

COURSE CODE:	<i>PBS 502</i>
COURSE TITLE:	<i>Seed Production</i>
NUMBER OF UNITS:	<i>3 Units</i>
COURSE DURATION:	<i>Three hours per week</i>

COURSE DETAILS:

Course Coordinator:	Prof. M. A. Ajala
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Other Lecturers:	Dr. I. O. Daniel and Mr. O. O. Ajani

COURSE CONTENT:

Environment and other factors affecting seed multiplication. Pollination – wind and insect. Pollination of F1 hybrid seed production. Controlled multiplication. Cultural practices: plant protection, chemical application. Crop maturity and time of harvest. Seed certification. Protection against foreign pollen. Isolation distance. Deterioration of seed stocks. Contract growing philosophy, principles and applications.

Practicals: Dormancy breaking techniques. Application of pesticides and visit to commercial seed processing companies: National Seed Service and MANR, Asero to familiarize students with seed processing, packaging and storage principles.

COURSE REQUIREMENTS:

This is a compulsory course for all 500 level PBST students. All registered students must have minimum of 70% attendance to be able to write the final examination.

READING LIST:

1. Basra, A. (1999). Heterosis and hybrid seed production in agronomic crops. Harworth Press Inc.. 294 pages.
2. Basra, A. (2006). Handbook of seed science and technology. Harworth Press Inc. 824 pages.
3. Copeland, L. O. and Macdonald, M. B. (2001). Principles of seed science and technology. Kluwer Academic Publishers. 492 pp

LECTURE NOTES

Lecture 1

Environmental & other factors affecting seed multiplication

Introduction:- Seed Industry has played a vital role in the availability of high quality seed of improved crop varieties with attendant modern power equipment, improved fertilizers, and better methods of insect and weed control. These altogether have revolutionised farming. Note the vital roles played by seed industry in modern revolution.

- Expansion of production capability
- Efficiency in rapid increase of new cultivars
- Maintenance of genetic purity.
- Quantity of seeds needed by farmers each year is enormous.

Environment affecting seed production include:

- Availability of water through rainfall/irrigation: During vegetative phase, ample rain is needed by a seed crop, but this should ideally be followed by a relatively dry period for the reproductive phase. In dry districts, irrigation water should be supplemented, the latter permitting water to be controlled to advantage. Note that flowering, pollination, seed setting are assisted by a moderate humidity, while drier conditions are needed for ripening. Use of artificial drying must be considered where relative humidity is relatively high or unfriendly.
- Suitable soil temperature: In the temperate regions, temperature at sowing time influences establishment in the soil. In the tropics, soil temperature at sowing is not a major factor. This explains why fruits thrown arbitrarily in the tropical forests give rise to maturing flowering/fruited plants some years later.
- Appropriate light intensity/quality: As important as light is needed for the manufacture of food of many plant species, through the process of photosynthesis, many seeds germinate under light conditions. Among cultivated plants, most seeds germinate without any light requirements. Seeds of certain species require either light or dark for germination to occur. While others require brief illumination for germination, some are completely indifferent. Effect of light on germination is also dependent on the intensity (and duration) and quality. The chemical reaction is controlled by wave length of light absorbed in plant cells by the same chemical pigment controlling floral induction phytochrome: The far-red absorbing form/induced by exposure to red light) is believed to be biologically active form that functions as an enzyme in seed germination.



Red light (660nm) exposure converts, phytochromes to the biologically active far-red absorbing form and germination can proceed (for light requiring seeds. Exposure to far red light (730nm) reconverts phytochrome the red-absorbing form and germination is blocked (or suitable for dark requiring seed. Stimulation of germination by red light and its inhibition by far-red light can be repeated many times and always the nature of the last illumination decides the germination response.

Factors influencing light sensitivity: include age of seed, period of inhibition, temperature of inhibition, stratification, germination temperature (also osmotic effects and oxygen tension). Chemicals affecting light sensitivity to seeds e.g. Thiourea, Kinetin and Gibberellic acid can substitute for light requirements of some seeds.

Where light and other environmental conditions are not available, other regions should be explored for interstate/international operation.

Other factors:-

- **Soil:** The history of the land area must be known. One should not dabble into land areas under strict tenure control. Good if plots are large enough for mechanisation, but if not it is not a major requirement. The soil itself should be fertile (judging from the plants growing on it). Besides, the soil should be deep and well-drained to discourage water – logging but sufficiently retentive to avoid drying out. The soil should never be acid or alkaline. Good if soil is free from soil-borne pests and diseases, Application of seed treatment chemicals to seeds before sowing may help to reduce hazards from infected soils. For leguminous crops, it would be desirable to have correct strain of Rhizobia bacteria for root nodulation. Organic/inorganic fertilizers must be applied with care, strictly following proper dosage application. Also note that organic fertilizers do not release their nutrients in good time. It is important also for the soil to have adequate mineral status.

Wind: This should be properly looked into where they pose problems. Wind breaks in form of structures should be considered. Strong winds especially during the reproductive phase may result in severe crop losses through lodging, shattering and shedding of seed.

- **Biological factors:** Population of insects (both wild and/or domestic) may be needed for pollination.

Note: Care should be exercised in the use of insecticides, bearing in mind, effects on pollinating insects.

Note: Plant protection operations involving the use of insecticides should bear in mind effects on pollinating insects.

- Disease - ridden areas and seed-borne pathogenic areas should be avoided as much as possible.
- **Season:** Although climate in an area may be fixed, but one could make the best choice of season in order to use climate of an area to our best advantage.

Note: Choice of sowing date must be made to provide the best possible conditions for the reproductive phase.

Farms should be accessible to permit visitation from field inspectors/extension officers.

Farms/Regions with large farms are best for seed multiplication where holdings are small and fragmented, isolation is difficult to arrange system of land ownership and tenure should permit continuity for crop rotations to be well planned in advance. Farms should be accessible to permit visits from extension officers/field inspectors.

Farmers Qualities:- Farmers must be energetic, meticulous, intelligent and reliable. An indolent farmer can bring nothing out of farming.

Pollination:- This is the deposition of pollen on the stigma. Pollination is assisted by moderately dry weather. When controlling insect pests, farmers must be mindful of not killing pollinating insects along. There are two major types of pollination, wind and insect.

Wind pollination:- Plants exhibiting wind pollination do not need to have beautiful flowers. They are usually unattractive to insects and are easily spread by wind to neighbouring plants bearing flowers. Insect pollination; Insects in search of nectar spread pollens from one flower to another on the same plant (Self pollination) or on another plant (Cross pollination). Insect pollinated flowers are by nature attractive, colourful and possess scents appealing to insects for visitation. In spreading pollens, the latter is laid on the sticky stigma of another flower.

Fertilization: After pollination, the receptive stigma sends pollen tube through the style of the flower. In the pollen tube flows the generative and endosperm cells, and in most flowers, double fertilization occurs, leading to individual formation of embryo and endosperm. The rate of development of embryo and endosperm after fertilisation will eventually determine whether seed is endospermic or non-endospermic. In cocoa, flowers

are ill-adapted to self pollination, have no scent or nectar, and the pollen is too sticky for wind pollination, the mechanism of fertilization remained a mystery for a long time but it is now believed that ceratopogonid midges are mainly responsible. After pollination, the fruits develop and become ripe in 5- 6 months.

Lecture 2

What is hybrid maize?

When maize is self-pollinated, each generation becomes weaker. Self-pollination is the process of taking the pollen from a single plant and applying this to the silks of the same plant. This is called **inbreeding**, and after successive generations leads to weakened plants called inbred lines. These inbred lines are small in size, have small cobs and reduced yields. However, when two inbred lines are crossed, the vigor is restored in the resulting seed, and the yield of the plants grown from the seed is greatly increased. This is called **hybrid vigor**. It occurs as a result of the interaction between the sets of genes obtained from the two different inbred lines. The effect of some of the harmful genes expressed in one of the inbred lines will be masked by more beneficial ones found in the other parent plant. This is called **heterosis**, and has been exploited to develop hybrid cultivars that are now widely grown by farmers.

The characteristics of hybrid maize

- It is uniform in appearance
- It has vigor (makes them more competitive with weeds)
- It is high yielding.
- It is selected for improved grain quality.
- A particular hybrid can be selected for specific pest and disease resistance or drought tolerance.

Developing new hybrids

Hybrid maize is produced by cross-pollinating two unrelated male and female plants of different inbred lines. By nature of the maize plant having separate male and female flowers, the tassel and cob, it is possible to control the crossing or mating of the plants. A plant may be used as either a male or female parent. If a plant is used a male, the pollen from the plant is used to cross onto the silks of a different female plant. The pollen from the female plant is eliminated, usually by physically removing the tassel from the female plant before it sheds its pollen. The resulting seed on the female plant gives rise to hybrid plants that are uniform in color, maturity, plant height and other plant characteristics. In order to produce seed of hybrid maize, the male and female inbred lines are grown under strict conditions and evaluated for yield potential and field characteristics.

Crosses between males and females can be made in four different ways to give rise to different kinds of hybrids:

1. **Single-cross hybrids** – This is when two unrelated inbred parents are crossed.
2. **Three-way hybrids** – Three parents are involved in a three-way cross. The female of a three-way hybrid is a single-cross hybrid, while the male is an inbred line.
3. **Double-cross hybrids** – In this cross, both parents are single-cross hybrids.
4. **Top-cross** – In this case, one of the parents is an open-pollinated variety and the other is a single-cross hybrid or an inbred line.

Plant breeders carefully select the parents of hybrids over many years of testing. They are chosen based on performance, disease resistance, drought tolerance, and maturation

length. Only the best hybrids are released for commercial production and sale. The production of seed is done in a very controlled manner.

Hybrid seed production

Hybrid seed production is strictly monitored in order to avoid contamination. Male and female parents are inter-planted in alternating rows. There are normally 3 to 6 female rows and 1 or 2 male rows. The female plants are de-tasseled before they shed any pollen, i.e., the tassels are physically removed. Only the male plants will shed pollen in the field. Inspectors check to see that all emerging female tassels are removed and that neighboring maize plants are at least 360 meters away. This is to ensure that pollen from nearby crops do not fall on to the silks of the female plants. Thus, the female plants are fertilized by pollen that comes only from the male plants. Once the male plants have provided the pollen, they are removed from the field to ensure there is no mixing of seed between the male and female plants. Only the seed from the female plants constitutes the hybrid seed.

It is important that the male and female plants flower at the same time and that the pollen is shed from the male plants when the female silks are receptive, in order to produce a maximum amount of seed. This is called **nicking**.

There are three stages in commercial seed production:

The production of the breeder's seed – this is when the breeder selects and produces the seed for the inbred lines. Only a little seed will be produced as inbred lines are not very vigorous. This seed will then be used for foundation or basic seed production.

The foundation or basic seed is the first multiplication of the breeder's seed (inbred lines). This is also the stage in which the single-cross hybrid will be produced for the three-way or double-cross hybrids. Enough seed of the parents will be produced in order to produce the hybrid seed.

Certified seed is the last stage in seed multiplication. Seed companies contract approved and capable farmers to plant the foundation seed in the ways described above in order to ensure purity and to produce enough seed for the farming sector.

Throughout the production of hybrid seed, the seed company and the seed producer have to adhere to certification standards. The seed fields are checked for isolation, off-types and purity, while the harvested seed is verified for lack of defects, adequate germination rate and freedom from pests and diseases. Any crop that fails to meet the standards is rejected and may not be sold as seed. Seed that has been certified by the authorizing agency is labeled accordingly and may be sold.

The advantages of growing hybrid maize:

- Hybrids are generally higher yielding than open-pollinated varieties, if grown under suitable conditions.
- Hybrids are uniform in color, maturity, and other plant characteristics, which enables farmer to carry out certain operations, such as harvesting at the same time.
- The uniformity of the grain harvested from hybrids can also have marketing advantages when sold to buyers with strict quality standards.

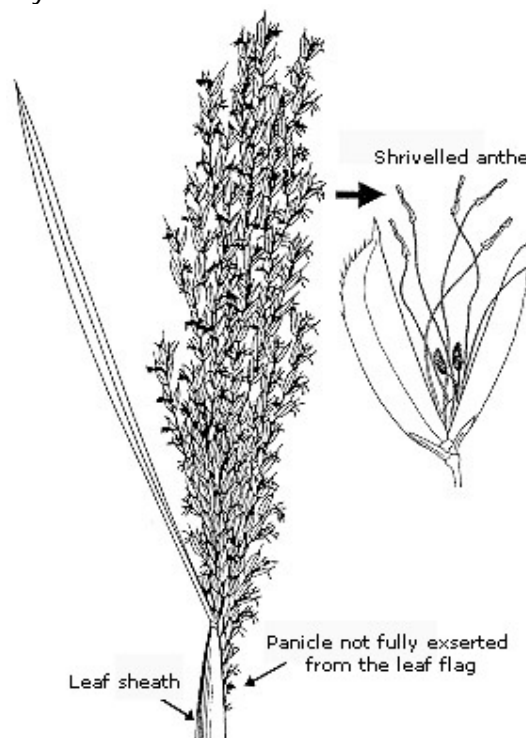
The disadvantages of growing hybrid maize

- Hybrid seed is more expensive than open-pollinated maize seed.

- The farmer needs to have more than 2 t/ha in order to justify the cost of the seed. Farmers situated in a low potential environment and who cannot afford extra inputs such as fertilizer will not recover the costs of the hybrid seed.
- Fresh hybrid seed needs to be bought every planting season.
- The grain from a crop grown with hybrid seed should not be used for seed. The farmer cannot replant grain as seed without major reductions in yield, which might be a decrease of 30 % or more.
- The farmer might not always be able to source new seed in time for the planting season.

Male sterile line

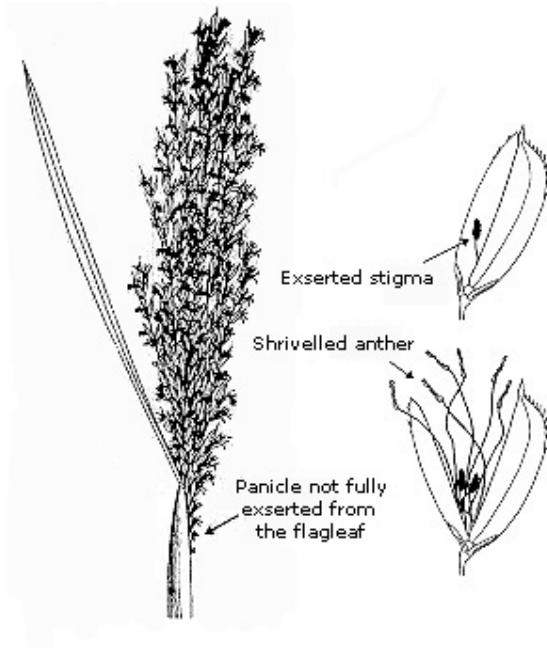
- A rice line that cannot produce viable pollen due to the interaction between cytoplasmic and nuclear genes is described as being cytoplasmic male sterile (CMS).
- It is used as a female parent for hybrid rice seed production.
- The male sterile line is commonly called a CMS line, the seed parent, the female parent, or the A line.
- Panicles may not exert fully. Their basal portion remains inside the flag leaf sheath.
- Anthers are pale or white and shrivelled.
- The flowering period usually lasts for 7 days.





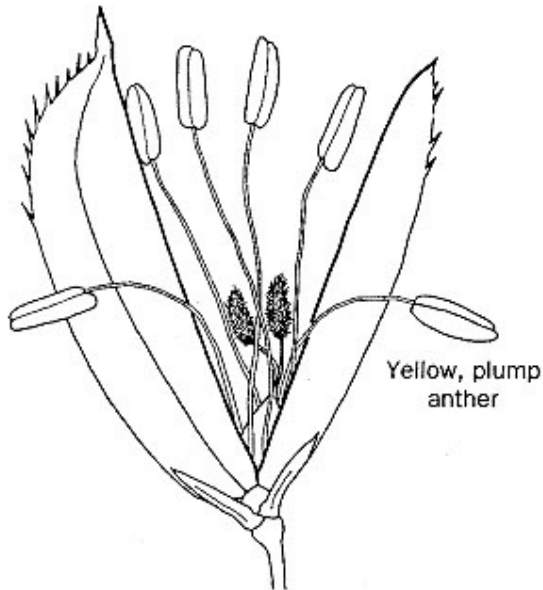
Desirable characteristics of the CMS line

- High seed yields depend on desirable panicle, floret, and stigma characteristics of the CMS line.
- The panicle should be exerted from the flag leaf as far as possible.
- There should be at least 100 spikelets per panicle.
- The floret should open wide and remain open for at least 45 minutes or longer.
- Blooming florets should have exerted stigmas.
- Stigmas should be receptive to pollination for 5 to 7 days.



Maintainer line

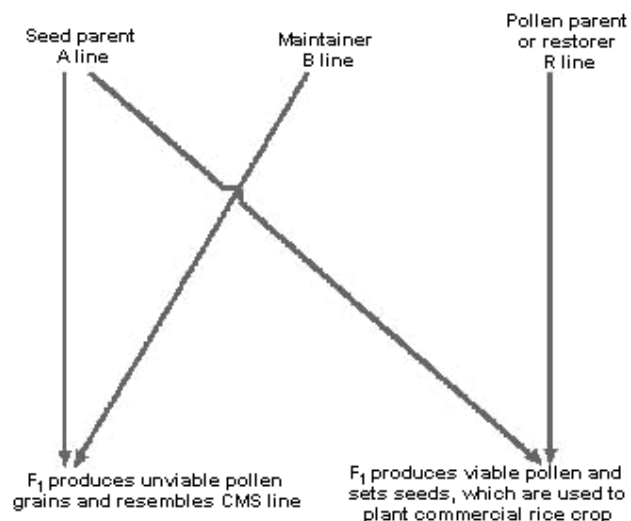
- A maintainer line is similar to a CMS line except that it has viable pollen grains and normal seed setting.
- The maintainer line is used as a pollinator for maintaining a CMS line.
- The maintainer is also called the B line.
- The B line cannot restore fertility to the F₁ generation when it is crossed with a CMS line.
- Panicles exert fully out of the flag leaves.
- Anthers are yellow, plump, and shed pollen.
- The B line flowers 2-3 days earlier than the CMS line.
- Flowering lasts for about 5 days



Spikelet of maintainer/restorer line

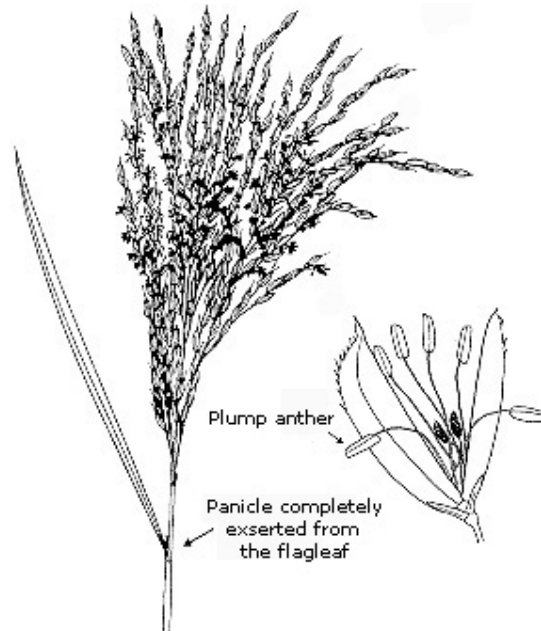
Restorer line

- Any rice cultivar that restores fertility in the F₁ when it is crossed to a CMS line is called a restorer.
- The restorer is also called the pollen parent, the male parent, or the R line.
- The R line is used as the pollinator for the CMS parent for hybrid seed production.
- Growth duration may or may not be similar to that of CMS lines.
- Panicles exert fully out of the flag leaves.
- Anthers are yellow, plump, and shed pollen.
- Flowering lasts for about 5 days.



Desirable characteristics of maintainer and restorer lines

- Panicles should be:
 - long and contain 125 or more spikelets.
 - completely exerted from the flag leaf.
- Filaments should be long for complete anther exertion from the floret.
- Anthers should be large and plump with many pollen grains.
- The anther should shed most of its pollen only after it has exerted from the floret.



Choice of parents for hybrid seed production

- Seed growers normally produce seeds of F_1 hybrids released for commercial cultivation in their country.
- The parental lines should be adapted to the grower's area, even if the hybrid seed may be produced for another geographical area.
- Government agencies or commercial seed companies are the grower's best source of parental seed of hybrids that are popular with farmers.

Seedbed preparation

- Puddle the seedbed field twice at an interval of 7 days to destroy any germinated rice seeds or weed seeds.
- Construct 5-10-cm raised seedbeds of approximately 1 m width of any convenient length.
- Construct drainage channels between seedbeds to drain excess water.
- Apply 5-6 grams of NPK (14:14:14) fertilizer or ammonium phosphate (16:20) fertilizer for each square meter of seedbed area and mix it with the soil.
- Nitrogen increases seedling growth and induces tillering

Lecture 4

Controlled Seed Multiplication

This is a practice whereby seed multiplication is properly monitored to prevent contamination of crop plants with undesirable pollens. Control also involves monitoring of seed quality throughout the various stages of production, processing and marketing. One attribute which cannot be controlled through laboratory tests is cultivar purity. This requires some degree of control from the growing crop right through to marketing of the harvested and processed seed. For this purpose, a certification authority is necessary with a corps of inspectors engaged in visiting farms, processing plants and retail outlets.

Details of hybrid seed production to be given later. Also, protection from foreign pollens would be stressed using isolation distance especially.

Cultural practices: - These range from weeding (manual/chemical) to fertilizer application (manual/machine), plant protection chemical application. Weeds are objectionable in any crop and all efforts must be reasonably made to ensure a weed – free population of crop plants. Where weeding is by use of hoe and/or cutlass, care should be taken to avoid any damage to the plants.

When spraying chemicals for weed or pest control, care should be taken to protect the nose and body of the person doing the spraying. Nose protector must be used, and hards and exposed body washed thoroughly. Soon after planting, thinning and supplying may be carried out before two weeks of planting.

Crop maturity and time of harvest: Two phases characterise plant development-vegetative and reproductive phases. Ample water is required for plant establishment and vegetative growth. At reproductive phase, vegetative phase becomes less luxuriant. The switch from vegetative to reproductive phase is controlled by a hormone called 'florigen', which encourages flower bud production. At flowering, a little dry weather or very limited water supply is beneficial for pollination. After fertilization, ample water supply is again required for seed setting/development. This phase is followed by ripening of the seeds/pods, which requires no water at all.

Time of Harvests: Harvest only when crop seeds are matured. Seeds should never be stored on the plant in the field. The field is seldom favourable for storage. Weathening of the crop seed must be avoided as this deteriorates seed quality. For some legumes, harvesting must be done when pods are ripe or turning yellow. Further delay results in shattering of the pods, releasing their seeds to the ground, making harvesting difficult.

Deterioration of seed stocks may arise from:-

- (a) Cross-pollination – major factor
- (b) Substituting one cultivar for another through wrong labelling.
- (c) Poor viability status – some seeds deteriorate before storage. The best of storage conditions cannot improve seed quality. It only maintains it.
- (d) Genetic shift – mainly arising from producing cultivars outside their domain.

Isolation distance in crops:- for self – pollinating and cross - pollinating species.

Deterioration of seed stocks may arise from:-

- (a) Cross pollination
- (b) Substituting one cultivar for another due to wrong labelling
- (c) Poor viability status
- (d) Genetic shift, etc.

Lecture 5

Seed Certification: It can be regarded as a legally sanctioned system for quality control for seed multiplication and production and it consists of 3 control measures in 3 general areas: (1) Field (2) Pre and post control plot (3) Laboratory test for seed quality

Purposes of seed certification

- Is to maintain and make available to the public high quality seeds and propagating materials of superior crop or plant varieties grown and distributed as to ensure genetic and varietal purity

- Is to maintain a reasonable seed quality standard
- Protection against foreign pollen.
- Isolation distances
- Deterioration of seed stocks.

Lecture 6. Deterioration of seed stocks may arise from:-

- (e) Cross pollination
- (f) Substituting one cultivar for another due to wrong labelling
- (g) Poor viability status
- (h) Genetic shift, etc.

Lecture 7. Contract Growing of Seeds

Contract – growing, philosophy, principles and application. Contract growing of seed is encouraged where the seed needed is in enormous quantity and shortage of land, equipment, personnel and other resources make it impracticable for seed companies/government agencies e.g National Seed Service (NSS). Farmers enter into contractual agreements with the seed company, sometimes with legal transactions. The quantity and quality must be guaranteed. Processing of harvested seed could be made in the premises of the farmer or in the seed processing depot of the seed company. In principle, difficult or new varieties are given as contract only to experienced farmers who have the experience and the facility to cope with them. There is usually freedom of entry/exit from the contract. The contract document is signed by both parties.

Practicals

Seed dormancy breaking techniques:

Depending on the type of dormancy, methods for breaking dormancy in the laboratory/field would include:-

- (i) **Hard seed coat dormancy** – Scarification, rubbing on abrasive surface or in the laboration, rubbing seed on sand paper.
- (ii) **Embryo immaturity:** Time factor is important here. Importance and definition of after- ripening stressed here.

Note: During after – ripening, it is discovered that chemical/physical changes do occur within the seed or seed coat; composition of storage material may alter, germination promoters may appear while inhibitory ones disappear, embryo may also complete its growth.

- (iii) **Temperature requirements:** Stratification defined, during which a number of changes occur e.g. embro growth may be completed, Application of GA3 replaces chilling requirement; also some seeds require alternating temperature to break their dormancy.
 - For light – requiring seeds and use of coumarine in inducing/replacing light requirements etc.
 - Germination inhibitors e.g Cyanide, Flouride Azide, etc should be demonstrated. ABA, Coumarin are also popular.Growth regulators promoting germinators include:-
 - KNO_3 , H_2O_2 , Thiourea, Gibberellins, Auxins (IAA), Cytokinnins, Ethylene etc.
 - Application of Pesticides to seeds – their implications on undried seed stressed.

Visits to commercial seed processing companies: National Seed Service (now National Seed Council in Abuja), MANR, Asero, Abeokuta.