Laboratory Manual
On
Seed Production and Testing

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Contents

PRACTICAL: 1

Objective: To study the identifying characteristics of seeds

Seed:

A seed is mature fertilized living embryo consist of stored food material and protective covering *i.e.* seed coat. As per Indian Seeds Act (1966), seed will also include vegetative propagules like tubers (potato), bulbs (onion), rhizomes (turmeric) and cuttings (sugarcane). It is a connecting link between generations. Production of new generation is prime function of a seed. On different basis the seeds can be categorize as follow-

a. On the basis of plant part used as seed

True seed

The seed originates from flower after sexual reproduction is called true seed.

Vegetative seed

Any plant part other than true seed which used or can be used for growing next generation plant is called vegetative seed. The stem, roots, leaves or there modification like stolen, rhizomes, tubers, bulbils, bulbs, corns etc. may be used for plant propagation.

b. On the basis of number of cotyledons

Dicotyledonous seed:

Seeds whose embryo consist two cotyledons are known as dicotyledonous or dicot seed. These are commonly known as broadleaved plants e.g. Gram, pea, mango, gourd, turmeric, cotton and sunflower etc.

Monocotyledonous seed:

Monocotyledonous or monocot seeds are those seeds which contain only single cotyledon like most of the grasses. Eg. paddy, wheat, onion, palm etc.

b. Based on presence or absence of endosperm

Endospermic seeds (albuminous seeds): Seeds which are contain endosperm as a well-developed food storage part. Eg. castor, onion, rice, maize, palms, wheat, ragi,

Non-endospermic seeds (exalbuminous seeds): Seeds in which endosperm either absent or present in a rudimentary position and other part of seed mainly cotyledon function as storage food reserve part known as non-endospermic seeds. Eg. Bean, gourd, sunflower, cotton, pea, mango etc.

c. Based on type of germination

Hypogeal germination: In hypogeal germination, the cotyledons remain below the soil surface and plumule is carried above the cotyledon or scutellum. Eg. Gram, rice, maize, pea, mango, palms etc.

Epigeal Germination: In epigeal germination cotyledons or storage part are emerge above ground by elongation of the hypocotyls, *i.e*. the stem below the cotyledons. Eg. Bean, gourd, cotton, onion, sunflower, castor etc.

d. Based on growing season

Kharif seed: Seeds of crops which are produced during kharif season. Eg. rice, finger millet, barnyard millet, sorghum etc.

Rabi seed: Seeds which produced during rabi season. Eg. wheat, barley, oat, pea, lentil etc.

Zaid seed: Seeds which are produced during zaid season. Eg. most of the cucurbits.

Characteristics of Agricultural and horticultural crop's seeds

Cereal and Millet crops

Wheat (*Triticum aestivum*):

- it has hump at dorsal and crease at ventral side
- monocot seed, hypogeal germination
- seed is caryopsis
- Embryonic end known as collar end and other end as brush end.

Barley (*Hordium vulgare*)

- Seed is caryopsis having pericarp, endosperm and embryo
- Monocot, hypogeal germination
- Seed is 8-12 mm long, 3-4 mm wide and 2-3 mm thick.

Rice (*Oryza sativa*):

- monocot seed with hypogeal germination
- Seed is caryopsis, tightly closed in lemma and palea.
- Two types of endosperm i.e. mealy (high breaking during milling) and vitreous (less breaking and non sticky)

Maize (*Zea mays*):

- Monocot seed with hypogeal germination
- Seed is caryopsis, signle cotyledon called scutellum
- Seed is conical in shape with broad and round upper end and a sharply pointed lower end embedded in the cob
- White and oval part indicates embryo and yellow part indicates endosperm

Sorghum (*Sorghum bicolor*)

- Seed caryopsis, hypogeal germination
- Pericarp consists of an epicarp, mesocarp and endocarp
- Hilum turns black at physiological maturity

Perl millet (*Pennisetum glacum)*:

- Seed caryopsis, black layer at base of seed indicates physiological maturity
- Monocot seed, hypogeal germinaton

Finger millet (*Eleusine coracana*):

- Seed is utricle, since pericarp is loose and get easily broken from the seed, it is naked
- Monocot seed, hypogeal germination
- Seed generally reddish brown or brown in colour

Indian barnyard Millet (*Echinochloa frumentacea*)

- Seed is caryopsis, monocot, hypogeal germination, white or yellow or light brown in colour.

Foxtail millet (*Setaria italica*)

- Monocot, endospermic seed, hypogeal germination
- Seed coat is shiny, white, yellowish, light orange, orange colour

Kodo Millet (*Paspalum scrobiculatum*)

- Seed is caryopsis

- Creamy white, yellow, red or white color seed

Little millet/Kutki (*Panicum sumatrense*)

Seeds are white, yellow, brownish in colour, monocot, caryopsis.

Pulse Crops

Pea (*Pisum sativum*)

- Dicot seed, hypogeal germination
- Cotyledons function as storage tissue, endosperm absent

Cowpea (*Vigna unguiculata*)

- Dicot seed, epigeal germination
- Dark black ring present around hilum
- Endosperm absent and cotyledons function as storage tissue

Chickpea (*Cicer arietinum*)

- leguminous crop having a beak like structure in the seed
- beak has micropyle and hilum structure
- chalazal end is prominent

Pigeon pea (*Cajanus cajan*)

- Dicot seed, endosperm absent, epileal germination
- White hilum present, seed color range from silver, white, cream, fawn, black, pink or red or purple
- Seed are oval, pea shaped, square or elongate

Green gram (*Vigna radiata*)

- Dicot seed, endosperm absent, epigeal germination
- White concave hilum

Black gram (*Vigna mungo*)

- Cotyledons function as storage tissue, non endospermic seed
- Epigeal germination, coloured round hilum
- Seed is oblong with square ends

French bean (*Phaseolus vulgaris*)

- Dicot seed, epigeal germination, non endospermic
- mature seeds are 1 to 3 cm long and oval to kidney shaped

Oilseeds Crops

Mustard (*Brassica juncea*)

- Dicot seed, epigeal germination
- Spheroid to irregularly globose, dark reddish brown to brownish black seed.
- A scar is visible on seed coat.

Sunflower (*Helianthus annuus* L.)

- Dicot seed, epigeal germination
- Seed is achene called cypsela
- Beneath the pericarp, brown membranous seed coat is present.

Safflower (*Carthamus tinctorius* L.)

- Aluminous dicot single seeded fruits, covered with a fruit wall having some ridges.
- a very thin layer of endosperm is present in between the outer covering of seed and cotyledons
- cotyledons are flat with clear nerves
- Embryonic axis is short and radicle is present in extended form at one side of it.

Niger (Guizotia abyssinica)

- Seed is pale yellow with nutty taste and pleasant odour
- Seed contain high per cent age of oil (37-47%)

Ground nut (*Arachis hypogaea*)

- Dicot seed, epigeal germination
- Thin, papery reddish seed coat, cotyledons contain oil

Sesame (*Sesamum indicum***)**

- Flattish-ovate, white to light brown small seed
- Seed with dark base, faint marginal line and an equally faint central line on one face.
- Ex-albuminous with straight embryo.

Castor (*Ricinus communis* L.)

- Large seed covered with a hard seed coat
- At one end of seed caruncle is present as whitish outgrouth of integument
- Hilum is present at the base and partly hidden due to caruncle

- Micropyle is located in between the caruncle and hilum
- Testa has white and brown spot, On the removal of the testa, a white oblong flattered endosperm covered with a thin tegmen layer becomes visible

Linseed (*Sesamum indicum*)

- Flat to elliptical-ovate, brown and glassy seed
- Epigeal germination, non endospermic, Dicot seed
- Cotyledons contain a large amount of oil

Soybean (*Glycine max*)

- Dicot seed, epigeal germination
- Concave hilum
- Non endospermic seed

Sugarbeet (*Beta vulgaris*)

- Seeds with endosperm, cotyledon and nucellus tissues as store of food
- Seed is very rough and irregular in shape
- seed is circular, approximately 1-2 mm in diameter

Fiber crops:

Cotton (*Gossypium spp*.)

- Folded cotyledons
- Thin layer of endosperm below the seed coat
- Dicot seed, epigeal germinaton

Jute (*Corchorus sp*.)

- Seed is copper coloured or bluish green to steel grey coloured depending upon species
- Amorphous seeds with a length of 2-3 mm

Sunhemp (*Crotolaria juncea*)

- Seeds are heart-shaped, grayish olive, dark grey or dark brown to black

PRACTICAL: 2

Objective: To study the principles of seeds production.

The following general principles must be during the seeds production of crops.

Agro-climate and Location

1. The crop variety to be grown for seed production must have a suitable agro-climate, adapted to the photoperiodic and temperature conditions prevailing in that location.
2. Specific selected locations would be needed to economically grow crop varieties sensitive to photoperiodism (short days *viz*., long days) and temperatures.
3. The regions with moderate rainfall, humidity and extreme temperatures
4. Most agronomic crops require a dry sunny period and moderate temperatures for flowering and pollination.
5. Excessive dew and rains affect normal pollination, resulting in poor seed set.
6. Extreme temperatures may cause desiccation of pollen and poor seed set.
7. Very hot and dry weather conditions adversely affect the flowering of several crops, especially vegetables, legumes and fruit crops, which fail to set seed. These crops invariably require cooler climates with low atmospheric humidity to flower and pollinate normally.
8. Oil seed crops may tolerate hot weather during flowering, but very high temperatures can result in premature flowering and the production of poor quality seeds.
9. Extreme cold temperatures also damage seed quality in the early phases of seed maturation. Thus, locations with extreme agro-climate (summer hot and cold winters) are generally not suitable for seed production.
10. Excessive rainfall conditions normally result in a higher incidence of pest and diseases making the harvesting and other operations of seed production extremely difficult. They may also cause delayed maturity and pre-germination of seed in many standing crops.
11. A mature seed crop becomes increasingly susceptible to shattering, strong winds, and heavy rainfall.
12. Ample sunshine, moderate rainfall, climate and absence of strong winds are ideal for the production of high quality seed.

Isolation

1. The seed crop must be sufficiently isolated from nearby fields of the same or other contaminating crops as per the requirements of certification standards.
2. The seed crop should be isolated by providing enough distance between seed plots and contaminating fields.
3. In the case of hybrid maize seed production, time isolation can be followed if distance isolation is not feasible.
4. On a small scale in nucleus / breeder's seed production, isolation may be achieved by enclosing individual flowers or by removing male flower parts and employing artificial pollination.
5. Even after the seed crop is harvested, effective isolation of seed from different varieties is essential to avoid mechanical contamination.
6. Bags and other equipment must be thoroughly clean to maintain seed purity.

Variety

1. After the land is prepared for improving germination, including freedom from weeds and uniform irrigation, the selected crop variety is carefully planted.
2. The variety selected should suit the prevailing agroclimatic conditions, highyielding and possessing desirable attributes such as disease resistance, earliness and grain quality. Similarly the seed should be known purity, appropriate class, and obtained from an authorized official agency.
3. The seed may require treatment before sowing, if not treated already. Seed treatment may be given with appropriate fungicides or involve bacterial inoculation for legumes or for breaking dormancy.
4. Seeds having hard seed coats may require soaking in water overnight to facilitate germination.
5. The seed must be planted at its normal planting time in soil having adequate moisture content for germination. Lower than usual seed rates of commercial crops will facilitate the roguing and inspection of seed crops.

Sowing

1. The seed crop is generally sown in rows by mechanical drillers, which allow the desired quantity of seeds to be planted at uniform depth.

2. The sowing equipment must be thoroughly clean to avoid any contamination.

3. Sowing in rows facilitates effective plant protection measures, roguing operations, and field inspection.

4. Adequate spacing within rows and distance between rows are given as per the plant bases.

5. For hybrids, female and male parent lines are planted in 4:2 or 6:2 proportions to ensure that the seeds of the male and female parent lines are not mixed while planting.

6. Small seed is generally sown shallow and large seed a little deeper to secure good planting.

7. Seed emergence is better from greater depths in sandy soils than in clayey soils and as well as from warmer soil.

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Pollination and Weeding

1. Supplementary pollination provided by honey bees in hives in close proximity to seed crops that are cross pollinated by insects may be necessary to ensure good seed set and thereby increase seed yield.

2. Production of high quality seed requires through control of weeds on the seed plot.

3. In addition to reduction in seed yield, weeds are often a source of contamination by way of mixing at the time of harvest.

4. Weeds in the seed plot or nearby areas may also harbor a number of pests and diseases

5. Effective control of weeds at all the phases of crop growth is essential and they must not be allowed to flower or set seed in any case.

6. Planting seed crops on clean, fallow land or following crop rotations is generally recommended to keep at a minimum. Hand weeding, intercultural operations or chemical weed control may be necessary.

Irrigation

1. Because drier climates are more suitable for producing high quality disease free seeds, irrigation is essential to obtain good seed yields.

2. Irrigation may be required before planting and at suitable intervals up to flowering.

3. One or two irrigation's may be desirable for many seed crops.

4. The frequency of irrigation and amount of water supplied depend upon the physical texture of the soil and crop requirements.

5. Maximum benefits from irrigation's can be derived only with adequate crop nutrition in the form of organic manure and fertilization, especially readily available sources of nitrogen and phosphorus.

6. Seed crop is rather sensitive to moisture stress at the vegetative, flowering and maturity stages. Adequate soil moisture is also necessary for uniform seed germination necessary to further crops stand and good seed yields.

7. Both excessive moisture conditions and prolonged drought will adversely affect germination, growth and development of the seed crop.

8. Water may be applied by surface irrigation, sprinkler, drip or overhead irrigation or subsurface irrigation.

9. The irrigation should be stopped 2-3 weeks before seed maturity to ensure the dried conditions needed for harvesting.

Plant Nutrition

1. Adequate amounts of nitrogen, phosphorus, potassium and other essential minerals are crucial for the proper growth and development of the seed crop. It is, therefore necessary to know the nutritional requirements of any individual seed crop and to ensure proper nutrition at all the stages of crop growth.

2. Split applications of nitrogen are generally advocated to avoid lodging of a crop due to excessive vegetative growth.
3. Application of nitrogen at the time of flowering leads to an increase in yield and quality of the seed of most crops.
4. In some early crops nitrogen dressing at flowering may tend to delay ripening.
5. While most grasses and peas are benefited by early applications of nitrogen, lettuce crops respond well to nitrogen application at the time of flowering.
6. Phosphorus and potassium favour root growth, increased strength of straw fruiting and seed development. They also hasten plant maturity and increase disease resistance.
7. Potassium improves the photosynthetic efficiency of plants and favours both protein and lipid metabolism in oil seeds.
8. Deficiencies of other essential secondary and micronutrients also need to be monitored carefully using soil test measures.

Plant Protection

1. Effective control of all pests, including diseases and insects, is essential to produce a healthy seed crop. In addition to heavy reductions in seed yields, diseases and pests damage the quality of the produce.
2. Planting seed chemically treated with the appropriate fungicides effectively checks the seedling and many of seed borne diseases.
3. Applying the appropriate fungicides and insecticides in proper quantities and at the right time can effectively control most seed crop pests.
4. Adoption of appropriate schedules of plant protection and roguing of diseased plants and earheads from time to time will further check the spread of disease and insects.

Harvesting

1. After completion of essential cultural operations and approval of seed fields for certification, the crop is ready for harvest. The appropriate time of harvest to ensure maximum seed yield and quality is of great significance.
2. Fully matured seed is easily harvested and cleaned with minimal harvest losses. While early harvests may make combining difficult, with increased losses in threshing and cleaning,

harvesting at later stages may result in increased losses due to weather, lodging, seed shattering and pest and dieseas.

3. Seed moisture content is a good indication of the optimum time of harvest. Combines do not normally operate well above 15% seed moisture. While soybeans may be harvested best at a seed moisture content of 13% for wheat the best moisture content varies from 15 to 17%. Harvesting of seed crops at seed moisture contents of less than 20% minimizes mechanical damage to seed. If maize ears are picked and dried moisture content of less than 20% minimizes mechanical damage to seed. If maize ears are picked and dried, they may be harvested at 30-35% seed moisture content.

4. A seed crop may be harvested manually or mechanically, taking care to avoid mechanical injury to seeds during harvesting and threshing operations. Care must also be taken to avoid any chance of mechanical mixing of seeds and maintain lot identity.

Drying

1. Cemented threshing floors or use of tarpaulins is preferred to maintain the quality of seeds. A crop may be harvested by directly combining in the field using mechanical combines. Sun drying of seeds on threshing floors, spreading the seeds in thin layers, may be necessary to reduce its moisture content and improve the storage quality.

2. Drying of a seed crop to its safe moisture limit to preserve its viability and vigour must be carried out rather quickly. If the seed is to be dehydrated mechanically, it should be taken to the processing plant soon after harvesting.

3. Care must be taken at all stages to avoid mechanical mixing and to minimum the identity of seed lots.

Seed Storage

1. Seed may be stored in sacks or bags for short periods. Bags may need to be disinfected with DDT solutions, dried and cleaned before use.

2. They should be labelled properly and stacked on wooden pallets.

3. Storage facilities should be dry, cool, and clean disinfected with malathion, and fumigated if necessary.

PRACTICAL: 3

Objective: To collect a uniform and true representative sample from a seed lot.

It is essential that the samples be prepared in accordance to ISTA rules to ensure that the small size sample should represent truly and in the same proportion all constituents of seed lot.

Seed lot: It is specified quantity of seed, physically identifiable, in respect of which a seed test certificate can be issued.

Methods of sampling

1. Hand sampling

This is followed in the non free flowing seeds or chaffy and fuzzy seeds of crops such as cotton, tomato, grass seeds etc. In this method, it is very difficult to take samples from the deeper layers of bag. To overcome this, bags are emptied completely or partly and then seed samples are taken. While removing the samples from the containers, care should be taken to close the fingers tightly so that no seeds escape

2. Sampling with triers/probe

By using appropriate triers, samples can be taken from bags or from bulk. The triers are used for taking free flowing seed samples.

a) Bin samplers: Used for drawing samples from the lots stored in the bins.

b) Nobbe trier: The name was given after the father of seed testing Fredrick Nobbe. This trier is made in different dimensions to suit various kinds of seeds. It has a pointed tube long enough to reach the centre of the bag with an oval slot near the pointed end. The length is very small. This is suitable for sampling seeds in bag not in bulk.

c) Sleeve type triers or stick triers: It is the most commonly used trier for sampling: There are two types viz.,

1. with compartments
2. without compartments.

Types of Samples

1. Primary sample

Each probe or handful of sample taken either in bag or in bulk is called primary sample.

2. Composite sample

All the primary samples drawn are combined together in suitable container to form a composite sample.

3. Submitted sample

When the composite sample is properly reduced to the required size that to be submitted to the seed testing laboratory, it is called submitted sample. Submitted sample of requisite weight or more is obtained by repeated halving or by abstracting and subsequently combining small random portions.

4. Working sample

It is the reduced sample with required weight obtained from the submitted sample after repeated mixing and dividing with which the seed quality tests are conducted in seed testing laboratory.

Size of Samples

For seeds in bulk

Up to - 500 kg	At least 5 Primary samples
501 - 3000 Kg	One primary sample for each 300 kg but not less than 5 primary samples
3001-20,000 Kg	One primary sample for each 500 kg but not less than 10 Primary samples
20,001 and above	One primary sample for each 700 kg but not less than 40 primary Samples

Types of sample used in Seed Testing Laboratory (STL)

Service sample: Sample received from other than seed certification agencies and seed inspectors

Certified sample: Sample received from certification agencies or officers

Official sample: Sample received from the seed inspectors.

PRACTICAL-4

Objective: To estimate the physical purity of seeds sample

Physical purity analysis deals to quantify the proportion of pure seed component in the seed lot as well as the proportion of other crop seed, weed seed and inert matter for which Seed Standards have been prescribed.

Requirements: Purity work board, magnifying lens, weighing balance, seeds sample, forceps etc.

Procedure

1. Sit comfortably in relaxed position with forearms resting on sloping sides of work board.
2. Spread the seeds sample uniformly on the physical purity board.
3. If using hand lens, hold the lens in the left hand fairly close to the eyes and in focus over seeds. If using the fixed lens of the purity board, lean gently over the lens, but don't put your weight on the lens.
4. Incline your body from the hips with both feet on the floor.
5. Seed is sorted with the help of forceps by visual observation and separated in different parts as:

(i) Pure seeds: The seeds of kind/species stated by the sender. It includes all botanical varieties of that kind / species. Immature, undersized, shriveled, diseased or germinated seeds are also pure seeds. It also includes broken seeds, if the size is >1/2 of the original size except in *leguminosae* and *cruciferae* where the seed coat entirely removed, are regarded as inert matter.

(ii) Inert matter: The inert matter in seed sample includes seed like structures, leaves, stem pieces, sand particles, stone particles, empty glumes, lemmas, paleas, chaff, awns, stalks longer than florets and spikelets.

(iii) Other crop seeds (OCS): Seed of crops other than the crop sample taken.

(iv) Weed seeds (OWS): Weed seeds that should not be present or which should be present is very little quantity as per the prescribed seed standards of the crop.

(V) Diseased & pest infected/infested seeds: The crop seeds which infected/infested by disease or pest should separate and weigh separately.

Observation recorded:

S. No.	Crop Name	Pure seeds (g)	Inert matter (g)	Other crop seeds (g)	Weed seeds (g)	Diseased Seeds

During purity analysis, each 'pure' seed fraction from the working sample is separated from the inert matter and other seeds. Per cent weight of 'pure' seed fraction should be express as the purity percentage. Weight of pure seed over the total weight of the working sample is calculated as shown below-

A purity percentage is calculated as:

$$\textbf{Purity (\%)} = \frac{\text{Weight of pure seeds (g)}}{\text{Total weight of working sample (g)}} \times 100$$

Reporting of Results

- Weight by percentage Single decimal place
- All components should add to 100 %
- Less than 0.05% reported as 'trace"
- Any component is found to be nil- reported as -0.0-
- The components scientific names should be mentioned

PRACTICAL: 05

Objective: Determination of seed moisture of given seeds sample through hot air oven method.

Seed Moisture: Seed moisture content (SMC) is the amount of water in a seed. Water is present both in free form and bound to chemical compounds in cells such as carbohydrates and protein.

Requirements: Seeds sample, hot air oven, weighing balance, seed grinder etc.

Procedure

The most accurate method for determining moisture content is the oven-drying method, in which water is removed from seeds by heat under controlled conditions. This method is destructive to seeds and should be carried out only when essential. It is recommended that one accurate determination be conducted using this method after the drying period to determine the initial moisture content of the stored seeds. ISTA (2005) has prescribed two different oven-drying methods for determining moisture content, based on the chemical composition of seeds:

- The low constant temperature oven method for oily seeds
- The high constant temperature oven method for non-oily seeds.

Pre-drying

Pre-drying is obligatory if seeds are wet and their moisture content is suspected to be above 17 % (10 % for soybean and 13 % for rice); it should be conducted prior to moisture content determination by oven-drying. If pre-drying is required, proceed as follows:

1. Weigh two sub-samples of 5 g each of seeds in their containers.
2. Pre-dry the samples overnight in a warm, dry place such as a laboratory bench.
3. Weigh them again in their containers and determine the loss of weight (loss of moisture) by subtraction.
4. Calculate the moisture content on a fresh-weight basis.

Sample size and sampling

1. Take the two equal quantity seeds sample depending upon the availability of seeds.

2. The sample should be representative of the entire accession. Make sure that the seed lot is well mixed and that the sample is drawn from small portions in different positions of the seed lot.
3. Once sampled, keep the seeds in moisture-proof containers until they are tested to avoid changes in moisture content.

Grinding

Some seeds require grinding into smaller particles to promote uniform and complete drying. Such seeds should be grind by mortar-pestle or seed grinder before drying in hot air oven.

High constant temperature method for non-oily seeds

Moisture content is determined in the following way:
1. Dry the containers at 130ºC for one hour and allow them to cool in the desiccator for one hour.
2. Label and weigh each container, including the lid, and record the weights on the data sheet. For accuracy in moisture determination, the size and weight of the containers should be relative to the sample weight used.
3. Place two 0.5–1.0 g sub-samples, randomly selected from each sample (pre-dried and ground if necessary), into two separate containers, which will serve as two replicates. Replace the lids, weigh again and record the weights in Table 4.3 (column W2).
4. Place the containers with the lids removed in an oven maintained at 130°–133ºC.
5. Dry the seeds for one to four hours depending on the species (four hours for Zea mays, two hours for other cereals and one hour for other species).
6. Replace the lid on each container at the end of the drying period.
7. Move the containers to a desiccator and allow them to cool for 45 minutes.
8. Record the weight of the containers, including the samples, in Table 4.3 (column W3).
9. Calculate the moisture content on a wet-weight basis and express it as a percentage to one decimal place, using the following formula:
10. Repeat the test if the moisture content between the two replicates differs by more than 0.2%.

High constant temperature oven method

Alfalfa (Medicago), Asparagus (Asparagus), Barley (Hordeum), Bean (Phaseolus), Beet (Beta), Bentgrass (Agrostis), Bermuda grass (Cynodon), Black salsify (Scorzonera), Bluegrass (Poa),

Brome (Bromus), Buckwheat (Fagopyrum), Canarygrass (Phalaris), Caraway (Carum), Carrot (Daucus), Chervil (Anthriscus), Chicory (Cichorium), Chickpea (Cicer), Clover (Trifolium), Cocksfoot (Dactylis), Cress (Lepidium), Crested dogtail (Cynosurus), Cucumber (Cucumis), Cumin (Cuminum), Dallisgrass (Paspalum), Fescue (Festuca), Foxtail (Alopecurus), Lettuce (Lactuca), Lupin (Lupinus), Maize (Zea), Millet (Panicum), Oat (Avena), Parsley (Petroselinum), Pea (Pisum), Rhodes grass (Chloris), Rice (Oryza), Rye (Secale), Ryegrass (Lolium), Sainfoin (Onobrychis), Serradella (Ornithopus), Sorghum (Sorghum), Squash (Cucurbita), Sweetclover (Melilotus), Tall oatgrass (Arrhenatherum), Timothy grass (Phleum),Tomato (Lycopersicon), Trefoil (Lotus), Tufted hairgrass (Deschampsia), Velvetgrass (Holcus), Vetch (Vicia), Watermelon (Citrullus), Wheat (Triticum).

Low constant temperature method for oily seeds

For oily seeds, use a lower temperature for longer period so only water is lost from the seeds. Follow the procedure described above, except for steps 4 and 5, which should be modified as follows:

1. Place the container with the lids removed in an oven maintained at 103°±2ºC.
2. Dry seeds for 17±1 hours.

Use of a higher temperature and longer drying period than normally recommended will lead to loss of volatile compounds and water, particularly in oil-rich seeds. This will result in an over-estimation of the moisture content.

Crops required low constant temperature oven method

Brassicas Castor (Ricinus), Pepper (Capsicum), Cotton (Gossypium), Eggplant (*Solanum*), Falseflax (*Camelina*), Flax (*Linum*), Groundnut (*Arachis*), Onion (*Allium*), Radish (*Raphanus),* Sesame (*Sesamum*), Soybean (Glycine), all tree species.

Observation

S. No.	Crop name	Weight of container (g)	Weight of sample before drying (g)	Weight of sample after drying (g)

Calculation

Seed moisture content is expressed in terms of the weight of water contained in a seed as a percentage of the total weight of the seed before drying, known as the wet-weight (wb) or fresh-weight basis {International Seed-Testing Association (ISTA) 2005}.

$$\textbf{Seed moisture content (\% weight basis)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

Moisture content can also be expressed on a dry weight basis (db)—that is, the loss in weight as a percentage of the dry weight of the seeds.

$$\textbf{Seed Moisture Content (\% dry basis)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$$

Conclusion

PRACTICAL: 6

Objective: To study seed viability test by tetrazolium test

Principle

The TZ is a biochemical test, which differentiates live from dead seeds based on the activity of the respiration enzymes in seeds. Upon seed hydration, the activity of dehydrogenase enzymes increases resulting in the release of hydrogen ions, which reduces the colorlesstetrazolium salt solution (2,3,5-triphenyltetrazolium chloride) into a chemical compound called formazan. Formazan stainsliving cells(respiring)with a red color while dead cells(not respiring)remain colorless. The viability of seeds is interpreted according to the staining pattern of seed tissues.

Procedures

The main steps in conducting a TZ test are:

1. **Hydration:** Seeds must be completely imbibed in order to activate respiration enzymes. This process is needed to release hydrogen ions.
2. **Cutting or puncturing:** This process permits the access of the TZ solution to the internal tissues of seeds. For some grasses, e.g., bentgrass and Kentucky bluegrass, piercing seeds is performed under the microscope for accuracy. For fescues and ryegrass cutting is performed under a magnifying lens. Knowledge of morphology of various seed species is essential for appropriate cutting and piercing of seeds. Preparing grass seeds for TZ test is somewhat time-consuming compared to soybean or corn because of the size of the seeds.
3. **Staining:** Seeds are placed in a TZ solution (0.1-1.0%) for a period of time24 to 48 h in dark at 30 °C. During this process hydrogen ions reduce the colourless TZ solution to red formazan, which stains live tissues with red colour while dead tissues remain unstained.
4. **1% Tetrazolium (TZ) solution** Add 1 g of 2, 3,5 triphenyltetrazolium chloride in 100 ml autoclaved distilled water in amber colour bottle. Mix well and store in dark at 4 °C (can be kept for several months under such conditions).
5. After staining, wash the seeds 2-3 times with distilled water.
6. **Evaluation:** Critical evaluation of the TZ staining pattern and intensity is needed for accurate interpretation. For reliable evaluation, seed analyst should be familiar with the

structure and the anatomy of the seeds to identify the location of the embryos and determine their staining pattern. In some grasses, lactic acid is used to allow for a clear vision of the internal tissues through the seed coat.

PRECAUTION

1. The pH of the TZ staining solution should be 7. Solution with pH > 8 or pH < 4 would result in either intense staining or would not stain even viable seed tissues. If water is out of neutral range then use phosphate buffer with pH 7 to dissolve TZ.
2. TZ assay can be used for seeds of legume, cotton and grasses. The incubation time varies with seed type and morphology. Remove the seed coats of larger seeds (like legume seeds) before examination.
3. The dicot seeds can be germinated further as the stained seeds are not damaged.
4. When performed appropriately, the percentage of viable seeds obtained by tetrazolium assay is very close to the percentage of seed germination expected under most favourable conditions.

PRACTICAL: 7

OBJECTIVE: To test the seed germination per cent and calculation of vigour indiex of seed sample

In seed testing germination has been defined as "the emergence and development from the seed embryo of those essential structures which, for the kind of seed tested indicate its ability to develop into a normal plant under favourable, conditions in soil". The seedlings devoid of an essential structure; showing weak or unbalanced development; decay or damage affecting the normal development of seedling are not considered in calculating the germination percentage.

Material required

a) Seed Germinator

The seed germinators are the essential requirement for germination testing for maintaining the specific conditions of temperature, relative humidity and light.

b) Counting devices

The counting devices include the counting boards, automatic seed counter and vacuum seed counter. These devices are required to aid germination testing by minimizing the time spent on planning the seeds as well as to provide proper spacing of the seed on germination substrata.

c) Other equipments:

The other equipments required for germination testing include the refrigerators, scarifier, hot water bath, incubator, forceps, spatula, germination, boxes, plastic plates, roll- towel stands and plastic or surgical trays, etc.

Methods of germination test

A. Between Papers

B. Top of Paper

According to ISTA 400 seeds, 100 seeds in each replication (4 replications) have to be used for seed germination test. Spacing between seeds should be uniform and there should not be any over lapping of seeds Temperature to that specific species should be maintained Species which required light (Grasses) has to be provided.

Procedure

A. Between Paper (BP) Media (Roll Towel Test):

1. Soak the towel paper in water.Remove the water. Wash the paper with running water.
2. Remove extra moisture by pressing the soaked paper by hand and holding it in plastic/ surgical trays placed on the table top in slanting position. Place two layers of wet paper toweling as substratum.
3. Check Test number provided on the Analysis Card sample and label tally each other.
4. Record the test number, crop and date of putting on the wax paper or tag.
5. Arrange seeds spaced properly.
6. Place one layer of wet towel paper over the seed.
7. Turn up two inches of the bottom edge.
8. Roll firmly from left to right and secure with rubber band in the center. Place the prepared roll towel in roll towel stand or baskets.
9. Transfer the basket or roll towel stand in the germinator maintained at the desired Temperature.

B. Top of Paper (TP) Media:

1. Paper of known quality such as 'Sunlit' or 'Whatman' filter paper should be used.
2. Crepe Kraft (towel) paper or blotter paper of unknown quality should not be used for Top of paper tests.
3. Put 2-3 layer of filter paper in the petridish/germination box having airtight lids.
4. Put enough water to moisten the filter paper.
5. Hold the petridish /germination box in slanting position in order to drain out the Extra moisture.
6. Record the test number and date of putting on the lid of the container on die paper Slip.
7. Space the counted seeds on the moist blotter/filter paper.
8. Cover the lid
9. Transfer the test in the germinator maintained at the desired temperature.

Observations recorded:

S.	**Crop**	**Number of**	**Number of**	**Average**	**Average**	**Average dry**

No.	Name	germinated seeds at final count	unterminated seeds at final count	seedling length (cm)	fresh weight of seedlings (g)	weight of seedlings (g)
1.						
2.						

CALUCULATION

Germination per cent:

$$\text{Germination per cent} = \frac{\text{Number of germinated seeds}}{\text{Total Number of seeds sown}} \times 100$$

Vigour index-I

Vigour index-I= Germination per cent x seedling length

Vigour index-II

Vigour index-II= Germination per cent x dry weight of seedling

PRACTICAL- 8

Objective- To study the organic techniques of seeds treatment in agricultural and horticultural crops

Seed Treatment:

Objective of seed treatment:

1. To improve germination per cent
2. To get healthy seedlings
3. To prevent the pest and disease attack
4. To provide nutrition

Seed treatment in paddy

1. Soaking the seeds in cow dung extract enhances the germination capacity. Take ½ kg of fresh cow dung and 2 litres of cow's urine and dilute with 5 litres of water. Soak 10 - 15 kg of seeds that are previously soaked in water for 10 - 12 hours, in this cow dung extract for 5 - 6 hours. Dry the seeds in shade before sowing in the nursery.
2. Fill the paddy seeds in a closely-knit bamboo basket lined with Salvadora persica leaves at the bottom and pour about 10 to 12 litres of water over the basket. Cover the basket with Salvadora leaves and place a weight over it. Leave the setup undisturbed for 24 hours before sowing. This will help in early and vigorous germination.
3. Mix biofertilizers like Azospirillum / Phosphobacteria / Pseudomonas (@ 1.25 kg / 60 – 70 kg of seeds) in one litre of cooled rice gruel and mix it with sprouted seeds and shade dry for 30 minutes before sowing.
4. Mix Vitex, Tulsi and Pongam leaves extract (pound 3 kgs of each leaves and extract) with fresh cow dung solution and soak 25 kg of paddy seeds tied in a gunny bag in this solution for 12 hours. Seeds should be shade dried for half an hour before sowing. This will produce healthy and disease resistant seedlings.
5. Soak seeds in water for 12 hours and then mix it with 10% cow's urine (10 ml cow's urine + 90 ml water) or 5% prosophis kashaayam (5 ml kashaayam + 95 ml water) and dry it for 30 minutes. Use the seeds for sowing within 24 hours. This will enhance the resistance of the paddy against bacterial leaf blight disease.

6. Soak paddy seeds in 20% mint (Mentha sativa) leaf extract (200 ml of leaf extract mixed with 800 ml of water) for 12 hours before sowing. This will increase the germination rate and vigour of seedlings. This will also help in the control of Helminthosporium leaf spot disease in paddy.

Maize

Soak seeds in 2% Panchagavya (20 ml of Panchagavya in 980 ml of water) for 2 hours before sowing for the production of healthy seedlings.

Sorghum (Jowar)

1. Treat the seeds with asafoetida solution (75 – 100 gms in 1 litre of water) and shade dry before sowing. This seed treatment method prevents ergot disease in sorghum.
2. Mix the seeds with the extract of Ashwagandha and Datura (for 1 kg seeds, pound 250 gms of Ashwagandha / Amukura (Withania somnifera) roots and 50 gms of Datura / Oomathai (Datura metel) leaves by adding water) and shade dry before sowing. This will help in the production of healthy and disease free seedlings.
3. Treat the seeds with dried cow dung powder and cow's urine (100 g cow dung powder and 250 ml cow's urine per kilogram of seeds). This will break the dormancy and improve germination.

• Soak the seeds in lime water (1 kg lime in 10 litres of water kept for 10 days and the superficial water is collected and used) for overnight. Dry the seeds before sowing.

Pearl Millet and Finger Millet

1. Soak seeds of pearl millet / finger millet in Panchagavya (35 ml in one litre of water) for 7 – 8 hours before sowing for the production of disease free seedlings.
2. Mix the seeds with the extract of Ashwagandha and Datura (for 1 kg seeds, pound 250 gms of Ashwagandha / Amukura (Withania somnifera) roots and 50 gms of Datura / Oomathai (Datura metel) leaves by adding water) and shade dry before sowing. This will help in the production of healthy and disease free seedlings.

Chikpea

1. Soak seeds in water before sowing to enhance the germination percentage of the seeds.

2. Smear seeds (1 kg) with a mixture of turmeric and sweet flag powder (50 g turmeric powder and 15 gms sweet flag powder with 10 ml of water) and sow after 10 minutes. This will enhance the disease resistance of the crop.
3. Smear seeds with mustard oil @ 100 ml / 40 kg of seeds before sowing to prevent wilt disease.
4. Soak seeds of pigeon pea / chickpea in curd for 24 – 48 hours before sowing to control wilt disease.

Blackgram and Greengram

1. Treat seeds with Trichoderma viride @ 4 gms/kg of seeds or Pseudomonas @ 10 gms/kg of seeds for the protection against disease causing microorganisms.
2. To prepare seed pellets take the seeds in a plastic tray and add a small quantity of adhesive (10% maida solution) to the seeds. Shake this gently to enable the seeds to spread evenly on all parts of each of the seed. Add Arappu powder (Albizia amara) as filler material evenly over the seeds and continue shaking until the uniform coating is ensured. Remove the seed clumps manually and also the excess filler material by sieving. Shade dry this before sowing. This process helps to handle small and irregular shape seeds. It also enables precision sowing of seeds and physiological characters of seeds are strengthened.

Groundnut

1. In Groundnut, the pre germinated seeds are used for sowing to get good yield by maintaining optimum plant population in the field. Soak the seeds tied in a gunny bag in water for 4 – 6 hours. Then untie the gunny bag and cover it with another wet gunny bag for 12 – 14 hours. Shade dry the germinated seeds for 3 – 4 hours and treat with Rhizobium (@ 600 gms / 110 – 120 kg of seeds) and sow within 1 or 2 days.
2. Smear the seeds with kallipal (milky latex from leafy spurge or milk hedge) before sowing @ 100 gms of kallipal / 10 kgs of seeds. This will protect the crop from pest and diseases.
3. Soak the seeds in asafoetida solution (250 gms in 2 litres water) for 12 hours before sowing to prevent blight disease.
3. Treat the seeds with Trichoderma viride (4 gms/kg of seeds) or Pseudomonas fluorescens (10 gms/kg of seeds) and sow after 24 hours.

4. Treat the seeds with Rhizobium (5 gms/kg of seeds) mixed with cool rice gruel and shade dry for 30 minutes before sowing. There are chances of tearing of the seed coat hence seed treatment should be done with care.
5. Soak the seeds in Jeevamirtham / Amirthakaraisal / Panchagavya for 4 - 6 hours and shade dry before sowing.

Vegetables seeds

Soak all kinds of vegetable seeds in biogas slurry for 30 minutes before sowing.
Soak vegetable seeds in 2% Panchagavya (20 ml of Panchagavya in 980 ml of water) for 30 minutes before sowing for the production of healthy seedlings.

Tomato

1.Fumigate the seeds with Vasambu (Acorus calamus) and Vaividanga (Embelia ribes) powder. Take seeds in a metal sieve. Take hot coal in a metal plate and sprinkle Vasambu or Vaividanga powder over the hot coal and hold the sieve with seeds against the fumes in a standing position for 2 – 3 minutes. This will enhance the germination rate and protect the seedlings from fungal pathogens. For treating 100 gms of seeds 5 gms of Sweet lag or Vasambu and 5 gms of Vaividanga is required.
2. Soak the seeds tied in a khada cloth in diluted milk solution (75 ml milk and 425 ml water) for 6 hours and then sow. This will prevent the infection of seed borne diseases and enhance germination.
3. Soak the seeds in a mixture of fermented buttermilk (3 days old) and water in 1:4 ratio for 6 hours and shade dry before sowing. The practice is applicable only for 6 to 12 months old seeds. Buttermilk can be replaced by Coconut or Palmyra toddy.
4. Soak the seeds in sweet flag rhizome extract (dilution 1:5 ratio – 1 part of extract in 5 parts of water) for 30 minutes before sowing. This will enhance the resistance against bacterial and fungal diseases.
5. Treat the seeds with Trichoderma viride and Pseudomonas fluorescens (@ 5 gms /100 gms of seeds). This will help in the control of early blight and other pathogens.

Chillies

1. Soak seeds in sweet flag extract or cow's urine at 1:5 ratio (1 part of extract or cow's urine with 5 parts of water) for 30 minutes before sowing. This will inhibit the seed borne diseases like fruit rot and die back.
2. Soak seeds tied in a cotton cloth in biogas slurry for 12 hours before sowing. This will kill the disease causing microbes and enhance the seed vigour. • Treat the seeds with Trichoderma viride @ 4gms/kg of seeds and then sow after 24 hours.

Bottle Gourd

1. Soak seeds in water for 24 hours before sowing to break the dormancy and to quicken the germination.
2. Soak seeds in warm water for 30 minutes before sowing. This helps in the softening of the hard seed coat.
3. Soak seeds in cow's urine solution (1 part cow's urine + 5 parts of water) for 30 minutes prior to the sowing. This will inhibit the seed borne diseases.
4. Treat the seeds with Trichoderma viride @ 4 gms/kg of seeds and then sow after 24 hours.

Snake Gourd

1. Treat the seeds with cow dung @ 1 kg per kg of seeds for 30 minutes. This will increase the drought resistance and make the seeds germinate quickly.

Beans

1. Soak the seeds in raw cow's milk for 24 hours before sowing for good germination and yield.
2. Treat the seeds with powder form of Trichoderma viride @ 4 gms/kg or Pseudomonas @ 10 gms/kg of seeds. Seed treatment with Trichoderma or Pseudomonas protects the crops from disease causing microorganisms.

Bhindi

1. Treat seeds with 15% or 25% raw cow's milk (150 ml of milk in 850 ml of water or 250 ml of milk in 750 ml of water) for 6 hours and then sow. This will increase the germination percentage and seedling vigour. It will also reduce the intensity of the vein clearing disease and increase the yield.

2. Soak seeds in cow's urine at 5% or 10% concentration (50 ml of cow's urine in 950 ml of water or 100 ml of cow's urine in 900 ml of water) for 12 hours before sowing for good germination percentage.
3. Soak seeds in 1 - 2% of Panchagavya (10 - 20 ml of Panchagavya in 990/980 ml of water) for 6 hours before sowing. This will improve the germination and seedling vigour.
4. Treat the seeds with Trichoderma viride @ 4 gms/kg of seeds.
5. Treat the seeds with biofertilizers - Azospirillum and Phosphobacteria (each @ 60 gms mixed with 60 ml of rice gruel for one kilogram of seeds) and shade dry for 30 minutes before sowing.
6. For summer crop, soak the seeds in water for 12 hours before sowing.
7. Soak the seeds in sweet flag rhizome extract or cow's urine solution (dilution 1:5 ratio – 1 part of extract or cow's urine in 5 parts of water) for 30 minutes before sowing. This will enhance the resistance against bacterial and fungal diseases.

Brinjal

1. Soak the seeds in 12% raw cow's milk (120 ml of raw cow's milk in 880 ml of water) for good germination percentage and seedling vigour. The germination speed is also increased.
2. Seeds should be soaked in a solution of cow's urine (1 part cow's urine + 5 parts of water) for 30 minutes prior to the sowing. This will inhibit the seed borne diseases like fruit rot and die back.
3. Seeds should be bundled using a thin cotton cloth and soaked in the biogas slurry for 12 hours prior to the sowing. This will kill all the disease causing microbes and also enhance the seed vigour.
4. Treat the seeds with Trichoderma viride @ 4 gms/kg of seeds or with Pseudomonas @ 10 gms/kg of seeds and then sow after 24 hours.

Bitter Gourd

1. Soak the seeds in diluted cow's urine for 12 hours and in diluted cow's milk for 6 hours before sowing for good germination percentage. The dilution should be at the ratio of 1:1 (1 part of cow's urine or cow's milk with 1 part of water).
2. Soak the seeds in raw cow's milk for 24 hours before sowing for good germination and yield.

Root Vegetables

1. Soak the seeds of beetroot and radish tied in a cotton cloth in water overnight or in warm water for 30 minutes before sowing. This will help to quicken the germination and result in fast growth and healthy plants.
2. Soak seeds in a solution of cow's urine (1 part cow's urine + 5 parts of water) for 30 minutes prior to the sowing. This will inhibit the seed borne diseases.
3. Treat the seeds with Trichoderma viride @ 4 gms/kg of seeds and then sow after 24 hours.

Cotton

1. Seeds for rainfed and summer sowing should be hardened using 1% Prosopis and Pungam leaf extract (10 ml of each extract in 980 ml of water) to resist water stress.
2. Treat seeds with termite hill soil to get resistance for drought and grow luxuriantly. Prior to this treatment seeds should be soaked in water for 6 hours. Mix equal quantities of termite hill soil and water and mix it with seeds and dry for 1 hour before sowing. Seeds should be shade dried for half an hour before sowing.
3. Treat the seeds with Trichoderma viride @ 4 gms/kg of seeds. Mix Trichoderma in 100 ml of cooled rice gruel and mix it with seeds and then sow the seeds within 24 hours. Seeds should be shade dried for half an hour before sowing.

Sugarcane

1. Dip the sugarcane setts in an extract of Keezhanelli (Phyllanthus niruri), Poovarasu (Thespesia populnea) and Pongam (Pongamia pinnata) (Dry and boil 1 kg of leaves of each type with enough water and filter after 2 days and use) and cover it with a wet gunny bag for a day and plant on the next day. This will control the seed borne diseases.

PRACTICAL: 09

Objective: To conduct the genetic purity test through grow out test.

Principle:

The main aim of grow-out test is to determine the genetic purity of the variety of the given sample. In grow-out test plant characters that are less influenced by the environment and which are highly heritable are observed by growing the plants in the field. The variety, which is to be tested for genetic purity, should be grown in the area for which it has been released so that the characters of that variety are fully expressed. Each sample should be sown with proper spacing by adopting the recommended cultural practices so that the differences between the varieties are fully expressed.

Sampling: The sample for grow out test are to be drawn simultaneously with the samples for other quality tests and the standard procedure shall be followed. The size of the submitted sample shall be as follows:

1000 g for maize, cotton, groundnut, soybean and species of other genera with seeds of similar size

500 g For sorghum, wheat, paddy and species of other genera with seeds of similar size.

250 g species of other genera with seeds of similar size.

100 g for bajra, jute, and species of all other genera.

250 tubers / cuttings/roots etc. Seed potato, sweet potato and other vegetatively propagated crops.

Procedure

Before sowing the seed in the field the seed should be examined on the diaphanoscope to identify the seeds of other variety. The seeds of other variety should be separated and the percentage should be noted. One may also separate the doubtful seed, which may be sown separately for through examination. The various samples of the same cultivar are sown in adjacent plots with standard samples at regular intervals. In case of self pollinated crops the characters are fixed and it is easy to identify the plants of other cultivars. In cross pollinated crops where the variability for characters is more it is essential to sow the authentic samples at regular intervals for comparison between the samples to be tested and the standard sample. The sample plots should be regularly observed during the entire growing period of the crop as some of the characters are

expressed at seedling stage while the others are expressed at flowering or at maturity stage. The size of plots, row length etc. will differ from crop to crop. However the specifications for different crops are indicated in the following table. The certification agency may change the specifications if considered necessary.

The seed rate may be adjusted depending on the germination percentage of individual samples and the sowing may be done by dibbling. Subsequent thinning is not recommended.

The test crop may be raised along with the control either in the areas recommended for the variety or in off-season nurseries. The authentic control sample from the originating plant breeder/breeding institute is to be maintained by the testing station/Agency following standard procedures. A minimum of two hundred plants from control sample will be raised along with the test crop.

Observations

a. All plants are to be studied keeping in view the distinguishing characters described for the cultivar both in the test crop as well as the control. Necessary corrections may be incorporated if the control is found to be heterogeneous.

b. Observations are made during full growing period, or for a period specified by originating breeding Institute and deviations from the standard sample of the same variety are recorded. At suitable development stage the plots are examined carefully and plants which are obviously of other cultivar are counted and recorded. The specifications of the field plot, row length etc. may be determined from the information given in the table. On the basis of the number of plants required for taking observations is depended on maximum permissible offtypes, which are as follows:

Maximum permissible offtypes %	**Minimum genetic purity %**	**Number of plants required per sample for observation**
0.10	99.9	4000
0.2	99.8	2000
0.3	99.7	1350
0.5	99.5	800
1.00 and above	99.0 and above	400

Advantages

1. It is the cheapest way to examine reasonable number of plants. 2. It is possible to examine a large number of plots and for each plot it is possible to check large number of plants. 3. The plants are examined during the whole period of growth. Some characters are more prominent at one time of the year than another, and the samples may therefore, be examined several times during the season.

Disadvantages:

1. The results are not available until 4 to 12months after the seed was received for testing.

Reference

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