.

$$LAD = \frac{(L1 + L2)}{2} \times (t2 - t1)$$

L1 = LAI at the first stage

L2 = LAI at the second stage, (t 2 - t 1) = Time interval in days.

***vi. Absolute Growth Rate (AGR)**

AGR is the function of amount of growing material present and is influenced by the environment. It gives Absolute values of biomass between two intervals. **It is mainly used for a single plant or single plant organ** e.g. Leaf growth, plant weight etc.

$$AGR = \frac{W2 - W1}{t2 - t1} \text{ } \textit{g day-1}$$

Where, W1 and W2 are the plant height at t1 and t2 times respectively.

***vii. Net Assimilation Rate (NAR)**

The term, NAR was used by Williams (1946). NAR is defined as dry matter increment per unit leaf area or per unit leaf dry weight per unit of time. The NAR is a measure of the average photosynthetic efficiency of leaves in a crop community.

$$NAR = \frac{(W2 - W1)(\log_e L2 - \log_e L1)}{(t2 - t1)(L2 - L1)}$$

Where, W1 and W2 is dry weight of whole plant at time t1 and t2 respectively

L1 and L2 are leaf area at t1 and t2 respectively

t1 – t2 are time interval in days

NAR is expressed as the grams of dry weight increase per unit dry weight or area per unit time***(g g -1day-1)(Leaf Area)***

***viii. Relative Growth Rate (RGR)**

The term was coined by Williams (1946). Relative Growth Rate (RGR) expresses the total

plant dry weight increase in a time interval in relation to the initial weight or Dry matter increment
per unit biomass per unit time or grams of dry weight increase per gram of dry weight and expressed as unit dry weight / unit dry weight / unit time ***(g g -1day-1)(Leaf Weight)***

$$RGR = \frac{\log_e W2 - \log_e W1}{t2 - t1}$$

Where, W1 and W2 are whole plant dry weight at t1 and t2 respectively
t1 and t2 are time interval in days

***ix. Crop Growth Rate (CGR)**

The method was suggested by Watson (1956). The CGR explains the dry matter accumulated per unit land area per unit time **(g m-2 day-1)**

$$CGR = \frac{(W2 - W1)}{\rho\,(t2 - t1)}$$

Where, W1 and W2 are whole plant dry weight at time t1 – t2 respectively
ρ is the ground area on which W1 and W2 are recorded.
CGR of a species are usually closely related to interception of solar radiation.

***x. Harvest Index**

The harvest index is expressed as the percent ratio between the economic yield and total biological yield and was suggested by Nichiporovich (1951) / C.M. DONALD (1967).

$$HI = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100$$

xi. Land Equivalent Ratio:

It denotes relative land area under sole crop required to produce the same yield as obtained under a mixed or an intercropping system at the same level of management. It is the ratio of land required by pure crop to produce the same yield as intercrop.

LER = Ya/Sa + Yb/Sb

Where,

Ya, Yb is the yield of a and b crop grown as intercrop,Sa, Sb is the yield of a and b crop grown as sole crop,LER = Yield of intercrop over yield of pure crop.

xii. Relative Crowding Coefficient (RCC):

It is used in replacement series of intercropping .It indicates whether a crop, when grown in mixed population, has produced more or less yield than expected.

K a b = Y ab / Y aa Y ab X Zba/Zab

Where,

Kab=RCC of crop a intercropped with crop b,Yab=Yield per unit area of crop a intercropped with crop b,Yaa= Yield per unit of sole crop a, Zab=Proportion of intercropped area initially allocated to crop, a, Zba=Proportion of intercropped area initially allocated to crop, b

RCC > 1 means yield advantage

RCC = 1 no difference

RCC < 1 yield disadvantage

xiii. Aggressivity

It is the mixture of how much the relative yield increase in component a is greater than that for b.

Aab = Yab / (Yaa x Zab) - Yba/(Ybb x Zba)

Where,

Aab = Zero mean component crops are equally competitive, Aab = negative means dominated, Aab = Bigger value either positive or negative means bigger difference in competitive abilities.

xiv. Competition Index:

It is measure to find out the yield of various crops when grown together as well as separately. It represents the yield per plant of different crops in mixture and their respective pure stand on unit area basis.

CI = (Yaa -Yab) X (Ybb -Yba) / Yaa x Ybb

Yab- mixture yield of a crop grown with b, Yba- mixture yield of b crop grown with a

Yaa-yield in pure stand of crop a, Ybb-yield in pure stand of crop b

xv.Competition coefficient:

Ratio of the RCC of any given spp. in the mixture

CC = RCC of a given spp. /Total RCC of all crops in mixture

EXERCISE 4

Determination of cost of cultivation of different crops

Variable Cost

1. Nursery management =
2. Land preparation

a)Ploughing=

b)Harrowing=

c) Preparation of beds and channels =

3. Transplanting =
4. Manures and fertilizers application =
5. Interculture operations =
6. Irrigation =
7. Plant protection =
8. Harvesting

a) Picking =

b) Grading =

c) Packing =

d) Transportation =

9. Seed =
10. Manures and fertilizers =

11. Plant Protection =
12. Miscellaneous =
13. Interest on working capital =

II. Fixed Cost

Land revenue, Rental value of land, Management cost, Risk margin, Depreciation cost, Plough, Harrow, Ridges, Buckets, Pump, Sprayer, Total Fixed Capital, Interest on Fixed Capital

Total Fixed Cost =

Therefore,

1. Total cost of cultivation =Total variable cost +Total fixed cost

2. Total income = Yield (kg) × Market price of the produce (Rs./kg)

3. Net Profit = Total Income - Total cost of cultivation

4. Benefit cost Ratio = Cost of total benefit / Cost of production

EXERCISE 5

Calculation of crop and rotational intensities.

a) Rotational Intensity: This is calculated by counting the number of crops grown in a rotation and is multiplied by 100 and then divided by the duration of rotation.

b) Cropping intensity:Total cropped area over net cultivated area x 100

Or

Area under kharif + rabi + zaidover area under actual cultivation x 100

c) Multiple Cropping Index or Multiple Cropping Intensity (MCI):

It is the ratio of total area cropped in a year to the land area available for cultivation and expressed in %.

$$MCI = \frac{a1}{A} * 100$$

Where

i = 1, 2, 3, n, n= total number of crops,

a1 = area occupied by crop and

A= total land area available for cultivation.

MCI is the sum of area planted to different crops and harvested in a single year divided by total

cultivable area and expressed as percentage.

OR

MCI means the sum of areas under various crops raised in a single years divided by net area available for that cropping pattern multiplied by 100. It is similar to cropping intensity.

$$MCI = \frac{\text{Total number of crops + with their respective area}}{\text{Net cultivable area}} * 100$$

AGRONOMY OF MAJOR *rabi* CEREALS AND PULSES-AGR-202

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Where, W1 and W2 are whole plant dry weight at time t1 – t2 respectively
ρ is the ground area on which W1 and W2 are recorded.
CGR of a species are usually closely related to interception of solar radiation.

***x. Harvest Index**

The harvest index is expressed as the percent ratio between the economic yield and total biological yield and was suggested by Nichiporovich (1951) / C.M. DONALD (1967).

$$HI = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100$$

xi. Land Equivalent Ratio:

It denotes relative land area under sole crop required to produce the same yield as obtained under a mixed or an intercropping system at the same level of management. It is the ratio of land required by pure crop to produce the same yield as intercrop.

LER = Ya/Sa + Yb/Sb

Where,

Ya, Yb is the yield of a and b crop grown as intercrop,Sa, Sb is the yield of a and b crop grown as sole crop,LER = Yield of intercrop over yield of pure crop.

xii. Relative Crowding Coefficient (RCC):

It is used in replacement series of intercropping .It indicates whether a crop, when grown in mixed population, has produced more or less yield than expected.

K a b = Y ab / Y aa Y ab X Zba/Zab

Where,

Kab=RCC of crop a intercropped with crop b,Yab=Yield per unit area of crop a intercropped with crop b,Yaa= Yield per unit of sole crop a, Zab=Proportion of intercropped area initially allocated to crop, a, Zba=Proportion of intercropped area initially allocated to crop, b

RCC > 1 means yield advantage
RCC = 1 no difference
RCC < 1 yield disadvantage

xiii. Aggressivity

It is the mixture of how much the relative yield increase in component a is greater than that for b.

Aab = Yab / (Yaa x Zab) - Yba/(Ybb x Zba)

Where,

Aab = Zero mean component crops are equally competitive, Aab = negative means dominated, Aab = Bigger value either positive or negative means bigger difference in competitive abilities.

xiv. Competition Index:

It is measure to find out the yield of various crops when grown together as well as separately. It represents the yield per plant of different crops in mixture and their respective pure stand on unit area basis.

CI = (Yaa -Yab) X (Ybb -Yba) / Yaa x Ybb

Yab- mixture yield of a crop grown with b, Yba- mixture yield of b crop grown with a

Yaa-yield in pure stand of crop a, Ybb-yield in pure stand of crop b

xv.Competition coefficient:

Ratio of the RCC of any given spp. in the mixture

CC = RCC of a given spp. /Total RCC of all crops in mixture

EXERCISE 2

Determination of cost of cultivation of different crops

Variable Cost

1. Nursery management =
2. Land preparation

a)Ploughing=

b)Harrowing=

c) Preparation of beds and channels =

3. Transplanting =
4. Manures and fertilizers application =
5. Interculture operations =
6. Irrigation =
7. Plant protection =
8. Harvesting

a) Picking =

b) Grading =

c) Packing =

d) Transportation =

9. Seed =
10. Manures and fertilizers =
11. Plant Protection =
12. Miscellaneous =
13. Interest on working capital =

II. Fixed Cost

Land revenue, Rental value of land, Management cost, Risk margin, Depreciation cost, Plough, Harrow, Ridges, Buckets, Pump, Sprayer, Total Fixed Capital, Interest on Fixed Capital

Total Fixed Cost =

Therefore,

1. Total cost of cultivation =Total variable cost +Total fixed cost

2. Total income = Yield (kg) × Market price of the produce (Rs./kg)

3. Net Profit = Total Income - Total cost of cultivation

4. Benefit cost Ratio = Cost of total benefit / Cost of production

EXERCISE 3

Estimation of protein content in pulses

Kjeldahl method

The Kjeldahl method was developed in 1883 by a brewer called Johann Kjeldahl. A food is digested with a strong acid so that it releases nitrogen which can be determined by a suitable titration technique. The amount of protein present is then calculated from the nitrogen concentration of the food. The same basic approach is still used today, although a number of improvements have been made to speed up the process and to obtain more accurate measurements. It is usually considered to be *the* standard method of determining protein concentration. Because the Kjeldahl method does not measure the protein content directly a *conversion factor (F)* is needed to convert the measured nitrogen concentration to a protein concentration. A conversion factor of 6.25 (equivalent to 0.16 g nitrogen per gram of protein) is used for many applications, however, this is only an average value, and each protein has a different conversion factor depending on its amino-acid composition. The Kjeldahl method can conveniently be divided into three steps: digestion, neutralization and titration.

6.2.1.1. Principles

Digestion

The food sample to be analyzed is weighed into a *digestion flask* and then digested by heating it in the presence of sulfuric acid (an oxidizing agent which digests the food), anhydrous sodium sulfate (to speed up the reaction by raising the boiling point) and a catalyst, such as copper, selenium, titanium, or mercury (to speed up the reaction). Digestion converts any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia, and other organic matter to $C0_2$ and H_20. Ammonia gas is not liberated in an acid solution because the ammonia is in the form of the ammonium ion (NH_4^+) which binds to the sulfate ion (SO_4^{2-}) and thus remains in solution:

N(food) ® $(NH_4)_2SO_4$ (1)

Neutralization

After the digestion has been completed the digestion flask is connected to a *recieving flask* by a tube. The solution in the digestion flask is then made alkaline by addition of sodium hydroxide, which converts the ammonium sulfate into ammonia gas:

$(NH_4)_2SO_4$ + 2 NaOH ® $2NH_3 + 2H_2O + Na_2SO_4$ (2)

The ammonia gas that is formed is liberated from the solution and moves out of the digestion flask and into the receiving flask - which contains an excess of boric acid. The low pH of the solution in the receiving flask converts the ammonia gas into the ammonium ion, and simultaneously converts the boric acid to the borate ion:

$NH_3 + H_3BO_3$ (boric acid) ® $NH_4^+ + H_2BO_3^-$ (borate ion) (3)

Titration

The nitrogen content is then estimated by titration of the ammonium borate formed with standard sulfuric or hydrochloric acid, using a suitable indicator to determine the end-point of the reaction.

$H_2BO_3^- + H^+ \rightarrow H_3BO_3$ (4)

The concentration of hydrogen ions (in moles) required to reach the end-point is equivalent to the concentration of nitrogen that was in the original food (Equation 3). The following equation can be used to determine the nitrogen concentration of a sample that weighs *m* grams using a *x*M HCl acid solution for the titration:

$$\%N = \frac{x \text{ moles}}{1000 \text{ cm}^3} \times \frac{(v_s - v_b) \text{ cm}^3}{m \text{ g}} \times \frac{14 \text{ g}}{\text{moles}} \times 100 \quad (5)$$

Where *v*s and *v*b are the titration volumes of the sample and blank, and 14g is the molecular weight of nitrogen N. A blank sample is usually ran at the same time as the material being analyzed to take into account any residual nitrogen which may be in the reagents used to carry out the analysis. Once the nitrogen content has been determined it is converted to a protein content using the appropriate conversion factor: %Protein =5.51× %N. (For pulses)

DRYLAND FARMING- AGR-203
EXERCISE 1

Seed treatment, seed germination and crop establishment in relation to soil moisture contents

SEED TREATMENT, ITS IMPORTANCE, METHOD OF APPLICATION AND SEED PACKING

Maintaining the quality of seed is dependent on many environmental factors, some of which are moisture, temperature, humidity, and storage conditions. Even though these factors are properly accounted for, seed quality may still be reduced by certain seedborne diseases or destroyed by insects and other pests. Research has shown that treating seed with one or more pesticides is the most economical and efficient way to protect seed from these pests and improve seed quality. Since pesticides are poisonous, extra care and safety precautions must be taken when applying them and in handling seed after it has been treated.

Definition of treated seed

The term "treated" means "to give an application of a pesticide or subject seed to a process designed to reduce, control or repel disease organisms, insects, or other pests which attack the seed or seedlings."

Types of Seed Treatment

A. Pre sowing seed treatments

It is the treatments given to the seeds before sowing to improve the germination and vigour potential and as well as to maintain the health of the seed. Pre sowing seed treatments includes the following

I. Chemical treatments to improve germination and vigour potential.

II. Insecticidal and fungicidal treatment.

III. Special treatments

I. Chemical treatments to improve germination and vigour potential

Soaking / treating the seeds with nutrients vitamins and micronutrients etc.

Paddy: Seeds can be soaked in 1 % KCl solution for 12 hours to improve the germination and vigour potential.

Sorghum: Seeds could be soaked in NaCl2 (1 %) or KH2PO4 (1%) for 12 hours for improving the germination and vigour potential.

Pulses : Seeds can be soaked in ZnSO4, MgSO4 and MnSO4 100 ppm solution for hours to improve the germination and vigour potential.

II. Insecticidal and Fungicidal treatments

Seed health: It is an important attribute of quality seed. Though a seed lot that meets high standards of germination, vigour and purity if it is contaminated with seed borne pathogens and insect pests, may be useless to farmers because it may result in severe yield loss or even crop loss in an entire area.

Benefits of the insecticidal and fungicidal treatments:

1. Prevents the spread of plant diseases
2. It protects the seed from seed rot and seedling blights.
3. It improves the seed germination
4. It provides protection from storage insects.
5. It controls the soil insects.

Seed may be affected by viruses, bacteria, fungi, nematodes and insects. Seed pests and diseases of which the seed is a victim (e.g., grain weevils, Tricoderma spp., and storage pathogens such as Aspergillus flavus) should be distinguished from seed-borne diseases of which the seed is the vehicle of pest and pathogen dissemination (e.g., bunt of cereals, Tilletia spp.)

Seed Treatment Fungicides

Fungicides are applied to seed prior to planting to provide effective protection against many seed and soil-borne plant pathogens. Chemical (fungicide) treatment guards against the various seed rots and seedling blights that occur during storage or after planting. It is not usually a "cure-all" and will not provide disease protection throughout the growing season after the plants become self-sufficient. (An exception to this would be the control of loose smut by seed disinfection). Fungicidal seed treatment may be divided into three categories, depending on the nature and purpose of the treatment. These categories are: (1) seed disinfection, (2) seed disinfestation, and (3) seed protection. A given fungicide may serve in one or more of these categories.

Seed disinfection - Disinfection is the elimination of a pathogen which has penetrated into living cells of the seed, infected it and become established-for example, loose smut of barley and wheat.

Seed disinfestations - Disinfestation is the control of spores and other forms of pathogenic organisms found on the surface of the seed.

Seed protection - Seed protection is chemical treatment to protect the seed and young seedling from pathogenic organisms in the soil. Seed treatment materials are usually applied to seed in one of four forms: dust; slurry (a mixture of wettable powder in water); liquids; and planter-box formulations. Based on composition, seed treatment fungicides may be organic or inorganic, metallic or non-metallic, and, until recently, mercurial or non-mercurial. Before the cancellation of the 'volatile mercurials, fungicides for treating seed were generally classified as volatile and non-volatile. Vlith the elimination of the volatile mercurials, most fungicides now approved for use on seed are classified as non-volatile. When using this type material, complete coverage of the seed is necessary to obtain effective control. Some of the systemics, a fairly new class of pesticides, may now be used as seed treatment materials. The desirability of having materials that would move inside the seed or plant and control the pest has long been recognized. Such materials are called "systemic." When used according to the manufacturer's recommendation (see label), a systemic moves through the host plant and controls or retards the growth of certain fungi and insects without affecting the host's metabolic system.

Seed Treatment Insecticides

Insecticides are often applied to seed to control or reduce insect damage to seed during storage and, to a lesser degree, to prevent damage from such insects as wireworms and seed corn maggots in the soil.

Combinations

Since some pesticides are selective in their control of pests, many times two or more compounds are combined in the treater tank, or an extra tank may be used, to give the spectrum of control needed.

The manufacturers of pesticides are now making combinations available to seed processors, but should a processor blend two or more pesticides, the compatibility of the materials must be determined, since some combinations of materials may seriously reduce seed germination. Also, when applying two or more pesticides, even at different times, the sequence of application may be very important. Whether a single pesticide or a combination is to be applied to the seed, read the label and follow the manufacturer's directions carefully.

Formulation of fungicides /insecticides

Fungicides / insecticides are available in the form of dusts, wettable powders and liquids.

1. Dusts: It is usually applied @ 200-250 gms / quintal of seed. Main dis-advantage is dusty condition will prevail during the seed treatment and after handling.

2. Slurry: This type of fungicide is applied to the seed along with soap like water suspension which can be mixed with seed by using special slurry treater.

3. Liquids: The use of liquid solution is known as the "quick wet ' method. Here a volatile fungicide is applied to the seed and it throughly mixed with them. e.g. Chemicals like panogen, mercuran, etc. can be applied by this method.

Safety

There is a general tendency to use chemicals that are safe for user and environment. Very toxic substances, such a organic mercurials (Ceresan and others) and very persistant fungicides, such as Hexachlorobenzene ((HCB), are being replaced by new chemicals, In the past, these chemicals have caused severe cases of poisoning, some resulting in death. Most if not all occurred because treated seed was used for human consumption or livestock feeding instead of for planting. Even with the new, less toxic chemicals, the following safety precautions must be taken.

- Treated seed must be clearly labelled and under no circumstances be used for feed or food.
- Seed treatment should be carried out in a well-aerated area. Contact with chemicals through breathing of dusts and skin contact must be avoided. Protective clothing should be worn.
- As with all pesticides, empty containers should be properly disposed of and never reused in a household or on the farm.

III. Special treatments

i) Seed hardening treatment

Seeds can be hardened for 2 purposes I) Drought tolerance ii) Cold tolerance .The treatments are imposed to the seeds mainly to tolerate initial drought and cold. Cold tolerance treatment is given to germinated seeds, such treatments are given only to temperate crop and tree seeds.

The most important factors to be considered while seed hardening are

- Seed : solution ratio (1:1)
- The duration of soaking
- Method of drying.

The effectiveness of the treatment depends upon the conduct of seed hardening process. The solution amount never be higher than the amount of the seeds. All solution added should be imbibed by the seeds. There should not be any leftover solution as it causes leaching effect. Once the seeds imbibe water, the germination process takes place. At the end of soaking period the seeds should be dried back to its original moisture content. These seeds when sown the germination will be completed earlier whereas in non hardened seeds the process germination takes a longer period. Chemicals used : $CaCl_2$, KCl, KH_2PO_4,

ii) Seed fortification

Main aim is to supply nutrients to seeds. The main objective is to achieve the high vigour to overcome unfavourable soil reactions. eg.) seed fortification with $MnSO_4$ @ 0.5 to 1 %. will improve oxidation - reduction potential of seeds, which ultimately leads to higher germination.

iii) Moist sand conditioning

It is a need based treatment the concentration can be increased upto 2-4 %. Amount of solution should be 1:1 ratio or slightly excess amount of water can be used.

Protinaceous seeds should not be soaked in water (e.g) soybean, etc. for these seeds, mix the seeds with moist sand @ 5 to 10% MC. It should be kept for specified period of time.

The method is known as moist sand hydration.

iv) Seed pelleting

Here the nutrients are coated on the seeds. This technique is very much adopted in forest tree seeds.

Importance

- Normally in small seeds this technique is adopted .
- By pelleting we can increase the size of seed and we can make it free flowing one.
- Through this we can able to reduce the seed rate.
- It is also important for aerial sowing (gum arabica) in tree seeds.

Materials used: Nutrients, adhesive, filler material.

Inert materials: Lime, $CaCO_3$, Chalk powder.

Plant products: Neem, Notchi, Arappu, Arappu (Albizia amara) is found good contains a susbstance saponin (growth promoter) which is similar to GA in action.

v) Seed infusion

Infusion of nutrients and growth promoting substances with organic solvents like acetone and dichlormethane. The organic solvents, slowly increase the chemicals in to the seed. In this

method there is no need for drying the seed materials to bring back the original moisture content of seed. The organic chemicals are evaporative in nature, after infusion is over, just we have to keep the seeds as such for 5 to 10 minutes in dry condition the organic solvents will evaporate during this time and we can perform sowing. Seed infusion can also be used for breaking the seed dormancy.

vi) Osmotic priming

It is a very expensive but it is a required process, particularly for large seeded legumes like peas, beans etc., They have high protein content and large embryo and are susceptible to soaking injury. High protein seeds are hygroscrpic and hydrophilic. Osmotic priming is nothing but making the seeds to imbibe water very slowly. Osmotic solutions used are (PEG) (poly ethylene glyster). Maintol is highly toxic. PEG is inert and will increase very slowly the water in to seeds. By preconditioning through osmotic priming, the seeds are invigourated which results in uniform, early and higher field emergence and higher seedling vigour.

vii) Fluid drilling

This is a technology evolved for mechanical sowing of seeds particularly the germinated seeds. The seeds are coated with a jelly material called guar gel. It is to have a buffer action to avoid damage of the germinated seeds during sowing.

viii) Separation of viable seeds

It is a new concept particularly for groundnut. This is a good method to get desired seed germination and plant population. Incase of groundnut the actual population requirement is 30 plants / m2. Actual seed multiplication rate in groundnut is 1:8 . There are about 30-40% of dead seeds and of such dead seeds are eliminated, and then we will be able to maintain the required plant population in the field. This is the base for evolving this technology.

This can be done in 2 ways

1. Manual separation based on radicle emergence (groundnut)
2. IDS (Incubation - Drying and Separation) method.

B. Pre storage treatments

Prestorage treatments of harvest-fresh seed are primarily aimed towards protection against deteriorate senescence during storage. Seed storage which is again threatened by insect and pathogen attack, can also be taken care of by prescribed prestorage seed treatments.

i. Halogenation
ii. Antioxidant treatment
iii. Seed sanitation

C. Mid storage treatments

Seeds in storage accumulate damage to cell membranes during senescence. Mid storage seed treatments are capable of reducing the age induced damages and restoring the seed vigour to a certain extent besides, the seed viability and productivity of stored seeds are also improved.

i) Hydration – Dehydration

It is the process of soaking the low and medium vigour seeds in water with or without added chemicals usually for short durations to raise the seed moisture content to 25 – 30% and drying back the seeds to safe limits for dry storage.

The hydration – dehydration treatments

1. Should be given only to stored seeds.

2. Is effective in low and medium vigour non- leguminous seeds,

3. The moisture equilibration and moist sand conditioning treatments in which moisture is taken up by the seed in a slow and progressive manner, are recommended for relatively high-vigour seeds and seeds of pulses and leguminous vegetable crops

6. Direct soaking of leguminous seeds should be avoided.

7. Would not make a seed germinable, which has already lost viability.

Types of H-D treatments

The wet treatments include soaking-drying, dipping-drying, spraying-drying, stepwise hydration-drying, moisture equilibration-drying, moisture equilibration soaking, drying, moist and conditioning-drying, etc. The choice of the treatment depends upon the characteristics of seed and initial vigour status of the seeds.

Soaking – Drying (S-D)

Stored seed is soaked in water or solution of chemicals sufficient to cover it and kept at room temperature for 2-6 hour depending on the material with occasional stirring. The soaked seed is taken out and after surface drying in the shade for some time, dried back to the original moisture content Dilute solution of chemicals such as sodium or potassium phosphate (di and mono basic), sodium chloride, p-hydroxy benzoic acid, pamino benzoic acid, oxalic acid, potassium lodide, etc can also be used at 10-4 to 10-3 M concentrations. Fungicidal and insecticidal formulations can also be incorporated in the soak water.

Dipping – Drying (D-D)

Seeds are dipped in water or solutions of the aforesaid chemicals for only 2-5 minutes and the wet seed is taken out immediately and kept covered for 2 – 6 hours depending on the material, for absorption of surface water followed by drying back in SD. This treatment is effective in most high and high-medium vigour seeds of rice, wheat, jute, summer and winter vegetables

Spraying – Drying

Seeds are spread in a thin layer and then an amount of water (approximately 1/5 to ¼ of the seed weight) is sprayed on to it in two equal installments (turning over the seed layer after the first spray) and then kept covered by a polythene sheet for 2-4 hours before drying back. This treatment is similar to D-D in its efficacy and suitability.

Moisture equilibration – drying (ME – D)

Here, the seeds are placed in thin layers on trays kept on a raised platform in a closed moisture saturated chamber lined internally with moist blotters giving nearly 100% RH at room temperature. After 24-48 hours, depending on the material and ambient temperature, the seed is dried back in the usual way. For soaking injury prone seeds this treatment, which gives a slow and progressive rise in moisture content, is very effective. ME-D, however, difficult to practice on a large scale and is not advocated for low vigour non leguminous

seeds because of possible aging effect of the treatment especially when given for prolonged periods.

Moist sand conditioning – drying (MSC-D)

This treatment is similar to the moisture equilibration treatment but easier to practice. For slow and progressive moisture uptake, the seed is thoroughly mixed with pre-moistened sand, using 3 times the amount of air dry sand than seed. Moisture content of sand is adjusted to 5-10 by adding the requisite amount of water or solution of chemicals to previously washed and dried fine grain building grade sand. The addition of water should be so adjusted as to get the required hydration effect without initiating the germination process. After mixing the dry seed with the premoistened sand, the mixture is kept at room temperature for 16 – 36 hours depending on the material and sand

moisture content. The seed absorbs moisture from sand and after incubation the hydrated seed is separated from sand by sieving and dried back to the original weight.

Mode of Action The main purpose of hydration is to raise the seed moisture content to 25 – 30% (wet weight basis) before drying back to safe limits for dry storage. The hydration - dehydration treatment may improve the vigour by controlling free radical reactions and consequent peroxidative damage to lipoprotein cell membranes.

SEED TREATING EQUIPMENT

Commercial seed treaters are designed to apply accurately measured quantities of pesticides to a given weight of seed. Basically, there are three types of commercial seed treaters on the market: dust treaters, slurry treaters, and direct treaters-the Panogen and Mist-O-Matic treaters are examples of direct treaters.

1. Dust Treater *(Gustafson XL Dry Powder Seed Treater)*

Controlling the Flow of Seed:

The amount of seed which flows into the weigh pan (which is just beneath the feed hopper on top of the treater) is controlled by opening or closing the gates of the feed hopper by means of the hand wheel on the side of the hopper. The scale on the hopper shows how far the gates are open (in inches). Gates should be open to whatever number of inches it takes to keep the weigh pan filled to the required number of pounds per dump as it tilts in either direction. The number of pounds per dump is adjusted by correctly setting the counterweight up or down on the counterweight arm.

Powder Application:

To be sure that the correct amount of powder is being applied to the seed flow, a preliminary test must be made in which a given number of pounds of seed (such as 100 lbs) is run through the feeder. During this run, the measuring cup provided with the feeder should be used to catch the powder as it comes off the vibrator. After the given amount of seed has run through, the powder should be weighed in order to determine how much is being applied to that amount of seed. The vibrator speed can then be adjusted accordingly. Then a second or more tests should be run until proper setting of the vibrator speed is determined for correct coverage.

2. Slurry Seed Treater

The slurry treatment principle involves suspension of wettable powder treatment material in water. The treatment material applied as a slurry is accurately metered through a simple mechanism composed of a slurry cup and seed dump pan. The cup introduces a given amount of slurry with each dump of seed into a mixing chamber where they are blended. While operation of the slurry treater is relatively simple, the various operation procedures must be thoroughly understood.

1. The metering principle is the same in direct, ready-mix or fully automatic treaters-i.e., the introduction of a fixed amount of slurry to a given weight of seed.
2. To obtain a given dump weight, slurry treaters are equipped with a seed gate that controls seed flow to the dump pan. With the proper seed gate setting, a constant dump weight for a given can be obtained.
3. The amount of treatment material applied is adjusted by the slurry concentration and the size of the slurry cup or bucket. As the dump pan fills, a point is reached where it over-balances the counter weight and dumps into the mixing chamber. This brings the alternate weighing pan in position to receive the inflow of seed and activates a mechanism to add a cup of slurry to the mixing chamber. Thus, one cup of slurry is added with each dump of seed.
4. The mixing chamber is fitted with an auger type agitator that mixes and moves seed to the bagging end of the chamber. The speed of the auger is important, because at slow speeds more uniform distribution is obtained.
5. Slurry tanks have 15 to 35 gallon capacities, depending upon the size of the treater. They are equipped with agitators that mix the slurry in the tank and keep it suspended during operation. It is important that the powder be thoroughly suspended in water before treating. If the treater has been idle for any period of time, sediment in the bottom of the slurry cups must be cleaned out.
6. The proper size slurry cup must be used. Most machines now have cups with ports and rubber plugs for 15 cc, 23 cc, and 46 cc quantities. Some users prefer to mix the slurry in an auxiliary tank and then transfer to the slurry chamber as needed.

DIRECT TREATERS

Direct treaters are the most recent development and include the Panogen and Mist-O-Matic treaters. These two were initially designed to apply undiluted liquid treatment. Instead of applying 23 cc of material per 10 pounds of wheat, as in slurry treaters, they apply 14 to 21 cc (1/2 to 3/4 ounces) per bushel of "wheat. This small quantity of material is suitable only with liquid materials which are somewhat volatile and do not require complete, uniform coverage for effective action.Later modifications for direct treaters include dual tanks that permit simultaneous addition of a fungicide and an insecticide, and adaptations for the application of slurries. The metering device used in both types of direct treater is similar to that of the slurry treater, since it is attained through synchronization of a treatment cup and seed dump.

Otherwise, the two direct treaters differ decidedly from the slurry treater and from each other. Both of these direct treaters have an adjustable dump pan counter weight to adjust the weight of the seed dump. This is not practical with slurry treaters.

3. Panogen Seed treater

The operation of the Panogen treater is relatively simple. A small treatment cup, operating from a rocker arm directly off the seed dump pan and out of a small reservoir, meters one cup of treatment with each dump of the seed pan. Fungicide flows through a tube to the head of the revolving drum seed mixing chamber. It flows in with seed from the dumping pan and is distributed over the seed by the rubbing action of the seed passing through the revolving drum. The desired treating rate is obtained by the size of the treatment cup and by adjusting the seed dump weight. Treatment cup sizes are designated by treating rate in ounces and not by actual size-e.g., the 3/4 ounce cup applies 3/4 ounce (22.5 cc) of treatment per bushel with six dumps per bushel. The actual size of this cup is
approximately 3.75cc.

4. Mist-O-Matic Seed Treater:

The "mist-o-matic" treater applies treatment as a mist directly to the seed. The metering operation of the treatment cups and seed dump is similar to that of the "Panogen" treater. Cup sizes are designated by the number of cc's they actually deliver-e.g., 2 ½ , 5, 10, 20 and 40. The treater is equipped with a large treatment tank, a pump and a return that maintains the level in the small reservoir from which the treatment cups are fed. After metering, the treatment material flows to a rapidly revolving, fluted disc mounted under a seed-spreading cone. The disc breaks droplets of the treatment solution into a fine mist and sprays it outward to coat seed falling over the cone through the treating chamber. Just below the seed dump are two adjustable retarders designed to give a continuous flow of seed over the cone between seed dumps. This is important since there is a continuous misting of material from the revolving disc. The desired treating rate is obtained through selection of treatment cup size and proper adjustment of the seed dump weight.

EXERCISE 2

Moisture stress effects and recovery behaviour of important crops

Moisture stress (moisture deficit) : It indicates the action of lack / deficit or excess of water on plants. However, in general, stress is used to imply moisture/water deficits. The term moisture stress is generally used for moisture deficit conditions through it is applicable to excess moisture also. The plant water stress may be severe when the soil water potential is low and environmental or plant factors interfere seriously with absorption of water.

Effect of moisture stress in crop: Moisture stress is one of the most important elements influencing plant growth, development, and yield profitability, posing a substantial threat to sustainable agriculture. It does not affect all aspects of plant growth and development equally. Moisture stress causes serious reduction in growth, quantity, and quality in many plants. Some processes are highly susceptible while others are less affected. The final yield of the crop at harvest is the integrated after effect of these impacts of stress on water relations, photosynthesis, respiration, nutrition/sustenance, hormonal activities, growth and development.

Water Relations: Several changes show in the plants due to moisture stress in the soil. It alters the water status by its effect on water absorption, translocation and transpiration. The lag in absorption behind transpiration result of increase in the atmospheric dryness as a result in loss of turgor.

Photosynthesis: In plants photosynthesis process is decreased by moisture stress because of decrease in photosynthetic rate, chlorophyll content, leaf area and increment assimilates saturation in leaves (because of absence of translocation). When lack of moisture, stomata are closed to reduce transpiration. Therefore, section of carbon dioxide into leaf is reduced resulting in decline in photosynthetic rate. Moisture stress is known to decline photosynthesis by reducing both leaf area and photosynthetic rate per unit leaf area. Translocation of assimilates is also affected by water stress and this limits photosynthesis.

Respiration: Respiration increase with mild drought condition but more serve drought lowers water content in soil. More severe moisture stress reduces respiration.

Moisture stress in vegetative stage: Moisture stress in vegetative stage less important than in reproductive stage of stress and the impact on yield and its yield attributes. However, since the stress at this stage of growth and development of plant, photosynthesis and the accumulation of most importance is the effect in plant. Water shortages condition, with the disappearance of cells, disrupted physiological processes of plants, plant growth, photosynthesis, stomatal closure, changes in metabolism of plants and dying plants.

Anatomical changes: Size of cells and inter cellular spaces is decrease, thicker cell wall, greater development of mechanical tissue. Stomata per unit leaf will in general increment.

Metabolic Reactions: Almost all metabolic reactions are affected by moisture deficits. Serious moisture shortfalls cause decline in enzymatic activity. Accumulation of sugars and amino acids takes place under moisture stress condition due to breakdown of carbohydrates and proteins.

Hormonal Relationship: Growth promoting hormones like cytokinin, gibberellic acid, and indole acetic acid etc., decreases and growth regulating hormones like abscisic acid, ethylene etc. increases. The translocation of growth promoting hormones is also reduced by moisture stress. With change in hormonal balance, growth of leaves production of tillers or branches is reduced and stomata closure and leaf senescence are increased.

Nutrition: The uptake of nitrogen, phosphorus and potassium is reduced by moisture stress. The fixation, uptake and assimilation of nitrogen is affected by moisture deficits. Nitrogen fixation by leguminous plants is reduced by moisture stress due to reduction in leghaemoglobin, specific activity of nodules and number of nodules.

Growth and Development: Growth and development are the most drought sensitive physiological processes with water stress limiting growth more than any other abiotic stress. Because of water deficits on several physiological processes, plant growth is reduced Generally, the organ becoming most quickly at the hour of stress is the one generally influenced. Maturity is delayed if drought occurs before flowering while it advances if drought occurs after flowering. Moisture stress influences germination of seeds, leaf area, leaf expansion and root development of plant.

Reproduction and grain growth: Moisture stress at flowering and grain development determines the number of fruits and individual grain weight, respectively. Moisture stress at grain development reduces yield while vegetative and grain filling stages are less sensitive to moisture stress.

Yield: Moisture stress during flowering and grain development determines the number of fruits and individual grain weight respectively. During ripening which involves dehydration and certain biochemical process, moisture stress has little effect on yield components. The impact on yield depends hugely on what extent of the complete dry matter is considered as valuable material to be harvested. At the point when the yield comprises of most or all the aeronautical parts like forage crops, tobacco etc., the impact of moisture stress is equivalent to those on all over growth and development. Crop yields are reduced by 69% on average when plants are exposed to unfavorable conditions in the field.

EXERCISE 3

Estimation of moisture index and aridity index

They have taken the Moisture Index (Im) as the criteria for classification of dry climates.

Im = [(P-PE)/PE] 100

where, P = Precipitation, PE = Potential Evapo-transpiration

Aridity Index (AI) is a numerical indicator which is used for measuring the degree of dryness of climate of a place. It is opposite to humidity index. It is calculated as the ratio of P/PET, where P is the average annual precipitation and PET is the potential evapotranspiration.

EXERCISE 4

Water Use Efficiency

It measures the quantity of water taken up by the crop during its crop life to produce a unit quantity of the output i.e., crop yield.

Crop water use efficiency/ Water use efficiency (WUE)(kg/ ha.mm) = Marketable crop yield /Evapotranspiration

Field water use efficiency (FWUE)(kg/ ha.mm)= Marketable crop yield/ (ET+DP) .

PRINCIPLES AND PRACTICES OF ORGANIC FARMING- AGR-205

EXERCISE 1

Aerobic and anaerobic methods of making compost

Aerobic composting takes place in the presence of ample O. In this process, aerobic microorganisms break down organic matter and produce carbon dioxide (CO_2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production.

The aerobic composting process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70-80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20-45 °C) multiply rapidly on the readily available sugars and amino acids. They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. Then a few thermophilic fungi and several thermophilic bacteria (optimum growth temperature range =

50-70 °C or more) continue the process, raising the temperature of the material to 65 °C or higher. This peak heating phase is important for the quality of the compost as the heat kills pathogens and weed seeds.

The active composting stage is followed by a curing stage, and the pile temperature decreases gradually. The start of this phase is identified when turning no longer reheats the pile. At this stage, another group of thermophilic fungi starts to grow. These fungi bring about a major phase of decomposition of plant cell-wall materials such as cellulose and hemi-cellulose. Curing of the compost provides a safety net against the risks of using immature compost such as nitrogen (N) hunger, O deficiency, and toxic effects of organic acids on plants.

Eventually, the temperature declines to ambient temperature. By the time composting is completed, the pile becomes more uniform and less active biologically although mesophilic organisms recolonize the compost. The material becomes dark brown to black in colour. The particles reduce in size and become consistent and soil-like in texture. In the process, the amount of humus increases, the ratio of carbon to nitrogen (C:N) decreases, pH neutralizes, and the exchange capacity of the material increases.

Anaerobic Composting

Anaerobic composting generally takes place in nature. Composting which progresses without the entanglement of oxygen is known as anaerobic composting. In this process, the organic material is broken down by the different species of anaerobic microorganisms. Like aerobic microorganisms, anaerobic microbes also employ the N, P, K and other nutrients for their metabolic development. The major differences between aerobic and anaerobic composting are: breakdown of organic nitrogen to ammonia and organic acids; release of methane (CH_4) from the decomposition of carbon compounds. Reduction is the main process of breakdown of organic matter under anaerobic composting, though for a shorter period of time oxidation also takes place for preparation of final end product in anaerobic composting. There are four major stages of anaerobic decomposition i.e. Hydrolysis, acidogenesis, acetogenesis and methanogenesis. In hydrolysis which is the first stage, the insoluble complex organic materials i.e. cellulose, hemicelluloses, lignin etc. are hydrolysed into the soluble simple amino acids, fatty acids and sugars. The hydrolysis process has a significant stage in anaerobic composting as it decomposes the raw organic matter with high complex organic content. The fermentative acidogenic bacteria further decompose the remaining complex organic matter into simple molecules under the acidogenesis process which is the second stage of anaerobic composting. In the third stage i.e. acetogenesis, simple organic molecules created by the acidogenesis process are further digested to acetic acid, carbon dioxide (CO_2) and hydrogen. The microbes involved in acetogenesis process are: *Acetobacter woodii, Clostridium aceticum and Clostridium termoautotrophicum.* Production of methane gas (CH_4) by methane forming microbes i.e. Methanosarcina takes place in the fourth and final stage which is known as methanogenesis

EXERCISE 2

Making of vermicompost

Earthworms have been on the Earth for over 20 million years. In this time they have faithfully done their part to keep the cycle of life continuously moving. Their purpose is simple but very important. They are nature's way of recycling organic nutrients from dead tissues back to living organisms. Many have recognized the value of these worms. Ancient civilizations, including Greece and Egypt valued the role earthworms played in soil. The Egyptian Pharaoh, Cleopatra said, "Earthworms are sacred." She recognized the important role the worms played in fertilizing the Nile Valley croplands after annual floods. Charles Darwin was intrigued by the worms and studied them for 39 years. Referring to an earthworm, Darwin said, "It may be doubted whether there are many other animals in the world which have played so important a part in the history of the world." The earthworm is a natural resource of fertility and life.

Earthworms live in the soil and feed on decaying organic material. After digestion, the undigested material moves through the alimentary canal of the earthworm, a thin layer of oil is deposited on the castings. This layer erodes over a period of 2 months. So although the plant nutrients are immediately available, they are slowly released to last longer. The process in the alimentary canal of the earthworm transforms organic waste to natural fertilizer. The chemical changes that organic wastes undergo include deodorizing and neutralizing. This means that the pH of the castings is 7 (neutral) and the castings are odorless. The worm castings also contain bacteria, so the process is continued in the soil, and microbiological activity is promoted.

Sieved finished vermicompost

Vermicompost ready for sale

Vermicomposting is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good topsoil. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 percent.

Vermicomposting is done on small and large scales. In the 1996 Summer Olympics in Sydney, Australia, the Australians used worms to take care of their tons and tons of waste.

They then found that waste produced by the worms was could be very beneficial to their plants and soil. People in the U.S. have commercial vermicomposting facilities, where they raise worms and sell the castings that the worms produce. Then there are just people who own farms or even small gardens, and they may put earthworms into their compost heap, and then use that for fertilizer.

Vermicompost and its utilization

Vermicompost is nothing but the excreta of earthworms, which is rich in humus and nutrients. We can rear earthworms artificially in a brick tank or near the stem / trunk of trees (specially horticultural trees). By feeding these earthworms with biomass and watching properly the food (bio-mass) of earthworms, we can produce the required quantities of vermicompost.

Materials for preparation of Vermicompost

Any types of biodegradable wastes-

1. Crop residues
2. Weed biomass
3. Vegetable waste
4. Leaf litter
5. Hotel refuse
6. Waste from agro-industries
7. Biodegradable portion of urban and rural wastes

Phase of vermicomposting

Phase 1 : Processing involving collection of wastes, shredding, mechanical separation of the metal, glass and ceramics and storage of organic wastes.

Phase 2 : Pre digestion of organic waste for twenty days by heaping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption. Cattle dung and biogas slurry may be used after drying. Wet dung should not be used for vermicompost production.

Phase 3 : Preparation of earthworm bed. A concrete base is required to put the waste for vermicompost preparation. Loose soil will allow the worms to go into soil and also while watering, all the dissolvable nutrients go into the soil along with water.

Phase 4 : Collection of earthworm after vermicompost collection. Sieving the composted material to separate fully composted material. The partially composted material will be again put into vermicompost bed.

Phase 5 : Storing the vermicompost in proper place to maintain moisture and allow the beneficial microorganisms to grow.

What Worms Need

The Five Essentials

Compost worms need five basic things:

1. An hospitable living environment, usually called “bedding”
2. A food source
3. Adequate moisture (greater than 50% water content by weight)

4. Adequate aeration
5. Protection from temperature extremes

These five essentials are discussed in more detail below.

Bedding

Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have the following characteristics:

High absorbency

Worms breathe through their skins and therefore must have a moist environment in which to live. If a worm's skin dries out, it dies. The bedding must be able to absorb and retain water fairly well if the worms are to thrive.

Good bulking potential

If the material is too dense to begin with, or packs too tightly, then the flow of air is reduced or eliminated. Worms require oxygen to live, just as we do. Different materials affect the overall porosity of the bedding through a variety of factors, including the range of particle size and shape, the texture, and the strength and rigidity of its structure. The overall effect is referred to in this document as the material's bulking potential.

Low protein and/or nitrogen content (high Carbon: Nitrogen ratio)

Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding.

Requirements

- **Housing:** Sheltered culturing of worms is recommended to protect the worms from excessive sunlight and rain. All the entrepreneurs have set up their units in vacant cowsheds, poultry sheds, basements and back yards.
- **Containers:** Cement tanks were constructed. These were separated in half by a dividing wall. Another set of tanks were also constructed for preliminary decomposition.
- **Bedding and feeding materials:** During the beginning of the enterprises, most women used cowdung in order to breed sufficient numbers of earthworms. Once they have large populations, they can start using all kinds of organic waste. Half of the entrepreneurs have now reached populations of 12,000 to 15,000 adult earthworms.

3. Vermicompost Production Methodology

i) Selection of suitable earthworm

For vermicompost production, the surface dwelling earthworm alone should be used. The earthworm, which lives below the soil, is not suitable for vermicompost production. The African earthworm (*Eudrillus engenial),* Red worms (*Eisenia foetida)* and composting worm (*Peronyx excavatus)* are promising worms used for vermicompost production. All the three worms can be mixed together for vermicompost production. The African worm (*Eudrillus eugenial)* is preferred over other two types, because it produces higher production of vermicompost in short period of time and more young ones in the composting period.

African earthworm (*Eudrillus euginiae*)

Tiger worm or Red wrinkle (*Eisenia foetida*)

Asian worms (*perinonyx ecavatus*)

ii) Selection of site for vermicompost production

Vermicompost can be produced in any place with shade, high humidity and cool. Abandoned cattle shed or poultry shed or unused buildings can be used. If it is to be produced in open area, shady place is selected. A thatched roof may be provided to protect the process from direct sunlight and rain. The waste heaped for vermicompost production should be covered with moist gunny bags.

iii) Containers for vermicompost production

A cement tub may be constructed to a height of 2½ feet and a breadth of 3 feet. The length may be fixed to any level depending upon the size of the room. The bottom of the tub is made to slope like structure to drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water.

In another option over the hand floor, hollow blocks / bricks may be arranged in compartment to a height of one feet, breadth of 3 feet and length to a desired level to have quick harvest. In this method, moisture assessment will be very easy. No excess water will be drained. Vermicompost can also be prepared in wooden boxes, plastic buckets or in any containers with a drain hole at the bottom.

Cement tub

Coir waste

Saw dust

Sugarcane trash

iv) Vermiculture bed

Vermiculture bed or worm bed (3 cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in the bottom of tub / container. A layer of fine sand (3 cm) should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water.

Common Bedding Materials

Bedding Material	Absorbency	Bulking Pot.	C:N Ratio
Horse Manure	Medium-Good	Good	22 - 56
Peat Moss	Good	Medium	58
Corn Silage	Medium-Good	Medium	38 - 43
Hay – general	Poor	Medium	15 - 32
Straw – general	Poor	Medium-Good	48 - 150
Straw – oat	Poor	Medium	48 - 98
Straw – wheat	Poor	Medium-Good	100 - 150
Paper from municipal waste stream	Medium-Good	Medium	127 - 178
Newspaper	Good	Medium	170
Bark – hardwoods	Poor	Good	116 - 436
Bark -- softwoods	Poor	Good	131 - 1285
Corrugated cardboard	Good	Medium	563
Lumber mill waste -- chipped	Poor	Good	170
Paper fibre sludge	Medium-Good	Medium	250
Paper mill sludge	Good	Medium	54
Sawdust	Poor-Medium	Poor-Medium	142 - 750
Shrub trimmings	Poor	Good	53
Hardwood chips, shavings	Poor	Good	451 - 819
Softwood chips, shavings	Poor	Good	212 - 1313
Leaves (dry, loose)	Poor-Medium	Poor-Medium	40 - 80
Corn stalks	Poor	Good	60 - 73
Corn cobs	Poor-Medium	Good	56 - 123
Paper mill sludge	Good	Medium	54
Sawdust	Poor-Medium	Poor-Medium	142 - 750
Shrub trimmings	Poor	Good	53
Hardwood chips, shavings	Poor	Good	451 - 819
Leaves (dry, loose)	Poor-Medium	Poor-Medium	40 - 80
Corn stalks	Poor	Good	60 - 73
Corn cobs	Poor-Medium	Good	56 - 123

If available, shredded paper or cardboard makes an excellent bedding, particularly when combined with typical on-farm organic resources such as straw and hay. Organic producers, however, must be careful to ensure that such materials are not restricted under their organic certification standards. Paper or cardboard fibre collected in municipal waste programs cannot be approved for certification purposes. There may be cases, however, where fibre resources from specific generators could be sourced and approved. This must be considered on a case-by-case basis. Another material in this category is paper-mill sludge, which has the high absorbency and small particle size that so well complements the high C:N ratios and good bulking properties of straw, bark, shipped brush or wood shavings. Again, the sludge must be approved if the user has organic certification.

In general, it should be noted by the reader that the selection of bedding materials is a key to successful vermiculture or vermicomposting. Worms can be enormously productive (and reproductive) if conditions are good; however, their efficiency drops off rapidly when their basic needs are not met (see discussion on moisture below). Good bedding mixtures are an essential element in meeting those needs. They provide protection from extremes in temperature, the necessary levels and consistency of moisture, and an adequate supply of oxygen. Fortunately, given their critical importance to the process, good bedding mixtures are generally not hard to come by on farms. The most difficult criterion to meet adequately is usually absorption, as most straws and even hay are not good at holding moisture. This can be easily addressed by mixing some aged or composted cattle or sheep manure with the straw. The result is somewhat similar in its bedding characteristics to aged horse manure.

Mixing beddings need not be an onerous process; it can be done by hand with a pitchfork (small operations), with a tractor bucket (larger operations), or, if one is available, with an agricultural feed mixer. Please note that the latter would only be appropriate for large commercial vermicomposting operations where high efficiency levels and consistent product quality is required.

v) Worm Food

Compost worms are big eaters. Under ideal conditions, they are able to consume in excess of their body weight each day, although the general rule-of-thumb is ½ of their body weight per day. They will eat almost anything organic (that is, of plant or animal origin), but they definitely prefer some foods to others. Manures are the most commonly used worm feedstock, with dairy and beef manures generally considered the best natural food for Eisenia, with the possible exception of rabbit manure. The former, being more often available in large quantities, is the feed most often used.

vi) Selection for vermicompost production

Cattle dung (except pig, poultry and goat), farm wastes, crop residues, vegetable market waste, flower market waste, agro industrial waste, fruit market waste and all other bio degradable waste are suitable for vermicompost production. The cattle dung should be dried in open sunlight before used for vermicompost production. All other waste should be predigested with cow dung for twenty days before put into vermibed for composting.

vii) Putting the waste in the container

The predigested waste material should be mud with 30% cattle dung either by weight or volume. The mixed waste is placed into the tub / container upto brim. The moisture level

should be maintained at 60%. Over this material, the selected earthworm is placed uniformly. For one-meter length, one-meter breadth and 0.5-meter height, 1 kg of worm (1000 Nos.) is required. There is no necessity that earthworm should be put inside the waste. Earthworm will move inside on its own.

viii) Watering the vermibed

Daily watering is not required for vermibed. But 60% moisture should be maintained throughout the period. If necessity arises, water should be sprinkled over the bed rather than pouring the water. Watering should be stopped before the harvest of vermicompost.

ix) Harvesting vermicompost

In the tub method of composting, the castings formed on the top layer are collected periodically. The collection may be carried out once in a week. With hand the casting will be scooped out and put in a shady place as heap like structure. The harvesting of casting should be limited up to earthworm presence on top layer. This periodical harvesting is necessary for free flow and retain the compost quality. Other wise the finished compost get compacted when watering is done. In small bed type of vermicomposting method, periodical harvesting is not required. Since the height of the waste material heaped is around 1 foot, the produced vermicompost will be harvested after the process is over.

x) Harvesting earthworm

After the vermicompost production, the earthworm present in the tub / small bed may be harvested by trapping method. In the vermibed, before harvesting the compost, small, fresh cow dung ball is made and inserted inside the bed in five or six places. After 24 hours, the cow dung ball is removed. All the worms will be adhered into the ball. Putting the cow dung ball in a bucket of water will separate this adhered worm. The collected worms will be used for next batch of composting.

Worm harvesting is usually carried out in order to sell the worms, rather than to start new worm beds. Expanding the operation (new beds) can be accomplished by splitting the beds that is, removing a portion of the bed to start a new one and replacing the material with new bedding and feed. When worms are sold, however, they are usually separated, weighed, and then transported in a relatively sterile medium, such as peat moss. To accomplish this, the worms must first be separated from the bedding and vermicompost. There are three basic categories of methods used by growers to harvest worms: manual, migration, and mechanical. Each of these is described in more detail in the sections that follow.

a) Manual Methods

Manual methods are the ones used by hobbyists and smaller-scale growers, particularly those who sell worms to the home-vermicomposting or bait market. In essence, manual harvesting involves hand-sorting, or picking the worms directly from the compost by hand. This process can be facilitated by taking advantage of the fact that worms avoid light. If material containing worms is dumped in a pile on a flat surface with a light above, the worms will quickly dive below the surface. The harvester can then remove a layer of compost, stopping when worms become visible again. This process is repeated several times until there is nothing left on the table except a huddled mass of worms under a thin covering of compost. These worms can then be quickly scooped into a container, weighed, and prepared for delivery.

There are several minor variations and/or enhancements on this method, such as using a container instead of a flat surface, or making several piles at once, so that the person harvesting can move from one to another, returning to the first one in time to remove the next layer of compost. They are all labour-intensive, however, and only make sense if the operation is small and the value of the worms is high.

b) Self-Harvesting (Migration) Methods

These methods, like some of the methods used in vermicomposting, are based on the worms tendency to migrate to new regions, either to find new food or to avoid undesirable conditions, such as dryness or light. Unlike the manual methods described above, however, they often make use of simple mechanisms, such as screens or onion bags.

The screen method is very common and easy to use. A box is constructed with a screen bottom. The mesh is usually ¼", although 1/8" can be used as wel. There are two different approaches. The downward-migration system is similar to the manual system, in that the worms are forced downward by strong light. The difference with the screen system is that the worms go down through the screen into a prepared, pre-weighed container of moist peat moss. Once the worms have all gone through, the compost in the box is removed and a new batch of worm-rich compost is put in. The process is repeated until the box with the peat moss has reached the desired weight. Like the manual method, this system can be set up in a number of locations at once, so that the worm harvester can move from one box to the next, with no time wasted waiting for the worms to migrate.

The upward-migration system is similar, except that the box with the mesh bottom is placed directly on the worm bed. It has been filled with a few centimeters of damp peat moss and then sprinkled with a food attractive to worms, such as chicken mash, coffee grounds, or fresh cattle manure. The box is removed and weighed after visual inspection indicates that sufficient worms have moved up into the material. This system is used extensively in Cuba, with the difference that large onion bags are used instead of boxes. The advantage of this system is that the worm beds are not disturbed. The main disadvantage is that the harvested worms are in material that contains a fair amount of unprocessed food, making the material messier and opening up the possibility of heating inside the package if the worms are shipped. The latter problem can be avoided by removing any obvious food and allowing a bit of time for the worms to consume what is left before packaging.

xi) Nutritive value of vermicompost

The nutrients content in vermicompost vary depending on the waste materials that is being used for compost preparation. If the waste materials are heterogeneous one, there will be wide range of nutrients available in the compost. If the waste materials are homogenous one, there will be only certain nutrients are available. The common available nutrients in vermicompost is as follows

Organic carbon	:	9.5 – 17.98%
Nitrogen	:	0.5 – 1.50%
Phosphorous	:	0.1 – 0.30%
Potassium	:	0.15 – 0.56%
Sodium	:	0.06 – 0.30%
Calcium and Magnesium	:	22.67 to 47.60 meq/100g
Copper	:	2 – 9.50 mg kg^{-1}
Iron	:	2 – 9.30 mg kg^{-1}
Zinc	:	5.70 – 11.50 mg kg^{-1}
Sulphur	:	128 – 548 mg kg^{-1}

xii) Storing and packing of vermicompost

The harvested vermicompost should be stored in dark, cool place. It should have minimum 40% moisture. Sunlight should not fall over the composted material. It will lead to loss of moisture and nutrient content. It is advocated that the harvested composted material is openly stored rather than packed in over sac. Packing can be done at the time of selling. If it is stored in open place, periodical sprinkling of water may be done to maintain moisture level and also to maintain beneficial microbial population. If the necessity comes to store the material, laminated over sac is used for packing. This will minimize the moisture evaporation loss. Vermicompost can be stored for one year without loss of its quality, if the moisture is maintained at 40% level.

4. Advantages of vermicompost

- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of new
- shoots / leaves and improves the quality and shelf life of the produce.
- Vermicompost is free flowing, easy to apply, handle and store and does not have bad
- odour.
- It improves soil structure, texture, aeration, and waterholding capacity and prevents
- soil erosion.
- Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers,
- cellulose decomposing micro-flora etc in addition to improve soil environment.
- Vermicompost contains earthworm cocoons and increases the population and
- activity of earthworm in the soil.
- It neutralizes the soil protection.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.

- Vermicompost is free from pathogens, toxic elements, weed seeds etc.
- Vermicompost minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins et

5. Pests and Diseases of vermicompost

Compost worms are not subject to diseases caused by micro-organisms, but they are subject to predation by certain animals and insects (red mites are the worst) and to a disease known as "sour crop" caused by environmental conditions.

EXERCISE 3

Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Certification

Organic certification system is a quality assurance initiative, intended to assure quality, prevent fraud and promote commerce, based on set of standards and ethics. It is a process certification for producers of organic food and other organic plant products.

Need for certification

- Third party assurance from producer to the consumer separated by distance
- For uniform label
- Assurance to the consumers that its concern for healthy food has been addressed.
- Effective marketing tool for Image, credibility, visibility/ Transparency

The Organic Quality Control

There are 4 keys for this:

1. Accreditation
2. Standards
3. Inspection
4. Certification

1. Accreditation

- As per the National Programme for Organic Production (NPOP) an accreditation refers registration by the accreditation agency for certifying agency for certifying organic farms, products and processes as per the guidelines of the National Accreditation Policy and Programme for Organic Product.
- Guarantees that the certification program is competent to carry out specific tasks • Authoritative body defines policies, standards and checks whether a certification system is operating according to standards
- Various accreditation programs: national, EU (EN 45011), ISO (No. 65), IFOAM, NPOP, NOP, JAS

Functions of Accreditation agencies

In context of Indian accreditation scenario, NPOP defined the function of accreditation agencies like :

- Package of practices for organic products.
- Accreditation of inspection and certifying agencies.
- Monitor the inspection.
- Lay down inspection procedures.
- Advise the National Steering Committee.
- Accept Accredited certification programmes.
- Shall evolve accreditation criteria for inspection and/or certifying agencies.
- Shall prepare an operating manual to assist accredited agencies.
- Identification of Eligible inspection and certification agencies.

2. Standards

- Standards defining production methods, not the product quality
- Minimum requirements, not “best practice”
- Standards <--> regulations
- Continuously developed, dynamic
- Can be International, National or regional standards

3. Inspection

- On-site visit to verify that the performance of an operation is in accordance with specific standards.
- Evaluation and verification of agricultural production, processing and trading.
- Inspection requires complete documentation by producers, processors and handlers.
- Findings are presented in a report to the certifiers.

4. Certification

- Monitoring the market for misuse of certification mark or label.
- Assesses the results of the inspection in relation to the requirements of the organic standards.
- Decides about issuing of certificates, conditions and sanctions.
- Written confirmation that a process or product is in compliance with certain standards Certificate is granted.

Labelling

- Easy recognition of organic quality and certification system.
- Confirms the fulfilment of the label regulations and of legal rules.
- They help to achieve a better price for organic products.

NPOP is Internationally Recognized.

- NPOP has equivalence agreement with European Union.
- NPOP has equivalence agreement with Switzerland.
- USDA has accepted NPOP conformity assessment system Means product certified by any Indian certification body can be exported without the need for recertification in above countries. For USA Indian certification bodies issue certificate based on NOP standards.

Inspection and Certification process

- Appointment of Inspection and Certification bodies
- Accreditation of Inspection and certification agency by NAB
- Deployment of competent persons for audit
- Undertaking inspection and certification
- Annual Surveillance and Review of Inspection and Certification Agencies
- Continuous improvement in system
- Renewal of accreditation at 3 year interval

Inspection and Certification by Accredited agency

- Receipt of applications
- Providing standards and operational documents
- Agreement
- Demand for Fee
- Document audit
- Physical field inspection
- Risk assessment
- Compliance verification
- Reporting by inspector
- Review by reviewer
- Certification decision

Inspection Methods

- Visits of facilities, fields, etc.
- Review of records and accounts.
- Calculation of input/output norms, production estimates etc.
- Assessment of production system.
- Interview with responsible persons.
- Risk assessment.
- Part Conversion and Parallel Production.
- Inspection for Use of Genetically Engineered Products.
- Use of off-farm inputs.
- Analysis for residue testing (if required).

Internal Control System: Smallholder Grower Group Certification

- Based on internal quality system
- Applicable to producer groups, farmer's cooperatives, contract production and small scale processing units.
- The producers in the group must apply similar production systems and the farms should be in geographical proximity.

Internal Quality System

- A group of producers create internal team for some tasks.
- External certification agency delegates some inspection tasks to this group (known as IQS).
- IQS undertakes inspection on behalf of CB.
- Certification agency evaluates the working of IQS and do random field inspection for verification Certification is granted to group as a whole as one unit.

Constitution of a group

- 25 to maximum 500 members
- Should have legal status
- All members in geographical proximity
- Similar production system

Internal Control System Procedure

- Registration of members
- Train members in standard implementation and risk management
- Register group with certification agency
- Maintain each member's documents
- Internal inspections
- Submission of report to certification agency
- External inspections
- Compliance of deficiencies
- Yield estimates
- Grant of certification