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"Requisites of seed production, processing, testing and quality assurance"

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CONTENT

Basic Principles of Quality Seed Production

Introduction

Production of genetically pure / otherwise quality pedigree seed is an exacting task requiring high technical know-how, skill and comparatively high financial investment. During seed production strict attention must be given to the maintenance of genetic purity and other qualities of seeds in order to exploit the full dividends sought to be obtained by introduction of new superior crop plant varieties. In other words, seed production must be carried out under standardized and well-organized condition.

Two principles need to be taken care with

I. Genetic principles
II. Agronomic principles

I. Genetic principle

Causes of genetic deterioration of varieties:

Genetic purity of a variety deteriorates due to several factors during multiplication cycle. Factors responsible for deterioration of varieties were listed by Kadam (1942).

- ✓ Developmental variations
- ✓ Mechanical mixtures
- ✓ Natural crossing
- ✓ Mutations
- ✓ Selective influence of diseases
- ✓ Minor genetic variations
- ✓ Technique of plant breeder

Mechanical mixtures, natural crossing and selective influences of diseases are most important reasons for genetic deterioration.

Developmental variations: When seed is produced under different environmental conditions *i.e.* change in climate, soil fertility variations etc., cause numerous changes in plant growth, flowering and maturity of developing embryos. These factors are reflected in the next crop period, known as developmental variations. To minimize the opportunity for such genetic shifts in varieties, it is suggested to grow the seed of a given variety in its area of adaptation.

Mechanical mixtures

It is a physical process by which seed of a number of varieties' by mistake, unknowingly or unavoidably, are mixed and deteriorate the genetic purity of the seed. This happens usually:

a. through seed drills while sowing;
b. by wind carrying the harvested crop from one field to another;
c. on the threshing ground, where many varieties are kept together;
d. through gunny bags, seed bins etc; and
e. through rats/ other interferences

Natural out-crossing

In sexually propagated crops, natural crossing is most important source of vertical deterioration.

The deterioration in varieties due to natural crossing is of three reasons

- Natural crossing with undesirable types
- Natural crossing with diseased plants
- Natural crossing with off- types

According to Bateman (1947) genetic contamination in seed field due to natural crossing depends upon factors *viz.*,

1. The breading system of species
2. Isolation distance
3. Vertical mass
4. Pollinating agents.

As the isolation between varieties is increased the contamination decreases. Isolation of seed crop is a primary factor in the seed production of crop plants of cross pollinated by wind or insects and their activities, humidity and temperature at the time of anthesis etc.

Mutations

Mutation means sudden genetic change occurring naturally or artificially. It can improve as well degenerate crop. This is not a serious factor of a varietal deterioration. In the majority of the cases it is difficult to identify or detect minor mutation.

Selective influence

Sometimes the assessment of the variety release committee, prior to release is faulty and a premature variety still segregating is released, which becomes an important source of deterioration. The susceptibility to diseases or other factors also become an important source of deterioration. To avoid such mistakes, periodical selection during maintenance and production of seed is necessary. Some vegetatively propagated stocks deteriorate fast, if infected by viral, fungal and bacterial diseases.

Minor genetic variations

Minor genetic variations may exist even in the Varieties appearing phenotypically uniform and homogeneous at the time of their release. During later production cycle some of this variation may be lost because of selective elimination by the environment. To overcome this yields trials are suggested.

Technique of plant breeder

In certain instances, serious instabilities may occur in varieties due to cytogenetically irregularities not properly assessed in the new varieties prior to their release. Other factors, such as break down in male sterility, certain environmental conditions, and other heritable variations may considerably lower the genetic purity.

Maintenance of Genetic Purity during Seed Production

The various steps suggested by Hartmann and Kester (1968) for maintaining genetic purity.

a. Providing adequate isolation to prevent contamination by natural crossing or mechanical mixtures.
b. Roguing of seed fields, prior to the stage at which they could contaminate the seed crop
c. Periodic testing of varieties for genetic purity
d. Avoiding genetic shift by growing crops in areas of their adaptation only.
e. Certification of seed crops to maintain genetic purity & quality seed.

f. Adopting generation system (the seeds produced is restricted to four generation only i.e. starting from breeders seeds.) and the seeds can be multiplied up to three more generations i.e. foundations, registered and certified.
g. Grow out test

The important factors / safeguards for maintaining genetic purity during seed production are:-

Control of seed source: For raising a seed crop the seeds should be required from an approved source and from an appropriate class is necessary. Four classes of seeds are generally recognized in seed certification namely breeder seed, foundation registered and certified. But as per Indian system of seed multiplication, registered seed class is about is absent but there is provision for certified seed stage I & II depending on quality of seed class.

Breeder's seed: Is a seed or vegetative propagating material which is directly controlled by originating breeder or breeder of sponsoring institution and provides basis of foundation seed.

Foundation seed: is a seed stock so as to maintain specific genetic identity and purity and is managed by personnel having technical expertise from relavant production centres. Foundation seed is the source of certified seed class.

Certified seed: Is the progeny of foundation seed, that is handled to maintain genetic identity and purity and comes under purview of certifying agencies.

Preceding crop requirement: Preceding Crop Requirement has been fixed to avoid contamination through volunteer plants and also from soil borne diseases. (Volunteer plants mean plants grown in the field from previous crops).

Isolation: Isolation is required during seed crop production to avoid contamination due to natural crossing and diseases infection by wind and insects from neighbouring field and to avoid mechanical mixtures during sowing, harvesting, threshing and handling of seeds.

Isolation distance is different from crop to crop and among different classes of seeds. *i.e.* certified and foundation.

Minimum isolation requirements of crops

S. No	Crop	Isolation distance required (in metre)	
		Foundation seed	Certified seed
1	Paddy, wheat, barley, oats	3*(150)	3*(150)
2	Hybrid sorghum	300 *(400)	200 *(400)
3	Pearl millet	1000	200
4	Maize		
	Maize – OPV and composite	400	200
5	Soybean	3	3
6	Rape seed & mustard	400	200
7	Groundnut	3	3
8	Cotton	50	30
9	Berseem	400	100
10	Peas	20	10
11	Cabbage & Cauliflower	1600	1000
12	Carrot, Onion	1000	800
13	Brinjal	200	100
14	Chillies, Okra	400	200

15	Tomato	50	25
16	Cucurbits	800	400

** Isolation distances are frequently increased due to the following reasons*

a. infection of diseases *i.e.* 0.1 % infection of loose smut disease in cereal crops results in isolation distance from 3 m to 150m;

b. expectation of natural crop between wild grass or plantations i.e. the isolation in sorghum increases from 25m to 400 m if Johnson grass (*Sorghum halepense*) is found in the region;

c. differential maturity between receptive stigma and pollen; and

d. isolation distances are sometimes reduced, by growing some border rows which on harvesting are discarded.

Roguing: The off type plants *i.e.* plants differing in their characteristic from those of the seed variety is another source of genetic contamination. Their continued presence would certainly deteriorate the genetic purity of the variety. The removal of such type of plant is referred as "Roguing".

There are three main sources of off- type

1. The off-type plant may arise due to presence of recessive genes in heterozygous condition at the time of release of variety. (The recessive genes may also arise by mutation).
2. Off-type plants are due to volunteer plants or from seed produced by earlier crop.
3. Mechanical mixtures also constitute the major source for off- type plants.

Seed certification: Genetic purity in commercial seed production is maintained through a system of seed certification. The objective of seed certification is to maintain and make available crop seeds, tubers, bulbs, etc., which are of good seeding value and true to variety.

Grow out test: Varieties being grown for seed production should periodically be tested for genetic purity by grow out test, to make sure that, seed being maintained in their true form.

II. Agronomic Principles

Selection of agro-climatic region: A crop variety to be grown for seed production in an area must be adapted to the photoperiod and temperature conditions prevailing in that area.

Selection of seed plot: The plot selected for seed crop must be free from volunteer plants, weed plants and have good soil texture and fertility. The soil of the seed plot should be comparatively free from soil borne diseases and insects pests.

Isolation of seed crops: The seed crop must be isolated from other nearby fields of the same crops and the other contaminating crops as per requirement of the certification standards.

Preparation of land: Good land preparation helps in improved germination, good stand establishment and destruction of potential weeds. It also aids in water management and good uniform irrigation.

Selection of variety: The variety of seed production must be carefully selected, should possess disease resistance, earliness, grain quality, a higher yielder, and adapted to the agro-climatic conditions of the region.

Seed treatment: Depending upon the requirement the following seed treatment may be given

- Chemical seed treatment.
- Bacterial inoculation for the legumes.

- Seed treatment for breaking dormancy.

Time of planting: The seed crops should invariably be sown at their normal planting time. Depending upon the incidence of diseases and pests, some adjustments, could be made, if necessary.

Seed rate: Lower seed rates than usual for raising commercial crop are desirable because they facilitate roguing operations and inspection of seed crops.

Method of sowing: The most efficient and ideal method of sowing is by mechanical drilling.

Depth of sowing: Depth of sowing is extremely important in ensuring good plant stand. Small seeds should usually be planted shallow, but large seeds could be planted a little deeper.

Roguing: Adequate and timely rouging is extremely important in seed production. Rouging in most of the field crops may be done at following stages as per needs of the seed crop.

- Vegetative / pre-flowering stage
- Flowering stage
- Maturity stage

Supplementary pollination: Provision of honey bees in hives in close proximity to the seed fields of crops largely cross pollinated by the insects, ensure good seed set thereby greatly increase seed yields.

Weed control: Good weed control is the basic requirement in producing good quality seed. Weeds may cause contamination of theseed crop , in addition to reduction in yield:

Disease and insect control: Successful disease and insect control is another important factor in raising healthy seed crops. Apart from reduction of yield the quality of seeds from diseased and insect damaged plants is invariably poor.

Nutrition: Regarding nutrition of seed crops, nitrogen, phosphorus, potassium, and several other elements play an important role for proper development of plants and seed. It is, therefore, advisable to know and identify the nutritional requirements of seed crops and apply adequate fertilizers.

Irrigation: Irrigation can be important at planting for seed crops. Excess moisture or prolonged drought adversely affects germination and results in poor crop stands.

Harvesting: It is of great importance to harvest a seed crop at the time that will allow both the maximum yield and the best quality seed.

Drying of seeds: In order to preserve seed viability and vigour, it is necessary to dry seeds to optimum moisture content.

Maintenance of Nucleus Seed and Breeder Seed in Self and Cross Pollinated Crops

Introduction

Seed is the first critical input needed for farmers to improve and maintain their crop productivity. On this basis, seed security has been defined as the availability of the appropriate variety, at the right place and time, in sufficient quantity and quality (Mekbib, 2008). The expected potential of a new variety or any well-known variety will not be expressed in actual advantages and profits if poor quality seed is used. This can be due to a deficiency in physical or physiological requirements, such as physical purity, germination, vigour, seed health, or to low genetic purity of the seed lot or even to a miss-identification of the variety. Variety testing represents the most useful tool to evaluate the genetic quality of the seed and may be aimed at identifying the variety, to discriminate between different varieties, to check for genetic purity or to provide a characterization of the variety.

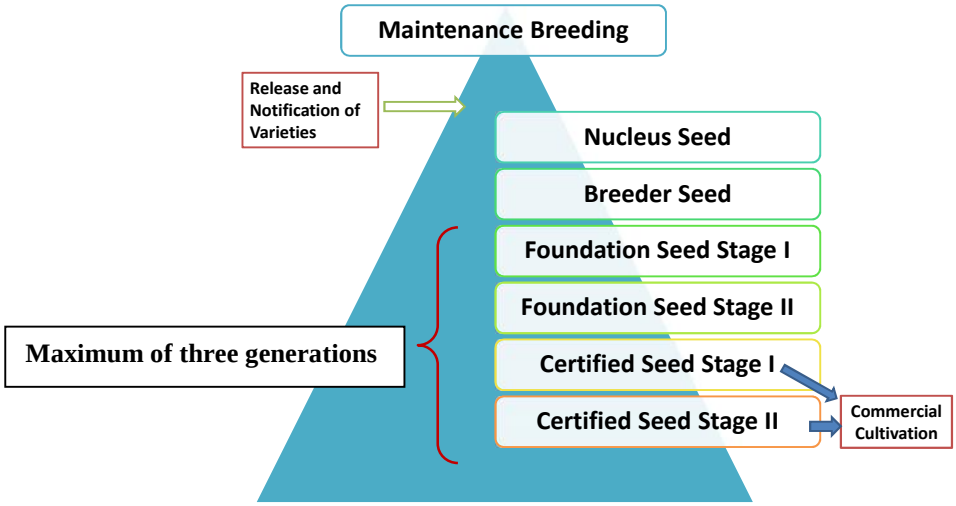


Figure 1. Generations/steps in seed multiplication programme

After the release of a variety, seeds have to be multiplied in sufficient quantity which takes 3-4 generations before it reaches to the farmers for commercial cultivation. During these multiplication cycles, care has to be taken so that the variety does not degenerate but maintains its original characteristics. In order to achieving this goal, the seed production programme becomes an exhausting task requiring high technical skills, financial investments and proper methodology and care.

The factors responsible for loss of genetic purity during seed production Kadam (1942) are:

1. Developmental Variation
2. Mechanical Mixtures
3. Mutations
4. Natural Crossing
5. Genetic drift
6. Minor Genetic Variation
7. Selective influence of Diseases
8. Techniques of the Breeder

9. Breakdown of male sterility
10. Improper / defective seed certification System

The genetic purity of foundation and certified classes will depend on the type of nucleus/breeder seed use. Therefore, the maintenance of original characteristics of the variety/parental lines at the nucleus and breeder seed level is very important. It is absolutely necessary to select single panicle or single plant having true-to-type characteristics of the particular variety or parental line from the base population and grow them in plant progeny rows for proper evaluation and rejection of undesirable types.

Breeder involved in nucleus/breeder seed multiplication should know:

- Breeding behaviour of the particular crop and the impact of environmental conditions on it.
- The diagnostic characteristics of the variety/parental lines (DUS test)
- Specific requirement of the crop/variety/parental lines like isolation, land requirement, disease infection etc.

Maintenance of Nucleus seed and Breeder seed in self and cross pollinated crops

Nucleus seed is the handful of original seed obtained from selected individual plants of a particular variety for maintenance and purification by the originating breeder. It is further multiplied and maintained under the supervision of qualified pant breeder to provide breeder seed. This forms the basis for all further seed production. It has the highest genetic purity and physical purity.

Maintenance of nucleus/breeder seed can be divided into two groups:

1. Maintenance of newly released varieties
2. Maintenance of established varieties

Maintenance of nucleus seed of pre-released or newly released varieties

1. Sampling of a variety to obtain nucleus seed: In any crop not more than 15 new varieties should be sampled in any research station. Select approximately 200 plants from one of the yield trials. Discard poor diseased and inferior plants. The selected plants should be harvested 4 to 5 days before harvest to avoid shattering. All the 200 plants should be tied individually and wrapped in a cloth bag and stored till the yield results are obtained. The bundles of high yielding varieties are taken for further examination and the inferior varieties are discarded.

2. Table examination of samples: The bundles are threshed separately and the seed should be examined in piles on the purity work board. Piles with undesirable characters (diseased, off-types etc.) should be discarded. The remaining pure seed of individual plants is sown in a variety purification nursery called as nucleus seed.

3. Location and seeding of nucleus seed: Select clean fertile land in which the same crop was not grown in previous season. The land should be free from volunteer plants and it should be properly isolated. The 200 or less progenies should be sown in 200 double rows in 4 series of 50 double rows in each plot. Sufficient spacing should be there between and within the rows to facilitate examination of each row during the crop growth.

4. Inspection of nucleus double row plots and removal of off-types: The double row plots should be critically examined from the seedling stage until maturity. If any plot differ distinctly from that of the nucleus seed variety it should be removed before flowering stage. After flowering and during maturity plots should be examined critically for other characters like flower colour, ear head shape, awn colour, seed colour etc. and the off-types should be

removed before harvest. When off-type plants are removed after flowering, all the plants within three meters should be removed as they may contaminate the surrounding plants.

5. Harvesting and threshing: The remaining plots (between 180-200) should be harvested individually and tied into a bundle. The individual plots are threshed cleaned and dried separately. The seed of each plot should be placed on the purity work board in piles and examined for uniformity of seed characters. If any piles appears to be of off-type or diseased, it should be discarded. All the remaining seed should be mixed together into one lot and treated with fungicide and insecticide and then bagged, labelled and stored as breeder seed stock for next year.

Maintenance of Breeder seed of pre-released or newly released varieties

1. Breeder seed should be sown in clean fertile land where the same crop was not grown in previous one season.
2. The field should be properly isolated to avoid natural crossing and spread of diseases.
3. Adopt latest farm practices to raise a good crop.
4. Sufficient spacing should be provided between and within the rows to examine individual plants and for removal of off types.
5. Roughing should be done before flowering and when plants are removed after flowering all the surrounding plants within one meter should be removed.
6. Harvesting the breeder seed should be done with utmost care. The equipment used for harvesting, threshing and cleaning should be clean to avoid mechanical mixtures. The seed should be stored in new gunny bags. The seed produced should be of 99.99 % pure and it is used for producing Foundation seed. A portion of breeder seed should be retained to continue of breeder seed production.

Maintenance of breeder seed of established varieties:

The breeder seed can be maintained satisfactorily by any one of the following methods

1. **By raising the crop in isolation**: Breeder seed can be maintained by growing them in isolated pots and by following rigorous roguing during various stages of crop growth. The methods of handling the breeder seed are same as that described earlier.

2. **By Bulk selection**: Genetic purity of established varieties could be satisfactorily improved by bulk selection. In this method select 2000 to 2500 plants which are typical to that of the variety. Harvest and thresh them separately. The seed of each plant are examined and any plot which shows off-types or dissimilar ones are discarded.

Maintenance of Nucleus and Breeder seed in cross pollinated crops

The maintenance of varieties of cross pollinated crops is much more complicated than self pollinated crops.

Maintenance of composites/ open pollinated varieties (OPV's):

Composite variety is a variety derived from advance generation of random mated outstanding lines (Germplasm inbreds, varieties, hybrids, advance generation lines). Mixing the seeds of several phenotypically outstanding lines produces a composite variety and encouraging open pollination to produce crosses in all combinations among, the mixed lines. The lines used to produce a composite variety are rarely tested for combining ability with each other. Mixing the seeds of various genotypes, which are similar in maturity, height, seed size, colour etc., develops composite varieties. Like synthetic, composites are commercial varieties and are maintained by open pollination in isolation. Farmers can use their own seed for 3 to 4 years.

Synthetic variety is produced by crossing a number of inbred lines in all combination that combine well with each other. Once synthesized, a synthetic is maintained by open-pollination in isolation. A synthetic variety can be developed from inbreds, clones, and open pollinated varieties. Generally 5-8 good general combining inbreds are used to constitute a synthetic variety. Synthetic variety consists of several heterozygous initially. Since subsequently the variety is maintained by open pollination, some degree of selfing occurs resulting in fixation of some genes. A result in later generation synthetic variety consists of several heterozygotes. Thus a synthetic variety has a heterogeneous population.

Open pollinated varieties (OPV's) refer to collection of individual, which share a common gene pool. OPV's are easier to develop than hybrids, their seed production is simpler and relatively inexpensive and are adapted to local environment. The farmers can save and exchange own seed for planting the fallowing season, reducing their dependency on external source. OPVs are particularly suitable for tribal and hilly regions, where, seed replacement rate is very low.

In case of OPV's care must be taken for actual representations of the variety. Only off-type plants should be removed to minimize inbreeding depression. The number of plants to be used to advance generation is dependent on two factors: the number of plants required adequately to represent the variety and the quantity of the seed required to meet the future seed requirement. Mild selection during seed production and multiplication are inevitable. However, they should be minimized. Varietal maintenance is normally done in isolation following half sib method as described in Fig 2.

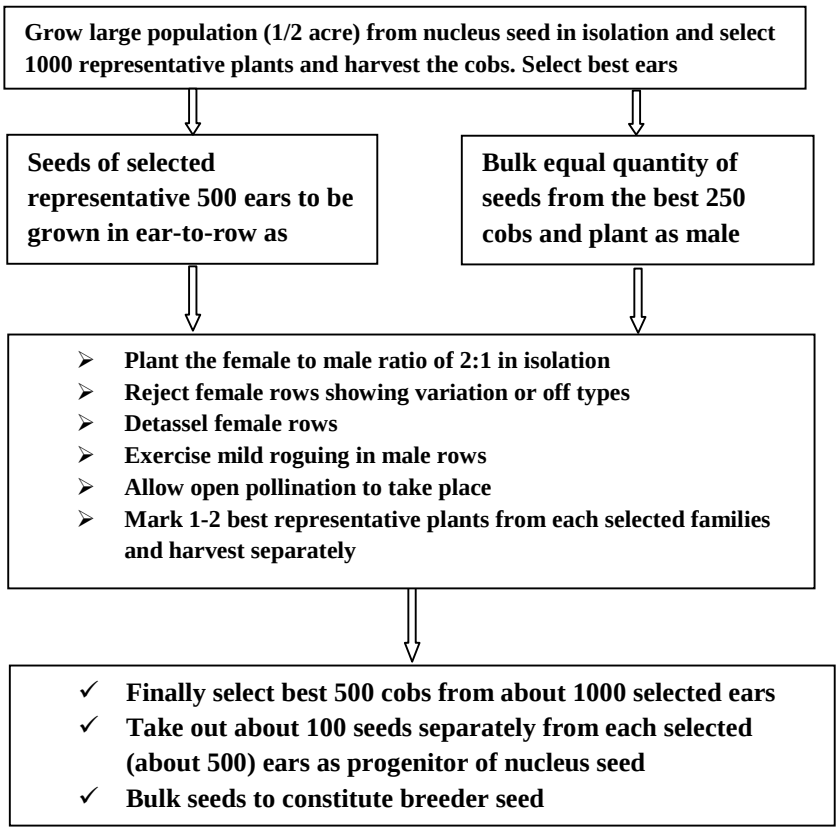


Fig.2 Varietal maintenance and seed production in composites /OPV's in maize: ear-to-row method

Maintenance of nucleus seed of inbred lines: After testing the hybrid thoroughly and if it is suitable, the seed of parental lines must be increased in the following manner;

1. **Hand pollination**: Method of maintaining nucleus seed of inbred lines involves self pollination, sib pollination or combination of both. Generally maintenance by sibbing is preferred because it does not reduce the vigour. It is also preferable to maintain some parental material by alternate selfing and sibbing from one generation to the next. The individual selfed or sibbed ears should be examined critically. Those which are off-types or inferior in any regard of differing in any character such as texture, seed size, color, shape etc. should be discarded. The individual selfed or sibbed ears may then be threshed separately and sown in ear to row method in double row plots. The advantage of ear to row planting is that the off-types from individual ears can be easily detected and controlled.

2. **Seeding of hand pollinated seed**: The hand pollinated seed should be sown in fertile land which is free from volunteer plants. The seed should be sown in the area where the hybrid is to be released.

3. **Isolation**: Proper isolation distance should be provided to avoid natural cross pollination. The isolation distance varies from crop to crop and depends on nature of contamination and direction of the prevailing wind. Generally more isolation is required at this stage than the later stages (foundation/certified seed). Distance or time isolation can be practiced to avoid contamination.

4. **Inspection of double row plots and roguing:** Despite of making all the efforts taken to maintain purity in inbred lines by hand pollination and adequate isolation distance still it is not possible to achieve perfection. The double row plots must be carefully checked for off-types prior to pollen shedding. It is very easy to recognize the off types because they are more vigorous than the inbred lines.

5. **Harvesting drying and shelling:** The nucleus seed crop can be harvested soon after it attains physiological maturity if artificial drying facilities exist. It is better to harvest the ear to row lines separately. These lines should be critically examined for ear characters and all off colored, off textured and diseased or undesirable ears sorted out. If the overall percentage of off types is more than 0.1%, hand pollination should be done again. After discarding the undesirable ones, remaining ears may be bulked and dried in clean dry bin at a temperature not exceeding 43^{o}C. After drying, shelling should be done in a cleaned machine to avoid mechanical mixtures. After shelling the seed may be cleaned, then treated with fungicide, insecticide and properly labelled before storage.

Maintenance of breeder seed of inbred lines: For increasing breeder seed the breeder stock seed obtained from nucleus seed is planted in an isolated field. During increase of Breeder seed adequate attention must be paid to

1. Land requirement
2. Isolation
3. Roguing
4. Field inspection
5. Harvesting and drying
6. Sorting of the ears

Maintenance of parental lines (A-line, B-line and R-line) or Hybrid seed production

Maintenance of parental lines is generally referred as foundation seed production and hybrid seed production as certified seed class. In hybrid crops one has to deal with maintenance of male sterile lines (A), maintainer (B) and restorer line (R). Parental lines are multiplied/ maintained separately in isolated plots by plant or ear to row method. Nucleus seed of female line (A) is maintained by undertaking mass selection in B line. Ear to row progenies of B lines are grown in isolation adjacent to A line. The off-type progenies of A

and B lines are removed. Seed parent rows are hand pollinated by collecting pollens from desirable B line progenies. Individual plants of B line are selfed. Similarly the parental stocks of R lines are maintained in isolation. If needed the nucleus seed may have one more multiplication. It is desirable if the breeder grow head to progeny row for purification/maintenance of the variety.

Conclusion

Maintenance of nucleus and breeder seed is the most important task in ensuring the high seed quality production in seed supply chain. Because during the maintenance of nucleus and breeder seed, the breeder strictly selecting and advancing only the true to type plant/ear of particular variety based on original characteristics of the variety. Therefore it is very-very essential in seed quality assurance. Besides preserving yield potential, improving adaptation of newly developed varieties to environmental changes, the continuous maintenance of nucleus/breeder seed of new/old varieties also ensures the very high levels of seed purity in seed production. Thus it helps in achieving the goals/objectives of seed quality assurance in seed supply chain by supplying the quality seed to the end users.

References

Chowdhury, R. K. and Lal, S. K., 2003. Nucleus and breeder seed production manual. National seed project (crops), IARI, New Delhi.

Responding to the challenges of a changing world: The role of new plant varieties and high quality seed in agriculture, *Proceedings of the second world seed conference*, FAO Headquarters, Rome, September 8-10, 2009

Participatory Varietal Selection and Seed Production: Realizing Untapped Potential

Introduction

Plant breeding is a complex process starting from selection of desirable parents to release of varieties and hybrids. In majority of cases, only a small fraction of it takes place in farmers' field. Most of the activities take place in research stations where all the decisions are taken by breeders and collaborating scientists. Therefore, large number of breeding materials is discarded before knowing whether it could have been useful in the real condition of farmers' field or not. Most of the improved hybrids and varieties have been developed for near optimal conditions where adequate supply of various inputs available similar to research station. Large genotype × environmental (G×E) interactions pose critical problems for broad-spectrum breeding and adoption in the case of low-potential areas where mainly small and poor farmers living (Ceccarelli and S. Grando, 2006). Therefore, participatory crop improvement (PCI) has developed as an alternative and complementary breeding approach to formal crop improvement (FCI), aims to address more effectively the needs of farmers in marginal areas in developing countries (Almekinders and Elings, 2001). Participatory approaches in plant breeding, varietal selection and seed production activities offers a solution to the problem of fitting crop to the target environments, speedy way of seed multiplication and distribution of varieties or hybrids among the farmers with end user preferences. This chapter outlined in detail about participatory plant breeding, varietal selection and seed production activities, methods, success stories, etc. in different crops and countries. It will be useful for agricultural researchers in formulating and incorporating the participatory approaches in their research to address diversity of environments and end-user preferences.

Need of farmers' participation in crop improvement

The principal reasons for increasing the involvement of farmers in crop improvement programs can be outlined as follows:

(1) Addressing different expectations, criteria and diverse needs (Socio-economic needs)
(2) Evaluation directly in target environment (diverse or broad environment)
(3) Supporting genetic diversity
(4) Rapid increase in seed replacement and varietal adaption rate
(5) New varieties to grow with the existing package (management practices)

Participatory crop improvement (PCI)

The FCI had brought little significant crop improvement to small-scale farmers in agro-ecologically and socio-economically marginal and variable environments (Almekinders and Elings, 2001; Kerr and Kolavalli, 1999). Because of the fact that, FCI in developing countries concentrated on developing crops for favourable and high-input agricultural systems. It was expected that, at least some of the materials which were developed for high-input production systems would also be successful in low-input environments. However, the farming systems in marginal environments where agriculture is dominated by variation in agro-ecological and socio-economic conditions, resulting in complex stress and high production risks, are too different from those in the more favourable production areas with high-input production systems (Hardon and de Boef, 1993). In order to address a broad range of environments and end user preference, PCI has emerged as an alternative to FCI.

Participatory plant breeding (PPB), participatory varietal selection (PVS) and participatory seed production (PSP) approaches are discussed below in detail.

I. Participatory plant breeding (PPB)

PPB is based on a set of methods that involve scientists, farmers and others, such as consumers, extensionists, industry, rural cooperatives, non-governmental organizations (NGOs), etc. in plant breeding research. In PPB programmes, farmers select germplasm for their particular environmental conditions, offer the hope of providing well-adapted varieties (Almekinders and Elings, 2001; Sperling et al., 2001; Ceccarelli et al., 2000; Vernooy, 2003). 'Users' become co-researchers as they can help set overall goals, determine specific breeding priorities, make crosses, screen germplasm entries in the pre-adaptive phases of research, take charge of adaptive testing and lead the subsequent seed multiplication and diffusion process.

Farmers' involvement in PPB

Defining breeding goals and priorities; generating variability; selecting among variable materials or providing sources of germplasm; evaluating experimental varieties; hosting trials on farmers' land; selecting lines for further crossing; discussing results with the scientists; planning for the following year's activities; suggesting methodological changes; and multiplying and commercializing the seed of the selected lines (Halewood et al. 2007) are different activities of PPB. In complete participatory plant breeding, farmers are consulted at every stage, where as in PVS, initial stages of the breeding process are performed exclusively by scientists and farmer participation is restricted to evaluate finished cultivars. Few examples of PPB in different crops and places are presented in Table 1.

Table 1. Participatory plant breeding in different crops and remarks

Crop	Location	Remarks	Reference
Rice	Rainfed uplands of eastern India	Through PPB, two varieties, Ashoka 200F and Ashoka 228 were released.	Virk et al. (2003)
	Low-altitude areas of Nepal	Collaboration with farmers was effective in improving the efficiency and cost-effectiveness of breeding programme. Several varieties have been produced through programme that has performed better than existing check varieties in participatory trials.	Gyawali et al., (2002)
	Central region of Kenya	The fourteen parents selected by farmers to include that in crossing program for the development of hybrids to ensure parents selected for the crossing block had farmers' traits of preferences	Kimani et al., 2011
Maize	Gujarat, India	PPB programme produced several varieties that have performed well in research-station and on-farm trials. One of them, GDRM-187, has been officially released as GM-6 for cultivation in hill areas of Gujarat state, India.	Witcombe et al., 2003
	Mexico and Honduras	Farmers' selection seemed to offer the greatest yield benefit over experiment station selection on the farm with the lowest yield potential	Smith et al., 2001
Cotton	Angaradebou, Mone, Savalou, Okpara in Benin republic and Samaru in Nigeria	Farmers made significant improvement in population density, days to boll opening, seed cotton yield and seed index. The average of the population from farmer's selection was compared to the average of the research selection.	Djaboutou et al., 2007

II. Participatory Varietal Selection (PVS)

Participatory varietal selection (PVS) is the selection process of testing released or pre-released advanced lines and local or traditional varieties, by farmers, on-farm, for increasing production in diverse agro-ecological conditions. PVS underscores the importance of partnership between farmers and researchers, with the strong support of development workers for wider technology promotion. The main goal of PVS is to efficiently transfer improved varieties to farmers in order to reduce the time required to move varieties onto farmers' field, determine the varieties that farmers want to grow, learn the traits that farmer's value in varieties to assist breeding and selection.

Steps to identify farmers preferred variety through PVS

1. Situation analysis and identify farmers' needs
2. Search for genetic materials to test in farmer's condition
3. Experimentation of on-farm research and
4. Dissemination of preferred varieties

Designing PVS

There are two types of trials viz. (i) researcher-managed, (ii) farmer-managed. Researcher-managed is similar to a research station trial, except that it is conducted in farmers' field. The second one is farmer-managed (FM) PVS, is closely associated with the farmer's cropping system. Only top-performing varieties/genotypes, which are determined from previous researchers managed PVS, are included in this trials to verify and evaluate the performance of varieties/genotypes chosen by the farmers themselves.

Evaluation of many varieties of different maturity groups (early, medium and late maturity) in a single instance may be practically difficult. Such a wide varietal mix, simultaneous evaluation may automatically bias against some varieties. Grouping the varieties by maturity at planting could partially overcome the problem—if the information is available. The time of planting should coincide with the farmers' planting time so that during evaluation visits, farmers can better compare the PVS entries with their local varieties. Cooking quality of PVS varieties should be evaluated three months after harvest, when the grains have reached equilibrium, or have 'rested.' PVS have been successfully implemented in different crops in many developing countries. Farmers were interestingly involved in participatory research to select varieties of their preference and need (Table 2). PVS is effective and reliable for identifying appropriate cultivars for resource-poor farmers. Partnerships between breeders and NGOs would be a most effective way of carrying out PVS programmes. Wider adoption of farmer participatory methodology by both NGOs and governmental organisations result in rapid adoption of higher-yielding cultivars in marginal environments.

Table 2. Few examples of Participatory varietal selection employed in different crops

Crop	Location	Objective	No of varieties/hybrids included in PVS	Varieties preferred by farmers	Remarks	**Reference**
Rice	West central Bhutan	To broaden the genetic base of rice crop	Two released and four pre-released varieties	Farmers have adopted one released and one pre-released variety	Now 80% of the farmers cultivate new varieties selected through PVS along with their local variety	**Tshewang and Ghimiray, 2010**
Wheat	Haryana, India	Increasing wheat productivity in a sustainable way, promoting resource conservation technologies for the north western India, increasing the profitability of farmers in rice-wheat system, and training the farmers on resource conservations technologies and seed production	Nine	PBW 502 was ranked first followed by PBW 343, HD 2687, UP 2338, WH 711, PBW 373, UP 2425, RAJ 3765 and WH 542.	Higher varietal replacement was achieved. The area under PBW 343 declined, other varieties of similar potential were being adopted.	**Singh et al. , 2008.**
Sorghum	Malawi	To select diverse and productive sorghum lines adapted to local conditions and accepted by farmers	Initially 101 accessions were evaluated and the best 20 accessions were evaluated	Top six accessions Acc 1052, Acc 952, Acc 953, Acc 1002, Acc 967, and Acc 965	Farmers' characterization of several accessions combined with statistical, nutritional, and genetic analyses performed by the breeders were useful in selecting the best elite accessions that have been adopted by the farmers at large.	**Nkongolo et al., 2008**
Cabbage	Tanzania, East Africa	To select cabbage varieties with horticultural characters preferred by farmers	32 which includes hybrids and open pollinated varieties	Cheers HYB, Victoria F1, Pruktor, Riana, Green Coronet, Tropical Delight, Summer Tide, Glory of Enkhuizen, Spring Deligt and Besta	The farmers identified head yield and size, head firmness, shape and taste as important characteristics for good cabbage.	**Adeniji et al., 2010.**
Faba bean	Dabat district, Ethiopia	To evaluate the performance of alternative improved faba bean varieties and select better varieties for further seed production.	Ten improved varieties	Dosha, Wolki and Wayu	Generally, PVS was effective and reliable for identifying appropriate cultivars through partnership with resource-poor farmers.	**Mulualem et al., 2012**

III. Farmers Participatory Seed Production (FPSP)

Seed is the basic and vital input in agriculture. The potential yields of crops depend on quality of the seed used. Use of quality seed alone can enhance the crop productivity by 15-25%. One of the main reasons of low productivity of crops is unavailability of reliable quality seeds in local markers. Timely availability of sufficient quantity of quality seeds of varieties/hybrids adapted to different agro-climatic conditions at affordable prices is a measure of the strength and health of an agricultural economy.

Advantages of FPSP

- ✓ FPSP increases the awareness and access to improved varieties/hybrids and technologies to farmers, thereby enhance the seed replacement ratio
- ✓ Large-scale seed production and distribution through FPSP programme could leads to assured and timely supply of quality seeds to farmers at a reasonable price
- ✓ Employment generation at village level through seed production activities
- ✓ Farmers will get benefited through meetings, training programs organized by researchers for dissemination of useful information and knowledge to farmers on seed production technology, post-harvest technology and quality control

Types of Seed systems

If the mentioned two types of seed systems i.e. (i) formal seed system and (ii) informal seed system are reconsidered, Formal seed systems are deliberately constructed, involving a chain of activities leading to clear products. Example: certified seed of verified/notified varieties. Formal systems generally consist of public sector research institutions, public and private sector agencies producing and marketing seeds, organizations responsible for seed certification and quality control. The guiding principles in the formal system are maintenance of varietal identity and genetic purity and production of seed with optimal physical, physiological and sanitary quality. The formal seed often retains a sufficiently good quality for several generations. However, a formal seed system has the following limitations like, (i) difficulty in addressing the varied needs of small farmers in marginal areas as they offer only a limited range of varieties, (ii) the public sector formal seed system is unable to meet the huge demand of seeds of legumes and oilseeds., (iii) small farmers in remote rural areas are generally by-passed due to poor logistics in seed diffusion, (iv) the private sector formal seed system is reluctant to produce the seed of self-pollinated crops and open-pollinated varieties particularly in legumes and oilseeds due to business considerations and very low seed replacement rate, (v) prohibitive seed prices are a limitation for resource-poor farmers, and (vi) formal seed systems are sensitive to natural disasters and political or other turmoil.

In case of informal system, farmers themselves produce, disseminate and access seed directly from their own harvest, through exchange and exchange among friends, neighbours and relatives; and through local grain markets. Village seed systems, farmer seed systems, or local seed systems are different names for the informal seed system. The varieties disseminated may be landraces or mixed races and may be heterogeneous mixture of different varieties. Limitations of informal systems are (i) varietal integrity and genetic purity are not assured, (ii) seed quality is often suboptimal due to biotic stresses and storage problems, (iii) seed exchange is restricted to a geographical area and is governed by cultural barriers, (iv) crop failures or low yields have a tremendous effect on the availability of seed and local prices.

Farmer's participatory seed production success stories and models

Participatory seed production may be a good option in order to overcome the limitations of both formal and informal seed production and distribution system, and to harvest the benefit of both seed system. Systematic way of seed production by involving farmers under the direct supervision of the researchers will be more effective in timely supply of adequate good quality seeds of different crops. Several institutions have been implemented FPSP in different crops. Some of the successful models are discussed here under.

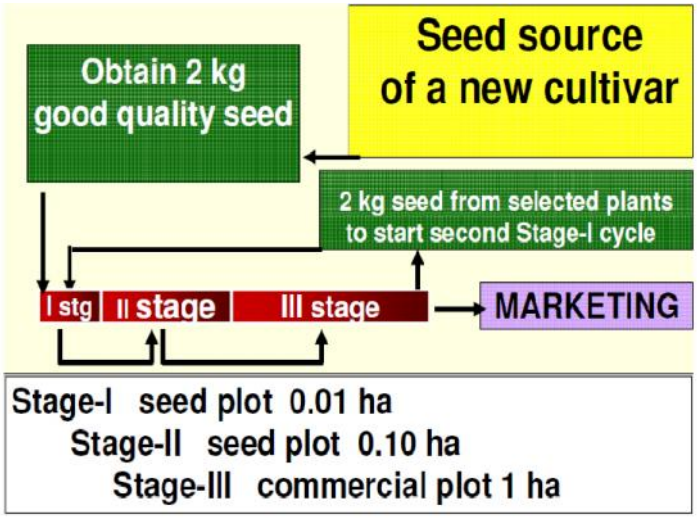
i. Community based seed production model

CBSP (Monyo, et al. 2003) is an informal mechanism of seed production which basically entails the production of seed of the varieties preferred by the farmers by themselves in their own locality by organizing themselves into small groups. These groups cultivate the same variety avoiding cross pollination and follow the recommended cultivation practices particularly seed selection procedures.

Example: In Tanzania (Granquist 2000), 2-3 progressive farmers are selected per village. These farmers are given the appropriate training, and supplied with good quality foundation seed for multiplication, so that they become the source of improved seed for the entire village. Each season the farmers are supplied with foundation seed of different crops; if they produce, say, sorghum seed for the village one year, the next year they will produce groundnut or another crop, returning to sorghum every third year.

ii. Punjabrao Deshmukh Krishi Vidyapeeth (PDKV) Seed system model

Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV) is an agricultural university located at Akola, in Maharashtra, India, has developed a seed system model and successfully adopted in several places. The farmers receiving small seed samples were encouraged to adapt the PDKV model of seed system to multiply the seed of improved varieties and also supply them to the neighboring farmers (Abate, 2012). In Tamil Nadu and Karnataka, PDKV model was promoted (Abate, 2012). Two kg (Groundnut) pods of improved varieties were distributed to farmers. They multiply the seed for two seasons to produce 20 kg in the first season, and then 200 kg at the end of the second season. This 200 kg pod is sufficient to raise crop in 1 ha field in the third season. The cycle was repeated with 2 kg of selected pods from third season. Farmer level self-sufficiency in seed is attained through this model. This system has high adoption among farmers in both states as the majority of them use their own-saved seed.



iii. Directorate of Rape-Mustard Research (DRMR) Model

Directorate of Rape-Mustard Research (DRMR), Bharatpur, India, recently launched a participatory seed production programme with the objective of overall increase in production of mustard at farmers' field by involving public research institutes/ government farms and private stakeholders on mutually beneficial terms for knowledge, dissemination of technology and human resource development. In this programme, breeder/genetically pure

seed was supplied by the Directorate, whereas, all the other inputs for quality seed production are borne by the farmer(s). Regular monitoring was done by a committee of experts to monitor the progress of the seed production field and also to recommends the final procurement. Procurement of whole seed material was done at 10% higher rate than the highest price of mustard seed in the local market. During 2009-10, DRMR procured 77.06 q seed of mustard variety NRCDR- 02 from farmers of Bharatpur district and 22.10 q Truthfully Labeled seed of Rohini from Madhuri kund farm of Veterinary University, Mathura. The model has achieved manifold advantages to the farmers as well as to the Directorate, therefore, DRMR decided to expand it further (Sarson News 2010).

iv. Seed Village concept, "Dharwad Model"

The gap between requirement of quality seeds and supply rate is large. The supply of seeds by public sector organizations and private agencies is insufficient to bridge the gap. To reduce the gap, a group of farmers or villages was identified near to research stations for easier and higher quality multiplication of different varieties of different crops under the "Seed Village". The main objective of the seed-village program is to involve farmers in seed production and thereby to make quality seed available earlier and at a reasonable price. Another objective is to demonstrate and saturate selected potential villages with improved varieties/hybrid seeds of major crops. The implementation of this program by University of Agricultural Science (UAS), Dharwad, Karnataka, India has been most successful and other institutions throughout India have adopted this concept as the "Dharwad Model" Based on the model, large quantities of quality seeds were produced. University scientists monitor activities at all stages.

Under this program, villages with high potential for production are selected and villagers were trained and educated about the Seed Village concept and its importance in dissemination of improved production technologies and saturation of the area with quality seeds. UAS supplied genetically pure seeds of improved varieties on a credit or exchange basis. Breeders/scientists of the respective crops visited seed production plots in each village at 10-15 day intervals and provided technical guidance to the farmers. During the crop season, training programs were organized to educate the farmers on seed production skills. Field days and meetings was also organized by inviting all farmers of a village and of nearby villages to make them aware of improved varieties, the importance of quality seed in achieving increased yields, and providing information regarding the availability of seed. Of the seed produced 70-80% was purchased by the University to distribute seeds under various government programs and the remaining 20-30% of seeds retained to famers, to enable them to distribute the seed to relatives and neighbours within and outside their villages.

v. Farmers participatory seed production through modern seed plot techniques

A farmers participatory action research programme (FPARP) was carried out during 2009–2011 in Baank and Bannki villages in Hamirpur district of Bundelkhand region of Uttar Pradesh, India for seed production and multiplication of major pulses *viz.*, chickpea, lentil and pigeonpea through modern seed plot techniques (SPT). The aim of this program was to generate awareness about SPT and ensure availability of quality seed to farmers. A total of 161 farmers with 61 ha of net cultivated area participated in this programme by sharing half of the seed cost in three major pulses *viz.*, chickpea, lentil and pigeonpea. Farmers were trained through one institutional, six field level and one special training on "*know your crops* (KYC)" for acquiring initial know-how and subsequent skill/expertise development. The study amply demonstrated that yield advantages to the tune of 37.3, 24 and 51% in improved varieties of chickpea, lentil and pigeonpea, respectively over their counterparts (local variety) were obtained following above practice. The highest yields of 1320, 1000 and

1370kg/ha were realized in chickpea, lentil and pigeonpea, respectively under farmers' condition. The average cost of cultivation of improved varieties of chickpea, lentil and pigeonpea were also reduced. Due to FPARP, farmers could able to produce 19.3, 9.0 and 14.2 tonnes of truthfully labelled seed for the chickpea, lentil and pigeonpea crops, respectively. In addition, significant quantity (73.4%) of this produce could also enter into the seed chain (31.2 t of seed materials out of 42.5 t total produce) by the adapted farmers themselves. Chickpea seed was diffused fastest (from 60 adapted farmers to 119 other farmers in the very first season) and farthest (from the adapted villages to other 18 villages in a radius of 24 km).

Conclusion

Integration of PPB, PVS and PSP may be good concept as it is a progressive and viable 'fast track' option to speed up varietal distribution and adoption of new varieties. It offers a solution to the problem of fitting the crop to the target environments, diverse socio-economic conditions, production environments and management practices. The close collaboration between scientists and farmers helps to ensure that farmers had access to select variety that was adapted to their circumstances and met the requirements of the community for quality and livelihood use. Researchers should also involve voluntary organizations such as the SHGs, and other NGOs in participatory research, since, these organizations also work closely with farmers and might help to scaling up of activities. Continuous feedback mechanisms between breeders and farmers should be established to ensure appropriate materials/varieties are disseminated to farmers. However, the challenge lies in institutionalizing farmer participation as integral part in the formal breeding programs.

References

Abate T. (ed.). 2012. Four Seasons of Learning and Engaging Smallholder Farmers: Progress of Phase 1. PO Box 39063, Nairobi, Kenya. International Crops Research Institute for the Semi-Arid Tropics. 258 pp.

Almekinders, C.J.M. and A. Elings, 2001. Collaboration of farmers and breeders: participatory crop improvement in perspective. Euphytica 122: 425-438.

Ceccarelli and S. Grando, 2006. Participatory Plant Breeding: Precept and Practice. In: International Symposium on "Participatory Plant Breeding and Knowledge Management for strengthening Rural Livelihoods". M.S. Swaminathan Research Foundation, Taramani Institutional Area, Third Cross Street, Chennai 600113, India.

Ceccarelli, S., S. Grando, R. Tutwiler, J. Baha, A.M. Martini, H. Salahieh, A. Goodchild & M. Michael, 2000. A methodological study on participatory barley breeding I. Selection Phase. Euphytica 111: 91–104.

Djaboutou M.C., Lançon J., Sekloka E., Alabi S.O., Echekwu C.A., Olarewaju J.D. 2007. Innovative farmer-participatory cotton improvement programme in the Savanna agro-ecology. Agricultura Tropica Et Subtropica Vol. 40 (4): 180-186.

Granquist, B. 2000. On-farm seed production component of the agricultural sector programme support. In in E.S. Monyo, M.Z. Lumbadia, H.M. Saadan, M.A. Mgonja, and G.M. Mitawa (eds.), *Seed System for the New Millennium: An Action Plan for Tanzania. Proceedings of the Stakeholders' Review and Planning Workshop, 7-8 Dec 1999, Dar es Salaam, Tanzania.* PO Box 776, Bulawayo, Zimbabwe: SADC/ICRISAT Sorghum and Millet Improvement Program.

Gyawali, S., K.K. Joshi, and J.R. Witcombe. 2002. Participatory plant breeding in rice in low-altitude production systems in Nepal. In: Witcombe, J.R., L.B. Parr, and G.N. Atlin (edn). Breeding rainfed rice for drought-prone environments: Integrating conventional and participatory plant breeding in South and Southeast Asia.

Proceedings of a DFID plant sciences research programme/IRRI conference, 12-15 March, IRRI, Los Baňos, Laguna, Philippines.

Halewood M, Deupmann P, Sthapit B, Vernooy R and Ceccarelli S. 2007. Participatory plant breeding to promote Farmers' Rights. Bioversity International, Rome, Italy. 7 pp.

Kimani JM, Tongoona P., Derera J. and Nyende A.B. 2011. Upland rice varieties development through Participatory plant breeding. ARPN Journal of Agricultural and Biological Science. VOL. 6 (9): 39-49.

Monyo, E.S., D.D. Rohrbach., and M.A. Mgonja. 2003. New partnerships to strengthen seed systems in Southern Africa: Innovative community/commercial seed supply models. Paper presented to the successful community based seed production strategies, co-organized by CIMMYT and ICRISAT, 3rd – 6th August 2003, CIMMYT/ICRISAT, Harare, Zimbabwe.

Mulualem, T., T. Dessalegn, and Y. Dessalegn. 2012. Participatory varietal selection of faba bean (*Vicia faba* L.) for yield and yield components in Dabat district, Ethiopia. Wudpecker Journal of Agricultural Research Vol. 1(7): 270 – 274.

Sarson News, January - June 2010. Participatory seed production programme for quality seed at DRMR. Published by Director, Directorate of Rapeseed-Mustard Research, Sewar, Bharatpur- 321303 (Raj), India. Vol 14 (1). pp. 9.

Singh, R., R. Chatrath, S.C. Tripathi, G. Singh, B.S. Tyagi, S.K. Singh, J Shoran, A. Kumar, S. Singh, D. Rai and S. Kumar. 2008. Impact of Participatory Varietal Selection on Varietal Diversification in Northern India. Indian Res. J. Ext. Edu. 8 (2 & 3): 14- 18.

Smith, M.E., G. Fernando Castillo and F. Gómez. 2001. Participatory plant breeding with maize in Mexico and Honduras. Euphytica 122: 551-565.

Sperling, L., J.A. Ashby, M.E. Smith, E. Weltzien and S. McGuire, 2001. A framework for analyzing participatory plant breeding approaches and results. Euphytica 122: 439-450

Vernooy, R. 2003. Seeds that Give: Participatory Plant Breeding; International Development Research Centre: Ottawa, ON, Canada.

Virk, D.S., D.N. Singh, S.C. Prasad, J.S. Gangwar and J.R. Witcombe1 2003. Collaborative and consultative participatory plant breeding of rice for the rainfed uplands of eastern India. *Euphytica* **132:** 95-108.

Witcombe JR, Joshi A and Goyal SN. 2003. PPB in maize: A case study from Gujarat, India. Euphytica 120:413-422.

Seed production in Rice and Glimpses on Hybrid Rice and System of Rice Intensification (SRI)

Introduction

Rice is the most important food crop that feeds more than half of the world's population. It is the major staple food crop for 17 countries in Asia and the Pacific, nine countries in North and South America and eight countries in Africa. World production of rice has risen steadily from about 200 million tonnes in 1960 to over 678 million tonnes in 2009. Asia is the leader in rice production accounting for about 90% of the total world's production. Over 75% of the world supply is consumed by people in Asian countries and thus rice is of immense importance to food security of Asia. The demand for rice is expected to increase further in view of expected increase in the population. Quality of seed has a direct and significant bearing on productivity. Good quality seed can increase yield by 15-20%. However, the extent of this increase is directly proportional to the quality of seed that is being sown. High-quality seed enables farmers to grow crops with most economical planting rate, vigorous seedling establishment, uniform plant stand, faster growth rate and better resistance to stress and diseases and uniformity in ripening.

Advent of semi-dwarf, non lodging, fertilizer responsive high yielding varieties coupled with adoption of improved crop production and protection technologies led to spectacular increase in rice production during the 1970-80 and ushered in an era of green revolution. Miracle rice in the form of IR 8 developed by using the dwarfing gene from the Taiwanese rice variety 'Dee-Gee-Woo-Gen' laid the strong foundation for varietal improvement. Among the various genetic approaches contemplated to raise the yield ceiling in rice, hybrid rice has proved to be readily adoptable and practically feasible.

Seed production in rice varieties

A crop breeder develops a variety by the process of selecting a novel recombinant from existing natural variation or created segregating population. It is essential that no change be allowed to interrupt the genetic quality. Maintenance of varietal purity is essential which can be achieved through good quality seed production practices.

Nucleus Seed production

It is the responsibility of the concerned breeder to produce and supply the nucleus and breeder seed. The seed of a given variety maintained by the breeder forms the base material to start the nucleus seed production.

Base material for nucleus seed production: For released varieties the material may be taken from Breeder seed/Nucleus seed production plot, where as for pre-released varieties, the source may be Advanced Variety Trial-2 (Rangaswamy *et al*., 2000). Sufficient numbers of single plants (minimum of 200) are selected based on the morphological identity, uniformity and genetic purity and these should be serially numbered. From the selected single plants panicle is harvested, threshed, cleaned, dried and screened in the laboratory for grain characters specified for given variety. The panicles confirming to the specified grain characters are retained to form material for production of nucleus seed by panicle-progeny row method.

The seedlings of each progeny row are transplanted in a single row of about 6m length with a spacing of 30 x 20 cm. Gap filling should not be done in nucleus seed production. All standard agronomic practices for the rice crop should be followed. Nucleus seed plot has to be critically observed at five different stages by the breeder himself.

1. Maximum tillering stage: observations for vigour, tillering, plant height, sheat colour, leaf angle, and other plant and leaf characters.
2. Boot leaf stage: observations for early flowering and angle of boot leaf.
3. 50% flowering: observations for late flowering panicle type and panicle exertion.
4. Dough stage: observations for grain type, glume tip colour, and other grain characters.
5. Maturity stage: observations for glume colour and grain colour.

The breeder should examine each and every plant carefully and any row found to be deviant at any stage for any of the characters the whole line should be uprooted.

Breeder seed production of varieties

Nucleus seed is the source material for producing the breeder seed. About 20 kg seed per hectare would be required. The crop should be inspected by breeder at regular intervals, mainly at five different stages as suggested for nucleus seed production. The breeder seed plot should be monitored by a team constituted for the purpose during flowering to maturity period. After obtaining the approval from the monitoring team, the crop can be harvested at maturity, threshed, cleaned, dried, bagged and labeled.

Similarly, foundation and certified seed may be produced to increase the sufficient quantity of seed for distribution to the farmers.

Hybrid rice seed production

Since the yield of high yielding varieties (HYVs) of rice is plateauing, it is rather difficult to meet the domestic demand of increasing population by the present day inbred varieties. The rice hybrids, recently introduced in cultivation, on an average, give 10 to 15 q/ha additional yield over the conventional varieties (about 20 % increase). Therefore, the introduction of hybrids and popularization of their production technology are feasible and readily adoptable to achieve targeted production. Hybrid technology which has made wonders in rice production in China may give similar dividends in India in case the adequate quantity of quality seed of hybrid rice is made available at reasonable price to the farmers. The success of hybrid rice technology primarily depends on genetic purity, timely availability and the affordability of hybrid seed costs to the farmers. There are mainly three methods of hybrid seed production followed in rice.

Cytoplasmic Genetic Male Sterility (CGMS): The CGMS system involving CMS (A line), maintainer (B Line) and restorer (R) lines (three-line system) is commonly used for commercial hybrid seed production in many hybrid rice growing countries of the world. The CGMS is the result of interaction between specific sterility inducing cytoplasm and the nuclear genes. To get male sterility expression both sterile cytoplasm and recessive (rf) nuclear genes are required. Hybrid seed production using the CGMS system mainly involves the following two steps.

I. Production of 'A' line (A x B): CMS line is always multiplied by crossing it with its maintainer (B) line.
II. Production of hybrid seed (A x R): Restorer or 'R' line possesses dominant fertility restorer genes, when crossed to a CMS line it restores fertility in the derived hybrid.

Production of nucleus and breeder seed

Parental lines get contaminated at different stages of handling and it is necessary to regularly purify them (at least once in three years). Parental lines have to be purified under the direct supervision of the rice breeder. Purification process essentially involves four steps: i. Growing the source material (Source nursery); ii. Test crossing (Test cross nursery); iii. Evaluating the test crosses (Identification nursery); and iv. Multiplication of the lines

(Multiplication nursery). Breeder seed production involves the further multiplication of A, B and R lines using nucleus seed. The seed material obtained from systematic paired crossing can be used to produce the breeder seed. Breeder seed production has to be taken up in a field where no rice crop is grown during previous crop season. Recommended isolation distance is 300 – 500 m. A row ratio of 2 : 4 and 2 : 6 can be adopted for nucleus and breeder seed production respectively. Utmost care is needed for meticulous rouging as the seed has to be very pure. Other practices are similar to those recommended for hybrid seed production. Further multiplication as foundation seed of A, B and R lines can be done in similar fashion. The seed chain of nucleus, breeder, foundation and certified seed production should be maintained regularly with highest standard of genetic and physical purity at each of the stages.

Two line system

Environment Sensitive Genic Male Sterility (EGMS) has been deployed for developing commercial hybrids particularly in rice. In this system, male sterility condition is due to the interaction of nuclear genes with environmental factors such as photoperiod, temperature or both. A particular range, duration or concentration of environmental factors, at sensitive stage of the plant induces male sterility, whereas some other range, duration or concentration induces fertility in the same plant (Virmani and Ahmed, 2001).

The EGMS comprises of the following three types:

1. **Photoperiod sensitive Genic Male sterility (PGMS)** : The line is sterile when the photoperiod (day light) exceeds 14 h and the same line becomes fertile when subjected to photoperiod of < 13 h. PGMS system is useful and can be deployed in temperate countries where the day length differs considerably during different seasons.
2. **Temperature sensitive Genic Male Sterility (TGMS):** The line is sterile when temperature exceeds 32°C / 24°C (day / night) and becomes fertile when the temperature is below 24°C / 18°C (day / night). However, in few cases, sterility is observed at lower temperature and fertility is observed at higher temperatures. TGMS system can be utilized in tropical and sub tropical countries, where there are large temperature differences across locations, regions, seasons and at different attitudes.
3. **Photo-thermo sensitive Genic Male Sterility (PTGMS):** This line is controlled by the interaction of photoperiod and temperature, most of the PGMS lines earlier discovered such as the classical Nongken 585 were later reported to fall in this category. At relatively low temperatures, short light hours ensure complete fertility, while at relatively higher temperature, still more short light hours are needed to make it completely fertile.

Seed productions of two line hybrids

Seed production of two line rice hybrids is not much different from that of three line hybrids. Most important consideration is to precisely determine the location or season which is ideal for inducing complete male sterility. Hybrid seed production with EGMS lines involved two steps. EGMS lines are multiplied at appropriate locations and seasons where stable fertility inducing environmental (photoperiod / temperature) conditions prevail for a continuous period of 30 days. Let us take the example of TGMS lines which turn to fertility at lower temperature and the most ideal temperature regime to induce higher fertility is 27°C / 21°C. In this case, the TGMS line has to be planted in such a way that the sensitive stage (5-20 days after planting) occurs in the middle of the fertility inducing phase.

Advantages of two line v/s three line system

1. Wide choice of parental lines, hence increased chances of identifying superior heterotic hybrids
2. Multiplication of female line is very simple, since it is multiplied as any ordinary genotype through self pollination
3. Risk of outbreak of epidemics associated with large scale use of unitary source of cytoplasm as well as the negative effects of sterility inducing cytoplasm can be avoided.
4. In rice, two line system is specifically useful for developing hybrids in Basmati and Japonica type, since the frequency of restorer gene(s) is very low.
5. Magnitude of heterosis in two line hybrids is 5 to 10 % higher than in three line hybrids.

Some of the important rice hybrids released in India

Hybrid	Year of release	Duration	Developed by	Characteristics
APHR-1	1994	130-135	APAU, Hyderabad	Suitable for uplands of coastal AP
APRH-2	1994	120-125	APAU, Hyderabad	Grains are long and slender
CORH-1	1994	110-115	TNAU, Coimbatore	Grains are medium slender, resistant to the gall midge
KRH-1	1994	120-125	VC Farm , Mandya , Karnataka	Suitable for irrigated areas
DRRH-1	1996	125-130	DRR, Hyderabad	Grains are large slendor, mild aroma, resistant to blast disease
KRH-2	1996	130-135	VC Farm, Mandya, Karnataka	Grains are LB, resistant to the pest, BPH and blast disease, suitable for irrigated areas
Pusa RH-10	2001	125	IARI, New Delhi	Aromatic basmati hybrid

Chemically induced male sterility using chemical hybridizing agents / Gametocides

A large number of chemical compounds possess gametocidal activity, which induces male sterility when used in appropriate concentration. The male gametocide are absorbed by leaves and translocated to panicle within 30 minutes of spraying. Male gametocides concentration in panicle amounts to 0.001% of the total spraying. Within 6 hours the amount reaches to 0.01% of the total spray used. They are present in pistil, stamen and lodicules within the spikelet in the ratio 2:1:1 respectively which makes the pollen to be sterile.

Chemical emasculants / gametocides

- **Malic Hydrazide**: 1-2 dichloropyridoxin 3, 6 dione. Crystals of MH will not dissolve in water. To get required strength of MH, first we have to dissolve in NaOH 10 N (least quantity of NaOH should be used) and later make it up with water.
- **Ethrel**: 2 chloroethyl phosphonic acid. We can get up to 90% of male sterility.
    - 6000-8000 ppm 1st spray – one week before boot leaf stage
    - 4000-6000 ppm 2nd spray – boot leaf stage.
- **Zinc methyl arsenate** – 4000 ppm
- **Sodium methyl arsenate** – 2000 ppm
- **Calcium sulphomate** – 2000 ppm

Isolation distance

Space isolation: An isolation distance of over 100m is found to be satisfactory. Within this range, no other rice varieties should be grown except the pollen parent.

Time isolation: Generally, a time of over 25 days is practiced. In other words, the heading stage of varieties grown within 100 m around the seed production field should be over 25 days earlier or later than that of the CMS line.

Barrier isolation: Topographic features like hills, woodlot or vegetative barriers like maize, sesbania, sugarcane etc., can be utilized. A distance over 30m and artificial obstacles (plastic sheets above 2m height) will provide better isolation.

Seed rate: A line: 20 kg/ha

B and R lines: 10 kg/ha

Spacing: In hybrid rice seed production the seed parent and pollen parent are planted in a certain row ratio at certain spacing.

- Between 'R' line rows: 30 cm
- Between 'A' line rows: 15 cm
- Between 'R' & 'A' line blocks: 20 – 30 cm
- Between hills ('A' & 'R' lines): 15 cm
- Row Ratio: 2R: 8A

Manures and fertilizer: Fertilizer dose - 150: 60: 60 NPK kg /ha and FYM - 10 t /ha. N and K should be applied thrice *viz*, basal, active tillering and panicle initiation stage. Fertilizer dose and splits may be increased or decreased according to soil and crop condition. More splits of N to male line will prolong pollen supply to female line.

Roguing: The undesirable and volunteer plants either in A or R line rows that differ from plants and not true to type should be removed. In A line, pollen shedders and partials should also be removed. The most important stages for rouging are at maximum tillering stage, at flowering and just before harvesting.

Supplementary pollination

Rod driving and rope pulling: Shaking the R line panicles by rope pulling at panicle level or rod driving during anthesis can make the anthers dehisce and spread the pollen widely and evenly, thus the out crossing rate could be increased. It is more effective especially on clam or breezy days. Generally, supplementary pollination is carried out at 30 min interval for 5 times daily both in morning and evening hours during peak anthesis (10-12 am and 2-4 pm) until no pollen remains on the R line. It is not needed when the wind is greater than moderate breeze.

Leaf clipping: Leaves taller than the panicles are the main obstacles to cross pollination. The flag leaf cutting enhances uniform pollen movement and wide dispersal of the pollen grains to give higher seed set. The blade of flag leaf is cut back ½ to ⅓ from the top.

Application of gibberellins: GA_3 plays an important role in rice hybrid seed production. About 25 to 30 per cent spikelets of a panicle are inside the flag leaf sheath in most of the indica CMS lines than that of the japonica CMS lines. GA_3, has a definite role in exertion of panicle. It is recommended that spray of GA_3 @ 75 g/ha with knapsack sprayer in two split doses, i.e. 1st spray on 15 – 20% earhead emergence and 2nd spray in the next day for enhanced seed set. GA_3 will not dissolve in water and hence it should be dissolved in 75 –

90% alcohol (1 gm in 20 -25 ml of alcohol) and make the required solution. Spraying should be done at 8 to 10 a.m. and 4 to 6 p. m.

Adjustment of flowering through management practices

- Ideal synchronization – male is late by 2-3 days
- Flooding of water enhances flowering in male
- Draining of water delays flowering in male
- Urea spray @ 2 % delays flowering
- Foliar spray of KH_2PO_4 @ 1.5 % enhances flowering

Harvesting

The plants with intact panicles are harvested. Lodged plants should not be selected for seed purpose. Delayed harvest may lead to heavy shattering. Bundled plants should be stacked as earheads facing side to avoid heat damage. Male parent should be harvested first and care should be taken to avoid admixture of male line with female while harvesting.

Threshing and drying

The harvested plants are stacked in clean threshing floor. Then, either by hand beating or with use of LCT threshers, the seeds are separated from the plant. Thresh at proper moisture content to avoid crushing/ cracking (16-17%). The threshed seed should be winnowed and dried to reduce the seed moisture content to 12%. The seed should not be dried under direct sun between 12 to 3.00 p.m. and during hot sunny days.

Seed certification standards

The recommended field and seed standards for seed certification are given below:

1. Field standard			
Factors		**Foundation**	**Certified**
Off-types (Female plant) (%)		0.05	0.2
Off-types (Male parent) (%)		0.05	0.2
Pollen shedders (Female parents) (%)		0.05	0.1
Objectionable weeds (%)		0.01	0.02
2. Seed Standards			
1.	Pure seed (minimum) (%)	98	98
2.	Inert matter (maximum) (%)	2	2
3.	Dehusked seed (maximum) (%)	2	2
4.	Other crop seeds (maximum)	10/kg	20/kg
5.	Other variety seeds (maximum)	10/kg	20/kg
6.	Objectionable weed seeds (maximum)	2/kg	5/kg
7.	Germination per cent (maximum)	80%	80%
8.	Moisture content (maximum)		
	Moisture pervious containers	13%	13%
	Moisture vapour proof containers	8%	8%

System of Rice Intensification (SRI)

Rising food demand, slowing productivity growth, poor N-use efficiency in rice, and environmental degradation necessitate the development of more productive, environmentally-sound crop and soil management practices. The system of rice intensification (SRI) has been proposed as a methodology to address these problems. SRI was developed in 1983 by the

French Jesuit Father Henri de Laulanie in Madagascar after 20 years of observation and experimentation (Laulanie, 2011).

SRI concepts and practices have continued to evolve as they are being adapted to rain-fed (unirrigated) conditions and with transplanting being superseded sometimes by direct-seeding. Regarding the management of rice plants, the basic practices of SRI according to SRI-Rice at Cornell University are:

- Rice plant seedlings should be transplanted very young (usually just 8-12 days old) with just two small leaves
- Seedlings should be transplanted carefully and quickly to avoid transplanting injury.
- Seedlings should be transplanted singly, with only one per hill instead of 3-4 together to minimize root competition
- Seedlings should be widely spaced to encourage greater root and canopy growth
- Seedlings should be transplanted in a square grid pattern (25x25 cm, or wider in good quality soil)

Results from the field studies of Directorate of Rice Research (DRR) conducted in four seasons and also AICRP trials indicate good scope for saving irrigation besides improving rice growth and production. However, water saving could be attributed to reduction in water losses through percolation/seepage/ runoff/evaporation that are common with flooded rice culture. Increased productivity is associated with improved plant growth, yield attributes and higher grain output has been apparent

References

Laulanie, H. D., (2011). Intensive Rice Farming in Madagascar, *Tropicultura,* **29(3):** 183-187.

Rangaswamy, M., Ramalingam, R. S., Arunmugachamy, S and Vidyanathan, P, (2000). Rice – Nucleus and Breeeder seed production. Technical bulletin no. 17 National Seed project (NSP), ICAR, New Delhi. p. 42.

Virmani S.S. and Ilyas Ahmed M. (2001): Environmentally induced genic male sterility in crop plants. Advances in Agronomy 72: 139-195.

Seed Production in Potato and TPS

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops in human nutrition and is popular throughout the world. Now, potato occupies fourth position in terms of its importance after rice, wheat and maize in world front and is principal source of carbohydrate in few countries. In India potato is most important crop after rice and wheat. World scenario is that more than 3 billion people consume potatoes. Over the past three decades, Asia has experienced the world's highest annual growth rate in potato production. With its short cropping cycle, potato fits well into multiple cropping system calendar and is particularly compatible with fast- growing hybrid cereals.

In India potato is grown in almost all the states. Nearly 80% of the crop is grown in Indo- Gangetic plains comprising Punjab, Haryana, Utter Pradesh, Bihar and West Bengal. During the past decade, potato has emerged as high yielding cash crop in India. It has gained economic importance in the country and there is a rapid increase in area and production under its cultivation. Area increased from 1.2 million ha in 2000 to 1.9 m hectares in 2011 with a production of 46.6 M.T. in 2011-12. However, the average yield of 24.52 tons per hectare is low as compared to developed potato growing countries viz. New Zealand, Netherlands, France, Germany and USA. Potatoes contribute about 1.3% of the gross production from agricultural & allied activities in India.

Non-availability of quality seed tubers, high seed cost, virus infiltration in seed tubers causing degeneration of seed stocks and problems of long distance transport of seed from seed-producing areas have led to the development of true potato seed (TPS) technology of potato production. It has gained significance because unlike seed tubers, TPS can be produced in all parts of the country providing extra light for 4-5 hours depending upon climatic condition. It can be easily stored over long periods of time. Disease transmission by TPS is negligible and it provides cheap planting material. They also provide better disease resistance because of high heterogeneity in the population.

Seed

Potato crop is generally raised through tubers. It is the bud within eye on tuber which grows into sprouts. These sprouted tubers when planted in the soil establish itself into a plant. Productivity per se primarily depends on the quality of seed. Quality seed implies that the seed tubers should be: (a) Pure, free from varietal mixtures (b) Free from diseases and pests (c) Viable or physiologically sound capable of sprouting readily and (d) suitable variety.

Specific requirements

Factor	Maximum permissible limits			
	Stage	Foundation (%)		Certified (%)
		Stage I	Stage II	
Off types	I & II Inspec.	0.050	0.050	0.10
Mild mosaic plants	I & II Inspec.	1.0	2.0	3.0
Severe mosaic, leaf roll and yellows	I & II Inspec.	0.50	0.75	1.0
Total virus	----------	1.0	2.0	3.0
Plants infected by brown rot	I & II Inspec.	None	None	3 plants per ha.
Re-growth of plants after destruction of haulms	IV Inspection	0.50	0.50	0.50

Maximum tolerance limit of potato tubers showing visible symptoms caused by the diseases

Diseases	Maximum permissible		
	Foundation (%)		Certified (%)
	Stage I	Stage II	
Late blight, dry rot or charcoal rot	1.0	1.0	1.0
Wet rot	None	None	None
Common scab	3.0	3.0	3.0
Black scurf	5.0	5.0	5.0
Total diseases	5.0	5.0	5.0

Potato seed standards: Specification in respect of size and weight of seed material for FS-I, FS-II and certified seeds are:

Size	Mean length and two widths at the middle of tuber	Corresponding weight
a) Hill seed(HS) seed size large size	 30-60 mm Above 60 mm	 25-150 g Above 150 g
b) Plains seed (PS) seed size large size	 30-55 mm Above 55 mm	 25-125 g Above 125 g

True potato seed (TPS)

TPS is emerging as a promising alternative to the traditional method of using seed tubers in developing countries like India. Traditionally farmers were growing potatoes by planting seed tubers for several reasons. Seed tubers are easy to plant, and plants grow quickly vigorously, harvested tubers are uniform in size, and yields are usually high. Despite of mentioned advantages, propagation by seed tubers has hampered to a certain extent, the adoption and expansion of potato production, especially in developing countries.

Production of potato by seed tubers, have constraints viz. high production cost, tubers are often the main carriers of diseases-pests and these diseases can reduce yields, seed tubers are perishable, bulky and difficult to transport to distant production areas. Furthermore, seed tubers are often require costly refrigerated storage facilities to prevent rotting in storage. But, most important, seed tubers used for planning represent food that is being buried in the field when it could be eaten instead. Two to three tons of seed tuber needed to plant one hectare and one is enough to feed an average Indian family of 5 to 20 years.

Potato production from TPS

a) **Transplanting to field**

The seedlings are raised in nursery beds. About 150 g TPS and 75 m^2 nursery area is required to produce sufficient seedling for transplanting in one hectare. Organic manure / FYM should be applied in enough quantities to nursery bed. Seedling emergence starts normally after eight to ten days of sowing. Seedling are thinned a week to ten days after emergence to produce healthy seedlings. Approximately 35 days after sowing, seedlings are ready for transplanting in main field. Further reducing transplanting shock due to adverse climatic conditions, seedlings can be transplanted with soil-covered roots using containers such as compost cubes, banana leaf, or thin plastic trays. This method is quite suitable for raising commercial crop in Assam, E-UP, Bihar, West Bengal, MP and Gujarat and areas

where vegetable production by transplanting is a common practice but not suitable for Punjab, Haryana and W-UP where the temperature at planting are high and winters are also severe, resulting stunted growth of the seedlings crop and consequent low yields. This approach suffer from the main short-coming that it takes more time to establish in the field and more labour intensive owing to longer duration.

b) **Planting seedling tubers produced from TPS**

The seedling tubers are produced by transplanting seedlings in nursery beds at a spacing of 10x10 cm or by direct seedling of TPS (2 seeds/hole) at the same spacing. About 40-50 g TPS and 300 m^2 nursery area are sufficient to produce enough tubers for planting one hectare area in the next season. When nursery is properly managed, a bed will yield as many as 800 clean seedling tubers per m^2. This approach is also good for the plateau areas where kharif and rabi crops are taken. The seedling tubers produced in kharif season, thus reducing the dependence on the seed produced in the northern states of the country.

Nutrient Management

The production of quality seed of potatoes require high amount of fertilizers because it is having shallow and sparse root system. However, the fertilizer recommendations should be based on soil and plant tests. The nutrient demand of crops are depends on soil and climatic conditions. Nitrogen need of the crop is high when grown on alluvial soils of the plains due to low organic matter of the soils, while phosphorous requirement is high when grown on acidic soils.

Zone wise fertilizer requirement of seed potato crops (kg/ha) are

Zone	Nitrogen	Phosphorous	Potassium
North west hills zone	100-120	100	100
North-eastern hills zone	100-120	120-150	60
NWPZ	150-200	80-100	100-150
NCPZ	150-200	80-100	100-150
NEPZ	150-200	60	100-150
Plateau zone	100-120	60	60
Nilgiri zone	90-120	130-150	90
For TPS crops	200	100-150	120-180

Weed management

Weeds are major problem for production of quality seed tubers or true potato seeds because of frequent irrigation, high fertilizer application and short duration of crops invite more weed competition. Herbicides like linuron or simazine @ 0.50 kg/ha applied as pre emergence are effective against most of weeds. For early post-emergence Paraquat @ 0.4-0.6 kg/ha can be applied to manage weed population below critical levels.

Seed Production in Maize with Emphasis on Single Cross Hybrids (SCH) and Quality Protein Maize (QPM)

Introduction

Maize (*Zea mays* L.) is the multi utility crop with wider adaptability and highest genetic yield potential among the cereals. It is an important cereal crop in world after wheat and rice. Maize is unique among the cereals on account of various features which make it as one of the top three cereals and its amenability to diverse uses is unparallel. Ranging from pharmaceuticals to many other industrial uses like biofuel, besides food, feed and fodder purpose, diverse corns find their place. There are many types of maize based on the grain composition such as dent, flint, pop, pod, waxy and floury maize. At global level, India ranks 4th in area and 7th in production of maize. In India as per the latest report, maize area, production and productivity is 8.55mha, 21.73mt and 2.54t/ha, respectively (2010-11). To meet the growing demand of maize, focused research on single cross hybrid (SCH) across the country has helped in increasing production and productivity of maize. Due to focused research on SCH, the national average productivity is improving at the rate of >120 kg/ha per annum (2006- 2010). High yielding SCH seeds with improved package of practices boosted maize production registering highest growth rate of 8.0% (2006-2010). This is the highest among all other food crops, surpassing the 4% growth rate for agriculture and 4.7% for maize set by Planning Commission in 11th Five Year Plan (FYP) and has contributed immensely to the national economy. The production target of 45-50 million tons by 2030 could be achieved through the deployment of SCH coupled with improved production and protection technologies.

In Central and South America, Africa, and Asia, several hundred million people rely on maize as their principal daily food, for weaning babies, and for feeding livestock. Unfortunately maize (corn) has two significant flaws; it lacks the full range of amino acids, namely lysine and tryptophan, needed to produce proteins, and has its niacin (vitamin B_3) bound in an indigestible complex. Thus, conventional maize is a poor-quality food staple; unless consumed as part of a varied diet – which is beyond the means of most people in the developing world. Quality Protein Maize (QPM) contains nearly twice as much usable protein as other maize (or corn) grown in the tropics and yields 10% more grain than traditional varieties of maize. QPM produces 70-100% more of lysine and tryptophan than the most modern varieties of tropical maize. These two amino acids allow the body to manufacture complete proteins, thereby eliminating wet-malnutrition. In addition tryptophan can be converted in the body to Niacin, which theoretically reduces the incidence of Pellagra.

Maize single cross hybrids (SCH) research in India

The focused research in SCH helped in addressing several issues of biotic and abiotic stresses *viz.*, lowering water table, rising temperature, etc. The success story of SCH in US Corn belt is well known. Its impact has been realized in China, Brazil, Canada and many other countries too. Even in USA with cultivation of Open Pollinated Varieties the productivity remained less than 2 tons/ha. And further, the results were not encouraging with the coverage of 100% area under double cross hybrids and the productivity was only 3.5 tons/ha over a period of 25 years (1936-1930). But with the adoption of SCH technology in 1960s USA productivity increased 3.5 tons/ha (1960) to 9.68 tons/ha (2008). The annual increase in productivity with 100% coverage under double cross hybrid was only 60kg/annum in 25 years and with single cross hybrid cultivation the productivity per annum is more than double in a period of 50 years. Parallel to USA in India the productivity

remained less than 1 ton/ha for many decades continued. After shifting to SCH technology (2006-2008), in India has witnessed 30% increase in production and 27% increase in productivity within two years with the coverage of 20% area under SCH. There is also 15% annual increase in production and more than 12% increase in productivity. India became net importer to potential exporter. This is the visible impact of single cross hybrid technology.

Directorate of Maize Research (DMR) with active support of AICRP (Maize) centres has developed and released as many as 234 cultivars since inception of the Project in 1957. Of these, 132 hybrids have been developed and released since 1961. Nearly four dozen are public-bred single cross hybrids of different maturity and suitable for cultivation in different agro-climatic conditions of the country, which including single cross hybrids of QPM and baby corn have been developed and released, and sweet corn single cross hybrids also released, SCH-1 by Haryana Agricultural University, Hisar. The present growth rate in maize production (8.94%) is much more than its consumption of around 5%. The focused research on single cross hybrid across the country has helped in increasing production and productivity of maize. Cultivation of single cross hybrids has become relatively more remunerative leading to expansion in non-traditional areas. India has great potential to export grain, feed, seed and specialty corn due to low cost of production and less freight charges. Thus, India is now net exporter with annual export of 2.5-3.0 mt since 2008-09.

Therefore development of single cross hybrids and their adoption in farmers' field should become the main strategy to ensure food and feed security of the developing World.

Advantages of single cross hybrids

- Uniformity and highest yield potential among cereals
- F_1 plants of single cross hybrids are homogeneous in nature
- Additive, dominance and epistasis component of variation is available for exploitation in SCH

Single cross hybrid (SCH) seed production

A SCH is the hybrid progeny from pollination between two homozygous inbred lines. For commercial hybrid maize seed production, seed producers employ various practices to control maize pollination including crop rotation to minimize volunteer maize plants and reduce the need for roguing, selection of parent seed of high purity, vigorous roguing of both male and female rows to insure only the desired parents remain, aggressive detasseling of the female parent to prevent self pollination, temporal isolation of the silking period so as not to coincide with corn in nearby fields, planting of pollen parent border rows around the seed production field to insure that the field is available with the enormous pollen and to dilute *adventitious pollen*, and adequate isolation distance to insure acceptable levels of protection from a adventitious pollen. Based on the descriptors, the inbred lines are categorized as female and/or male. Field management is essential for good seed production which requires adequate site selection including isolation, best agronomic management practices, appropriate female : male ratios, achieving a good nick between parental lines, properly controlling pollen production in female rows through detasseling, effectively removing off-type plants, and harvesting the crop in a timely fashion.

Maize hybrid seed production consists of three stages (Every stage of seed production is carried out in isolation)

Stage of seed productions	Particulars	Remarks
1. Breeder seed	Parental lines are increased in limited area	Parents should have genetic purity and certifying standards.
2. Foundation seed	The seed obtained on male and female rows is called foundation seed	Parents should have genetic purity and Certifying standards.
3. Certified seed	Male and Female single crosses are generally sown in 2:4 ratio. The seed obtained on female parent is called certified Seed or Hybrid seed.	Detasseling should be attended in all female plants at proper time. Both single crosses (Male & Female) should posses genetic purity and certifying standards.

Seed Standards in maize

Details	Breeder Seed	Foundation Seed	Certified Seed
Pure seed minimum (%)	100	98.0	98.0
Insert matter (%)	None	2.0	2.0
Weed seed (%)	None	None	None
Other crop seed (%)	None	0.2	0.2
Germination capacity minimum (%)	98.0	90.0	90.0

Factors affecting maize seed production

1. **Planting ratio**

- ✓ Uniform planting ratio of male and female lines in 2:4 for certified seed production plots has been recommended.
- ✓ Maize inbreds vary considerably in respect of plant height, Panicle size, the amount of pollen produced and duration of pollen availability. Sometime this factor may pose some problem to the producers.

2. **Non-synchronization of flowering**

- ✓ Good seed set in seed parent can be achieved by chronological adjustment of pollen shedding and silking respectively.
- ✓ Prolongation of effective flowering period, planting design, efficient alteration of rows planting ratio, staggered planting are some of measures which are effectively used to ensure maximum synchronisation and good seed set.

3. **Genetic drift**

- ✓ It is recognised as a important factor affecting quality of seed. The danger of genetic change in respect of cross pollinated crops like maize is prominent.
- ✓ Plants of different types permitted in a line may be susceptible to selection resulting in complete shift in the average perform and of a line over a period of time if produced repeatedly in smaller plots.

4. **Detasseling:** All tassels must be removed from the female rows before they have shed any pollen. Pulling the tassels usually as soon as they are well out of the boot is the most satisfactory method of removal

5. **Mutation:** Aging of seed under storage is reported to have increased frequencies of chromosomal aberrations and point mutation.
6. **Mechanical admixtures:** These can be avoided taking due precaution at harvesting, seed setting, bagging and storing operations etc.
7. **Roguing:** Based on distinct and diagnostic characters furnished by the breeder, roguing has to be performed in seedling stage, flowering stage and at the time of harvesting (Plant and Ear Characters).
8. **Physiological maturity of the crop:** The crop should be harvested at proper stage of maturity to minimise qualitative and quantitative losses.
9. **Seed size:** Grading of seed is important as it avoids smaller seed, under developed and damaged seeds. Smaller seeds had good germination but under stress condition the performance was significantly affected.
10. **Storage:** Proper care for aeration temperature and humidity etc. should be taken from time to time.
11. **Limit for breeder seed indent:**

- ✓Large indents of breeder seeds are not being entertained from the seed producing agencies. As there is a provision for stage I and stage II line increase, no producer should be permitted to indent more than 4 to 5 kg per inbred in a year.
- ✓If the total indent for a inbred comes to 30 to 40 kg per year, it will be possible for the breeder to multiply a quintal or two of each inbred and store them so that he does not have to multiply them in large quantities every year.
- ✓This will also ensure against the possibility of gene shift due to the frequent multiplication of any inbred.

Limitations of single cross hybrids (SCH)

1. Lack of population buffering and possess only individual buffing hence, more likely to be affected by biotic and abiotic stress
2. Both parents are inbred lines, they are low yielding and lower yield of F1 hybrid seed
3. Farmer to farmer distributions of seed is not possible
4. Higher cost of hybrid seed production
5. Proper infrastructure required for seed production and distribution

Quality Protein Maize (QPM)

Maize is a major cereal crop for both human and livestock nutrition, worldwide. With its high content of carbohydrates, fats, proteins and some of important vitamins and minerals, maize acquired a well deserved reputation as a poor man's nutria-cereal. Several million people, particularly in the developing countries, derive their protein and calorie requirements from maize. Therefore, this vast segment of human population depends upon cereals for their nutrition and livelihood. Protein from cereals including normal maize, have poor nutritional value because of reduced content of essential amino-acids such as *lysine* and *tryptophan* leading to harmful consequences such as growth retardation, protein energy mal-nutrition, anemia, pellagra, free radical damage etc. As a consequence, the use of maize as food is decreasing day by day among health conscious people.

The complex nature of these problems posed a formidable challenge before the agricultural scientists whose research priority always remains enhancement of the nutritional status of crops. This challenge was gladly accepted by two distinguished scientists of

CIMMYT, Mexico, Dr. S. K. Vasal and Dr. Evangelina Villegas whose painstaking efforts for a period of 3 decades led to development of Quality Protein Maize (QPM) with hard kernel, good taste and other consumer favouring characteristics. This work is globally recognized as a step towards nutritional security for the poor. Dr. S. K.Vasal and Dr. Evangelina Villegas were awarded world food prize for their path breaking research in QPM development.

QPM research and development efforts appropriately spread from Mexico to Central and South America, Africa, Europe and Asia. India also benefited with such germplasm and developed its first QPM composite variety 'Shakti–1' released in 1997 for commercial cultivation across the country. A continuous effort of plant breeder Dr. P. B. Jha yielded into the development of first hybrid variety of QPM in India in the year 1999-2000 as Shaktiman 1. Later on Shaktiman 2, Shaktiman 3 and Shaktiman 4, HQPM 5 and Vivek QPM 9 were developed with higher productivity. The kernel of Shaktiman 1 and 2 is white whereas that of Shaktiman 3 and 4 is yellow.

Nutritional impact of QPM on human and animal

As Food: (Human)

Impact on children: QPM feeding of preschool children continuously for six months showed a significant increase in weight and arm circumference with marginal increase in height. Increase in Intelligence Quotient (I.Q.) amongst children due to QPM feeding is also a reported fact.

Impact on pregnant women: Feeding of QPM to pregnant women continuously for six months starting from the end of 1st

Impact on old age people: Use of QPM as food by old age people proved beneficial by providing them relief from gastric and other indigestion ailments.

As Feed : (Animal)

Impact on animals: QPM feeding to pigs and chicks resulted into fast growth in their bodies. A significant increase in milk production has been reported when QPM is fed to cows and buffaloes.

The latest released hybrids (SCH) are (2002 onwards)

Normal Maize Hybrids

Name	Area of Adoption	Characteristics
Vivek 21 (SCH)	Uttaranchal, HP, J&K and NEH regions, Delhi, Punjab, Haryana & western UP & Penin sular India	Extra early, semi flint yellow, bold, , tolerance against TLB, avg yield 45-50q/ha
Vivek 23 (SCH)	Hills of Uttaranchal	Early- tall flint, yellow, bold, moderate tolerance against TLB, avg yield 45-50q/ha.
Vivek 25 (SCH)	Uttarakhand, HP, J&K and NEH region under rainfed ecosystem	Extra-early, bold yellow semi dent, tolerance against TLB, avg yield 50-55q/ha.
Vivek 27 (SCH)	Eastern UP & Bihar, Jharkhand, Orissa, Chattisgarh, & WB & Maharashtra, AP, Karnataka, & TN under rainfed agro-ecosystem	Extra-early, yellow, semi-dent, avg yield 50-55q/ha.
COHM 5 (SCH)	TN under irrigated & rainfed ecology	Late maturity, resistance to downy mildew, moderately resistance to stem borer, semi flint seeds & responsive to high inputs , avg yield 42-55q/ha.
PMH-1	Irrigated areas of Punjab	Late maturing stem is zig-zag, resistance MLB, stalk

Name	Area of Adoption	Characteristics
(SCH)		rots, average yield 52q/ha
Maize PAU 352(SCH)	Punjab, Haryana, Delhi.	Early, resistance to MLB, BSDM, ESR average yield 35-48q/ha
PMH-2 (SCH)	Delhi, Haryana, Central & Western UP, under rainfed condition	Early, short duration, resistance to MLB, BSDM, & PFSR
Vivek Hybrid Maize 15 (SCH)	J & K (Himalayan region) and (penin sular India	Extra early with moderate degree of tolerance against TLB , average yield 45-50q/ha.
Vivek Hybrid Maize 17 (SCH)	Across the country, except hill states.	Extra- early with moderate degree of tolerance against TLB, MLB, average yield 40-50q/ha.
Buland (SCH)	Punjab, UP, Haryana, Delhi, Tarai regions of Uttranchal.	Late maturing, resistance to TLB, Common rust, average yield 85q/ha
HM 5 (SCH)	Haryana in kharif & rabi	Medium tall, white dent medium maturing, responsive to high doses of fertilizers, tolerance to frost average yield 68-72q/ha.
Pusa Extra Early Hybrid Maize 5 (SCH)	J&K, Uttarakhand, NE, HP, Assam, Haryana, Punjab, Peninsular India	Extra early maturing, tolerance to TLB, MLB, ESR average yield 45-50q/ha.
Pratap Hybrid Maize 1 (SCH)	Rajasthan, Gujarat, MP, in kharif	Extra early maturing, white semi flint, moderately resistance to *C. partellus*, with average yield of 38 q/ha
DMH 2 (SCH)	Karnataka	Late , tall semi flint, yellow , resistance to SDM.

QPM Hybrids

Name	Area of Adoption	Characteristics
HQPM 5 (SCH)	Across the country during kharif	QPM hybrid with Orange flint grain, late maturing, resistance to MLB & *chilo partellus*, responsive to higher doses of fertilizers, avg yield > 58 q/ha.
HM 8 (SCH)	Peninsular India in kharif	Orange flint with medium maturity, avg yield 50-68 q/ha
Malviya Hybrid Makka 2 (SCH)	East UP, Bihar, Jharkhand, Chattisgarh, West Bengal, Orissa In kharif.	Medium ,semi flint, yellow, with resistance to MLB, responsive to higher doses of fertilizers, avg yield 54 q/ha.
Shaktiman 3 (SCH)	Bihar	Late, tall, QPM hybrid with 0.73% tryptophan in protein, semi flint orange-yellow fair tolerance against MLB, LSM.
Shaktiman 4 (SCH)	Bihar	QPM hybrid 0.930 tryptophan in protein, semi flint, resistance against MLB.
HQPM 1 (SCH)	J&K, Uttarakhand, NE, HP, Assam in kharif & rabi.	Yellow dent with late maturity, responsive to higher doses of fertilizers, tolerance to frost/ cold, average yield 62 q/ha resistance to MLB and common rust.
Shaktiman 2 (SCH)	Bihar	Late tall , full season maturing, resistance against MLB, QPM hybrid with 1.04% tryptophan in protein

Conclusion

To check the depleting ground water in country and to maintain the soil fertility by suggesting alternative remunerative crops to replace at least one third area from rice to other less water requiring but profitable crops like maize. Production of hybrid maize seed is a unique and dynamic industry worldwide. Many steps are involved in the production, processing, and marketing chain. This work is often done under contract with private farmers, thus the selection, training, and collaboration with the best farmers is essential. Once the seed crop has been harvested it must be transported to the processing facility where it is de-

husked, dried, sorted, cleaned, sized, treated, and packaged. The emphasize that Single Cross Hybrid breeding program and to meet the nutritional security of maize eating population, the QPM would remain the focussed area of research and seed production programs would receive greater attention in this direction which will provide more employment, good yield and higher food grain production.

Seed Production in Vegetable Crops Emphasis on Crops Suited to NEH Region

In modern agriculture, seed is a vehicle to deliver almost all agriculture-based technological innovations to farmers. The availability, access and use of quality seed of adaptable modern varieties is, therefore, determinant to the efficiency and productivity of other inputs like fertilizers, irrigation, pesticides etc, in increasing crop production to enhance food security and alleviating rural poverty in developing countries. Seed production is an exclusive, profitable method of farming of which the producers form part of a unique export industry. It is an ideal farming embranchment which contributes to enhancing the income basis of producers. India is a leading vegetable producing country in the world. Presently it occupies 8.50 million hectare area with the production of 146.55 million tonnes and productivity 17.30 mt/ha.

Table 1: Area, production and productivity for vegetable crops

Crops	2008-09			2009-10			2010-11		
	Area	**Prod.**	**Pdy.**	**Area**	**Prod.**	**Pdy.**	**Area**	**Prod.**	**Pdy.**
Potato	1828.0	34391.0	18.80	1835.0	36577.0	19.90	1863.0	42339.0	22.70
Tomato	599.0	11149.0	18.60	634.0	12433.0	19.60	865.0	16526.0	19.10
Onion	834.0	13565.0	16.30	756.0	12159.0	16.10	1064.0	15118.0	14.20
Brinjal	600.0	10378.0	17.30	590.0	10165.0	17.20	680.0	11896.0	17.50
Tapioca	280.0	9623.0	34.30	232.0	8060.0	34.80	221.0	8076.0	36.50
Cabbage	310.0	6870.0	22.10	331.0	7281.0	22.0	369.0	7949.0	21.50
Cauliflower	349.0	6532.0	18.70	338.0	6410.0	19.0	369.0	6745.0	18.30
Okra	432.0	4528.0	10.50	452.0	4803.0	10.60	498.0	5784.0	11.60
Pea	348.0	2916.0	8.40	365.0	3029.0	8.30	370.0	3517.0	9.50
Sweet Potato	124.0	1120.0	9.0	119.0	1095.0	9.20	113.0	1047.0	9.30
Others	2275.0	28006.0	12.30	2332.0	31724.0	13.60	2083.0	27557.0	13.20
Total Veg.	**7981.0**	**129077.0**	**16.20**	**7985.0**	**133738.0**	**16.70**	**8495.0**	**146554.0**	**17.30**

Source: Indian Horticulture Database 2011, Ministry of Agriculture, Government of India

The country being blessed with the unique of nature of diverse climate and distinct seasons, make it possible to grow an array of vegetables number exceeding more than hundred types. However, potato being the staple food and easy to mix in several preparations ranks first (28.9 %) in total vegetable production followed by tomato (11.3%), brinjal (8.1 %), onion (10.3%), cauliflower (4.6%) and cabbage (5.4%). Other important vegetables which are primarily grown in the country are vegetable pea, okra and a good range of cucurbits. Presently Uttar Pradesh ranks first in the total vegetables production. Bihar, Odisha and WB in north India and Tamil Nadu & Karnataka in south India are the other leading vegetable producing states in the country. India can claim to grow the largest number of vegetable crops compared to any other country of the world.

The eight states of India- Assam, Arunachal Pradesh, Manipur, Nagaland, Tripura, Meghalaya, Mizoram and Sikkim included in North eastern hill regions (NEH) forming 7.8% of total area and about 4 % of total population of India with rich natural resources of soil, water and vegetation. The agricultural production system in the region is mostly mono-cropped, rainfed and at a subsistence types. Vegetables, besides providing nutritional security, are also major source of income especially for small and marginal farmers. The vegetable crops, apart from higher productivity and high value produce, provide more food per unit area per unit time and can improve the economic condition of the growers as

compared to cereal crops in this region. Hence, they are becoming a potential commodity to provide economic security to the resource poor farmers of the NEH regions. Newly developed short duration varieties of vegetable crops like cabbage, tomato, french bean, vegetable pea and capsicum fit in the rice based cropping system of this region and thereby the cropping intensity can be increased many fold. The scope for horizontal expansion of area is very much limited for vegetable cultivation and thus the only option available is to increase the productivity.

Table 2. State-wise area, production and productivity (2010-11) of vegetables in NEH Region

State	Area (in 000'ha.)	Production (in 000'mt)	Productivity (mt/Ha)
Assam	261.10	2925.50	11.20
Meghalaya	41.80	356.50	8.50
Tripura	36.0	532.30	14.80
Sikkim	23.90	120.90	5.10
Manipur	22.20	236.50	10.70
Mizoram	17.50	115.60	6.60
Nagaland	10.70	79.40	7.40
Arunachal Pradesh	4.20	38.50	9.20
Source: Indian Horticulture Database 2011, Ministry of Agriculture, Government of India			

Table 3. Major vegetable crops identified for different states

States		Horticultural crops
Arunachal Pradesh	Vegetables	Pea , beans, colocassia
	Spices	Ginger, large cardamom, turmeric
Assam	Vegetables	Potato, cabbage, sweet potato, brinjal, onion, cauliflower
	Spices	Chilli, ginger, turmeric, black pepper
Manipur	Vegetables	tomato,cabbage, cauliflower
	Spices	Chilli, ginger, turmeric
Meghalaya	Vegetables	Potato, cabbage, cauliflower, radish, French bean, tomato, capsicum
	Spices	Ginger, turmeric
Mizoram	Vegetables	Chow-chow, cabbage, pumpkin, brinjal, beans
	Spices	Ginger, turmeric, chilli
Nagaland	Vegetables	Colocasia, chow-chow, tapioca, potato, pea
	Spices	Garlic, chilli, ginger
Sikkim	Vegetables	Cabbage, French bean, chow-chow
	Spices	Large cardamom, chilli
Tripura	Vegetables	Potato, brinjal, sweet potato, beans, tomato
	Spices	Chilli, ginger, black pepper

Major Constraints of vegetable production in NEH regions:

Though the NEH region has high potential for the development of vegetable crops, efforts have not been made to develop it as a commercial venture. Factors inhibiting vegetable development in the region are as follows:

- Shifting cultivation
- High rainfall during flowering stages

- Inappropriate plant protection measures
- Non availability of quality seeds at planting time
- Lack of knowledge about improved agronomic practices and storage
- Predominantly informal and unorganized seed supply in the region (Except Assam)
- Lack of marketing facilities
- Scarcity of trained manpower and extension support
- Land tenure system or land ownership system
- Problems of processing
- Financial constraints
- Absence of insurance facility

Future thrust areas:

- Collection, characterization and conservation of germplasm
- Identification of area specific major vegetable crops
- Hi-tech vegetable crops
- Infrastructure for vegetable crops
- Establishment of agricultural technology information centre
- Conduction of on-farm trials / frontline demonstration
- Post harvest management and processing
- Strengthening of vegetable farms and nurseries
- Training to extension / farmers functionaries
- Protected cultivation:
- Emphasis on organic farming
- Research on underutilized crop
- Crop diversification

Minimum seed certification standards of vegetable crops:

The certification standards in force in India are called the 'Indian Minimum Seed Certification Standards'. These were published by the Central Seed Certification Board. As a general principle, these standards have been kept at the level, which demand scrupulous attention of the certified seed growers but at the same time practical enough that these can be met also. The minimum seed certification standards can be broadly grouped into two groups.

1. **General Seed Certification Standards:** The general seed certification standard aims at outlining the general requirements for the production of genetically pure good quality seed. These standards prescribed the procedure for certified seed production so that maximum genetic purity and good quality of the seed is ensured.
2. **Specific Crop Standards:** Specific crop standard consists of Field Standards and Seed Standards Field standards consist of:

- The minimum preceding crop requirement has been specified to minimize genetic contamination from the disease, volunteer plants.
- The minimum isolation requirement has been specified to minimize seed born disease contamination.
- The number of feed inflection and specified stage of crop have been described to ensure verification of genetic purity and other quality factors.

Table 4. Minimum field standards of important crops

Crop	Class of seed	Land require-ment	Isolation (meters)	No. of field inspe -ctions	Off types	Insepar-able other crop plants	Objection-able weed plants	Affe-cted Plant /head
Vegetable Crops Potato Seed	CS	*	50,	4	.10	--	--	3.0
Tomato	FS	--	50	3	.10	--	--	.10
	CS	--	25	3	.20	--	--	.50
Cauliflower	CS	--	1000*	3	.20	--	--	.50
Onion	FS	--	5	2*	.10	--	--	--

Technology options to increase the vegetable seed production

Increasing area under improved varieties/Hybrids

Vegetable production is still dominated by the locally available genotypes or inferior landraces all over country including NEH. Thus there exists to replace the local cultivars with the improved high yielding and disease & pest resistant hybrids. Hybrids are well known for increasing vegetable production due to its high yield potential, earliness, quality and resistance attributes. Tomato, eggplant, pepper, cucumber muskmelon, watermelon, cabbage, cauliflower, carrot, etc. are important crops in which hybrids are largely available and farmers are adapting such varieties to a considerable extent. During the recent past, tremendous progress has been made to develop hybrid varieties in a number of vegetable crops. In general, the data on specific contribution of hybrids on the total vegetable production as well as degree of utilization of their seeds in NEH Region is lacking. However, the following varieties / hybrids developed and recommended (Table3) especially for NEH region can be utilized for increasing the vegetable productivity in the region.

Use of Disease Resistant Varieties

Table 5. Vegetable varieties to resistant and tolerant to diseases

Crops	Variety	Diseases	Source
Brinjal	Pusa Purple Cluster	Bacterial wilt	IARI, Katrain
	Pant Rituraj	Bacterial wilt	GBPUAT, Pantnagar
	BB-7, BB-44	Bacterial wilt	OUAT, Bhubaneshwar
	SM-6-7-1, SM-6-6	Bacterial wilt	KAU, Vellanikara
	Pant Samrat	Phomopsis blight	GBPAUT, Pantnagar
	Pusa Bhairav	Phomopsis blight	IARI, Delhi
Tomato	Hisar Anmole and Hisar Gaurav	Leaf curl	HAU, Hissar
	BWR-1, BWR-5	Bacterial wilt	IIHR, Bangalore
	BT-1,BT-2	Bacterial wilt	OUA&T,Bhubaneshwar
	Pant Bahar	Verticilium wilt	GBPUAT, Pantnagar
Cow pea	Pusa Komal	Bacterial blight	IARI Reg. station,Katrain
French bean	Pant Anupama	Commom mosaic virus and rust	G.B.P.U.A&T,Pantnagar
Okra	Pusa A-4	YVM Virus	IARI, New Delhi
	Parbhani Kranti	YVM Virus	MAU, Parbahani
	Punjab Padmini	YVM Virus	PAU, Ludhiana

Crops	Variety	Diseases	Source
	Arka Abhay	YVM Virus	IIHR, Bangalore
	Barsha Uphar	YVM Virus	HAU, Hissar
	Arka Anamika	YVM Virus	IIHR, Bangalore
	DVRM-1	CGMMB	IARI, New Delhi
Chilli	Pusa Jwala	Leaf curl virus	IARI, New Delhi
Cabbage	Pusa Mukta	Black rot	IARI, Katrain
Cauliflower	Pusa Shubra	Black rot	IARI, Katrain
	Pusa Snowbal K-1	Black rot	IARI, Katrain
Peas	NDVP-2	Powdery mildew	NDUA&T, Faizabad
	PMR-4	Powdery mildew	GBPAUT, Pantnagar
	JP-83,JP-4	Powdery mildew	JNKVV, Jabalpur
Cucumber	Poinsette	Powdery mildew	NSC, New Delhi
	Poinsette	Downy mildew	NSC, New Delhi
Capsicum	Arka Gaurav	Leaf curl virus	IARI, New Delhi

Nursery Management

Soil and seed treatments with bio-agents are the best feasible methods for the management of soil borne diseases. Organic amendments, green manuring, congenial moisture and moderate weather conditions are the best situation to establish bio-agents in the soil. Seed treatment with bioagents can be done by priming, soaking, seedling dip and dry powder treatment depending on nature and formulation of biocontrol agents. Generally biocontrol agents are used @ 5-10g/kg for seed treatment and 10-25 g per square meter for nursery bed application. Integration of neem cake @ 50 gram and bio-agents *T. viride* @ 10 g/m^2 area recorded 76.3% tomato seedling stand. *T. harzianum* and *T. viride* can not be integrated with carbendazim even at a concentration of 10 µg ml^{-1} while thiram can be used up to 50 µg ml^{-1}. Some of the strains of *T. harzianum* are tolerant to fungicides, which can be used for the integrated control of diseases

Integrated production systems: Production technology especially water management, integrated nutrient management, weed management, population density and others have been developed in all the major vegetable crops.

- Pre-emergence application of pendimethalin (stomp) was found very effective in controlling weeds in all solanaceous (tomato, brinjal, chilli, bell pepper, okra) vegetables crops.
- In tomato and brinjal drip irrigation was found very economical. In the cucumber replenishing 120 % of evaporation loss through drip irrigation resulted in maximum yield of quality fruit.
- Nutrient requirement and fertilizer scheduling works have been conducted for different agro-climatic regions and crop wise recommendations have been published for different regions. In leguminous vegetables high N depresses nodulation. Vesicular Arbuscular Mycorrhiza (VAM) increases available P to the plants. Glomus aggrega (VAM) increases available P to the plants. Glomus aggregatum is best in promoting growth and yield of pea and beans, whereas G. fasciculatum is best for cowpea.
- Production technologies for rainy season (kharif) onion for northern India and long day type onions for high altitudes have been standardised. Usually, onion is grown in the winter season (rabi) in the northern India, while it is grown both in rabi and kharif in major onion growing states like Maharashtra, Gujarat, Karnataka, Andhra Pradesh, and Tamil Nadu. The

recommended doses of nutrients by different states are 100-150 kg nitrogen, 40-80 kg phosphorus and 0-125 kg potato/ha.

- In cole crops (cabbage, cauliflowers) with the introductions of heat-tolerant hybrids and development of tropical lines of hybrids, the temperature barrier has been removed. It is therefore possible now to cultivate cabbage and cauliflower in southern India. Under tropical climate with an average yield of 70 t/ha cabbage requires 370 kg N, 85 kg P, 480 kg K, 60 kg Mgo and 80 kg S/ ha. Preplanting applications of weedicides likes Trifluralin (1 kg/ ha), Butachlor (2 kg/ha) were found to be effective for controlling weeds in cabbage and cauliflower.
- In potato, drip irrigation was found to be economical, giving highest productivity and saving about 50% water. Biofertilizers likes Azotobacter and phosphobacteria enabled the reduction of N dose by 16% and P dose by 30%.

Vegetable Seed Production

Vegetable Seed Production for over 120 open pollinated high yielding varieties of different vegetable crops has stabilised well in the country. Hybrid seed production has become easier due to development of self incompatible lines in cauliflower and gynoecious lines in crops like cucumber and musk melon. In tomato male sterile lines are used for hybrid seed production. Similarly in brinjal functional male sterility controlled by single recessive gene has been reported. The supply of breeders' seed of most of the vegetables is normally carried over by the research institutions that have developed them. The foundation and certified seeds are produced by public funded seed corporations and private seed companies. Many joint ventures for production and distribution of vegetable seeds have recently come up as a result of liberalised seed policy. Indian has achieved self sufficiency in seeds of temperate vegetables and has started exporting them.

To maintain the requisite genetic purity and to achieve the high level of seed standards during seed production it is essential to have field standards. Since the seed production programme organized by public as well private sectors organization at different locations, seasons and of various class, thus the field standards has to be maintained uniformly during the execution of the seed programme in field. The objectives of general and specific requirements field standard are to maintained genetic purity avoiding the genetic contamination and ultimately to meet the seed standards. The isolation requirement is variable among the crops and it is low in self pollinated crops while moderate in often cross pollinated crops and higher in cross pollinated crops where wind/ insects act as pollinating agent.

Table 7. Crop-wise minimum isolation distance requirement (M)

Crops	Contaminant	Minimum distance (m)	
		F/S	C/ S
Tomato	Field of the other varieties	50	25
	Fields of the same variety not confirming to varietal purity requirements for certification	50	25
Brinjal	Field of the other varieties	200	100
	Fields of the same variety not confirming to varietal purity requirements for certification	200	100
Capsicum & Chillies	Field of the other varieties	400	200
	Fields of the same variety not confirming to varietal purity requirements for certification	400	200
	Field of capsicum from chilli and vice versa	400	200
Okra	Field of the other varieties	400	200

Crops	Contaminant	Minimum distance (m)	
		F/S	C/ S
	Fields of the same variety not confirming to varietal purity requirements for certification and wild okra	400	200
Ash gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification	1000	500
Bitter gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from balsam apple (*Momordica balsamina)* , bhat kerala and jangli kerala	1000	500
Bottle gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification.	1000	500
Cucumber	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from *Cucumis hardwickii*	1000	500
Indian Squash (Tinda)	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification.	1000	500
Long melon	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and snapmelon, muskmelon, oriental pickling melon and other non-desserted forms of *Cucumis melo*	1000	500
Pumpkin	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from winter squash, summer squash and cushaw (*C. mixta*)	1000	500
Ridge gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from spongegourd (*L. cylindrica*)	1000	500
Snake gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from *Trichosanthes labata* ,*T.palmate* and *T. cucumerina*	1000	500
Sponge gourd	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from ridge gourd (*L. acutangula*)	1000	500
Summer squash	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and from pumpkin (*C. moschata*), C. mixta and C. maxima	1000	500
Water melon	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification and wild watermelon (*Citrullus colocynthis L.*)	1000	500
Amaranth	Field of the other varieties	400	200
	Fields of the same variety not confirming to varietal purity requirements for certification and wild amaranths	400	200
Celery	Field of the other varieties	500	300
	Fields of the same variety not confirming to varietal purity requirements for certification and from turnip rooted celery *Apium graveolens*	500	300
Methi	Field of the other varieties	10	5
	Fields of the same variety not confirming to varietal purity requirements for certification	10	5
Lettuce	Field of the other varieties	50	25
	Fields of the same variety not confirming to varietal purity requirements for certification and wild lettuce (*Lactuca scariola*)	50	25
Parsley	Field of the other varieties	500	300
	Fields of the same variety not confirming to varietal purity requirements for certification	500	300

Crops	Contaminant	Minimum distance (m)	
		F/S	C/ S
Spinich & Spinich Beat	Field of the other varieties	1600	1000
	Field of the swiss chard, sugar beet and garden beet for spinach beet only	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification	1600	1000
Cabbage	Field of the other varieties	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification and from the varieties of *Brassica oleracea(L)* var.*oleracea*, ramose, gemmifera, acephala, gongylodes, subaduda, italica and botrytis etc.	1600	1000
Cauliflower & Broccoli	Field of the other varieties	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification and from the varieties of *Brassica oleracea(L)* var. *oleracea*, ramose, gemmifera, acephala, gongylodes, subaduda, italica and botrytis etc.	1600	1000
Knol-Knol	Field of the other varieties	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification and from the varieties of *Brassica oleracea(L)* var. *oleracea*, ramose, gemmifera, acephala, gongylodes, subaduda, italica, capitata and botrytis etc.	1600	1000
Garlic	Field of the other varieties	5	5
	Fields of the same variety not confirming to varietal purity requirements for certification	5	5
Onion	Field of the other varieties	1000	500
	Fields of the same variety not confirming to varietal purity requirements for certification	1000	500
Carrot	Field of the other varieties	1000	800
	Fields of the same variety not confirming to varietal purity requirements for certification	1000	800
Radish	Field of the other varieties	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification and from rat-tail radish	1600	1000
Turnip	Field of the other varieties	1600	1000
	Fields of the same variety not confirming to varietal purity requirements for certification and from other species of genus *Brassica pekenensis, B. chinensis, B.napus* and various kind of sarson/rai	1600	1000
Peas	Field of the other varieties	10	5
	Fields of the same variety not confirming to varietal purity requirements for certification	10	5
Dolichos bean	Field of the other varieties	10	5
	Fields of the same variety not confirming to varietal purity requirements for certification	10	5
Cowpea	Field of the other varieties	10	5
	Fields of the same variety not confirming to varietal purity requirements for certification	10	5
French bean	Field of the other varieties	10	5
	Fields of the same variety not confirming to varietal purity requirements for certification	10	5

Protected cultivation

Seed production of brinjal, capsicum, cauliflower and broccoli is very difficult in open conditions in the region due to high rainfall at maturity stage. To reduce such weather aberrations micro climatic condition a protected environment is essential. So, the seed production of highly remunerative crops namely tomato, capsicum and cucumber is better performed under protected environments. The maintenance and purity of different varieties can be achieved by growing them under greenhouse without giving isolation distance particularly in cross-pollinated vegetables namely onion, cauliflower and cabbage. Such

production system has not only extended the growing season of vegetables and their availability but also encourage conservation of different races vegetable crops.

A bamboo frame green house cum rain shelter is used in NEH region. Low cost green houses have been found to be very successful under subtropical conditions for raising nurseries of vegetable crops, flowers and fruits. Environmental considerations in future will demand that the greenhouse technology of the 21st century is of the closed type with complete recycling of everything except the crop produce.

Promotion of organic cultivation

Considering the growing concern and potential market worldwide, a need is felt in recent years to standardize and develop protocols for organic agriculture. The common sources of bulky organic manure are FYM, press mud, digested sludge, compost, oil cakes etc. can be used at least once in a year before monsoon crops to improve the soil physiochemical and biological properties. The green manures contribute 30 to 60 kg N ha^{-1} per crop. The sunhemp and dhaincha could be a suitable green manure crops. Their incorporation in soils even a week earlier to sowing or planting of main crop is beneficial. Both green manures and legumes in crop rotation improve overall soil health. In NEH region, Sikkim and Mizoram have declared their intensions to shift towards total organic farming. The NEH region has the unique opportunity to promote organic production of vegetable crops because of the farmers in this region are most responsive to organic agriculture by their tradition and do not use chemicals.

Use of insect pollinators

Low productivity in most of the vegetable crops grown in the region is directly connected to use of genetically inferior varieties coupled with low input farming and incidence of insect pests and diseases. Further, the farmers fail to obtain bountiful crop if he neglect to provide for pollination, particularly in cross pollinated crops. The gradual elimination of natural pollinating insects by modern agricultural practices has also increased their growing dependence on honeybee. This presents an impending dilemma with reduction of native pollinators on one hand and an increased need for bees for cross pollination on the other hands. So, modern agriculture has come to depend greatly on bees to fulfill its pollination needs. Cucurbits being cross pollinated crops predominantly grown in the region require pollinators particularly honey bees for increasing crop yield, improving seed quality and for exploitation of heterosis. The Indian hive bee *Apis cerana* and rock bee *Apis dorsata* are the most abundant and predominant pollinators in the region for cross pollinated crops including vegetables which constitute 46 and 42% of the total pollinators population.

Diseases-pest and plant protection

About 50 recommendations for disease managements and 23 improved measures in vegetable pest control have been advocated for efficient management of diseases and pests of vegetable crops. Integrated pest managements (IPM) for control of diamond back moth of cabbage through use of trap crops like mustard have been demonstrated. IPM practice for control of tomato fruit borer includes intercropping a tall variety of marigold as a trap crop in a row after every 14 rows of tomato. The marigold attracts *Helicoverpa* and large number of its natural enemies. At a few places control of fruit borer *H. armigera* in tomato could also be achieved by release of *Trichogramma pretiosum* alone @ 0.5 million/ha and in combination with NPV @ 250 LE/ha. In potato, deadly diseases like late blight, bacterial wilt and insects like aphids and nematodes could be effectively controlled through use of tolerant varieties as well as chemical control measures. Resistant breeding both in a number of vegetable crops and potato has greatly helped in overcoming disease and pest problems in these crops.

Minimizing Post harvest losses

In NEH region, the post harvest losses in vegetable crops vary from 21-30 per cent depending upon the crop and variety. Reduction of post harvest losses can be achieved by

adoption of good pre-harvest production practices, harvesting at optimum maturity, proper harvesting, and adoption of pack house practices like washing, sorting, grading, packaging, transportation and storage under controlled condition of temperature and humidity. Packaging material like bamboo basket are used by putting cushioning material like paddy straw and lining with banana leaves are very much popular in NEH region. Now paper board boxes lines with polythene papers, ventilated corrugated fiber board boxes are being used for packaging of tomato, capsicum etc; and transported from its place of production to the place of marketing.

Conclusions: Poor adoption of such technologies has always been a major handicap in increasing productivity. Therefore, promotion of developed technologies through various mechanisms is a key to harness the available technologies, thus ensuring the increased productivity and profitability to the farmers. The following strategy needs immediate attention:

- Introduction of quality seed production of export quality vegetable crops suitable for the NEH region.
- Use of low-cost poly houses, promotion of off-season production and technology for low cost hybrid vegetable seed production.
- Training programmes on various aspects of vegetable seed production and protection technologies, post harvest management and processing.
- Establishment of biotech unit (tissue culture lab) for production of disease free planting material in important crops.
- Effective promotional use of predators, parasitoids and entomo-pathogens. Emphasis must be given to develop behavioural management practices with special reference to sex pheromone and trap crop based management tactics.
- Quality control and development of bio-agent release techniques need to be emphasized to improve the performance of bio-agents and microbial control agents.
- Botanicals, microbial and pheromones should be incorporated in IPM schedule to reduce dependency on chemical insecticides.
- Cost effective produce for the growers and ensured availability to the post harvest industries and consumers and better access to market.

References

Annonymous, 2000. Basic Statistics of North Eastern Region 2000.North Eastern Council, Ministry of Home Affair, GOI, Shillong.

Annonymous, 2002. Agril. Research Data Book, ICAR, 2002.

Annonymous, 2002. National Horticulture Board, Year Book-2002. Associated Publishing Company, New Delhi, 230p.

Ghosh, S.P. 1985. Horticulture in North Eastern India. Indian J. Hill Farming 7: 11-21.

Negi, J.P. 2002. Horticulture development in India: An Aids to Rural Economy. In: Souvenir, 62nd Annual conference of Indian Society of Agril Economics, Dec 19-21, 2002, IARI, New Delh.

Rai, N., Yadav, D.S., Rai, A. B., Rai, M., Yadav, R. K. and Sanwal, S. K. (2005) Enhancing vegetable production in NEH Region, IIVRVaranasi, UP, India

Sarkar, A.N. 1994. Resource potential and bio-diversity of North Eastern Region.

Verma, N.D. and Bhatt, B.P. 2001. Steps towards modernization of Agriculture in NEH Region. Venus Printers and Publishers, New Delhi, 536p.

Seed Cleaning and Upgrading - Principles and Methodology

Introduction

The seeds from threshing floor are mixed with seeds of other crops and of weed seeds, pieces of straw, gravel, soil etc. In the cleaning process, the separation of undesirable material from desirable material is done based on differences in physical properties. This is known as cleaning of seeds.

Principles of cleaning seeds

In the cleaning process, the separation of undesirable material, namely, inert matter, weed seeds, other crop seeds, light and chaffy seeds, undersized seeds, damaged or deteriorated seed from desirable material is done on the basis of differences in physical properties of desirable seed and undesirable matter. The principal physical differences found in seeds are seed size (length, width and thickness) density, shape, surface texture, color, affinity for liquids and seed conductivity. If the differences between desirable and undesirable material about any of these properties exist, separation of undesirable material could be done with the help of suitable machine/machines designed for the purpose.

Seeds of different species and inert matter widely differ with respect to the physical properties. Length, width, shape, weight, and surface texture differences are quite common in crop species and forms the basis of seed cleaning operations.

Method of Cleaning Seeds

Cleaning of seeds can be done in three steps:

1. Preparing seeds for basic seed cleaning (pre-conditioning and pre-cleaning operations)
2. Basic seed cleaning operation
3. Upgrading the quality of cleaned seed

Pre-conditioning and Pre-cleaning

Pre conditioning refers to operations such as shelling, debearding, etc., that prepare seed lots for basic seed cleaning, and also to the removal of particles such as pieces of trash, stones and clods larger in size than desirable crop seed, from threshed seed lots. Some pre-cleaners, in addition to removing larger sized particles, also remove particles that are lighter in weight and smaller in size than the crop seed. The necessity of both of these operations, other than shelling, is associated with advanced mechanized agriculture. No pre-cleaning is usually required on hand harvested and winnowed seed lots.

Pre-conditioning and pre-cleaning equipment and their use:

The most common equipments used in these operations are scalpers, debearders, huller-scarifier and maize sheller.

Scalper/Rough cleaner

Scalpers are simple devices intended to remove particles which are larger than the seeds. Such unit consists of a vibrating or rotating screen or sieve. The screen perforations are large enough to allow the rough seed to pass through readily while the larger inert material is 'scalped off' and removed from the seed lot. The scalpers manufactured for pre-cleaning may consist of several screens, or reels, with one or more controlled air separations. The single sieve pre-cleaners are called scalpers and the multiple sieve units are referred to as rough cleaners. The rough cleaners are essentially the simple air screen seed cleaners that make possible a separation of light chaff and dust with a controlled air current; a separation of large trash over a large hole screen; and a separation of small foreign material through a small hole screen. Most scalpers are arranged to make the air separation before the seeds reach the screens. After scalping/rough cleaning many kinds of seeds can be cleaned without any further pre-processing. Seeds of some crops, however, may require hulling, scarification, etc., after scalping.

Huller-Scarifier

Hullers and scarifiers usually abrade the seeds between two rubber-faced surfaces, or impel seeds against roughened surfaces, such as sandpaper. In a huller-scarifier, the seeds fall from the feed hopper on to a rotating distributing disc, where they are thrown against the hulling and scarifying surface by centrifugal force either once or twice, depending upon the machine. At this point the seed are hulled and/or scarified. After this operation the seeds are moved into a suction chamber where the suction removes the light, fine dust, and the seed discharge at the bottom of the chamber. The severity of abrasion or impact must be controlled accurately to prevent damage. Hulling (removal of an outer coat or husk) and scarification (scratching of the seed coat) can be done separately or jointly with a huller scarifier.

Debearder

The debearding machines have a horizontal beater with arms rotating inside a steel drum. The arms are pitched to move the seeds through the drum. Stationary posts, adjustable for clearance, with arms, protrude inward from the drum. These machines rub the seeds against the arms and against each other. Period for which seeds remain in the machine, is varied by regulating a discharge gate. The degree of action is determined by the processing time, beater clearance and beater speed.

Pebble Mill

The pebble mill is used for removing cob-webby hairs from blue grass and similar seeds. It has a drum rotating about a shaft, inserted off-centre at opposite ends. The mill is loaded with seeds and smooth half-inch pebbles and turned at a slow speed until the rubbing action of the pebbles rolls the fuzz from the seeds into small round balls. The mixture of pebbles, seeds and matted fuzz is then run over a scalper to remove the pebbles.

Maize Sheller

The maize sheller varies in size from small hand-powered sheller to large motor-driven sheller with capacities up to ten tonnes per hour. Small hand-power sheller consist of a

crank, a small feed inlet , a heavy cast iron fly wheel and burrs that remove the maize seed from the ear. Seeds drop out to the bottom and into a container, and the cobs are discharged out from the rear of the sheller. These types of sheller are useful for small lots of breeder's seed of inbred lines. At processing plants, power sheller is installed to give high capacity shelling. The power sheller has four main parts, namely, inlet hopper, rotating beating cylinder, concave, and fan.

Basic Seed Cleaning

This step of seed processing removes the larger, smaller, lighter and thicker adulterants as compared to the crop seed, from the seed lot. Basic cleaning is done on the basis of weight, size, density using cleaner with air screen cleaner with air screen. This process involves following equipments.

Grader – It separates the undersized seeds from the normal desirable seed on the basis of seed density and size with the help of a screen and its vibrations.

Scalper – It is the top most screen of a seed cleaner/grader with large holes than the desirable seeds size to remove the inert matter of larger size than the seed (scalping).

Aspirator – It removes lighter inert matter and adulterant than the crop seed from the seed lot with the help of air pressure.

Screen cleaner – It is generally made up of 2-3 screens of different mesh sizes, which are agitated to provide proper seed and place for separation. The air operation removes light seeds and inert matter.

Sieving - Removal of large and small objects from the seed lot. Also used during fruit cleaning (pre-cleaning) and for seed grading. High purity can be achieved for relatively spherical seeds and objects. Sieving separates material according to difference in size of separating material. Objects may pass an opening larger than their diameter while being retained by an opening of smaller diameter. Asymmetrical objects may pass an opening larger than their smaller diameter when their small diameter faces the opening. Thus an oblong seed will pass an oblong hole, while being retained by a round hole of the same diameter.

Method

The seed lot is sieved through a series of grids with decreasing mesh or hole size. The choice of screen depends on seed type and quantity. Seed lots of small seeded species like eucalypts are efficiently cleaned using 20 cm diameter laboratory sieves. Larger sieves are used for larger seeds and seed lots (ATSC 1995). The hole size and shape depend on seed size and shape and type of impurities.

A screening series consist of at least two sieves:

1. A sieve with openings larger than the seeds typically removes large material like fruit at twig fragments. The holes are adjusted to allowing the largest seeds to pass by their narrowest diameter. Shaking or sliding of the seeds over the screens will make them pass through the seeds.

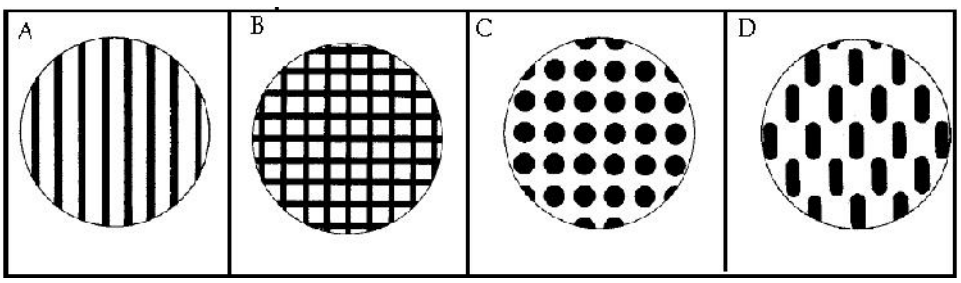
2. A sieve with openings smaller than the seed retains the seeds while smaller debris passes through. The holes are adjusted to retain the smallest viable seeds. Sometimes several screens with gradually decreasing mesh or hole sizes may be used and the seeds graded according to size. The grading may be maintained during subsequent cleaning. In some instances small seeds are deliberately discharged.

Many types of mechanical seed cleaners with different and replaceable screens are available. Some smaller laboratory seed cleaners may be supplied with more than 100 screens with different hole size and shape. Large industrial cleaners are normally supplied with a smaller number of screens, but screens can be purchased according to the main species processed. In general round holes are used when the items to be separated differ in width (width is the greater diameter of the cross section of the non-symmetrical seed); oblong holes are used when separation is according to thickness (i.e. the smaller diameter) (Karfalt 1998). The appropriate hole size is found by the following method:

1. Place a stack of screens with the correct hole type on top of each other, with the largest opening on top and then decreasing to the smallest opening at the bottom.
2. Pour the seed sample in the upper screen and shake gently to let seed and debris pass holes larger than their diameter.
3. Disassemble the stack of screens and examine the best separation. Choose the appropriate screen size(s).

With small difference in opening sizes more than one of the middle screens may contain both seed and debris. Here one must decide the degree of acceptable contamination. If high purity is required, using several screens (grading) may clean the seed lot. Round or spherical seeds can often be cleaned to high purity by sifting alone, while the method is less effective for flat or winged seeds. Meshes or holes will inevitably be blocked (blinded) by intermediate size fractions during operation i.e. seeds and particles too large to pass through the opening and too small to be left above the screen. The screens must therefore be regularly cleaned, e.g. by brushing. In mechanical cleaners, screens may be kept clean and blockages of intermediate material prevented during operation by brushing or by placing round rubber balls on the screens. The balls tend to push down or break material getting stuck in the holes. A more efficient method is to place the rubber balls on wire-mesh screens with large mesh size under the functional screens. The vibrating movements during operation will make the balls jump up against the screen above and push up material which blocks the holes

Different types screens for processing of seed



Screens with different hole types used for different seed types in mechanical seed cleaners. A) Grid type used mainly for pre-cleaning, e.g. branchlets and leaves from large

seed. B) Wire mesh type; this screen has a relatively large opening area compared to metal sheets and thus faster in use than these. However, the wire mesh more easily gets blocked by material, especially with small opening sizes. C) Metal sheet with round holes, especially used for round seed and for removing large debris (pre-cleaning). D) Metal sheet with oblong holes used for oblong seeds or for separating oblong debris like leaves, fruit stalks, branchlets, and fruit parts. Screens with oblong holes are normally oriented with the holes following the direction of the seed flow (longitudinally).

Applicability - Separation of seeds and debris according to size or length is especially useful for separating twig pieces, pine needles and the like from spherical seeds. Not useful for large seed and seed with large wings or hairs.

Selection of top screens – Screens with hole size slightly larger and smaller than the crop seeds are selected. Stack of these screens is made, keeping largest size on the top and smallest at the bottom in descending order. A quantity of 1-2 kg seed is placed on the top screen and the stack of screens shake vigorously until all the seeds have found their levels. The screens starting from the top of the stack are removed and the material held in each screen is recorded by weight. The screen size that just allows the crop seeds to fall through but holds the material larger than the crop seed is used as scalping screen. The material remaining on the screen is weighted as $X_{1.}$

Selection of bottom screen – From the same stack of the screens, the screen which holds the crop seed but allows broken seed, smaller wee seed and undersized crop seed to fall through is selected. This is the mess size best suited for the bottom screen. The material which passes through bottom screen is weighed as $X_{2.}$ The sum of X_1 and X_2 represent the clean out and is exhibited in percentage.

Selection of air pressure – The lighter contaminants present with graded seeds are removed by the air pressure adjusted in such a way that all the lighter contaminants are removed without any loss of crop seed.

Operation of seed cleaner – Proper screen is placed on the top and bottom. The air vents and feed hoppers are kept closed. Empty bags are placed at exit. The seed lot is poured through the hopper after turning on the machine. The flow gate of the hopper is opened gently to make the even flow of the seed on the top screen in such a way that it covers only ½ to 2/3 portion of the upper screen. The air vents are adjusted until all materials lighter than the crop is blown off. The operation is continued till all the seed in hopper have passed through the machine.

Upgrading the quality of cleaned seed

In certain instances, it is necessary to remove specific contaminants by precise size grading. The various processing operations conducted after basic cleaning to further improve seed quality are regarded as upgrading operations. The choice of upgrading operations, however shall depend upon the type of contaminants and crop seed.

While the objective of seed cleaning is to improve purity by eliminating non-seed material and foreign seed from the seed lot, the purpose of grading is to improve the average physiological quality of the seed lot by removing seed of the same species with low quality.

Such seed may be empty seed, immature seed, damaged or dead seed or seed developed after self-fertilization. In the latter case the removal also serves to improve the genetic quality of the seed lot. Sometimes a larger fraction of small yet viable seed is deliberately removed from the seed lot based on an assumed correlation between seed size and vigour.

Grading according to size can be useful to assure a more uniform germination speed and seedling growth within each grading class. A uniform seed size facilitates sowing with sowing machines and a uniform germination and seedling growth rate will imply fewer culling (Creemer 1990).

Seed grading is an extension of the seed cleaning process because the small and light seeds are removed together with chaff and other impurities. Methods of grading must, however, be adjusted much more precisely since the physical difference of seeds within a species is likely to be much less than between seeds of different species or seeds and extraneous matter.

Type of upgrading operations & types of machines

To obtain quality seed, it is necessary to clean the seed obtained from the farm to get rid of inert materials, weed seeds, other crop seeds, other variety seeds, damaged and deteriorated seed. Different kinds of seeds can be separated when they differ in one or more physical characteristics. Physical characteristics normally used to separate seeds are size, shape, length, weight, color, surface texture, affinity to liquids, electrical conductivity etc. The problem lies in identifying the most important property and use of the machine that separates seed using the identified property. Some of the identified properties and machines operating by following the properties are listed below:

Name of the separator	Property followed	Uses
Vibratory separator	Shape and surface texture	Removal of weed seeds
Spiral separator	Shape or the degree of its ability to roll	Separation of damaged/flat and wrinkled seeds from smooth seeds. Separation of mustard, rape, soybean and peas from wheat, flax, oats, etc, and round seeds from flat seeds.
Disk/Indented cylinder separator	Length	Dissimilar material like wheat, rye, mustard, barley from oats
Electrostatic separator	Electrical property	Johnson grass from sesame seed
Electronic color sorters	Color / brightness	Separation of off colored seeds
Inclined draper	Shape and surface texture	Separation of smooth or round seeds from rough flat or elongated seeds
Magnetic separator	Surface texture and stickiness	Removal of contaminating weed seed from clovers, alfalfa seeds and iron metals
Roll mill	Shape and surface texture	Separation of smooth clover seed
Gravity separator or destoner	Density or specific gravity	Removal of badly damaged, deteriorated, insect damaged crop seed and stones from good seeds.

Seed Enhancement: Scope and Opportunities

Introduction

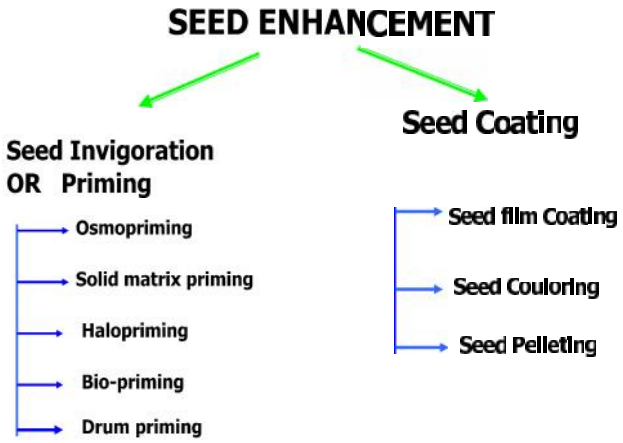
Any post harvest treatment that improves germination/seedlings emergence or facilitate the development of more number of normal, rapid, uniform and healthy seedlings in the field condition is termed as seed enhancement (M C Donald, 2000).

There are two goals of seed enhancement:-

- ✓ Seed functioning
- ✓ Seed designing

These above goals can be achieved by using seed enhancement techniques including seed invigoration (Priming), seed coating and seed pelleting.

Seed Invigoration or Priming



Seed Invigoration or Priming is a treatment, in which seeds are soaked in an osmotic solution/ other solutions containing different active ingredients, that allows water imbibitions and permits early stages of germination but does not permits radical protrusion through the seed coat (Heydecker, 1973).

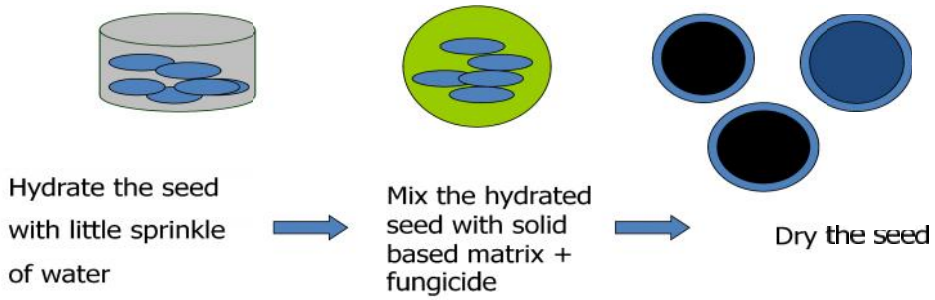
In priming osmotic potential of the solution is lowered due to solute accumulation in the embryo, which might generate sufficient turgor pressure to overcome endosperm/seed coat restraint (Bradford, 1986).

Osmopriming

Soaking the seed in osmotic solutions is osmopriming. In this process the germination is regulated by manipulating temperature, seed moisture content and duration. Water is either made freely available to the seed (as in steeping or soaking) or restricted to a pre determined moisture contents, typically using water potential between – 0.5 Mpa and -2.0 Mpa. Several osmotic like, inorganic salts such as Potassium nitrate, potassium phosphate, dipotassium hydrogen phosphate, potassium dihydrogen phosphate, magnesium sulphate, magnesium chloride, calcium chloride ,sodium chloride, sodium nitrate ,sodium polypropianate, sodium sulphate, chemically inert compounds such as PEG 6000, PEG-8000, monnitol.

Solid based matrix priming

Pre-sowing hydration in a solid based medium is called solid based matrix priming and it is used for increasing the efficiency of fungicide/ insecticide to control the seed borne infection and soil insects. In solid matrix priming seed slowly imbibe to reach an equilibrium hydration level, determined by the reduced matrix potential of the water adsorbed on the particle surfaces.



Bio-priming

Coating the seed with biological agent like bacteria, fungi etc.

Drum priming

The hydration of seeds over a period of 24-28 hrs in a drum revolving at 1-2 cm/sec. mixing of the seeds should be uniform and the seeds at the end of the treatment are plumbed and dried. A preset volume of water is injected during each cycle as regulated by an attached timer.

Seed hardening

It is a process of soaking seeds in water for a precise period followed by drying and re-soaking and re-drying. This process of alternate hydration and de-hydration cycles with water and later drying to original moisture is called seed hardening. Here it is the dehydration on cycle, which is responsible for hardening of seeds.

Dry seed
↓
Soaking in water and / or dilute solution of GR and chemicals for (1-12h at 15-25 0C)
↓
Shade drying (1-24h)
↓
Sun drying (1-2 days) to bring back to its original water content or weight
↓
Hardened seed

Advantages of priming

- Faster emergence and more uniform field stand in normal as well as in stress conditions.
- Uniformity, synchrony and significant yield increase in many vegetable crops.
- Primed seeds can be rinsed and dried for restorage for short periods in a number of crops.
- Effectively overcome the serious problem of soaking injury in many legumes.

Limitations

- This is expansive seed treatment so not very feasible for big seed lots.
- Causing ill effects of anaerobic respiration in seed lots when priming period is longer.
- Chances of attacking of microorganism are more in seed lots.
- Storability of seeds may adversely affected due to the advancement of germination reaction to a level not compatible with the drying back of the seed required for restorage.

If priming is followed by drying for seed hardening then it has the following beneficial effects

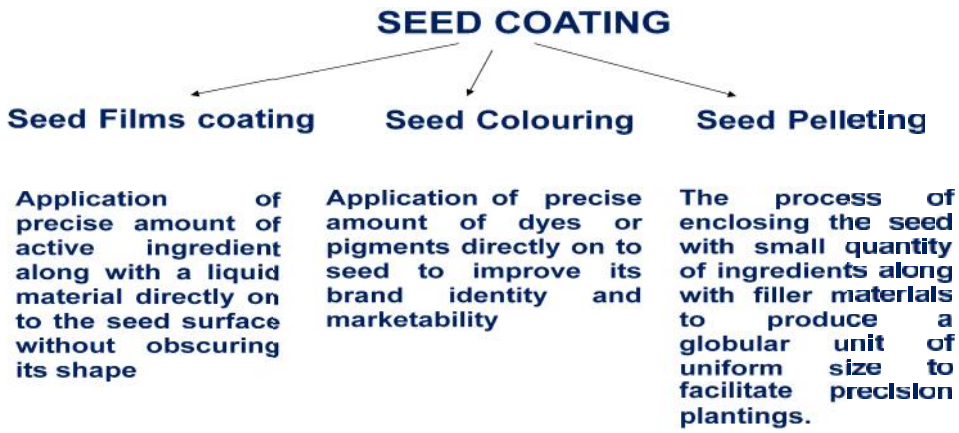
- Accelerates rapid germination and growth rate of seedling
- Plants recover much more quickly from abiotic stress than those from untreated plants.
- Flowering is slightly accelerated.
- Induces resistance to salinity / alkalinity and drought.
- Seeds are able to withstand high temperature [80-105 c) for prolonged period (24-46h).
- Plants are better in growth, productivity and resistance.

Effect of osmotic seed priming in different crop species

Crops	Osmoticum	Results	Reference
Vegetables i) Cabbage ii) Carrot Muskmelon	PEG 305 g/kg seed 15 oc 14 days PEG 273 g/kg seed 15 oc 14 days PEG -0.42 Mpa 15 oc, 10 days +6.4% Thiram	Accelerated emergence in heat damaged seed. Accelerated germination, field emergence and increased plant f.w. Improved storage over untreated seed.	Ralph 1978 Brocklehurst & Dearman 1983 Biniek 2001
Spices i) Cumin	PEG 4000-0.14 to -3.4 Mpa at 26oc for 2-3 days	Improved germination, emergence index and vigour index	Tawfin & Noga 2001.
Narcotics i) Tobacco	PEG 6000 -0.8 Mpa 250c, 8days	Helped in restoration of germination capacity after ageing	Min Taigi 2001.

Seed Coating

Among the seed enhancement technology, seed coating have a prominent role in future agriculture. Seed coating in broad sense includes seed film coating seed colouring and seed pelleting. The differences among these are as under.



Differences among the seed enhancement technologies

Particulars	Seed film coating	Seed colouring	Seed pelleting
Adhesive	Polymer (Plasticizer)	Natural/ synthetic dye	Adhesive, nutrients, filler materials
Use of fungicides /insecticides	Can be	Can be	Can be
Shape of the seed	Not obscured	Not modified	Shape modified in globular unit
Size of the seed	Not modified	Not modified	Modified due to the filler materials
Use of nutrient and bio-fertilizers	Usually combined	Not combined	Can be combined
Process	Coating	Colouring	Stamping, coating and rolling
Safety	Safe	Safe	No safety
Resistance to mechanical injury	More Resistance	No Resistance	More Resistance
Stability	More stable	Depending upon pigment/ dye used	Less stable
Seed germination and seedling vigour	Improved	Improved	Improved but not preferred by consumers
Applicability	Suitable for dry, garden and wet land	Suitable for dry, garden and wet land	Suitable for only garden / wet land
Storability	Good	Good	Seed can not be stored to 3 to 4 months

Performance of polymer coated seeds alone and in combination with fungicides, insecticides and nutrients on seed vigour and crop growth

Crop	Finding	Reference
Cotton	Coated with GR(60-90g) +Fenthiurar (10-12kg) + polymer (1.5kg)/tone seed- increased 7% germination	Zinin & Imamliev 1984.
	Coated with polymer sowed differences in water uptake pattern and increase not protein nitrogen.	Ruban *et. al*, 1985
	Coated with opacoat red polymer reduce dusting off at all application rate and methods, the effect was increased with the increase in rate of polymer and when applied as mixture with fungicide.	Williams & Hopper 1997
	Coating with easiflo polymer + fungicide improved germination and emergence of fuzzy cotton seed	Williams *et. al*, 1999
Maize	Seed coated with Polykote (3g) + Bavistin (2g) + imidachloropid (1ml diluted in 5ml of water) improved plant stand, establishment, crop growth and yield potential compare to uncoated seeds.	Sherin Susan jhon 2003.

Polymer film coating with reference to storage potential of seed

Crop	Finding	Reference
Turnip, carrot and cabbage	Coating seed with polyvinyl resin didn't decrease germination consistently after 18 months from storage.	Sauve and shiel 1980
Maize	Seed coated with Polykote (3g) + bavistin (2g) + imidachloropid (1ml diluted in 5ml water) maintained self life up to 10 months from storage under ambient conditions	Sherin Susan jhon 2003
Tomato	Seed coated with Polykote (3g) + bavistin (2g) + imidachloropid (1ml diluted in 5ml water) maintained self life up to 10 months from storage under ambient conditions	Ramya 2003.

Advantage of film coating

- Enables accurate and uniform sticking/ coating of chemicals
- It makes room for including all the required ingredients like inoculants, protectants, nutrients, herbicides etc.
- It ensures dust free handling of treated seed
- Addition of colorant helps visuals monitoring of placement accuracy
- Provides resistance against mechanical damage in the seed drill
- Polymer coating acts as a temperature switch and protective coat in regulating the intake of water.

Seed pelleting

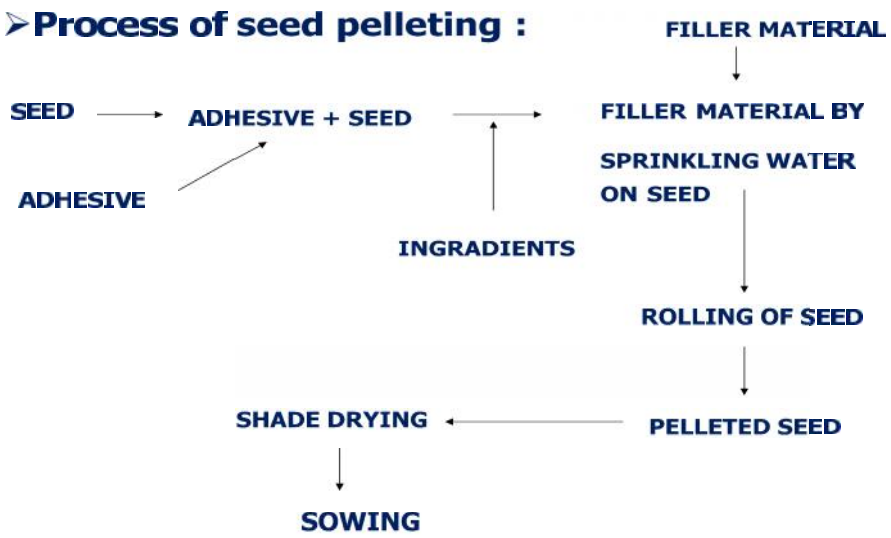
Seed pelleting is the mechanism of applying needed materials in such a way that they influence the seed or soil and the seed- soil interface (Scott 1989).

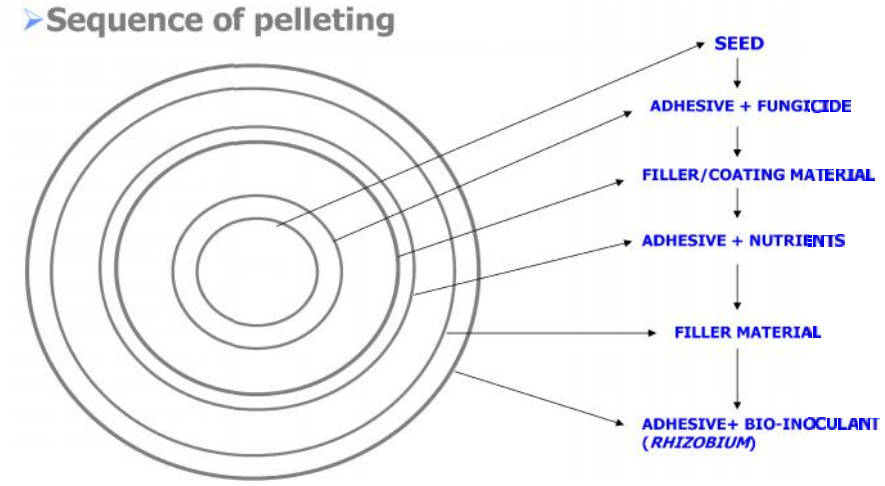
Seed pelleting technique: Three basic steps

i) Stamping ii) Coating iii) Rolling

Materials needed

i) Seed ii) Adhesive iii) Filler material





Advantage of pelleting

- Pelleting regulates the size of seeds for precision planting by machine/man.
- Singling of seeds and prevention of clogging.
- Attraction of moisture
- Supply of plant growth regulators and micronutrients
- Protection from birds, animals and insects.
- Adoptable even under water stress condition.
- Enhance storability in certain cases and accommodate well with other physiological treatments.

Principles and Methods of Seed Storage with Emphasis on Community and Village Seed Banks

Introduction

Seed longevity refers to the duration for which seed of a given kind is capable of remaining viable/ germinable under normal conditions provided that it is free from pests and diseases. Most of the seeds attain highest level of viability and vigour at physiological maturity. Thereafter, steady decline in seed vigour/ viability takes place depending upon the kind of species, environmental conditions & storage conditions of seed. It is true that loss in vigour & viability can not be completely checked but the process of deterioration can be slower down by controlling or manipulating various pre and post harvest factors, particularly the conditions of storage.

Stages of seed storage

The seeds are considered to be in storage from the moment they reach to physiological maturity up to germination in field. The entire storage period can be divided in to following stages:-

1. Storage on plants
2. Storage from harvest until processing
3. In storages/ warehouse
4. on farm storage before sowing

(1) Storage on plants

Seeds are considered to be physiologically and morphologically mature when they reach maximum dry weight. At this stage drying or dehydration of the seed is well underway. Dry down continues after physiological maturity until moisture content of the seed and fruit decreases to a level which permits effective and efficient harvest and threshing. This stage can be termed as harvest maturity. There is usually an interval time between physiological maturity and harvest maturity and this interval represents the first segment of the storage period. Any delay in harvesting of the seed after they reach harvest maturity, prolongs the first segment of the storage period.

The seed quality is greatly influenced by prevailing environmental conditions, from the time seeds reach physiological maturity until harvest. Weathering damages are often a serious factor at this stage. As a result of weathering damages, seeds of many crops, e.g. soybean, lose their viability and vigour and are already low in germination even before they are harvested. Several factors such as soil conditions, mineral nutrient deficiencies, during plant growth, water stress, high or low temperatures, disease and insect damage, etc., may also deteriorate seed quality by reducing viability and vigour at physiological maturity.

(2) Storage from harvest until processing-

Generally harvesting and clearing period of many crops coincides with high temperature. During this period seeds still have high moisture content and prone to rapid deterioration due to improper harvesting, handling, transport, drying and processing. If the moisture content of seeds remain above the acceptable limit i.e. more than 13%, chances of fungal/ insect attack increases manifold.

It is, therefore, necessary to take utmost care in handling of seed after harvest. If harvesting has been done above 13 percent moisture content, necessary arrangements for drying/ aeration, etc., of seeds are necessary to preserve seed quality. In addition, adequate care is necessary in handling the seed.

(3) Storage in warehouse

It is customary for storage of seeds, to give primary attention to rooms or buildings labelled as seed storages. Seed ageing, and loss of germination during storage, cannot be stopped altogether, though it could be appreciably reduced by providing good storage conditions.

Seed longevity in storage period is affected by several factors.

1. **Kind/ variety a seed-**
   The seed storability is considerably influenced by the kind/ variety of seeds. Some kinds are naturally short-lived, e.g., onion, soybeans, peanuts, etc. Some similar kinds, e.g., tall fescue and annual rye grass, though they look very much alike, differ considerably in storability. Similarly, the genetic make- up of the lines/ varieties in the same kind also influences storability.

2. **Initial seed quality-**

   The seed lots having vigorous, undeteriorated seeds store longer than deteriorated lots. Depending upon the severity of damage, extent of mechanical injury, flat, wrinkled & damaged seed are crucial factors for deciding storage of seeds.

3. **Moisture content**
   The amount of moisture content in seed is one of the very important factor influencing seed viability during storage. It is general principle that as moisture content increases rate of deterioration also increases. It is also important to note that very low moisture content (below 4%) is also detrimental as it damage seed due to extreme desiccation or cause hard seededness is some crops.

Moisture content and corresponding storage life of cereal seed at temperature not exceeding 90 ^{0}F for seeds of high germination & high vigour at start of storage (Harrington & Douglas, 1970)

Seed moisture content (%)	Storage life
1) 11 to 13 %	½ year
2) 10 to 12 %	1 year
3) 9 to 11 %	Two year
4) 8 to 10 %	Four year

Since the life of a seed and its span largely revolves around its moisture content, it is necessary to dry seeds to safe moisture contents. The safe moisture content, however, depends upon storage length, type of storage structure, kind/ variety of seed type of packaging material used. For cereals in ordinary storage conditions for twelve to eighteen months, seed drying up to ten percent moisture content appears quite satisfactory. However, for storage in sealed containers, drying up to 5 to 8 percent moisture content, depending upon the particular kind, may be necessary.

4. Relative humidity and temperature during storage

Relative humidity and temperature by far are the most important factors determining the storage life of seeds. Seed attain rather specific and characteristic moisture content when subjected to given levels of atmospheric humidity. This characteristic moisture content is referred to – equilibrium moisture content. Equilibrium moisture content, for a particular kind of seed at a given relative humidity, tends to increase as temperature decreases and as deterioration progresses. Thus the maintenance of seed moisture content during storage is a function of relative humidity, and to a lesser extent of temperature. At equilibrium moisture content, there is no net gain or loss in seed moisture content. Seed placed in an environment with a relative humidity higher or lower than that with which its moisture content is in equilibrium, will gain or loose moisture until equilibrium is established with the new environment. In sealed storage, seed moisture content determines the relative humidity of the environment in the containers.

Temperature also plays an important role in life of seed, although if does not appear to be a controlling one. Within the normal range of biological activity of seeds, insects and moulds increase as temperature increases. The higher the moisture content of the seeds, the more they are adversely affected by temperature. Decreasing temperature and seed moisture, therefore, is an effective means of maintaining seed quality in storage. Low temperatures are very effective in maintaining seed quality, even though relative humidity might be quite high.

How dry and how cool the conditions should depend upon storage needs and the physiological condition of the seed. The following simple rules put forth by Harrington are a useful guide as well as measure of the effect of moisture content, temperature and relative humidity on seed ageing.

1. A one percent decrease in moisture content nearly doubles storage potential of seed.
2. A 10 ºF decrease in temperature nearly doubles storage potential of seed.
3. Good seed storage is achieved when the percentage of relative humidity in storage environment and the storage temperature in degrees Fahrenheit add up to one hundred.

5. Bacteria and fungi

The important consideration in the control of seed microflora, is the relative humidity of the inter-seed atmosphere. Research indicate that storage fungi are completely inactive below 62 percent relative humidity and that there is little activity below 75 percent relative humidity. From 75 percent relative humidity upwards, the amount of fungi in a seed often shows an exponential relationship with relative humidity. The storage bacteria require at least 90 percent relative humidity for growth and they, therefore, only become significant under conditions in which fungi are already very active.

With regard to effect of temperature on the growth of the microflora, certain organisms can grow at temperature as low as -8ºC and others at temperatures as high as 80ºC. Consequently since high temperatures rapidly decrease seed viability, the only practical method of controlling microflora activity by temperature alone is by deep freezing.

6. Rodents and birds

Birds can be a constant source of seed loss, even if small openings exist at the lanes, or between the roof tiles. All openings should be sealed, or screened, if needed for ventilation. Rats and other rodents are a more of a serious problem in seed storage.

Rodents may result into a complete loss of seed. Rodent, control measures include building the store on an elevated platform, so that the floor is 90 cm above ground level at the entrance; having a 15 cm lip around the building at the 90 cm level of the floor; and providing a removable deck at the entrance for use only when seed is being loaded or unloaded.

Pre storage preventative measures

1. Before arrival of the new produce, all processing and storage structures should be thoroughly cleaned, white- washed if possible and then disinfected with sprays of insecticide such as malathion 50 EC @ 5 litres/ 100 m^3 area or fenitrothion 50 EC.
2. Seeds should be cleaned and its moisture content should be preferably be reduced below 9 %. Most species of insects do not breed at such low level of moisture content.
3. In most of cases insect infestation starts when seeds are kept in pre processing shed. Delay in processing and subsequent storage damages seed. In case of insect infestation, seed should be fumigated with aluminum phosphide @ 2 tablets of 3 g per tonne with exposure period of 3 to 5 days. Moisture content of seeds should not be more than 12 % at the time of fumigation.
4. For seed storage preferably new bags should be used to avoid insect infestation and mechanical mixtures. If old bags are to be used, they must be thoroughly cleaned and treated with aluminum phosphide @ 1 tablet of 3 g/ m^3.
5. Processed seed should be stalked properly and must not be kept in area where unprocessed or carryover seeds are kept.

Seed Storage

In order to maintain the optimum plant population and there by getting maximum yield, seed lot must possess a reasonably good germination and high vigour. Therefore, proper measures need to be undertaken from storage up to its sowing. The different types of seed storage depending upon the needs, conditions and duration are as follows

1. Commercial seed storage

Generally 70 % of the commercial seed produced is normally utilized within one cropping season, whereas 20- 25 % may be stored for two or more seasons which is known as carryover seeds. It includes unlifted / excess seed due to unpredictable market and cropping trends or unfavorable weather conditions during sowing. It also includes high value breeder seed or foundation seed of the parental lines of hybrids which are normally produced in larger quantities than that required for immediate use.

Types of storage used depends upon following factors

a) Storage behaviour of species
   eg. Poor storer - Soybean
   Moderate storer - Wheat
   Good storer – Sugar beat
b) Volume / bulk of seed to be stored
   eg. Field crops volume is much higher than vegetable seeds
c) Value/ cost of seed
   eg. Hybrid seed of tomato costs 100 to 200 times higher than that of hybrid rice.
d) Category of seed
   Breeder seed / foundation seed requires greater care during storage than certified or truthfully labelled seeds.

2. Ambient storage

Ambient storage refers to the storage without any environmental control. The storage of commercial seeds under ambient conditions however does not mean uncontrolled or unsupervised conditions. The following principles emerge as necessary for a good storage.

1. Properly maintained building with the floor, walls and roofs made of adequate thickness and free from cracks or crevices.
2. Seed storage conditions should be dry and cool.
3. Necessary space should be maintained for stacking of seeds and movement
4. Effective pest control with fumigation and pesticide sprays and treatments at regular intervals
5. Proper sanitation of seed stores
6. Before placing seeds in to storage they should be dried to safe moisture limits, appropriate for storage system.
7. Storing of high quality seed only i.e. well cleaned, treated as well as of high germination, vigour and good pre storage history.

Seeds stored in ambient conditions could be packed in moisture pervious containers (seeds having 12-13 per cent moisture content) or in moisture impervious containers (seeds having 5-8 per cent moisture content) as per the requirement and length of storage. This type of stores is suitable for bulk quantities of seed, which need to be maintained for a short period, say one planting season (6-9 months) or even less for pre-packaging storage before marketing.

3. Controlled storage

In this type of seed storage, with application of refrigeration or dehumidification principles, temperature and relative humidity in storage environment are controlled. These types of stores are suitable for medium or long term storage especially in high value low volume seeds or for the seeds of short lived species that cannot maintain germination level even to one planting season. This type of storage is also specifically recommended for areas of high temperature and high relative humidity for most part of the year viz., coastal and tropical region of country.

Although modern methods of seed storage have evolved over a span of time, farmers are following simple, cost effective and age old methods of seed storage for short duration. Such traditional conservation methods have also proved to be beneficial for conservation of genetic resources in various crops. Looking at the grim reality of climate change and loss of agro-biodiversity, it has become imperative to promote such traditional methods of in-situ conservation among farming community. Gene-cum-Seed Bank is one of the potential tool for effective conservation of valuable genetic resources in different crops at community level and will serve as an alternative source of seed at times of unforeseen eventualities like drought, flood, higher temperature, rise in sea level, storms, tsunamis etc.

Gene-cum-Seed Banks

Indian agriculture has witnessed remarkable growth in food production since 1966 and this success story is shaped by high yielding varieties and hybrids released under National Agricultural Research System (NARS). Along with plant breeding and varietal development programmes, seed production, processing, testing and marketing contributed significantly for the mentioned cause. However, over-exploitation and displacement by exotics and improved varieties have taken a heavy toll on the endemic plant genetic resources. Three main processes that caused loss of genetic diversity of cultivated crop species are genetic erosion, genetic vulnerability and genetic wipe out.

Gene-cum-Seed Banks are potential alternatives to counteract erosion of genetic diversity, could be established in agro-biodiversity rich areas by involving farming communities of that region. On the basis of information collected (trait-specific) from the farmers/farming community/literature, important land races can be included in Gene-cum-Seed Bank. Documentation of traditional knowledge and other related information through such gene banks will benefit local farmers and protect their intellectual property rights in terms of traditional knowledge. The establishment of Gene-cum-Seed Banks will be an important step towards the climate resilient farming and an action plan for achieving sustained food security. It will provide the opportunity to enhance germplasm resources, identification of trait-specific germplasm, better flow of information and above all better management of natural calamities.

Elucidation on Determination of Genuineness of Varieties Through Conventional and Biotechnological Tools

Introduction

The Purity Test provides the actual percentage of varietal purity from the nominated grain variety. This provides better assurance of crop purity. The test is particularly useful prior to seeding to identify the purity of seed grain. By conducting the test prior to seeding, it can potentially identify the purity of the crop before it is grown. Quality seed is one which meets the Minimum Seed Certification Standards *viz.*, physical purity, germination per cent, moisture content, seed health and genetic purity. The genuineness of the variety is one of the most important characteristics of good quality seed. Genetic purity test is done to verify any deviation from genuineness of the variety during its multiplication. For certification, genetic purity test is compulsory for all foundation and certified seeds. The genetic purity during multiplication stages is prone to contaminate due to the presence of out crossing with foreign pollens besides physical admixtures. Thus use of seeds with low genetic purity results in segregation of the traits, lower yields and genetic deterioration of varieties. Therefore, maintenance of varietal purity is a prerequisite to ensure high genetic purity of seeds.

With the introduction of Indian legislation on "Protection of Plant Varieties and Farmers Rights" the new crop varieties should be **distinct** from other varieties, **uniform** in their characteristics and generally **stable** over the years (DUS testing). Farmers and seed growers need an assurance that they are being supplied with correct seed material having known identity of a specific variety and assured quality. Thus, there is a need to search for rapid and reliable methods of varietal identification and genetic purity testing of seed. The characters for which a variety is distinct from other could be **morphological, chemical** and **biochemical** or **physiological** in nature which aids in varietal identification. According to International Union for Protection of New Plant Varieties (UPOV), any new characteristic used in varietal characterization should be clearly defined, accepted and should have standard method of observation and not affected by environment, accessible to breeders, associated with reasonable costs and efforts. There are three broad classes of markers available to estimate the genetic purity and they are,

- Morphological marker (those based on visually assessable traits)
- Biochemical markers (those based on gene product)
- Molecular markers (those relying on a DNA assay).

Types of markers

i) Morphological markers

Seeds, seedlings and plants of various cultivars exhibit a wide range of morphological distinctness which is helpful in varietal identification and genetic purity testing. Continuous usage of morphological data to describe cultivars indicated that these data retain popularity as descriptors. There are several undesirable factors that are associated with morphological markers.

1. High dependency on environmental factors. Often the conditions that a plant is grown in can influence the expression of these markers and lead to false determination.

2. These traits often have undesirable features such as dwarfism or albinism.

3. Performing genetic purity test (GOT) with these markers is time consuming, labour intensive and the large populations of plants required need large plots of land.

ii) Biochemical markers

Isozymes are used as biochemical markers in plant breeding. Isozymes are common enymes expressed in the cells of plants. The enymes are extracted, and run on denaturing electrophoresis gels. The denaturing component in the gels (usually SDS) unravels the secondary and tertiary structure of the enzymes and they are then separated on the basis of net charge and mass. Polymorphic differences occur on the amino acid level allowing singular peptide polymorphism to be Detected and utilized as a polymorphic biochemical marker.

Biochemical markers are superior to morphological markers in that they are generally **independent of environmental growth conditions**. The only problem with isozymes is that most cultivars (commercial breeds of plants) are genetically very similar and isozymes do not produce a great amount of polymorphism and polymorphism in the protein primary structure may still cause an alteration in protein function or expression.

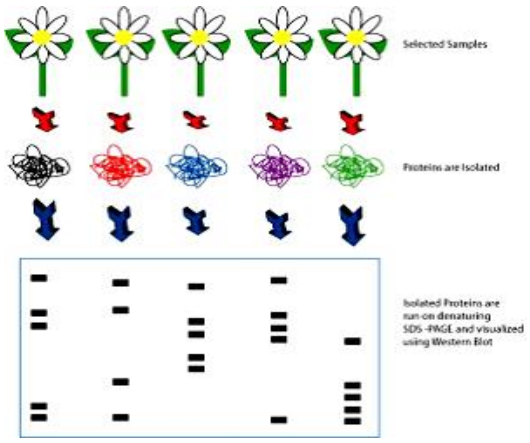


Fig.1: Sequential Summary of events occurring in isozymes analysis of plant samples. Although useful in some plant varieties, isozymes provide little variation in highly bred cultivars

iii) Molecular markers

Molecular markers are based on naturally occurring polymorphisms in DNA sequences (i.e.: base pair deletions, substitutions, additions or patterns). Molecular markers are superior to other forms of markers because

1. They are relatively simple to detect,
2. Abundant throughout the genome even in highly bred cultivars,
3. Completely independent of environmental conditions and
4. Can be detected at virtually any stage of plant development.

The ideal characters of suitable molecular marker:

1. Must be polymorphic
2. Co-dominant inheritance
3. Randomly and frequently distributed throughout the genome
4. Easy and cheap to detect
5. Reproducible

Varietal purity testing through conventional and biotechnological tools

The traditional way to assess the seed genetic purity of cotton is grow-out test (GOT), where the crop is grown and evaluated at different stages of crop growth with the aid of available morphological descriptors. The process is time consuming, requires larger area for replicated trails and highly skilled personnel for making often subjective decision (Lucchese *et al.,* 1999) and also the marketing of seeds is delayed due to late receipt of results. While the differential response of seeds or seedling to various chemical test, biochemical test and molecular marker can be used as a tool to identify the hybrids which are time consuming, simple and reproducible

Conventional tools: GOT/ morphological characters

To meet the demand of genetically pure seed, the Certification Agencies are following a Grow out techniques (GOT) where morphological characters are scored at various stages of plant growth, which has been used extensively in purity control mechanism of hybrid seed and for the purpose of identification of varieties. A set of morphological descriptors are currently in use for variety identification and description. Some of these characters, particularly those showing quantitative inheritance, interact with the environment in which the variety is grown and thus make the process of variety identification subjective. The main disadvantages of this method are time consuming, laborious and demanding more space. Besides, certain characters are influenced by the environmental factors and also require the collection of extensive data at different locations. The environmental effects mask the phenotype, so the phenotype provides an imperfect measure of a plant genetic potential. These limitations of conventional GOT demands a new technique which shall be environmental independent, quick and reliable ones. The alternative way to overcome this limitation and to speed up the testing procedures is to use chemical, biochemical and DNA markers in addition to morphological markers.

Chemical tests

The chemical tests are on spot tests and useful in identification by change in seed colour as well as solution due to added chemicals. Simple chemical tests *viz.*, phenol test, peroxidase test, NaOH, KOH test, seedling response to various chemicals have been proved quite useful in detecting varietal mixtures and grouping of large number of genotypes into distinct classes.

Biotechnological tools: biochemical and molecular markers

Biochemical markers

Electrophoresis of total proteins was found to be extremely useful technique for distinguishing genotypes as noticed by several workers (Anderson and Mc Daniel, 1979; Bonfitto *et al.,* 1999 and Basu *et al.,* 2002). The analysis of protein composition for plant variety identification is now well established (Cooke, 1984; Wrighley *et al.,* 1982). The success of electrophoretic procedure depends on the wide ranging polymorphism of seed and seedling proteins. During the last decade, use of electrophoresis of proteins and isozymes in seed purity testing has been recommended by International Seed Testing Association (Anon., 1996a) and possibility of usage of molecular markers is underway. The use of proteins as

genetic markers has been accepted as reliable tool, since proteins are the direct products of a gene and any change in the phenotype due to the effect of environment is not accounted in this method. The separation of seed proteins is based on the net charge and the molecular size of a protein in a charged electric field. The criteria for identification of a variety are based on presence or absence of a band, position and its intensity. Electrophoresis of seed storage proteins show promising results in genetic purity determination of cultivars and hybrids.

Molecular markers

Molecular markers is a powerful PCR based technique which is very fast reliable and require minimal amount of tissue for investigation (Rana *et al.*, 2006). This is a new approach to test the genetic purity of the seeds done at nucleotide level. This test screen through whole genome and produces enough polymorphism in closely related parental lines also. The DNA markers have several advantages over morphological traits, which are the resultant of genotype and environmental interactions, while, DNA markers are resultant of only genotype of the cultivar and are independent of environmental interactions. With the choice of techniques, proper sampling procedures and judicious interpretation, these laboratory methods can provide reliable and accurate results for varietal identification and assessing genetic purity in a considerably short period of time (Silvanacristae *et al*., 2005).

Genetic purity of F_1 hybrid seeds using molecular markers

Molecular genetic techniques have been applied to plant cultivar identification in the past decade by developing molecular markers that detect differences in DNA sequences between cultivars. Highly specific marker profiles commonly known as DNA fingerprinting can be developed for each cultivar and used for its identification. Identifying breeding lines and determining hybrid purity are major requirements in plant breeding and quality seed production. To test the conformity of hybrid seed, one must be able to distinguish the true hybrid resulting from cross between the male and female parents and one coming from self pollination of the female parent. Finger printing of parental lines, hybrid and off-types could be used as a data base to identify off-types in questionable seed lots.

Generally, F1 hybrid seeds in most of the crops are produced using established male-sterile systems. However, hybrid seeds are often contaminated with seeds from selfing of female parents or outcrossing with other cultivars because of weakening of self-incompatibility or restoration of pollen fertility in male-sterile lines (Crockett et al., 2000). Low genetic purity would cause seed suppliers a great loss from the planters' claim and could make it easy for a competitor to steal the inbred parent of a hybrid. Therefore, it is critical for seed suppliers to control seed genetic purity before marketing.

Higher genetic purity is an essential prerequisite for the commercialization of any hybrid. Besides, success of any hybrid seed technology depends on the availability of quality seed supplied in time at reasonable cost. The genetic purity during multiplication stages is prone to contaminate due to the presence of out crossing with foreign pollens besides physical admixtures. Thus use of seeds with low genetic purity results in segregation of the traits, lower yields and genetic deterioration of varieties. Therefore, maintenance of parental line purity is a prerequisite to ensure high genetic purity of hybrid seeds. Conventional GOT

requires one full season thus excluding the immediate cultivation of the hybrid seed produced. In addition, expenditure incurred on storage, ultimately increases the hybrid seed cost.

Furthermore, morphological differences between true and false hybrids are not always apparent and cannot be recognized easily, especially when parents are genetically similar, causing potential inaccuracy. Isozyme analysis has also been used in purity testing. However, this method may be limited by environmental conditions and tissue type and may require selection of a suitable isozyme. Because F1 hybrids contain DNA from both parents, identification of male and female parent-specific markers will allow differentiation of true hybrids from selfed parental lines and outcrossed lines. Molecular markers, such as RAPD, ISSR, SSR, SRAP, AFLP (amplified fragment length polymorphism), and RFLP (restriction fragment length polymorphism) have been used in hybrid seed purity testing in many species. Unlike radioactive chemicals involved RFLP and patent-protected AFLP, several other molecular markers, including RAPD, ISSR, SRAP, and SSR, could be effectively used for hybrid seed genetic purity testing and variety identification in many species.

Although male or female parent-specific markers can be used to screen hybrid seeds, codominant markers are always preferred for assessment of hybrid seed purity. It is suggested that a single codominant marker is sufficient to distinguish false hybrids from real hybrids. However, residual heterozygosity, detected only at the molecular level, occurs inevitably in many inbred lines; therefore, it is questionable to determine hybrid purity only using a single marker. The various researchers opined that RAPD, ISSR, SRAP, and SSR markers are fast and effective, and results are generally consistent with morphological analyses in field plots. Despite the added cost, use of multiple marker systems could result in more accurate and reliable assessment of hybrid seed purity. Combination of effective markers would be a good option for establishment of a seed quality control system to be applied for seed purity testing in commercial seed production. Molecular markers utilized for hybrid identification/genetic purity testing or assessment of genetic diversity in various crops *viz.*, maize, wheat, rice, cotton, cabbage, muskmelon, sugarcane hybrids. In this contest, conducting a natinal on varital purity testing through conventinal and biotechnological tools is an imparative vogue for training personals involved in seed production and certification.

Seed Testing: Sampling and Purity analysis

Introduction

Quality of seed has been given utmost priority from earlier times. Our ancestors used to soak seed in milk and honey, from time immemorial farmers used to soak seed before sowing for better germination. Hence importance of seed and its quality in agriculture is paramount and undeniable. It is the single most input having the ability to decide fate of the crop; hence seed testing carved its own niche in the field of seed technology. Modern seed testing is based on botanical and scientific principles that originated in Germany during the latter half of the 19th century. Prof. Nobbe opened the first seed testing laboratory in Tharandt, Germany, in 1869. By 1876, knowledge in this areahad advanced sufficiently for Nobbe to publish his classic treatise, Handbuch der Samenkunde (Handbook on Seed Testing). As the number of seed testing laboratories quickly expanded and trade in seed between countries increased, first in Europe and North America, there was a need to standardize testing methods, so that the same would be obtained in different laboratories and countries, thus increasing confidence and promoting trade. The European Seed Testing Association was formed in 1921, and in 1924 became the International Seed Testing Association. In North America, the Association of Official Seed Analysts (AOSA) was formed to perform similar functions to ISTA. Over the years ISTA has produced a set of internationally agreed rules on which all over seed testing procedures are based. In India, during the Pre-Independence era several committees recommended for quality seed programme with mechanism for seed testing. The result of which four seed testing laboratories viz. Central Seed Testing Laboratory at IARI and state laboratories at Hyderabad, Ludhiana and Patna came into existence. Initially seed testing laboratories were operated on service motive, but once seed law came into operation, assumed statutory role.

Sampling

Seed testing starts when a sample is drawn from the seed lot. A sample is defined as a small portion drawn from larger population. By analysis of sample, lot quality is determined in toto. Based on component analysis of sample, it may not be possible to say exactly what the level of a component is in the seed lot but it would be possible to say from the results that quality of seed lie in the proposed upper and lower limits.

"A sample which provides results which can be reliable used to predict the likely upper and lower limits of the quality of the seed lot" – (Bould and Smith, 1981). An important word in this definition is 'likely' because this implies that absolute certainty cannot be placed on these limits. There is, therefore, an element of risk in applying these limits and risk itself has commercial implications for buyers and sellers of seed. The level of risk which can be accepted by the seed merchant and the farmer and the cost of performing the test largely determine the size of sample which need to be examined. The most important fact to remember is that sample results are subject to random sampling variation so that tests done in duplicate would not necessarily give exactly the same result, which may be due to granular nature of seed.

Sampling should be carried out only by trained personnel, henceforth random sampling variation may be minimized. The principles on which sampling techniques are based can perhaps be illustrated most conveniently by considering the methods prescribed for statutory purposes.

Sampling Intensity

As per ISTA rules (2008), for seed lots in containers of 15 to 100 kg capacity (inclusively), following sampling intensity shall be regarded as minimum requirement

1-4 containers	3 primary samples from each container
5-8 containers	2 primary samples from each container
9-15 containers	1 primary samples from each container
16-30 containers	15 primary samples from the seed lot
31-59 containers	20 primary samples from the seed lot
60 or more containers	30 primary samples from the seed lot

For seed lots in containers smaller than 15 kg capacity, containers shall be combined into sampling units not exceeding 100 kg e.g., 20 containers of 5 kg, 33 containers of 3 kg or 100 containers of one kg. The sampling units shall be regarded as containers as described above.

When sampling seed in containers of more than 100 kg, or from streams of seed entering containers the following shall be regarded as the minimum requirement:

Lot size	Number of primary samples to be taken
Up to 500 kg	At least 5 primary samples
501- 3000 kg	One primary sample for each 300 kg, but not less than 5
3001-20000 kg	One primary sample for each 500 kg, but not less than 10
20000 kg and above	One primary sample for each 700 kg, but not less than 40

Types of Sample

1. Primary Sample: Primary sample is a small portion taken from one point in the lot, during one sampling action.

2. Composite sample: Formed ny combining and mixing of all the primary samples taken from the lot

3. Submitted sample: A submitted sample is a sample to be submitted to the testing laboratory. It must be of at least the size specified in ISTA Rules, and may comprise whole or sub sample of the composite sample.

4. Working sample: The working sample is a sub sample taken from the submitted sample in the laboratory, on which quality tests are deployed.

Purity Analysis

Purity analysis denotes the physical composition of a particular seed lot. The sample is separated into three main groups – pure seed, other seed (weed seed + other crop seed) and inert matter. Each group is weighed and expressed as percentage of total weight.

Pure seed

Pure seed is the portion of the working sample represented by the crop species for which the lot is being tested. No attempt is made to separate varieties of same species. Immature, shriveled and other damaged seed are considered as pure seed provided the can be definitely identified as that of species. Intact seed units as defined for each genus or species and pieces of seed units larger than one half of their original size are also categorized as pure seed.

Other seeds

These are the seeds of weeds and crop seeds which are not included in the description of pure seed.

Inert matter

The portion of the sample that is not seed is categorized as inert matter.

Calculation and expression of results

The total weight of all component fractions from the working sample must be compared with the original weight and checked against gain or loss. If there is discrepancy of more than 5 % of the initial weight, a retest must be made. The result of the retest is then reported. If the sum does not equal 100 per cent (either 99.9 or 100.1) then add or subtract 0.1 % from larger value (normally pure seed fraction)

The number of decimal places necessary for weighing, in order to calculate percentages are indicated below

Working sample weight 1000 g or more	Weigh to 0 decimal place
Working sample weight 100 g to 99.9 g	Weigh to 1 decimal place
Working sample weight 10 g to 9.99 g	Weigh to 2 decimal places
Working sample weight 1 g to 0.999 g	Weigh to 3 decimal places
Working sample weight 1 g	Weigh to 4 decimal places

The results are reported as percentages by weight to one decimal place. So calculate the percentage to at least two places. If the second decimal place is 5 or more, round off upwards. If the actual percentage is less than 0.05 per cent, report the result as trace.

Seed Germination Testing and Evaluation

Introduction

Germination testing is the most important quality test in evaluating the planting value of a seed lot. The ability of seeds to produce normal seedlings is measured in terms of germination test. Testing of seeds under field conditions is normally unsatisfactory as the results cannot be reproduced with reliability. Laboratory methods then have been used where the external factors are controlled to give the most uniform, rapid and complete germination. Testing conditions in the laboratory have been standardized to enable the test results to be reproduced within limits as early as possible as those determined by random sample variations.

Objective

The ultimate objective of seed germination testing is to obtain information with respect to the planting value of the seed and to provide result, which could be used to compare the value of different seed lots.

Definition

Germination of a seed lot in a laboratory is the emergence and development of the seedling to a stage where the aspect of its essential structures indicates whether it is able to develop further into a satisfactory plant under favorable conditions in soil (ISTA 1985). These essential structures are a well-developed and intact root system, hypocotyl, plumule and one or two cotyledons according to the species. Seedlings cannot be evaluated in a germination test until these essential structures are clearly identifiable and the reported percentage germination expresses the proportion of seed, which have produced normal seedlings within the period specified for each species.

General principle

Germination tests shall be made with seeds from the pure seed fraction of a purity test. A minimum of four hundred seeds are required in four replicates of 100 seeds each or eight replicates of 50 seeds each or 16 replications of 25 seeds each depending on the size of seeds and size of containers of substrate. The seeds shall receive no pretreatments except those recommended. If additional tests are undertaken after any other pretreatment, the result and pretreatment must be reported under other determinations on the certificate.

The seeds arranged in replicates are tested under favorable moisture conditions and in accordance with the methods prescribed. After the period indicated, the replicates are examined and counts made of the seedlings and seeds in various categories required for reporting.

General requirements for germination

Seeds require certain conditions for normal germination. The most important requirements are substrata, moisture, temperature and light.

A. Suitable substratum

The medium must be free from micro –organisms, toxic substances, insects and foreign seeds. It should have good water holding capacity with pH 6.0- 7.2. The commonly used substrates are paper, sand and soil.

Paper substrate

Most widely used paper substrates are filter paper, blotter or towel (kraft paper). These are easy to handle, versatile and comparatively cheap. It should be open and porous with sufficient strength are prepared from bleached wood.

Sand

It may be necessary to wash and sterilize the sand before use. For reuse of sand it must be washed, dried and re-sterilized. It is a medium consisting of silica particles ranging from 0.05 to 0.08mm.

Soil

Soil should be of good quality, and does not consists of large particles of soil. It must be free from weed seeds, bacteria, fungi, nematodes or toxic substances, which might interfere with the germination of seeds. For proper growth of seedlings or their evaluation, Soil should allow adequate aeration for germ initiation when water is added with a pH of 6.0-7.5. Before use soil may require sterilization and soil is not recommended for reuse.

B. Adequate moisture or water

High concentration of water at cellular level is necessary for the seed to start germination. Mobilization of food requires hydrolysis (breaking down process) to transport materials from storage to growing tissues. Moisture is supplied to the seeds through the substratum. Generally, the moistened substrata is sufficient to rehydrate to 10-80 per cent. However, when the radicle emerges additional moisture contributes better seedling growth. In the case of vegetable seeds, care is necessary in moistening the substrata. Too much water would allow fungal growth and decay of seeds. The general specifications for water are: It should be free from organic or inorganic impurities. The pH value should be within the range of 6.0 to 7.5. Distilled de-ionised water may be used.

C. Favorable temperature

Germination occurs under different ranges of temperatures provided that the adequate moisture is available for normal development of seedling. Water requirement is critical factor during the test. Some seeds germinate better at constant temperature while others require an alternating temperature. In case of requirement of alternative temperature, lower temperature should be maintained for 16 hours and the higher for 8 hours. If alternation of temperatures cannot be controlled over weekends or public holidays, the test should be kept at lower temperature.

Temperature control does provide the comparable conditions exactly under which test can he repeated. Normally seeds of kharif crops are exposed to 25^0C and Rabi crops to 20^0C for germination.

D. Light

The presence of light is desirable to enable the evaluation of seedlings easier and with greater certainty, crops like lettuce and tobacco require light during germination. Seeds of most of the species will germinate either in light or in darkness. However, illumination of the substrate from artificial source or by day light is generally recommended for better seedling development to avoid etiolation and also to detect seedlings having chlorophyll deficiency.

Procedures

Working sample

Four hundred seeds are counted at random from the well-mixed pure seeds. Replicates of 100 seeds are normally used for germination test. To ensure adequate spacing, split replicates of 50 or even 25 seeds are used particularly, where there is infection of seed-borne disease.

Methods using paper

Paper substrates are used for the following methods:

TP (Top of paper) In this method seeds are placed directly on one or more layers of moist filter or blotter papers in petridishes. These petridishes are covered with lid and placed inside the germinator. The relative humidity in the germinator must be maintained to 95-99% to prevent drying out during test period.

BP (Between paper) The seeds are germinated between two layers of paper. This may be achieved by loosely covering the seeds with an additional layer of paper or by placing the seeds in rolled towels. The rolled towels are to be placed inside the germinator in an upright position.

PP (Pleated paper) Seeds are placed in pleated strips. The paper may have 5-10 pleats which can be made in the laboratory. Each pleat may have 10 seeds. The pleated strips are kept in moistened boxes to ensure uniform moisture conditions. This method may be used as an alternative to TP or BP. This method is recommended for testing of coated and pelleted seeds.

Methods using sand

S (In sand) The seeds are planted on a leveled layer of moist sand and covered with 10-20 mm of uncompressed sand depending on the size of the seed. To ensure good aeration it is recommended that the bottom layer of sand is loosened by raking before sowing.

Moisture and aeration

The substrate must contain sufficient moisture to meet the requirements for germination. However, moisture content must not be excess or aeration may be limited. The initial quantity of water to be added will depend on the nature and dimensions of the substrate and also on the size and species of the seed to be tested.

The amount of water to be added to the sand can be calculated as follows (Anonymous, 1952).

$$\text{Water (ml) to be added to each of sand} = 100 \text{ gm} \frac{118.3\text{ml of sand} \times (20.2 - 8.0)}{\text{Wt. of } 118.3\text{ml of sand}}$$

The amount of water provided by this formula is satisfactory for seeds of the size of mustard. For larger seeds slightly more and for smaller seeds slightly less water should be added. Subsequent watering should be avoided wherever possible as it is likely to increase the variability between replicates and between tests. Therefore, precautions should be taken to ensure that the substrate may not dry out and that sufficient water is supplied continuously during the test period. Special measures for aeration are not usually necessary for TP and BP tests.

For BP, However, care should be taken that rolled towels are loose enough and material covering the seeds in sand or soil tests should not be compressed to allow sufficient air around the seeds.

Pretreatments for germination

For various reasons *(e.g.* physiological dormancy, hard seededness, inhibitory substances) a considerable number of hard or fresh seeds may remain at the end of the germination test. In order to prevent these non-germination and to have complete germination various kinds of pretreatment are recommended. These pretreatments include dry storage, pre-chilling (treat the moist seeds at a temperature of 5° - 10^0C for about seven days) preheating (at 30°-35°C), Light (750-1250 lux from cool white lamps for 8 hrs per day), potassium nitrate (0.2% KNO3), gibberellic acid (0.05-0.1 %) application etc. For hard seeds, puncturing the seed with a needle away from embryo, mechanical scarification and acid scarification are recommended for braking of dormancy. Similarly, for removing inhibitory substances, washing of the seeds under running water at a temperature of 25°C and drying back these prewashed seeds to its original moisture content is recommended.

Duration of the test

The duration of the treatment required to break dormancy before or during the test is not taken as part of the germination test period. if test is conducted in sand, first count may be omitted. If the maximum germination of the sample has been obtained before the end of the prescribed test period, a test may be terminated. The seed testing laboratory on request of producer may release the result of seed germination on the basis of first count if the sample in question meets the minimum limits of germination for certification/labelling.

Germination test duration including first and final count

Crops	First count	Final count
Wheat	4	8
Paddy	5	14
Barley	4	7
Maize	5	8
Cowpea	4	8
Greengram	4	8
Groundnut	5	8
Sunflower	3	7
Brinjal	7	14

Radish	4	6
Tomato	5	14
Sunhemp	4	10

Seedling evaluation

Seedlings which have reached a stage when all essential structures can be accurately assessed, shall be removed from the test at the first or any other Intermediate counts. Badly decayed seedlings should be removed in order to reduce the risk of secondary infection, but abnormal seedlings with other defects should be left on the substrate until the final count.

Categories of seedlings

Normal seedlings

Normal seedling is one which shows the capacity for continued development into mature plant when grown in good quality soil and under favorable conditions of water, temperature and light. This capacity for continued development depends upon the soundness and correct functioning of the developing structures during germination. According to the International Seed Testing Association (1985), seedlings to be classified as normal seedling must conform with one of the following criteria:

(a) **Intact seedlings***:* Seedlings with all their essential structures well developed complete in all proportion and healthy.

(b) **Seedlings with slight defects***:* Seedlings showing certain slight defects of their essential structures provided they show an otherwise satisfactory and balanced development comparable to that of intact seedlings of the same test.

(c) **Seedlings with secondary infections***:* Seedlings which are badly infected by fungi or bacteria are classified as normal, If it is evident that the parent seed is not the source of primary infection and if it can be determined that all the essential structures were present.

Abnormal seedlings

An abnormal seedling is one which does not have the capacity to develop into a normal plant when grown in the soil under favorable conditions because one or more of the essential structures is irreparably defective.

Three major classes of abnormal seedlings are:

(a) **Damaged seedlings***:* Seedlings with any of the essential structures missing or so badly damaged that balanced development does not occur. The damage to the embryo in the seed usually results from external cause *i.e.* mechanical handling, heat, drought or insect damage which leads to the abnormalities.

(b) **Deformed or unbalanced seedlings***:* Seedlings with weak and unbalanced development, which may be caused by internal disturbances of physiological and biochemical character. Such internal disturbances, however, are often due to the earlier external disturbances such as unfavorable growing conditions of the parent plants, poor ripening conditions for the seed, premature harvesting, effect of herbicides or pesticides and inappropriate storage conditions or ageing of the seed.

(c) **Decayed seedlings:** Seedlings with any of their essential structures diseased or decayed as a result of primary infection are considered as decayed seedling. These may result from the external or internal seed borne diseases.

(d) **Multigerm seed units:** Seeds which are capable of producing more than one seedling are known as multigerm seed unit. Several types of seed units can produce more than one seedling *e.g.* un-separated schizocarps of umbelliferae, clusters of Beta *vulgaris,* fruit of *tectona grandis,* polyembryonic seeds. In such cases only one normal seedling is counted for determining the germination percentage.

Ungerminated seed

Seeds, which have not germ initiated by the end of test period when tested under the conditions prescribed, are classified as follows:

(a) **Hard seeds**: Seeds, which do not absorb moisture till the end of the test period and remain hard.

(b) **Fresh seeds**: Seeds which are neither hard nor have germinated but remain clean and firm and apparently viable at the end of the test period. The viability of the fresh seeds may be determined by tetrazolium test.

(c) **Dead seeds:** Seeds at the end of the test period are neither hard nor fresh nor have produced any part of a seedling. Often dead seed collapses and a milky paste comes out when pressed at the end of the test.

Seedling descriptions

As per the ISTA Rules (1985 Para 5.2A.A. and 5.l.5.A. the following is the detailed description for normal and abnormal seedlings. These have to be taken into account while evaluating the seedlings.

Normal seedlings

1. **Intact seedling**

Depending on the species being tested, a combination of some of the following essential structures are generally found, a well developed root system having a long and slender primary root, usually covered with numerous root hairs and ending in a fine tip.

- secondary roots or seminal roots instead *of* one primary root in certain genera, *including Avena, Hordeum, Secale, Triticum, Triticosecale.*

- a well developed shoot axis consists of a straight and usually slender elongated hypocotyl in seedlings showing epigeal germination.

- a well developed epicotyl in seedlings showing hypogeal germination.

- both an elongated hypocotyl and epicotyl in some genera with epigeal germination.

- an elongated mesocotyl in certain genera of the *Gramineae.*

- a specific number *of* cotyledons, *i.e.*, one cotyledon in monocotyledons or exceptionally in dicotyledons (it maybe green and leaf-like or modified and remain wholly or partly within the seed).

- two cotyledons in dicotyledons (in species with epigeal germination they are green and leaf-like). In species with hypogeal germination they are hemi spherical, fleshy and remain within seed coat.

- green expanding primary leaves.

- a terminal bud or shoot apex.

- a well developed straight coleoptile in *Gramineae* containing a green leaf.

2. Seedlings with following slight defect

Primary root with limited damage of slight growth retardation, defective but with sufficient well developed secondary roots in specific genera of *Leguminosae (e.g. Phaseolus, Pisum, Vicia); Gramineae (e.g. Zea);* in all genera of *Cucurbitaceae(e.g. Cucumis, Cucurhita, Citrullus)* and *Malvaceae (e.g. Gossypium).*

- only two seminal roots in *A*vena, *Hordeum, SecaIe,Triticum, Triticosecole.*

- hypocotyl, epicotyl or mcsocotyl with limited damage

- cotyledons with limited damage

- only one normal cotyledon in dicotyledons

- Primary leaves/leaf with limited damage and healthy terminal bud

- Coleoptile with limited damage, loosely twisted forming a loop, coleoptile with a green leaf not extending to the tip but leading at least half-way up to the coleoptile.

Abnormal seedlings

One or a combination of the following defects in the seeding renders it abnormal.

I**. Primary root:**

1. Stunted
2. Stubby
3. Retarded
4. Missing
5. Broken
6. Split from the tip
7. Constricted
8. Spindly
9. Trapped in the seed coat
10. With negative geotropism

11. Glassy

12. Decayed as a result of primary infection

13. Only one seminal root or none.

Note: Secondary roots or seminal roots showing one or more of the above defect are abnormal and cannot replace an abnormal primary root in cases where the presence of several secondary roots (e.g. *Cucumis) or* at least two seminal roots (e.g. *Triticum)* determine the value of a seedling.

II. **The hypocotyl. epicotyl & mesocotyl:**

1. Short and thick

2. Deeply cracked or broken

3. Split right through

4. Missing

5. Constricted

6. Tightly twisted

7. Bent over

8. Forming a loop or spiral

9. Spindly

10. Glassy

11. Decayed as a result of primary infection

Ill. The cotyledons (apply 50% rule)

1. Swollen or curled

2. Deformed

3. Broken or otherwise damaged

4. Separate or missing

5. Discolored

6. Necrotic

7. Glassy

8. Decayed as a result of primary infection

Note: Damage or decay of the cotyledons at the point of attachment to the seedling axis or adjacent to the shoot apex renders a seedling abnormal, irrespective of the 50% rule.

Special cotyledon defects for *Allium* species.

9. Short and thick

10. Constricted

11. Bent over

12. Forming a loop or spiral

13. without a definite 'knee'

14. Spindly

IV. The primary leaves (apply 50% rule)

1. Deformed

2. Damaged

3. Missing

4. Discolored

5. Necrotic

6. Decayed as a result of primary infection

7. Normal shape but less than ¼ normal size.

V. The terminal bud and surrounding tissues:

I. Deformed

2. Damaged

3. Missing

4. Decayed as a result of primary infection

Note : If the terminal bud is defective or missing. the seedling is abnormal. even when one or two axillary buds (e.g. *Phaseolus)* or shoots(e.g. *Pisum)* have developed.

VI. The coleoptile and first leaf *(Gramineae)*

The coleoptile :

1. Deformed

2. Damaged

3. Missing

4. With the tip damaged or missing

5. Strongly bent over

6. Forming a loop or spiral

7. Tightly twisted

8. Split for more than one-third of the length from the tip

9. Split at the base

10. Spindly

11. Decayed as a result of primary infection

The first leaf

12. Extending less than halfway upto the coleoptile

13. Missing

14. Shredded or otherwise deformed.

VII. The seedling as a whole

1. Deformed

2. Fractured

3. Cotyledons emerging before the root

4. Two-fused together

5. Persisting endosperm collar

6. Yellow or white

7. Spindly

8. Glassy

9. Decayed as a result of primary infection.

50% rule*:* Seedlings are considered as normal if half or more of the total cotyledon tissue/primary leaf is functional but abnormal when more than half of the cotyledon tissue/primary leaf is not functional and defective.

Retesting

If the results of a test are considered unsatisfactory, it shall not be reported and a second test shall be made by the same method or by alternative method under the following circumstances. Replicates performance is out of tolerance. Results may be inaccurate due to wrong evaluation of seedlings or counting or errors in test conditions. Dormancy persistence or phytotoxicity or spread of fungi or bacteria may also contribute for deviation in normal results.

Reporting of results

The result of the germ initiation test is calculated as the averages of 4 x 100 seed replicates. It is expressed as percentage by number of normal seedlings. The percentage is calculated to the nearest whole number. The percentage of abnormal seedlings, hard, fresh and dead seeds is calculated in the same way. These should be entered on the Analysis Certificate under appropriate space. If the result is nil for any of these categories it shall be reported as '0' instead of leaving the appropriate column blank.

Seed Vigour Testing

Introduction

Seed vigour is a vital quality parameter which supplements germination and viability tests to predict the performance of a seed lot in the field or in storage. Seed vigour is a highly complex phenomenon and revolves around various aspects of performance of the seed, both in the field and in storage. Looking into difficulty in describing seed vigour, ISTA in 2001 adopted the definition of seed vigour as "the sum total of those properties of the seed which determine the activity and level of performance of seedlots of acceptable germination in wide range of conditions."

Seedlings with a vigorous growth pattern can compete successfully under stress, influencing stand establishment and ultimately grain yield. The role of seed vigour comes to the fore, when seeds are sown in adverse conditions and the vigour of a seed becomes a deciding factor for crop establishment and yield compared to normal conditions of plant growth. Testing for vigour becomes more important for carryover seeds, especially if seeds were stored under unknown conditions or under unfavourable storage conditions. Seed vigour testing is also used as indicator of the storage potential of a seed lot and in ranking various seed lots with different qualities.

In recent years considerable efforts are mounted on measurement of seed vigour levels and its relationship with field establishment and yield. Numerous tests have been developed and combined, and more will likely to develop to measure the seed vigour effectively.

Characteristics of seed vigour

The concept of seed vigour is to recognize the potential performance differences among high germination lots. The high vigour lots shows faster rate and good synchrony of germination, produces uniform, large seedlings and have good emergence potential in varied soil conditions.

Seed vigour	High	Low
Mean rate of germination	Fast	Slow
Synchrony of germination	Good	Poor
Mean seedling size	Large; Uniform	Small; Variable
Emergence potential	Good in most soil conditions	Poor in less than optimum soil conditions
Storage potential	Good	Poor

(Encyclopedia of Seeds, 742p)

Criteria of a vigour test

Due to varied soil condition and environmental conditions vigour cannot be an absolute value representing field emergence but can provide information about field

emergence, storage potential, and consistently ranking which are not offered in the germination test. The important criterions are

1. Provide a more sensitive index of seed quality than germination test.
2. Provide a consistent ranking of seed lots in terms of their potential performance.
3. Rapid, simple and economically practical
4. Reproducible and repeatable.

Classification of vigour tests

1) Direct test

Direct tests are those in which an environmental stress expressed in the field is reproduced in the laboratory and the percentage and rate of seedling emergence is recorded e.g., Hiltner test, Cold test, *etc.*

2) **Indirect test**

Indirect tests are those in which characteristics of seed which are proved to be correlated with an aspect of field performance are measured e.g., Tetrazolium test, Conductivity test, *etc.*

Seed vigour testing methods

A. Physical test

1. **Seed size –** 1000 seed drawn randomly and weighted in g. The seed lot with high seed weight is considered as vigourous.
2. **Physical soundness-** Seed lot containing shrivelled seeds is considered as weak seed lot.

B. Performance test

1. **First count:** The number of normal seedlings counted at the first count ($4/5^{th}$ day) represents the faster germinating seeds. Higher percentage of normal seedlings during the first count indicates the seed vigour.
2. **Speed of germination:** High speed of germination is an indication of vigorous seed lot. Number of germinated seeds are counted every day from the first day and the cumulative index is made by the formula

$$n1/1+ n2/2+ \ldots\ldots\ldots\ldots + nx/x= N$$

n1……nx are the number of seed germinated on day 1 to day

1 ….. x are the number of days.

High value of N indicates high seed vigour. Seed is considered as germinated when the radicle has appeared hence, it should be counted daily and seeds observed as germinated should be removed.

3. **Seedling length:** Length of 10 normal seedlings grown in moist towel paper kept at optimum temperature is measured in cm on the day of final count. The lot showing maximum seedling length is considered as vigorous.
4. **Seedling dry weight:** Dry weight of 10 normal seedlings grown in moist towel paper kept at optimum temperature is measured on the day of final count. The lot showing maximum seedling dry weight is considered as vigorous.
5. **Strong and weak seedling:** Seeds are placed on a moist paper towel at optimum temperature in an incubator. After 5 days of planting, seedlings are observed as strong or weak. Seedlings are designated as weak, when primary root, cotyledon or primary leaf is missing, short or missing primary leaf, spindly or poorly developed seedling.
6. **Vigour index I:** A combination of standard germination test with seedling length provides broad evaluation of seedling vigour. Seed lot with high vigour index is considered as vigorous (Abdul Baki and Anderson, 1973).

   Vigour index I = Germination x Seedling length on the day of final count
7. **Vigour index II:** Vigour index in terms of mass is determined by the multiplication of germination percentage with seedling dry weight on the day of final count.

   Vigour index II = Germination x seedling dry weight on the day of final count

C. Stress test

1. **Accelerated ageing test (Soybean):** For rapid determination of seed vigour and storage potential of the seed lot the process of ageing is accelerated into weeks or days by increasing the seed moisture content and temperature. Seed germinated well after the ageing treatment is considered as vigorous. Accelerated ageing for 96 hour at 45°C in pumpkin (Dutra, A.S. and Vieira, R.D, 2006); 120 hours at 45-47°C in melon (Kazim Mavi and Ibrahim Demir, 2007) shows better correlation with field emergence.
2. **Controlled deterioration test :**This test is similar to accelerated ageing test but, having better control of seed moisture content and temperature during the period of ageing. The results of this test correlate well with both field emergence and storage potential in many vegetable crops (Matthews, 1980). The controlled deterioration test at 45^0C and 18% seed moisture for 72 h provided good discrimination of low and high vigour seeds in wheat (Modarresi and Van Damme, 2003).
3. **Paper piercing test:** Seeds are planted on 1.25 cm of moist sand. It is covered with specially selected dry filter paper (with 0.4 mm thickness, 4-bulk, 90mg/mt m basic weight, 0.3kg/ cm dry bursting strength, 1000-5000 m breaking length, 500 ml/ min. filtering speed, 150 mm wet bursting strength, and content 0.1% fibre composition chemical wood pulp with high alpha percentage). This filter paper is again covered with 3.00 cm of moist sand. This is kept at 20-25ºC for the days required for final count. The seedlings which are able to penetrate the paper are considered vigorous.
4. **Pathogen infested soil test:** Seed are planted in soil mainly infested with species of *Pythium Fusarium* or *Rhizopus* and other fungi and kept at 10ºC for 7 days followed by

3 days at 30ºC up to the day of final count. The lot showing maximum germination percentage is considered as vigorous.

5. **Cold test:** Seeds are planted on the 2 cm thick levelled moist soil. The same quantity of soil is then placed on top of the seed. Enough cold water (10ºC) is added to the soil to bring it to medium to 70% of its water holding capacity and then incubated a 10ºC or 7 days. After 7 days it is transferred at optimum required temperature for germination. Suitable check should be run simultaneously without any treatment. The lot showing minimum variation in germination percentage in comparison to check is considered as vigorous.
6. **Cool germination test:** Seeds are planted in moist towel paper or sand and incubated at low temperature 10-15ºC up to the day of final count. The lot with more germination, seedling length and dry matter production is considered as vigorous.
7. **Hiltner test:** Hiltner test is based on the fact that damaged seeds is often weak (physiological injuries, frost injuries, fungicide treatments etc.) and unable to withstand adverse conditions during germination. This test sometimes fails to give additional information on seed quality in relation to standard germination test (Hampton and Tekrony, 1995). Hiltner test is used mainly for wheat seed vigour testing (Vujaković *et al.*, 2003). Brick gravel test was found positive relationship with field emergence although non significant in magnitude, which revealed reliable to some extent for methods the first count number is very essential it pea vigour parameter (Singh *et al.*, 2010).
8. **Complex stressing vigour test:** Maree *et al*., (2007) found that complex stress vigour test is most effective in predicting field emergence in maize. In the complex stress vigour test, seeds were soaked for 48 h at a moderate temperature (25^0 C) followed by another 48 h soak at low temperature (50^0C). After this seeds are planted in sand and grown for 4 days at 25^0C before evaluation. The complex stress vigour test predicts 100% better results than tetrazolium test, 25% better than soak test, 19.8% than accelerated ageing test and 17.4% than the cold test under cold and wet conditions.

D. Biochemical test

1. Electrical conductivity test

Principle: The solute leaked out from seeds into the water is not available to the seed, resulting in poor field emergence. Degradation changes in the cellular membrane causing increased permeability and leakiness. A deteriorated seed lot leaches more water soluble compounds than a vigorous one when soaked in water. The electrical conductance of a solution will be higher with the high concentration of ion in the solution.

Procedure: Three replicates of 50 seeds from each lot are weighed to 2 decimal place in beaker. 250 ml deionized water is added in each beaker. These beakers are kept at 20ºC for 24 hours after proper covering to reduce the evaporation and contamination. A beaker containing deionized water with no seed is set with each test as control. After 24 hours the soak water is poured through a coarse sieve into another beaker to remove the seed. The electrical conductivity to the water is measured by electrical conductivity meter at

constant temperature with shaking of beaker. The conductivity of water in control is subtracted form the reading of soak water before calculating the conductivity per gram of seed and expressed as micro siemens/ g of seed (µs/cm/g).

Garden pea (*Pisum sativum* L.) is often vigour tested using the conductivity test. The test is fast, non-subjective, and repeatable, and has been extensively correlated with field emergence results.

2. Tetrazolium test

Principal: The activity of dehydrogenase is expected to be more in vigorous seed in comparision to less vigorous seed (Lakon, 1942).

Procedure: Seeds are placed in Petriplates lined with moist blotter paper and kept at 25 ±1ºC for 24 hours. Embryonic axis is excised and kept in 1 ml of 15 (w/v) tetrazolium solution for 2 hrs at 30 ± 1ºC in dark. Excess solution is drained out and seeds are washed thoroughly with distilled water. The axes are soaked in 10 ml of methyl allosolve (methooxy cellosol) for 4-6 hours with occasional stirring till the extraction of red coloured formazan is complete i.e., axes turns colourless. Extract is decanted and its colour intensity is read at 480 nm in spectronic 20.

3. Glutamic acid decarboxsylase activity (GADA) test

Principle: The amount of carbon dioxide evolved by glutamic acid reflects the level of enzyme glutamic acid decarboxylase which is directly related with vigour and storability of the seed.

Procedure: Finely ground seed (30g) is placed in the jar of the manometer. 15 ml of 0.1 M glutamic acid in 67 MM Phosphate buffer (pH 6.8) is added in the ground seed and mixed quickly with the help of a glass rod. Then, the lid of the manometer is screwed tightly and the unit is placed at 30 ± 2º C in water bath. The manometer is adjusted to zero after 10 minutes. The CO_2 evolved results in displacement of ethyl lactate (crystal violet colour) which is measured in mm per 30g seed per 30 minutes at 30ºC.

Recent advances in seed vigour testing

1. New vigour tests in cabbage

The ageing based vigour test takes several days to complete. For example the controlled deterioration test for Brassica species takes around 72 hours for the deterioration of seed, followed by germination test of up to 10 days. Hence, Matthews *et al*, (2009) proposed the two new vigour test based on the work on the cabbage cultivar Yalova 1:

a. Initial Electric Conductivity after either 24 or 17 h of soaking

b. Electric Conductivity after controlled deterioration which could be completed in 2 to 3 days using shortened moisture equilibrium period.

The advantage of above tests is short time needed for vigour assessment. This is particularly true for initial EC which can be measured in an overnight (17hr) test. There was evidence that the time needed to complete the controlled deterioration can be reduced to between 2 and 3 days by modifying the test to include overnight EC measurements instead of

germination tests and reducing the time taken for the moisture equilibrium to 3 hr from 48 hrs without significant differences in results.

2. Radicle emergence test in maize

The radicle emergence test for *Zea mays* is an ISTA-validated vigour test which was accepted into the ISTA Rules at the Annual Meeting in Zurich in June 2011. The approach behind the new radicle emergence test for maize was to use single early counts of radicle emergence to predict Mean Germination Time (MGT). Close relationships were seen in maize between MGT and single counts after 66 h at 20 °C and after 6 days at 13°C. These close relationships formed the basis of the new vigour test for maize Matthews and Powell, (2011).

3. Computerised seed imaging

In the last two decades, the advent of computer-aided data acquisition by video camera, coupled with image processing and analysis, has allowed to capture time-lapse image sequences and to quantify several morphological features, necessary for germination and vigour testing.

Oakley *et al.,* (2004) showed that computer-aided analysis of digital images could be used successfully to rank seed lot vigour in *Impatiens* based on seedling length. Hoffmaster *et al.,* (2003) used an image processing computer application to automatically assess the vigor of three-day-old soybean. Combined with the post-processing corrective features, this computer software was able to achieve highly accurate and standardized measurements of each soybean seedling, providing an alternative to the current method of manually measuring vigor test in soybean.

4. Seed vigour ethanol test for canola

Two vigour assays, based on off-gassing of ethyl alcohol from poor vigour seed, are being developed. Test has been designed for on-farm use, and a technique using a hand-held gas monitor that will be suitable for various applications. The assays, which normally can be completed in 24 h, can be run at ambient temperatures varying from 19 to 27 °C (66 to 81 °F) and can be used to test seed with 4.5 to 10.5 % moisture. Tests appear to be equally suitable for hybrid, non-hybrid, genetically modified and mutagenically modified genotypes.

Principle: During imbibition, seeds undergo a period of aerobic metabolism during which ethanol and acetaldehyde are produced. Fairly soon, most seeds shift to aerobic metabolism and the production of ethanol and acetaldehyde drops dramatically or ceases. However, it appears that seeds that have deteriorated are less successful at making a rapid conversion from anaerobic metabolism to aerobic metabolism leading to increased ethanol and acetaldehyde production. Two experimental vigour assay techniques are developed. The first was a colour test utilizing the yellow-to-blue colour reaction of a potassium dichromate/sulphuric acid solution when exposed to alcohol. The second was an instrumental test utilizing a handheld gas monitor.

5. Near Infrared spectroscopy (NIR) test

Xing Wei Qi. *(*2011), developed a new non destructive method for discriminating vigour of soybean seeds. Near Infrared spectroscopy combined with principal component and Mahalnobis model was developed. The model could successfully complete the calibration sample and identify the prediction sample. This study proved that the use of near infrared spectroscopy combined with pattern recognition methods will offer a new method of testing soybean seed vigour with quick and non destructive characters.

Usefulness of vigour test

- ✓ Seed vigour tests helps in ranking seed lots based on its physiological quality, providing an indication of seed deterioration before it is noticeable in normal germination test results.
- ✓ Seed vigour test identifies seed lots that, in spite of acceptable germ test results, are unlikely to store well or perform well in suboptimal conditions.
- ✓ Seed vigour test results provide information which can be used to plan inventory carryover and marketing strategies.
- ✓ Seed vigour tests provide information which can be used by the seed industry to answer customer inquiries about seed lot performance or to prevent litigation.
- ✓ Seed vigour tests are a great tool for in-house quality control. Seed companies routinely use vigour tests to make quality assurance decisions during production, conditioning, storage and marketing.

Limitations of vigour test

- ✓ Precision and standardization of seed vigour (SV) testing methods can only be determined by referee testing among seed labs.
- ✓ Values obtained from seed vigour tests are relative, not absolute values of vigour.
- ✓ Comparison of the results of different vigour tests is sometimes difficult because results are often expressed in different units.
- ✓ Interpretation of results requires lab analyst experience, and education for the seed industry and consumer.
- ✓ Cut-off points between acceptable and unacceptable levels of vigour have only been established for a few recommended tests (e.g. conductivity test for pea) and needs to be established for other frequently used vigour tests.

Seed vigour is an important component of seed quality and essential to obtain optimum plant stand and emergence in field conditions. In order to assure high vigour seeds to end users there is need to integrate various vigour testing methods and simultaneously evolve new testing standards for vigour which are reliable, quantifiable, rapid, simple, inexpensive and relevant to field emergence.

References:

1. Abdul-Baki, A.A. and J.P. Anderson, 1973. Vigor determination in soybean seed by multiple criteria. *Crop Sci*., 13: 630-633.
2. Hoffmaster, A.L. Fujimura, K. McDonald, M.B. and Bennett, M.A. (2003) An automated system for vigor testing three-day-old soybean seedlings. *Seed Scien. & Tech.* 31 (3): 701-713
3. ISTA *International Rules for Seed Testing* (2008).
4. Oakley, K. Kester, S.T. and Geneve, R.L.(2004). Computer-aided digital image analysis of seedling size and growth rate for assessing seed vigour in Impatiens. *Seed Scien. & Tech*. 32 (3): 837-845
5. Singh, N. I. Verma, K. K. and Chauhan, J.S. (2010). Comparative efficacy of different vigour test parameters of pea (*pisum sativum* l.) seed testing. *Libyan Agric. Res. Cen. J. Intl.,* 1 (5): 332-335
6. Xing Wei Qi, (2011). Study on the vigour testing of soybean seed based on Near Infrared Spectroscopy Technology. *Applied Mechanics and Materials*, 58(60): 458-462.

Integrated Insect Pest Management to Ensure Seed Quality During Storage

Introduction

It is a well established fact that lot of efforts are made for the production of "Every single seed/grain" but this will be in vain if they are not safeguarded properly during storage. As the adage goes **"A grain saved is grain equally produced" and "A seed saved is thousands produced".** This adage depends on how best we protect the quality of the seed during storage assumes paramount importance. Storage loss is estimated to be about 10 per cent due to ravages of rats, insects, other microbial agents and spillage and the annual loss is about 6.00 million tonnes i.e., 3 per cent by insects alone (Ministry of Food and civil Supplies, 2010).Seed standards for seed damage has a rule given by ISTA which states that "A seed lot under certification shall not have apparent or visible evidence of damage by insects for both foundation and certified seed classes in excess of 1% for seeds of maize and legumes and 0.5% for the seeds other than maize and legumes". Successful management of storage insects is possible only when proper storage practices are implemented.

Major insect pests of storage

About 60 insect species and other arthropods can infest stored seed or grain. Out of which some of the major insect pests associated with the damage of seeds are as follows:

1. *Sitophilus oryzae* (Rice weevil)
2. *Rhizopertha dominica* (Lesser grain borer)
3. *Tribolium castaneum* (Rust red flour beetle)
4. *Callosobruchus sp.* (Pulse beetle or gram dhora)
5. *Trogoderma granarium* (Khapra beetle)
6. *Corcyra cephalonica* (Rice moth)
7. *Sitotroga cerealella* (Angoumois grain moth)
8. *Ploidia interpunctella* (Indian meal moth)

These insect pests are often classified as,

a) **Primary seed pests**: are those pests able to attack and destroy whole, undamaged seed. eg: Rice weevil, Lesser grain borer etc.

b) **Secondary seed pests**: cause losses where some type of kernel damage already exist. eg: Rust red flour beetle, Saw toothed grain beetle etc.

Integrated management of storage pests

Integrated pest management (IPM) is integration of all the available control techniques to keep the insect below economic injury level in socially and economically sound manner. The Food and Agriculture Organisation of the UN defined IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM has been urged by entomologists and ecologists for adoption of pest control for many years.

The concept of Integrated pest management have also generated the concept of economic injury level (EIL) and economic thresh hold level (ETL). An EIL is defined as the level of pest damage on which cost of damage exceeds the cost of resources upon control actions. ETL is population density at which control action should be initiated to prevent an increasing pest population from reaching the economic injury level. For seed storage ETL is very close to zero where seed certification standard demands a high value on freedom from any sign of insect infestation.

There are several effective methods available for the management of stored seed/grain from insect pests under varied conditions. Ideally integrated pest management should rely on the blend of those proven tactics. Increased concern over the potential effects of pesticides on health, environment and development of insecticide resistance in insects has attracted worldwide interest over search for alternatives to the pesticides in plant protection. Storage insect pests are the major threat to the seeds or food grain during post harvest stage.

Some of the IPM practices to control storage pests are as follows:

1. Sanitation

Before storing seed the container should be properly cleaned, the gunny bags should be exposed to sunlight. All the cracks and crevices of godown should be properly plug. Removal of the previous seed and debris of the previous storage is important to avoid the source of insects that attack the seed.

2. Disinfestation

After cleaning, treat all gunny bags and godowns about two weeks before storing the grain/seed so that the insect harbouring in the crack and crevices are killed.

3. Physical methods of control

Calderon suggested, "A sensible use of ambient or chilled air for aeration of grain offers new possibilities in many parts of the world for preservation of seed/grain without (or with very little) use of chemicals." The use of fumigants and controlled atmospheres together with forced drying procedures and aeration should be considered as complementary conservation methods that form part of an overall pest management programme.

4. Thermal disinfestations

Temperature control is widely used in post-harvest to slow down degradation of produce caused by physiological processes, pathogens and insects. For control of insects, both high and low temperatures can be effective.

5. Solar Heating

A solar heater made of dark cloth and translucent plastic sheet has been tested for bruchid control in stored grains. As the solar heater reaches temperatures >60 ◦C for an approximately 100 minutes, all stages of bruchids/weevils inside grains are destroyed.

6. Cold storage

Cold storage is one of the oldest and most widely used in storage of a wide variety of fruits and vegetables. Seed/Grain chilling in silos is a potential alternative to methyl bromide against a variety of stored product insect pests. In high value storage, cold can be used to treat organic food. However, this method takes longer time and is more expensive.

7. Turning

Turning helps in removing the "hot spots" that are formed when insects or fungi grow, generate heat, and raise the local grain temperatures up to 42-50°C. However, the cost associated with turning grain, the labour and energy is enormous. However, dissipation of these "hot spots" is important in reducing the rate of seed/grain deterioration.

Ambient Aeration using fans to ventilate seed/grain storage facilities helps to maintain the grain at a uniform temperature, usually within a few degrees of the ambient temperature, and can sometimes manage "hot spots".

Chilled Aeration involves the use of refrigerated air with low relative humidity. The major advantage of low temperature and low humidity aeration over ambient aeration is the ability to control the temperature and relative humidity of the airflow independent of ambient weather conditions.

8. Inert Dusts

Inert dust particularly use of sand, cow dung ash etc. in wheat storage has been in use since time immemorial in many parts of India. During the last two decades lots of work has been done on its use, resulting in commercial use of several inert dust formulations. There are many kinds of inert dusts such as lime, common salt, sand, kaolin, paddy husk ash, wood ash, clays, diatomaceous earths (Ca. 90% SiO_2), synthetic and precipitated silicates (Ca. 98% SiO_2), and silica aerogels (Golob, 1997). Because of their low mammalian toxicity, they are used to protect stored seed/grains against a number of coleopteran pests.

9. Oils

Many edible and non-edible oils such as mustard, ground nut, Neem, castor, Karanj etc. have been used to control storage insect pests particularly pulse beetles successfully. To date, no resistance has been reported. The oils act primarily at contact sites by obstruction of the respiratory system (hypoxia) and also as an oviposition repellent, because eggs do not adhere on the surface of seed/grain. However, the dose requirement of oils for seed is different from the grains.

10. Mechanical disinfestation

Mechanical seed processing removes large fraction of insects and insect infested seed. Also diseased seeds are removed with mechanical processing of seed lots. Of different machines, screen-grading machines separate out all seeds which are broken or damaged by insects in the field, besides removing live insects and some of its stages. The gravity separator is extensively used to remove internally infested seed where the >25% of endosperm has been eaten away by the insect. Similarly, removal of cut seed or damaged seed reduces infestation by secondary feeders.

11. Controlled condition seed storage

It is very well known that the life span of seed is influenced by storage conditions specifically the temperature and relative humidity (RH). Harrington proposed that, *the time* for 50% of seeds to die (P 50) doubled for every $5^{O}C$ reduction in temperature or 1% decreases in moisture level.

12. Use of modified atmosphere

The use and manipulation of natural components of the atmosphere, e.g. oxygen, nitrogen and carbon dioxide, to preserve food grains and products is known as "Modified" or "Altered" atmosphere storage. The normal gases of the atmosphere can be changed to

achieve control of storage pests. Modified atmosphere systems depend on either depletion of oxygen to suffocate the organisms or the addition of carbon dioxide to act directly and kill them.

Low Oxygen Atmospheres: Flushing storage structure/container with nitrogen to displace the normal atmosphere produces **Oxygen Deficient Atmospheres**. Liquid nitrogen from tanks may be used as a gas source.

High Nitrogen Atmosphere: Nitrogen is used to flush out oxygen from airtight container to achieve higher mortality of storage insects and microbes. In this system higher concentration of nitrogen is required to get <1% O_2 in the head space. This is commonly used in food commodity for better storage of food products and in modified atmosphere packaging of high value vegetable seeds.

Carbon Dioxide Rich Atmospheres: Insects are generally killed more rapidly by carbon dioxide than by lack of oxygen. A concentration of 60% carbon dioxide will give over 95% kill of most of the stored grain insects after four-days exposure at 27°C or higher. However, longer periods are needed for complete kill. An initial level exceeding 70% carbon dioxide and maintained at or above 35% for ten days is appropriate for complete insect mortality at temperatures above 20°C.

13. ECO_2 fume

It is a non-flammable, pre-mixed cylinderized gaseous mixture of 2% phosphine (by weight) in 98% carbon dioxide. Carbon dioxide is an excellent carrier for phosphine and diluting phosphine to this concentration ensures its non-flammable in all proportions with air. It provides highly effective fumigation in both sealed and unsealed storage facilities. This breakthrough in fumigation management system is available to professional applicators that seek an environmentally friendly alternative that is easy to use with improved worker safety. It also provides superior performance compared to other fumigation methods that use of phosphine generating compounds such as tablets or pellets. It is a product of M/s Cytec Industries Inc., USA.

Note: ECO_2 FUME causes no germination problems on seeds.

14. Sulfuryl fluoride (Profume/Vikane)

It is a product of M/S Dow Agro-Sciences and is effective as methyl bromide on all postembryonic life stages of insects. Like methyl bromide, Pro Fume can be used for short or long (i.e. 4 to 72) hour fumigation to meet the time constraints. Unlike methyl bromide, it does not deplete the ozone layer. The additional benefit is that it sorbs onto food and other commodities significantly less than methyl bromide and degasses faster.

15. Use of chemical protectants

Insecticides may be used to treat seed as prophylactic treatment as it moved into storage to prevent insect infestation. Malathion has been used for this purpose due to its low mammalian toxicity. Development of insect resistance to this insecticide led to use of many other insecticides *viz.*, chlorpyriphos methyl, pirimiphos methyl, bromophos, fenetrothion. Later pyrethroids like deltamethrin and fenvalerate proved effective. The recent experiments identified emamectin benzoate as effective seed protectant.

16. Fumigation

There are two methods of fumigation. One is space fumigation where 1.0 - 1.5 tablet of ALP/m^3 or 3-4.5 g/m^3 is used, another method is cover fumigation where 2-3 tablets or 6-9 g/m^3 of ALP is used. Godown walls should be of air proof, to make this enamel paint is used

to paint inside and outside of the walls. Phosphine tablets (1-2/cup) may be kept in aluminium foil lined cups and always placed on top of the bags to avoid burning and initial settling of gas from top to bottom. Commodity should be exposed for at least 5-7 days at 25^0C. However, for killing immature stages 15 days exposure should be preferred.

Role of Insect Pollinators Quality Seed Production

Introduction

Pollinators strongly influence ecological relationships, ecosystem conservation, stability, genetic variation in plant community, floral diversity, specialization and evolution. The presence of diverse forms of pollinators on earth is a gift from the nature to the mankind. Different pollinators which include insects like bees, butterflies, beetles, moths, flies, ants and wasps; birds; bats; and other animals that carry pollen from male to the female parts of flowers for plant reproduction are an essential part of natural and agricultural ecosystems. Without pollination, many plants are unable to reproduce or would produce fruit and seeds at much lower rates.

Pollination is an important ecosystem service considered as a regulating service by the Millennium Ecosystem Assessment. It is fundamental to the reproduction of flowering plants and is essential for the production of about one-third of the food consumed by humans. Insect pollination is necessary for many cross pollinated crops especially in case of hybrid seed production. Pollination is often taken for granted and is commonly thought of as a free service. Of the 352,000 species of flowering plants in the world about 87.5 per cent (i.e. 306,000 species) depend on animals, mostly insects, for pollination. Nearly 75 per cent of the world's food plants show increased fruit or seed set with insect visitation (Klein *et al.,* 2007). The economic value of this benefit is estimated to be about $ 153 Billion per year (Gallai *et al.,* 2009).

The annual economic value of insect pollinators to agricultural productivity for the major crops cultivated in the study areas in the HKH region was USD 2.7 billion. By crop category, the study estimates the annual economic value of insect pollination for fruit crops at USD 2.3 billion, for oilseed crops at USD 233.1 million, for pulses at USD 2.7 million, for spices at USD 5.5 million, for tree nut crops at USD 50.5 million, and for vegetable crops at USD 78.5 million. (ICMOD, 2012)

Honeybees are main pollinating agents, followed by solitary, alkali and carpenter bees. Among honey bees, *Apis dorsata,* was prominent and constituted 74.36 per cent, followed by *A. cerana indica* (18.73 per cent) and *A. florea* (6.73 per cent). Among 13 species of pollinators, *A. dorsata* was most prominent constituting 45.88 per cent, followed by *A. florea* (27.35 per cent), *A. mellifera* (10.81 per cent), *A. cerana indica* (4.17 per cent) and other pollinators (2.45 per cent) (Guruprasad, 2001).

Honeybees are known as the main pollinators of sunflower in most parts of the world. In the Indian sub-continent, honeybees viz. *Apis dorsata* and *A. florea* are common visitors to sunflower and are joined by *Apis cerana* foragers. Other Hymenoptera visitors include species of *Andrena, Anthophora, Ceratina, Halictus, Megachile, Scolia, Trigona* and *Xylocopa.* Many species of Diptera (syrphids, phytomia argyrocephela and *Eristalinus arvorum*) also readily visit the sunflower (Klein *et al.,* 2007)

Bumblebee's decreases pollination labor costs and promise a good crop yield, both in quantity and in quality. They are more effective than honeybees in cloudy weather and in greenhouse. Bumblebees also tend to devote themselves mainly to the crops within the greenhouse, whereas honeybees are apt to escape en masse to the outside. Bumblebees are particularly effective at pollinating Solanaceae, including the tomato and eggplant. (Velthuis and Van Doorn, 2006).

The ratio of vulnerability of agricultural crops is highest (44.8%) in Himachal Pradesh, followed closely by the mountain areas of Pakistan (44.2%) and Kashmir (40.2%), and lowest in the Chinese Himalayan provinces (only 6.1%) This indicates that, if there is a total loss of pollinators, the Himalayan region of Pakistan and Himachal Pradesh in India would lose nearly half of their farm production.

Agriculture and human food production is heavily dependent upon "pollination services". Sadly, many native pollinator populations appear to be threatened or facing uncertain future due to habitat loss and degradation. This poses a significant threat to the integrity of biodiversity, to global food webs, and to human health.

Pressures on Pollinators

1. Agricultural Intensification

Intensification has reduced the availability of food plants and nesting sites through conversion of semi-natural land to intensive farmland.

2. Honey hunting

An increase in honey hunting and ruthless hunting of the nests of wild honeybees is contributing to the decline in the population of indigenous honeybees (Partap 2010b). In a recent study, Ahmad *et al.* (2003) recorded evidence of pollinator decline at eight sites in Kaski District in Nepal. They reported a decline in the number of *Apis laboriosa* nests from 182 nests in 1986 to 48 in 2002.

3. Exotic honeybees and local honeybees

The introduction of exotic honeybee species can adversely affect populations of native bee species. This may be because of competition for food, the transfer of pests and diseases from one species to another, or economic preference for exotic species. The introduction of *Apis mellifera* to increase honey production has led to a decline in beekeeping with indigenous *Apis cerana* in several countries of the HKH region (Partap and Partap 1997).

4. Pests and Diseases

Pests and diseases are the main threat to honeybees, particularly an introduced parasitic mite, varroa, which is showing resistance to some treatments. Beekeeping associations feel that successful disease management is limited by lack of effective treatments and training in appropriate pest management.

5. Agrochemicals

Insecticides, by their nature, can be toxic to insect pollinators. Measures to protect honeybees, such as restricted spraying times, may not protect unmanaged pollinators that are active at different times of the day. Therefore, risks to wild pollinators remain difficult to assess. Herbicides and fertilizers may indirectly affect pollinators by reducing wildflower abundance and diversity.

Neonicotinoids are a family of insecticides that disrupt insect neurological functions. A few neonicotinoids are highly toxic to honeybees. They are systemic, which means they are absorbed and transported throughout a plant. This can improve pest control efficiency. However bees and other pollinators may ingest pesticide residues when feeding on treated plants. Unlike contact pesticides, this may occur over several days or longer, if contaminated pollen and nectar is stored in the hive, increase probability for cumulative pesticide exposure.

6. Urbanisation

Urban gardens, parks and trees can provide good habitat for a diversity of pollinators, for example bumblebee nests are more common in the suburbs than in arable areas (Osborne J, 2007). Increased building density and redevelopment of allotments and brown field sites threaten pollinators.

7. Climate change and other factors

Climate change is affecting insect numbers, as changes in local weather conditions, such as continuous drop in temperature and rainfall, affect the survival of natural pollinators (Partap and Partap 2002). Other factors such as lack of focus and capacity of national institutions in a changing economic and social landscape may be impacting on the decline in the populations of some common pollinators, such as indigenous honeybees, throughout the Himalayan mountains and valleys.

Strategies to Maintain Effective Pollination

In theory, requirement for pollinators for agriculture could be reduced by not growing insect-pollinated crops; but this would increase reliance on imports, affecting food security and consumer choice.

A) To Bee or Not to Bee?

Pollination services to agriculture could be maintained through managed pollinators, principally bees. However this is not a desirable strategy as huge numbers of colonies would be required and managed pollinators are prone to diseases, for example large-scale honeybee losses have occurred more than 30 times in the last 200 years. Moreover, the pollination needs of most wild plants and future potential crops are not known, and they may depend on wild pollinators. Therefore, to provide stable pollination services, policies to maintain both wild and managed pollinators are needed. This would also conserve wild pollinators as a valued part of biodiversity.

B) Deployment of pollinator habitat in agricultural land

Providing new habitat with forage and nesting sites is the best way of safe-guarding a diversity of pollinators. This has other benefits, including providing a refuge from agrochemicals and helping pollinators to migrate in response to climate change. Sowing wildflower seed mixes is a quick and relatively cheap way of creating habitat that benefits pollinators.

C) Conservation of natural pollinators

- Proper pest management strategy
- Right pesticide at right time and at recommended dose
- Encouraging agro and social forestry plantations
- Taking up plantation on waste land
- Provision of artificial nesting sites
- Grow garden plants with flowers that attract pollinating insects
- Avoid plants with double or multi-petaled flowers. Such flowers may lack nectar and pollen
- Providing nesting sites, nesting materials and egg-laying sites
- Providing nectar and pollen sources
- Managing diseases and parasites

REFERENCES

Ahmad, F., S.R Joshi and M.B. Gurung. 2003. *The Himalayan cliff bee Apis laboriosa and the honey hunters of the Himalayas*, Volume 1. Kathmandu, Nepal: ICIMOD.

Gallai, N., J.M. Salles, J. Settle and B.E. Vaissiere. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecol. Econ. 68: 810 – 821.

Guruprasad, G. S.,Viraktmath, S. A., Patil, B. and Murasing, S., 2001. Relative abundance of pollinator fauna of cross-pollinated oilseed crops at Dharwad in Karnataka (India). Indian Bee J., 63 (3 & 4): 64-67.

www.icimod.org

Klein A. M., Vaissière B., Cane J. H., Steffan-Dewenter I., Cunningham S. A., Kremen C., Tscharntke T., 2007. Importance of pollinators in changing landscapes for world crops, Proceedings of the Royal Society B, 274: 303-313.

Osborne J. 2007. *Applied Ecology* 45, 784-792.

Partap, U 2010b. 'Innovations in revival strategies for declining pollinators with particular reference to the indigenous honeybees: Experiences of ICIMOD's initiatives in the Hindu Kush-Himalayan region.' *Pest Management and Economic Zoology* 18: 85–95.

Partap, U and T. Partap. 1997. *Managed crop pollination: The missing dimension of mountain agricultural productivity*, Mountain Farming Systems' Discussion Paper Series No MFS 97/1. Kathmandu, Nepal: ICIMOD

Velthuis, H.H.W. and A. Van Doorn. 2006. A century of advances in bumblebee domestication and the economic and environmental aspects of its commercialization for pollination. Apidologie 37: 421-451.

Detection Techniques of Seed Borne Pathogens

Introduction

Seed is main propagule for plant perpetuation and at the same time one of the main vehicles for the dissemination of plant pests. " Seed quality" refers to seed that has a high germination, intact, free from foreign materials and weed seeds, and has zero or low levels of seed-borne diseases. Seed-borne pathogens, such as fungi, bacteria and viruses are serious constraints to crop productivity. In worst-case scenario, seed-borne diseases can be disastrous and even life threatening. Seed health is a priority area in any agriculture production programme. Seed health refers to the presence or absence of disease causing organisms such as fungi, nematodes, bacteria, viruses and insects, and to the status of seeds in a seed lot. Seed status is also affected by the presence of non disease-causing contaminants like weed seeds that compete with target seed for nutrients. Other seeds, plant parts other than the target seeds, soil particles and insect eggs etc. In recent years, awareness for seed health has increased among the growers, traders, consumers and policy makers. In post GATT era and with the emergence of WTO regulations, seed health acquired high importance. Under seed certification standards, several diseases have been designated as objectionable at field and seed levels. Many plant pathogens are seed-borne, and their association with seed is an important means of dissemination and carry-over between crops/seasons. The implementation of clean seed policies to exclude inoculum can be an effective means of disease control/management, at national, regional and individual farm levels. There are a number of approaches that can be taken to implement a clean seed policy:

1. Produce seed crops in areas known to be free of particular pathogens.
2. Test and reject, i.e. test seed lots for the presence of particular pathogens and reject if found to be present.
3. Test and treat, i.e. test seed lots and treat if found to be present.
4. Treat all, i.e. treat all seed lots regardless of health status.

Under these conditions, most effective disease management strategy is exclusion which is accomplished by using seed detection assays and monitoring for screening and elimination of infested seed lots before planting. The following will explore the current state of seed detection technology and include recent advances.

Type of seed infection

To have a perspective of seed-borne diseases, seed-borne microorganisms can be considered in following classes. First class consists of pathogens for which seed is the main source of inoculum; when seed infection is controlled, the disease is controlled. An example would be lettuce mosaic virus. For these pathogens, the importance of seed-borne inoculum has long been recognized, and control practices have been developed. The second class consists of important pathogens in which the seed-borne phase of the disease is of minor significance as a source of inoculum. Examples are those in which crop residues in the field were the major source of inoculum. The third and largest group of seed-borne microorganisms consists of those that have never been shown to cause disease as a result of their presence on seeds. The fourth class is a group of microorganisms that can infect the seed either in the field or in storage and reduce yield and seed quality. Examples of field fungi are *Diplodia*, *Fusarium*, *Cladosporium*, etc. The storage fungi *Aspergillus* and *Penicillium* can invade most types of seeds under high-moisture storage conditions. The process of seed infection is influenced by the conditions under which the crop grows. Factors that influence

in the process of infection are: host and its genotype, pathogen and its pathotype and environment. There are two circumstances i.e. Systemic infection of the seed and Contamination or Infestation of the seed.

1. Conventional seed detection assays
2. Visual examination
3. Selective media
4. Serology-based assays
5. Seedling grow-out assay
6. Polymerase Chain Reaction-based seed detection assays
7. Immunomagnetic Separation and PCR (IMS-PCR)
8. Magnetic capture hybridization and PCR (MCH-PCR)
9. Rapid-cycle Real-time PCR
10. DNA chip (microarray) technology

General features of seed detection assays including the time required for completion, sensitivity, ease of application, specificity, and applicability for the detection of fungi, bacteria and viruses.

Assay specificity	**Time required**	**Sensitivity**	**Ease of application**	**Specificity**
Visual examination	5–10 min	Low	Simple and inexpensive (requires experience)	Low
Semi selective media	2–14 d	Moderate	Simple and inexpensive	Low–moderate
Seedling grow-out assay	2–3 weeks	Low	Simple, inexpensive and robust	low
Serology-based detection	2–4 h	Moderate–high	Simple, moderately expensive and robust	Moderate–high
Conventional DNA extraction and polymerase chain reaction (PCR)	5–6 h	High	Complicated; easy to interpret, expensive	Very high
BIO-PCR (selective target colony enrichment followed by PCR)	3–4 d	Very high	Complicated, expensive	Very high
IMS-PCR (immune-magnetic separation and PCR)	2–5 h	Very high	Complicated, expensive	Very high
MCH-PCR (magnetic capture hybridization and PCR)	2–5 h	Very high	Complicated, expensive	Very high
Real-time PCR	40–60 min	Very high	Complicated, expensive	Very high
DNA microarrays	6 h	Very high	Complicated, expensive	Very high

Seed-borne pathogens restricted to seed coat are treatable by external application of anti-microbial agents such as bleach, acid, trisodium phosphate, or other commercial products. Rarely do these treatments effect 100% sterilization, but they can greatly reduce levels of pathogens. These types of treatments are typically used for the class of non-seed-specific diseases in which seed-borne transmission is minor compared to the levels of inoculum already present in soil due to crop debris. Seed-specific disease pathogens that reside inside the seed, which are typically bacteria or viruses, cannot be eliminated by surface sterilization. Because they're often inside the embryo itself, these pathogens are almost certain to divide and spread to cause infection when that seed germinates and grows. They cannot be eradicated by external application of chemicals however; they are susceptible to the

one agent that can penetrate the interior of the seed, which is heat. For sterilizing seed, is to treat it with either wet or dry heat, which penetrates to the core of seed. Heat kills majority of bacterial and fungal pathogens, and bacterial pathogens are particularly sensitive to heat. Wet heat, in the form of hot water, is more effective than dry heat, and thus the most common method for treatment of seed disease is hot water of 122ºF (50ºC) for 20-25 minutes. Hot water is commonly used for treatment of most small seeds, but is less effective and more difficult to use for large seeds. Large seeds tend to be damaged by wetting and re-drying, are more difficult to penetrate fully with heat, and are so bulky as to make it difficult to efficiently wet and dry them. Unfortunately, viral pathogens are generally not susceptible to heat, although dry heat has been shown to have some efficacy against certain tomato viruses. Solutions of bleach or trisodium phoshphate are sometimes used to remove surface infections of virus in pepper and tomato seed. *In general, though, viral pathogens are quite difficult or impossible to remove from seed, and thus virus-diseased plants in seed field are almost always pulled up and destroyed immediately.*

Conclusion

Conditions in seedling establishment systems are usually highly favorable for disease development. Therefore, it is critical to ensure that no potentially damaging pathogens are introduced through seeds. This can most effectively be accomplished by exclusion, using seed detection assays to identify contaminated seed lots that can then be discarded or treated. Conventional seed detection assays including visual examination, selective media, serological assays and the seedling grow-out assay have been used extensively, but all have shortcomings ranging from inefficiency to lack of specificity and sensitivity. PCR holds great potential for improving pathogen detection in seeds, as it embodies many of the key characteristics including specificity, sensitivity rapidity, ease of implementation and interpretation and applicability. While inhibitory seed compounds can limit the applicability of conventional PCR, modifications including BIO-PCR, IMS-PCR and MCH-PCR may provide opportunities to circumvent inhibitory compounds while improving detection of seed borne pathogens. IMS-PCR and MCH-PCR are particularly attractive because they provide simple and universally applicable formats for testing seeds for different culturable and nonculturable pathogens. Further improvements in the cost and efficiency will eventually allow DNA-based detection systems to replace the vast array of seed detection assays currently employed and provide superior detection capabilities necessary for healthy seedling establishment. Like other fields in which pathogen detection is critical, seed detection assays must be based on new technologies. However, before adopting these assays, it is critical to rigorously evaluate their applicability, precision, and accuracy in real-world, high throughput testing of naturally infested seeds. There are many reports of new seed detection assays in the scientific literature. However, few of these are developed past the initial stages. Hence, little is known about their applicability for routine seed testing. To ensure that these assays work, they must be validated in stringent multi laboratory tests which evaluate their reproducibility and repeatability. Only assays evaluated in this manner should be considered for testing of commercial seeds.

Reference

1. Anthony, R.M., T.J. Brown, and G.L. French. **2000**. Rapid diagnosis of bacteremis by universal amplification of 23S ribosomal DNA followed by hybridization to an oligonucleotide array. J. Clinical Microbiol. 38:781–788.
2. Audy, P., C.E. Braat, G. Saindon, H.C. Huang, and A. Laroche. **1996**. A rapid and sensitive PCR-based assay for concurrent detection of bacteria causing common and halo blights in bean seed. Phytopathology 86:361–366.

3. Chen, J.R., R. Johnson, and M. Griffiths. **1998**. Detection of verotoxigenic *Escherichia coli* by magnetic capture hybridization PCR. Appl. Environ. Microbiol. 64:147–152.

4. Cockerill, F.R. and T.F. Smith. **2002**. Rapid-cycle real-time PCR: A revolution for clinical microbiology. Amer. Soc. Microbiol. News 88:77–83.

5. de Moraes, R.R., J.E. Maruniak, and J.E. Funderburk. **1999**. Methods for detection of *Anticarsia gemmatalis* nucleopolyhedrovirus DNA in soil. Appl. Environ. Microbiol. 65:2307–2311.

6. Fessehaie, A., S.H. DeBoer, A. Quail, and A.C. Levesque. **2001**. Development of a DNA microarray for identification and detection of pathogenic bacteria associated with potato, p. 389–392. In: S.H. DeBoer (ed.). Proc. 10th Intl. Conf. Plant Pathogenic Bacteria. Kluwer Academic Publishers, Dordrecht, Netherlands.

7. Franken, A.A.J.M., G.C. Kamminga, W. Snijders, P.S. Vanderzouwen, and Y.E. Birnbaum. **1993**. Detection of *Clavibacter michiganensis* subsp. *michiganensis* in tomato seeds by immunofluorescence microscopy and dilution plating. Neth. J. Plant Pathol. 99:125–137.

8. Franken, A.A.J.M., C. Vanzeijl, J.G.P.M. Vanbilsen, A. Neuvel, R. DeVogel, Y. Vanwingerden, Y.E. Birnbaum, J. Vanhateren, and P.S. Vanderzouwen. **1991**. Evaluation of a plating assay for *Xanthomonas campestris* v. *campestris*. Seed Sci. Technol. 19:215–226.

9. Frommel, M.I. and G. Pazos. **1994**. Detection of *Xanthomonas campestris* pv. *undulosa* in infested wheat seeds by combined liquid-medium enrichment and ELISA. Plant Pathol. 43:589–596.

10. Hadas, R., G. Kritzman, T. Gefen, and S. Manulis. **2001**. Detection, quantification and characterization of *Erwinia carotovora* ssp. *carotovora* contaminating pepper seeds. Plant Pathol. 50:117–123.

11. Hampton,R., E. Ball, and S. De Boer. **1990**. Serological methods for detection and identification of viral and bacterial plant pathogens: A laboratory manual. APS Press, St. Paul, Minn.

12. Higley, P.M., D.C. McGee, and J.S. Burris. **1993**. Development of methodology for nondestructive assay of bacteria, fungi and viruses in large-seeded field crops. Seed Sci. Technol. 21:399–409.

13. Hussain, S., T. Tsukiboshi, and T. Uematsu. **2000**. Quick detection of *Ascochyta lentis* from lentil seeds using polymerase chain reaction (PCR) based techniques. Pakistan J. Bot. 32:45–56.

14. Kurian, K.M., C.J. Watson, and A.H. Wyllie. **1999**. DNA chip technology. J. Pathol. 187:267–271.

15. Langrell, S.R.H. and D.J. Barbara. **2001**. Magnetic capture hybridisation for improved PCR detection of *Nectria galligena* from lignified apple extracts. Plant Mol. Biol. Rpt. 19:5–11.

16. Latin, R.X. and D.L. Hopkins. **1995**. Bacterial fruit blotch of watermelon-The hypothetical exam question becomes reality. Plant Dis. 79:761–765.

17. McLaughlin,R.J. and T.A. Chen. **1990**. ELISA methods for plant pathogenic prokaryotes, p. 197–204. In: R. Hampton, E. Ball, and S. DeBoer (eds.) Serological methods

for detection and identification of viral and bacterial plant pathogens. APS Press, St. Paul, Minn.

18. Olsvik, O., T. Popovic, E. Skjerve, K.S. Cudjoe, E. Hornes, J. Ugelstad, and M. Uhlen. **1994**. Magnetic separation techniques in diagnostic microbiology. Clinical Microbiol. Rev. 7:43–54.

19. Pasquini, G., A.M. Simeone, L. Conte, and M. Barba. **1998**. Detection of plum pox virus in apricot seeds. Acta Virol. 42:260–263.

20. Rajeshwari, N., M.D. Shylaja, M. Krishnappa, H.S. Shetty, C.N. Mortensen, and S.B. Mathur. **1998**. Development of ELISA for the detection of *Ralstonia solanacearum* in tomato: Its application in seed health testing. World J. Microbiol. Biotechnol. 14:697–704.

21. Randall-Schadel, B.L., J.E. Bailey, and M.K. Beute. **2001**. Seed transmission of *Cylindrocladium parasiticum* in peanut. Plant Dis. 85:362–370.

22. Safarik, I. and M. Safarikova. **1999**. Use of magnetic techniques for the isolation of cells. J. Chromatog. B 722:33–53.

23. Saiki, R.K., D.H. Gelfand, S. Stoffel, S.J. Scharf, R. Higuchi, G.T. Horn, K.B. Mullis, and H.A. Erlich. **1988**. Primer-directed enzymatic amplification of DNA with a thermostable DNA polymerase. Science 239:487–491.

24. Schaad, N.W., Y. Berthier-Schaad, A. Sechler, and D. Knorr. **1999**. Detection of *Clavibacter michiganensis* subsp *sepedonicus* in potato tubers by BIO-PCR and an automated real-time fluorescence detection system. Plant Dis. 83:1095–1100.

25. Walcott, R.R., R.D. Gitaitis, A.C. Castro, F.H. Sanders, and J.C. Diaz-Perez. **2002**. Natural infestation of onion seed by *Pantoea ananatis*, causal agent of center rot. Plant Dis. 86:106–111.

26. Walcott, R.R. and R.D. Gitaitis. **2000**. Detection of *Acidovorax avenae* subsp *citrulli* in watermelon seed using immunomagnetic separation and the polymerase chain reaction. Plant Dis. 84:470– 474.

27. Yang, Y., K. Kim, and E.J. Anderson. **1997**. Seed transmission of cucumber mosaic virus in spinach. Phytopathology 87:924– 931.

Management of Seed Borne Diseases – Retrospect & Prospects

Introduction

Seed is the most important determinant of agricultural production potential, on which the efficacy of other agriculture inputs is dependent. One of the greatest challenges of the Indian economy is to eradicate food insecurity by ensuring growth of sustainable agriculture through supply of healthy and quality seeds. Several seed borne diseases with known economic impact have been reported from India. Among them Loose smut of wheat, Karnal bunt of wheat, Kernel smut of rice, Downy mildews in cereals, Blast and Bacterial leaf blight of rice, Ergot of sorghum, Downy mildew and Leaf spot of sunflower, and nematode diseases in rice and wheat etc. Seed is not only a victim of plant diseases but also a carrier of pathogens for trans-regional and long-distance dissemination. Further, seed health is the basis for seed certification, is having utmost significance in production of quality seed. Seed market is penetrating the global market at a very faster pace. To capture this seed market, quality assurance especially seed health is certainly a key issue. In the past, due to lack of sensitive detection facility in quarantine centers many diseases have been introduced and established in India. Poor seed health has following impact on crop production:

1. Leads to poor seed germination to various degrees
2. Give rise to pre and post emergence seedling mortality and progressive disease development in the field and thereby reduces the yield and quality of the crop
3. Contaminate previously disease-free areas.
4. Spread of the diseases across national or international boundaries
5. Reduce shelf life of the seed
6. Affects food safety, produce mycotoxins and reduce nutritional value

Therefore, detection and management of seed borne diseases by sophisticated techniques is of prime importance in the era of WTO and globalization. Seed health management techniques continue to evolve and advances in cultural, physical, biological and transgenic methods are in practice to ensure restriction in distribution of pathogen-infected seeds.

1. Production of healthy seed

General strategies for disease management in agriculture are pertinent to seed crops, i.e., exclusion of pathogens from regions of seed production, eradication of pathogens from seed crops, protection of seed crops, alleviation of disease pressure using cultural practices, and incorporation of disease resistance into cultivars. Seed production area should be selected in such a way that the high risk pathogens are unable to establish at critical levels during period of seed development. Areas having low rain fall and relative humidity is suitable for seed crop production. Healthy seed production positively correlated with proper seed crop management. Sowing of high quality seed at appropriate time along balanced fertilizer and irrigation may help in healthy crop stand. Disease plant from seed production plot should be rogued and destroyed. The control of plant diseases in seed production plot by chemical or biological means may affect the seed infection.

2. Mechanical methods

Pathogen infected seed become discolored, distorted, deformed, small or enlarged. Processing, screening and sieving can remove such infected seed in addition to inert material,

plant debris, and fungal fruiting bodies. The use of ergot sclerotia free seed in pearl millet may reduce the inoculum level. This can be done by hand picking either with a gravity separator or by immersing contaminated seeds in a 10% NaCl solution to remove floating sclerotia.

3. Seed treatment

Seed treatment is the process of application of chemical, biological, mechanical and physical agent on seed to manage the seed borne or soil borne pathogens. It is an effective step in managing seed-borne diseases. Seed treatment is one of the easy and economical methods for the management of several seedling diseases. Seed treatment has been considered as a prerequisite step in integrated disease management and it acts as insurance for seedlings protection for a period of 20-30 days after sowing.

a. Chemical seed treatment

Chemical seed treatment is a one of the cheapest and quickest method of management of seed borne diseases. Chemical used for seed treatment may kill or inhibit pathogens. It also forms a protective zone around seeds that may protect the seedling from soil borne pathogens. Commonly used chemical for seed treatment are captan, chloroneb, maneb, mancozeb, thiram, pentachloronitrobenzene (PCNB), and the systemic compounds carboxin, benomyl, thiabendazole, metalaxyl, triadimenol and streptocycline. Chemicals can be applied on the seed as dusts or as thick water suspensions (slurries) mixed with the seed. Seed can also be soaked in water or solvent solution of the chemical and then allowed to dry. Tubers, bulbs, corms, and roots can be treated in similar ways, but treatments are effective mostly when the chemical is applied to protect such organs.

b. Biological seed treatment

Biological seed treatment or seed bio-priming is application of an antagonist microbe on seed to reduce inoculum intensity or disease producing potential of pathogen. Seed bio-priming is suitable alternative to chemical seed treatment for seed health and crop health management by elicitation of systemic resistance in plants, enhancing seed's nutritional and physiological characteristics and result in better germination and adaptation under different soil. Most of these microorganisms increase nutrient uptake from soils, thus reducing the need for fertilizers and preventing the accumulation of nitrates and phosphates in agricultural soils. A reduction in fertilizer and pesticide use will reduce import of chemical fertilizer; lead to savings for farmers in addition to impart drought tolerance capacity to plants and would ensure ecological sustainability. Biological agents commonly used for seed treatment are *Bacillus subtilis*, *Pseudomonas fuorescens*, *P. aureofaciens, P. syringae, Gliocladium catenulatum, Chaetomium globosum, Arthrobotritis, Trichoderma* spp. *Paecilomyces lilacinus.*

c. Physical method of seed treatment

It is one of the oldest methods of seed treatment. The principle of physical treatment is that pathogen is killed at temperatures not injurious to seeds. Seed having low moisture content are ideal for physical seed treatment. Commonly used physical methods of seed treatment are hot water, hot air treatment, solar heat treatment, radiation and pulse magnetic field treatment.

I. Radiation

Different types of electromagnetic radiation (X rays, UV light and g rays, as well as particulate radiation) have been used for their ability to control seed borne diseases by killing the pathogens present on them. Unfortunately, with many of these diseases the dosage of

radiation required to destroy the pathogen may also injure the seed. Therefore, proper dosage and timing need to be standardize.

II. Hot-water treatment

It is used for certain seeds, bulbs, and nursery stock to manage seed borne pathogens. In some diseases, seed treatment with hot water was the means of control followed from many years, as in the loose smut of wheat, in which the fungus over winters as mycelium inside the embryo where it could not be reached by chemicals. Similarly, treatment of bulbs and nursery stock with hot water protect them from nematodes that may be present.

III. Hot-air treatment

Treatment of certain planting propagules with warm air reduces moisture level and hastens the healing of wounds, thus preventing their infection by certain pathogens. For example, keeping sweet potatoes at 28 to 32°C for 2 weeks helps the wounds to heal and prevents infection by *Rhizopus* and by soft-rotting bacteria.

IV. Solar heat treatment

Solar heat treatment is one of the cheapest physical method of seed treatment. It is generally used for seed treatment during hot summer times. It is most successfully used to control the loose smut of wheat. In this method, seeds are soaked in water for 4 h in the morning and then dried in the sun before storing.

V. Magnetic treatment

It is used as seed stimulus and enhanced seed vigour. Low vigour, old seeds, carry over seed stocks are basically subjected to 100 – 200 mT (magnetic field) for 2 – 3 h. It has not been commercially exploited because of operational difficulties.

4. Use of resistant varieties

The use of resistant varieties is the least expensive, easiest, safest, and one of the most effective means of controlling plant diseases in crops including the seed borne diseases. Cultivation of resistant varieties not only eliminates losses from disease, but also eliminates expenses for sprays and other methods of disease control and avoids the addition of toxic chemicals to the environment that would otherwise be used to control plant diseases.

5. Seed certification and quarantine

Seed certification and quarantine are legal methods formulated to manage the seed borne diseases and spread to new areas has been checked. Seed certification was based on seed production in isolation, field inspection, laboratory evaluation of seed borne infection and seed treatment with pesticides to eliminate the seed borne pathogen. Quarantine is originated from Latin word *quarantum*, meaning 40. It refers to 40 days detention of ships that arrive from countries with bubonic plague and cholera. Plant quarantine is the restriction imposed by the government on movement of plant, plant products, packing materials and commodities to protect agriculture and environment from avoidable damage by hazardous organisms. Now a day, quarantine has emerged as an important method of seed borne disease management because of burgeoning seed trade. The basic principle is to exlude the pathogen getting established in new areas.

Seed Certification and Minimum Seed Certification Standards- Indian Paradigm

Introduction

Seed certification is a legally sanctioned system for quality control of seed multiplication and production which consists of field and bin inspection, pre and post control tests and different seed quality tests (FAO, 1969, Delonche and Potts, 1971). It is a field inspection based process that aims to ensure the *genetic* identity and purity of a plant cultivar during multiplication from one generation to the next. Seed certification schemes rely upon a set of documented standards and procedures implemented at each step of the seed production process to protect the varietal identity and purity of a seed lot. Plants grown from seed of high genetic purity can be expected to look and perform in the manner as originally bred and described by the breeder. This in turn ensures users that the expected advantages of a cultivar will be delivered through use of certified seeds.

Purpose of seed certification

The purpose of seed certification is to maintain and make available to the public, through certification, high quality seeds and propagating materials of notified kind and varieties so grown and distributed as to ensure genetic identity and genetic purity.

Objectives of seed certification

Three primary objectives of seed certification are

- ✓ Systematic multiplication of superior varieties
- ✓ Identification of new varieties and their rapid increase under appropriate and generally accepted names
- ✓ continuous supply of quality seeds by careful maintenance

The General Seed Certification Standards are applicable to all crops which are eligible for certification, and with field and seed standards for the individual crop, shall constitute the minimum seed certification standards. The word 'seed' or 'seeds' as used in these standards shall include all propagating materials.

Certification agency

Certification shall be conducted by the Certification Agency notified under section 8 of the Seeds Act, 1966.

Certified seed producer

Certified seed producer means a person/organization who grows or distributes certified seed in accordance with the procedures and standards of the certification.

Eligibility requirements for certification of crop varieties

Seed of only those varieties, which are notified under section 5 of the Seeds Act, 1966 shall be eligible for certification.

Phases of seed certification

Certification shall be completed in six broad phases listed as under:

(a) Receipt and scrutiny of application

(b) Verification of seed source, class and other requirements of the seeds used for raising the seed crop

(c) Field inspections to verify conformity to the prescribed field standards

(d) Supervision at post-harvest stages including processing and packing

(e) Seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards

(f) Grant of certificate and certification tags, tagging and sealing

Classes and sources of seed

A. Breeder seed

Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is supervised by a plant breeder and which provides the source for the initial and recurring increase of foundation seed.

Breeder seed shall be genetically pure as to guarantee that in the subsequent generation i.e. Foundation seed class confirm to the prescribed standards of genetic purity. The other quality factors of Breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis.

B. Certified seed

Certified seed shall be the seed certified by Certification Agency notified under section 8 of the Seeds Act, 1966 or seed certified by any Certification Agency established in any foreign country provided the Certification Agency has been recognized by the Central Government through notification in the official Gazette. Certified Seed shall consist of two classes, namely, foundation and certified Seed and each class shall confirm to the following description:

1. Foundation Seed shall be the progeny of breeder seed or be produced from foundation seed which can be clearly traced to breeder seed. Thus, foundation seed can even be produced from foundation seed. During the production of foundation seed, the following guidelines shall be observed:

   a) Foundation seed produced directly from Breeder seed shall be designated as foundation seed stage –I

   b) Foundation seed produced from foundation seed stage-I shall be designated as foundation seed stage –II

   c) Foundation seed stage-II will not be used for further increase of foundation seed and shall be used only for production of certified seed class

   d) Minimum seed Certification Standards will be the same for the both foundation seed stage-I and II and unless otherwise prescribed

   e) Certification tag shall be of white color for both foundation seed stage-I and II and shall contain the information as to its stage;

   f) Production of foundation seed stage-II shall ordinarily be adopted in respect of such crop varieties provided, when it is expressly felt by the Certification Agency that Breeder seed is in short supply.

g) Production of foundation seed stage-II may be adopted for the following group of crops:

-vegetatively propagated crop

-apomictically reproduced crops

-self pollinated crops

-often cross pollinated and cross pollinated crops, these being gene-pools should not loose their genetic identity and purity if measures to safeguard the same or adequately taken

-composite and synthetics

-parental lines of hybrids

2. Production of foundation seed stage-I and II shall be supervised and approved by the Certification Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to, confirm to certification standards specified for the crop/variety being certified.

(a) Certified seed shall be the progeny of foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified

(b) Certified seed may be the progeny of certified seed provided this reproduction does not exceed three generations beyond foundation seed stage-I

- it is determined by the Certification Agency that genetic identity and genetic purity will not be significantly altered and when the Certification Agency is satisfied that there is genuine shortage of foundation seed despite all the reasonable effects made by the seeds producer.

(c) Certification tag shall be of blue color (shade ISI No.104 AZURE BLUE) for certified seed class.

(d) Certified seed produced from certified seed shall not be eligible for further seed increase under certification. Certification tags for such production for which is not eligible for further seed increase under certification shall be superscribed with, "not eligible for further seed increase under certification".

Establishing source of seed

The individual intending to produce seed under certification shall submit to the Certification Agency, one or more relevant evidence such as certification tags, seals, labels, seed containers, purchase records, sale records, etc, as may be demanded by the Certification Agency. Authenticity of seed is verified by certification agency, in order to confirm that seed used for raising the crop has been obtained from the source approved by it and conforms to the prescribed quality standards. This requirement also applies to parental lines used for hybrid seed production.

Field area for certification

There is no minimum or maximum limit for the area offered by a person for certification, provided the certified seed production meets all the prescribed requirements.

Unit of certification

For the purpose of field inspections, the entire area planted under seed production by an individual shall constitute one unit provided

a. It is all under one variety
b. It does not exceed ten hectares
c. It is not divided into fields separated by more than fifty meters between them
d. It is planted with or is meant to produce seed belonging to the same class and stage in the generation chain
e. The crop over the entire area is more or less of the same stage of growth so that observations made are representative of the entire crop
f. Raised strictly as a single crop and never as mixed.
g. Not so heavily and uniformly lodged that more than one third of the plant population is trailing on the ground leaving no scope for it to stand up again thus making it impossible for the Certification Agency to inspect the seed crop at the appropriate growth stage in the prescribed manner

h. As far as possible, needs to maintain as to show adequate evidence of good crop husbandry thereby improving the reputation for certified seeds.

i. Not grown as inter, companion or ratoon crop unless it is under the following conditions

Conditions for inter-cropping during certified seed production of oil seeds and pulses

(i) Inter-cropping will be applicable to oilseeds and pulses crops only for production of certified seed class and never followed in case of foundation seed.

(ii) Other types of cropping patterns such as mixed cropping etc. will not be permitted

(iii) The crops selected for inter-cropping should belong to different genus and preferably with different maturity

(iv) Only basic crop (Seed Crop) pertaining to oilseeds or pulses as the case may be will be registered for certification and companion crop will not be eligible for certification

(v) It should be ensured that the number of rows of seed crop alternating with the companion crop is uniform throughout the field

(vi) The Certification Agencies will prepare a list of the crop combinations, which may be followed in respective states.The list so prepared will be provided to the seed producers in advance.

At the time of deciding the crop combinations, the Certification Agencies will ensure that

(a) the companion crop does not hamper the operation needed for seed crop
(b) it does not starve the seed crop of nutrients and moisture
(c) it does not mature simultaneously with the seed crop or it does not carry weed seeds which may mix with the seed crop at maturity
(d) it does not have common pests and diseases
(e) it does not render certification work difficult

Use of chemical hybridizing agents (CHAs')

In case of hybrid seed production, the seed producer can use proper Chemical Hybridizing Agents (CHAs') on seed parent (female line) in order to induce male sterility. Consequently, the Minimum Seed Certification Standards specified for production of 'A' and 'B' lines shall not be applicable for the relevant hybrid. Hybrid seed produced through the application of CHAs' shall be compulsorily subjected to grow-out test as a pre-requisite for grant of certificate.

Field inspection

a. The field inspection work which requires technically-trained personnel shall be performed by the persons who have been so authorized by the Certification Agency.

b. Field inspection meant to verify those factors which can cause irreversible damage to the genetic purity or seed health shall be conducted without prior notice to the seed producer

c. Soon after the completion of the field inspection a copy of the report shall be handed over to the seed producer or to his representative.

Re-inspection

Seed fields not conforming to prescribed standards for certification at any inspection, the Certification Agency shall upon the request of seed producer and after he removes the sources of contamination in the seed field and within the prescribed isolation distance and/or the contaminated plants in the seed field (if so directed by the Certification Agency) perform one or more re-inspections provided such removal can ensure conformity of the seed crop to the prescribed standards and provided further that no irreversible damage has been caused to the quality of seed by the contaminants.

The Certification Agency may at its discretion, also perform one or more re-inspections over and above the minimum number of inspections prescribed, if considered necessary.

Harvesting, threshing and transportation

Seed crop meeting field standards for certification shall be harvested, threshed and transported to the seed processing plant in accordance with the guidelines issued by the Certification Agency. During these operations, seed producer will take all precautions to safeguard the seed from admixture and other causes of seed deterioration.

Bulking

Bulking of unprocessed seed stocks to obtain larger homogeneous seed stocks may be permitted by the Certification Agency provided the stocks to be bulked meet the following requirement;

- belong to the same certified seed producer
- belong to the same crop, variety, class of seed and stage in the generation chain
- were produced in the same season and under similar agro-climatic conditions
- were subjected to certification by the same Certification Agency
- have more or less similar physical appearance and levels of moisture
- are adequately homogeneous in composition

Seed processing and packing schedule

The Certification Agency shall prepare and communicate seed processing and packing schedule to all certified seed producers soon after the certification of seed crops at field stage. The seed producers shall adhere to the schedule specified by the Certification Agency. However, re-scheduling may be accepted by the Certification Agency on the request of seed producer on genuine grounds.

Seed lot

A seed is a physically identifiable quantity of seed which is homogeneous.

Lot size

A seed lot would represent any quantity of agricultural seeds up to a maximum of 20,000 kilograms for seeds of the size of rice or larger(except maize seed, seed potato, sweet potato, yams, taro, and chow-chow for which the maximum size of the lot may be 40,000 kilograms) and 10,000 kilograms for seeds smaller than rice subject to a tolerance limit of 5.0%. The quantities in excess of the above maximum limits shall be sub-divided and a separate lot identification shall be given for such lots.

Construction of seed lot number

Each seed lot shall be assigned a specific number in order to facilitate maintaining its identity, tracing back to its origin, handling in stores, transit etc., accounting and inventory maintenance and referring/communicating about a certain quantity of seed. The procedure for assigning lot numbers is given here under:

The lot number will have four parts:

1. **First part**- This shall be called the "Month-Year Code" and will indicate the month and (first three letters of month) and year (last two digits of the year) in which the concerned seed crop was harvested.
2. **Second part**- It shall be called "Production Location Code" and will indicate the State or Union Territory where the concerned seed field(s) was/were located. The State code of Uttar Pradesh is 24.
3. **Third part**- This shall be called the "Processing Plant Code" and will indicate the seed processing plant where the relevant lot processed.
4. **Fourth part**- This shall be called the "Seed Produce Code". It will indicate ultimate serial number of an individual lot.

Seed standards of genetic purity

All certified seed lots shall conform to the following Minimum Standards for genetic purity unless otherwise prescribed;

CLASS	Standards for Minimum Genetic Purity (%)
Foundation	99.00
Certified (i)Varieties, composites, synthetics, multi-lines	98.00
(ii) Hybrids	95.00

Grow-out test

The Certification Agency shall conduct grow-out test to determine genetic purity of a seed lot wherever it is a pre-requisite for grant of the certificate and also on the seed lots where a doubt has arisen about the genetic purity. The grow-out test can be complemented by certain related laboratory tests.

Recleaning, resampling and retesting

When a seed lot does not meet the prescribed seed standards, the Certification Agency on the request of seed producer may permit recleaning, resampling and retesting. The recleaning, resampling and retesting shall be permitted only once.

Seed standards for insect damage

A seed lot under certification shall not have apparent or visible evidence of damage by insects for both Foundation and Certified seed classes in excess of 1.0% for the seeds of

maize and legumes and 0.50% for the seeds other than maize and legumes unless otherwise prescribed.

Downgrading of seed class

If a seed field or a seed lot is not found meeting prescribed standards for the class for which it has been registered but conforms to the prescribed standards to the immediate lower class, the Certification Agency may accept such seed fields/seed lots for certification to the immediate lower class provided request has been made to this effect by seed producer. However, downgrading of the seed class not be applicable in case of hybrids and their parents.

Specification of the certification tag

Size, quality, colour, layout and contents of the certification tag shall be as given here under :

Length: 15cm
Breadth: 7.5cm
Quality- It shall be made of durable material such as thick paper, paper with cloth lining, wax coated paper, plastic coated paper etc.
Colour- Both sides shall be white for Foundation class and blue (ISI No. 104-Azure blue) for certified class.

Contents and Layout

<table>
<tr><td>TAG No. .....</td><td rowspan="2">CA's* EMBLEM</td><td>Certified Seed</td></tr>
<tr><td>KIND .....</td><td>Class of seed .....</td></tr>
<tr><td>Variety.....</td><td rowspan="3">Name and address of Certification Agency</td><td>Certificate No. .....</td></tr>
<tr><td rowspan="2">Lot No .....</td><td>Date of issue of certificate.....</td></tr>
<tr><td>Date of test.....</td></tr>
<tr><td colspan="2">"Use of the seed after expiry of the validity period by any person is entirely at his risk and the holder of the certificate shall not be responsible for any damage to the buyer of seed. No one should purchase the seed if seal or the certification tag has been tampered with".</td><td>Certificate to valid up to..... (Provided seed is stored under cool and dry environment)</td></tr>
<tr><td colspan="2">Name and full address of the Certified seed producer.....</td><td>Validity of certificate further extended up to .....</td></tr>
</table>

N.B. If tag is to be affixed on a smaller container then the size of the tag may be reduced proportionately. However, length and breadth ratio and contents would remain the same. *(CA's: Certification Agency)

Packing, tagging, sealing and issuance of the certificate

a. On receipt of Seed Analysis Report and the results of the growout test prescribed, and if seed lot has met prescribed standards, the Certification Agency shall ensure packing, tagging, sealing and issuance of certificate expeditiously. An authorized official of the Certification Agency shall endorse the signature on the reverse of each certification tag and shall affix rubber stamp indicating the official's name and designation. Containers to be used for packing of the certified seeds shall be durable and free from defects.
b. Advance tagging may be permitted at the discretion of the Certification Agency with proper safeguards.

Refusal for certification

The certification Agency shall have the authority to refuse certification of any seed production field or any seed lot that does not conform to the Minimum standards prescribed for that particular crop, either for field or for seed or for both.Such refusal will be subject to

any appeal made to the Appellate Authority constituted under section 11(1) of the Seeds act, 1966. The model composition of the Appellate Authority is given here under:

Model composition of the appellate authority

The Appellate Authority	All State Governments/Union Territories which have established the Certification Agency under Section 8 of the Seeds Act, 1966 shall invariably constitute an Appellate Authority under section 11 of the Seeds Act, 1966.
Composition	The Appellate Authority shall consist more than one member preferably three members to represent such interests as the State Government think fit, of whom at least one person shall be representative of seed producers.
Term of the Appellate Authority	The members of the Appellate Authority shall, unless their seats become vacant earlier by resignation, death or otherwise, be entitled to hold office for three years.
Decision	The Appellate Authority should ensure that decision on the appeals filed is taken expeditiously.

Validity period of the certificate

The validity period shall be nine months from the date of test at the time of initial certification. The validity period could be further extended for six months provided on retesting seed conforms to the prescribed standards in respect of physical purity, germination and insect damage for all seeds except vegetatively propagating material for which lot shall be re-examined for seed standards specified for respective crop. A seed lot will be eligible for extension of the validity period as long as it conforms to the prescribed standards. The procedure for extention of the validity period is given here under:

Extension of the validity period

1. The extension of validity period of certified seed shall be for a period of six months at each subsequent validation as long as the seed conforms to the prescribed standards. 2. Holder of the certificate or his authorized representative may request for extension of the validity of certified seed to a Certification Agency of the area in which the seed is located. He shall furnish the relevant information such as name of the crop, variety, class of seed, quantity of seed in lot, lot number, size and type of containers, number and date of certificate etc. to the Certification Agency at the time of submission of application.

3. The Certification Agency after receipt of application for extension of validity period shall verify that tags, labels and seals are intact on each seed container and arrange to draw samples and its analysis in a notified seed laboratory. The sample would be tested for physical purity, germination and insect damage.

4. If reprocessing and re-bagging at the time of extension of validity is requested to a Certification Agency which has not initially certified the seed, it may be permitted provided certification Agency is of the opinion that such operation may improve the quality of seed and seeds are not badly invaded by fungus, pest, etc. Infested seed lots shall meet the conditions laid down in para XXV of the General Seed Certification Standards. Whenever such operations are undertaken, a sample from each lot will be drawn before the seed containers are opened and shall be divided into three equal parts and sealed. One part shall be retained by the Certification Agency, another part by holder of the certificate or his representative and remaining sample will be sent under Registered Post to Certification Agency which had initially certified the seed. Besides this, holder of the stock shall retain at least two bags/containers for smaller packing's upto 10 kg and one bag/container above 10 kg in original packing of each seed lot being validated upto the next validation or till the stock is disposed off.

5. After analysis of sample, if seed is found to conform to the prescribed standards, the Certification Agency shall extend the validity of seed for a further period of six months from the date of test. The date of test and period of validity and name of Certification Agency who has extended the validity period must be rubber stamped on the tags affixed on the seed containers. However, if new tags are required to be issued due to reprocessing and re-bagging of the seed, the information indicated on the certification tags issued at the time of initial certification and name of the Certification Agency who performed the initial certification shall be recorded on the new tags. The serial numbers of new tags used for a seed lot shall be informed to the Certification Agency who performed the initial certification. The Certification Agency shall preserve at least two tags out of the tags removed from a seed lot and ensure the destruction of remaining tags in its presence.
6. A complete record shall be maintained by the Certification Agency of each lot offered for extension of the validity period.

Revocation of certificate

If the Certification Agency is satisfied, either on reference made to it in this behalf or otherwise that:

1. The certificate granted by it under section 9(3) of the Act has been obtained by misrepresentation as to an essential fact or
2. The holder of the certificate has, without reasonable cause, failed to comply with the conditions subject to which the certificate has been granted or has contravened any of the provisions of the Act or the Rules made there under, then, without prejudice to any other penalty to which the holder of the certificate may be liable under the Act, the Certification Agency may, after giving the holder of the certificate an opportunity of showing cause revoke the certificate, under the provisions of section 10 of the Act.

Retention of certification records

The Certification Agency shall preserve in order all the documents including the gaurd samples pertaining to certification of each seed lot for two years from the date of grant/extention of the certificate and four years in respect of rejected seed crops or lots from the date of communication of rejection unless and otherwise required for longer period.

Minimum Seed Certification Standards

Crop	Class of seed	Minimum			Maximum permissible level (%)			Remarks
		Isolation (m)	No. of field inspections	Off types	Inseparable other crop plants	Objectionable weed plants	Plants/heads affected by designated diseases	
Paddy	FS	3	2	0.05	-	0.01	-	
	CS	3	2	0.20	-	0.02	-	
Maize	FS	400	2	1.0				
	CS	200	2	1.0				
Pea, Cowpea	FS	10	2	0.10				
	CS	5	2	0.20				
Groundnut	FS	3	2	0.10				
	CS	3	2	0.10		0.5		For self compatible and self-

								incompatible type.
Jute	FS	50	3	0.5			1.0	
		5*						
	CS	30	3	1.0			2.0	
		5*						
Bottle Gourd	FS	1000*	3	0.10		None		
	CS	500*	3	0.20		None		
Tomato	FS	50	3	0.10			0.10	SBD; Early blight, leaf spot
	CS	25	3	0.20			0.50	Tobacco mosaic virus
Cauliflower	FS	1600	3	0.10			0.10	
	CS	1000	3	0.20			0.20	
Spinach	FS	1600*	2	0.10				SBD; Lettuce mosaic virus
	CS	1000*	2	0.20				

The Protection of Plant Varieties and Farmers' Rights Act, 2001

Introduction

India is signatory of World Trade Organization (WTO). WTO has at least half a dozen intergovernmental agreements that directly affect agriculture. Under the TRIPS Agreement Article 27(3) (b), which resulted from the negotiations of the Uruguay Round, requires members of protect plant varieties either by patents or by an effective '*sui generis*' system of protection or by a combination of both these systems. In compliance to the TRIPS Agreement India established Protection of Plant Varieties and Farmers Rights (PPV&FR) Authority, under the **Protection of Plant Varieties and Farmers Rights Act, 2001**. PPV & FR Authority has become operational since 11th November, 2005.

The objectives of the Authority are:

- Establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage development of new varieties of plants.
- Recognition and protection of the rights of farmers in respect to their contribution in conserving, improving and making the available plant genetic resources for the development of new plant varieties.
- Accelerated agricultural development in the country by stimulation of investment for research and development both in public and private sector.
- Facilitate growth of seed industry to ensure the availability of quality seeds and planting material to the farmers.

Any of the following persons can make an application to the PPV & FR Authority for registration of a variety:

- Any person claimed to be a breeder of a variety.
- Any person being the assignee of the breeder of a variety.
- Any farmer or group of farmers or community of farmers claiming to be the breeder of a variety.
- Any University or publicly funded agricultural institution claiming to be breeder of a variety.

PPV & FR Authority shall invite claims for beneficiary in respect of any variety for which registration has been granted. The PPV & FR Authority shall determine beneficiary on the basis of following:

- The extant and nature of the use of genetic material of the claimant.
- Commercial utility and demand in market of the variety relating to which benefit has been claimed.

The benefit determined by the PPV & FR Authority shall be deposited by the breeder with the National Gene Fund. The amount of benefit sharing shall be recoverable as arrear of land revenue. Certificate of Registration shall confer an exclusive right on the breeder, his successor, his agent or licensee the right to produce, sell, market, distribute, import or export the variety. Farmer who has developed or bred a new variety shall be entitled for registration as a breeder of a variety. Farmer shall be deemed to be entitled to save, use, sow, re-sow, exchange, share or sell his farm produce including seed of a variety protected under this Act in the same manner as he was entitled before coming into force of this Act provided that the farmer shall not be entitled to sell branded seed of a variety protected under this Act.

Farmer who is engaged in the conservation of genetic resources of land basis and wild relatives of economic plans and their improvement and preservation shall be entitled to recognition and reward from the Gene Fund provided the material so selected and preserved has been used as a donor of genes in varieties registerable under the PPV & FR Act. Any person or group of persons (whether actively engaged in farming or not) or any other Governmental or Non-governmental organization may stake a claim on behalf of the village or local community.

Duration of protection of a registered plant variety

- Trees and vines - 18 years.
- other crops - 15 years.
- Extant varieties - 15 years from the date of notification of that variety by the Central Government under section 5 of the Seeds Act, 1966.

Farmers' Variety (FV) in the context of Plant Variety Protection and Farmers' Rights Act, 2001.

The FV is one that was evolved by farmers / farming communities over several years and has proven special features compared to other materials. These materials must have been traditionally cultivated for considerable number of years. Because of repeated propagation, progeny assessment and advancement, the FV tend to be in a more homogenous, stable with distinct character(s). Such varieties have been provided with unique identity with a vernacular name or a name (predominantly) describing their unique features. This only goes to prove that market driven selection was done by farmers in the selection of FV. It can, therefore, be confidently said that FV are those plant varieties that are homogenous traditionally cultivated by farmers, selected by farmers in their own field and is an improvement over the wild relatives and/or land races. The FV can be elaborated as a variety that is almost uniform, homogenous, distinct trait and enjoys consumer acceptance (Nagarajan, 2007).

FV registration standards

FV is grouped under the class **'Extant Variety (EV)'** which has been defined in the PPV & FR Act 2001. The act further adds that the Registrar shall register the FV within three years from the date of Gazette notification of the species and genera eligible for registration under the Act. To facilitate the class of EV getting registered under the provisions of the Act, further a Gazette Notification was issued informing the constitution of the Extant Variety Recommendation Committee (EVRC). This committee is mandated to develop appropriate procedures and examine the EV applications that fall under the Seeds Act, 1966 and recommend to the Authority the suitability of the material for registration.

Norms for FV registration

The criteria of DUS to be adopted for the EV may marginally vary from that of what is specified for new varieties. It may also vary between species and depending upon if the candidate is a variety or hybrid. There is paucity of experimental data to indicate the level of distinctiveness that is available between FV to separate them from one another. The selection criteria followed by farmers has been the yield stability, risk avoidance, low dependence on external inputs and attributes related to storage, cooking and taste (Green Foundation, 2003). Implying that the special characters would be the main basis of difference since most of the FV may not have plant types with spectacular morphological variation. Yet, careful observation reveal perceivable differences for awn length, grain size, ear head shape, straw strength etc. Evaluating of FV as per descriptors notified in the Plant Variety Journal (PVJ) has not yet been done. The essential characters and grouping characters is based on UPOV

and Indian plant breeder's perception. It needs a fresh examination to assess whether the notified descriptors meet the requirements of the FV as well.

Testing procedure for FV

The FV are said to be high performers under low input conditions. This implies that a FV undergoing DUS test to resolve a tussle is to be conducted under restrictive input conditions. Such changed growing condition should give results comparable to the new variety tested under the recommended agronomic procedure. The type of irrigation and nutrient schedule needed for the pest vulnerable FV has not been examined scientifically to arrive at any meaningful recommendation.

Distinctiveness between FVs

The traditionally cultivated, farmer field evolved varieties are invariably tall ideotypes. More than that, the FV is likely to posses certain qualitative characters such as aroma, grain elongation on cooking, nutracutical uses, tolerance to flooding, soil salinity, etc. The 'Traditional Knowledge' associated with the FV should be recorded and the claims must be experimentally validated. Establishing the distinctiveness of the FV material based on the claims made by the applicant can be for the EVRC a demanding decision. The public funded agricultural research establishments, said to be dedicated for the cause of farmers should conduct critical experiments and provide the needed data to farmer/ farming communities on an acceptable term so that they are able to file FV with all supportive information.

FV in the context of cross pollinated crops and others:

The fore gone discussion is primarily in the context of self pollinated crops such as rice, wheat, french bean, peas, soybean, tomato, etc. where out crossing is up to 0-5%. But the issue becomes much more complicated when we examine the often cross pollinated crops as pigeonpea, okra, brinjal, chilli, etc. with about 5-12% of out crossing and cross pollinated crops such as sorghum, maize, pearl millets, gourds, cabbage, carrot, cauliflower, onion, melons, radish, etc. having greater than 12% out crossing. The extent of variation in the FV of these crops in farmers' field differs considerably between location and season. On a priority basis the level of farm level heterogeneity in these FV should be quantified before DUS test norms are framed. Such an argument can be extended to the vegetatively or clonally propagated material, bud sprouts and for chemaric material. The level of variation in these crops being large a proper understanding of the concept of FV as perceived by farmers and consumers is necessary before binding the FV for a high level of uniformity.

Number of varieties registered under PPV and FR Act,2001

Category	New varieties	Farmers' arieties	Extant Varieties
Application received	969	226	1423
Registered	452 *(as on September 2012)*		

Biochemical and molecular markers in DUS testing

DUS testing is an essential component of variety registration procedure. In Europe testing procedures are determined by UPOV. India has enacted a *sui generis* legislation as PPV & FR Act, 2001 similar to UPOV acts. Like UPOV, under PPV&FR act a variety must fulfil the criteria of DUS and novelty (if new), so as to get protection under this act. As per DUS guidelines, only morpho-physiological descriptors are used. However, serious problems may arise for establishing distinctiveness of a variety only on morpho-physiological DUS descriptors as number of candidate varieties are growing with decreased variability as well as expansion of reference collection. In such situation, biochemical and molecular markers considered as additional descriptors for establishing the distinctiveness of variety

The introduction of molecular methods to characterize and define varieties for DUS is an ongoing process. There are concerns that ease of finding minor genetic differences could erode the amount of genetic differences needed for distinctness. It is felt that this might promote breeding of varieties with minor cosmetic changes. Also an increase of genetic uniformity may result in greater potential risks of susceptibility to pest and diseases, unforeseen weather problems and the erosion of genetic resources. Whether or not a one band difference in genomic profile be considered for establishing distinctness also being debated. However, by adopting a judicial system of data analysis and interpretation, it could be possible to use a one band (one locus/allele) difference just as a single phenotypic characterstic is used for establishing varietal distinctness. Molecular markers also allow reliable, faster and cost effective comparisons to discriminate an EDV variety from initial variety.

Conclusion

It is clear that FV is a reputed product of elite farmers having a long tradition and was evolved in their own field from out of a non descriptive heterogeneous land race. The yard stick of DUS for FV needs a fresh look so that a pragmatic procedure to register the FV under the PPV&FR Act, 2001 can be designed. For crops where within field variation is very high and behaves as a population or as land race, fresh research efforts are necessary to purify them. Considerable research is necessary to understand the farmers' perception of a variety, and the reasoning behind why they permit certain degree of floating variation in the FV. It is also quite intriguing as to why consumers have all along been patronizing a product with certain degree of variability. Finally it's essential and right time to protect every seed of country which has potential and valuable genes (seed longevity, dormancy and vigor) through PVP&FR Act.

With the entry of huge number of varieties in different crops there is urgent need of new tools and technology (Biochemical and molecular markers) for rapid identification variety. Special Testing Groups need to be constituted for working out procedure and modalities for supplementary traits relating to biochemical and molecular markers which supplement the morpho-physiological descriptors in DUS testing. Molecular markers also allow reliable, faster and cost effective comparisons to discriminate an EDV variety from initial variety.

References

1. **Chakrabarty, S.K, Sharma, S.P., Surendra Prakash, Malavika Dadlani. 2007**. Testing of distinctness, uniformity and stability for plant variety protection. p51-57.
2. **Nagarajan, S., Yadav, S.P. and Singh, A.K., 2007**. Farmers' Variety in the context of Plant Variety Protection and Farmers' Rights Act, 2001**.**
3. www.seednet.gov.india
4. www.plantauthority.gov.in

Seeds Bill, 2004

Introduction

Seed, the 'embodiment of life's continuity and renewability', has been not only stated to be the source of culture and history but also importantly, the ultimate symbol of food security. Keeping the importance of seed at fore, the new seed bill was drafted, which will replace the old Seed Act of 1966 meant to govern trading in seed. A law regulating the seed trade is necessary to ensure that farmers are protected against spurious seeds and that seed producers are obliged to put into the market only seeds of good and reliable quality. The new seed bill, clause wise is discussed below: THE SEEDS BILL, 2004:A BILL to provide for regulating the quality of seeds for sale, import and export and to facilitate production and supply of seeds of quality and for matters connected therewith or incidental thereto. BE it enacted by Parliament in the Fifty-Fifth Year of the Republic of India as follows:

Preliminary

1. Short title, extent, application and commencement

(1) This Act may be called the Seeds Act, 2004.

(2) It extends to the whole of India.

(3) Save as otherwise provided in this Act, it shall apply to-

(a) every dealer; and

(b) every producer of seed except when the seed is produced by him for his own use and not for sale.

(4) It shall come into force on such date as the Central Government may, by notification, appoint.

2. Definitions: In this Act, unless the context otherwise requires

(1) "Agriculture" includes horticulture, forestry and cultivation of plantation, medicinal and aromatic plants;

(2) "Central Seed Testing Laboratory" means the Central Seed Testing Laboratory established or declared as such under sub-section (1) of section 32;

(3) "Certification Agency" means an agency established under section 26 or accredited under section 27 or recognised under section 30;

(4) "Chairperson" means the Chairperson of the Committee;

(5) "Committee" means the Central Seed Committee constituted under sub-section (1) of section 3;

(6) "Container" means a box, bottle, casket, tin, barrel, case, receptacle, sack, bag, wrapper or other thing in which any article or thing is placed or packed;

(7) "Dealer" means a person who carries on the business of buying and selling, exporting, or importing seed, and includes an agent of a dealer;

(8) "Export" means taking out of India by land, sea or air;

(9) "Farmer" means any person who cultivates crops either by cultivating the land himself or through any other person but does not include any individual, company, trader or dealer who engages in the procurement and sale of seeds on a commercial basis;

(10) "Horticulture nursery" means any place where horticulture plants are, in the regular course of business, produced or propagated and sold for transplantation;

(11) "Import" means bringing into India by land, sea or air;

(12) "Kind" means one or more related species or sub-species of crop plants each individually or collectively known by one common name such as cabbage, maize, paddy and wheat;

(13) "Member" means a member of the Committee;

(14) "Misbranded" - A seed shall be deemed to be misbranded if-

- it is a substitute for, or resembles in a manner likely to deceive, another variety of seed under the name of which it is sold, and is not plainly and conspicuously labelled so as to indicate its true nature;
- it is falsely stated to be the product of any place or country;
- it is sold by a name which belongs to another kind or variety of seed;
- false claims are made for it upon the label or otherwise;
- when sold in a package which has been sealed or prepared by, or at the instance, of the dealer and which bears his name and address, the contents of each package are not conspicuously and correctly stated on the outside thereof within the limits of variability prescribed under this Act;
- the package containing it, or the label on the package bears any statement, design or device regarding the quality or the kind or variety of seed contained therein, which is false or misleading in any material particular or if the package is otherwise deceptive with respect to its contents;
- it is not registered in the manner required by or under this Act;
- its label contains any reference to registration other than the registration number;
- its label does not contain a warning or caution which may be necessary, and sufficient, if complied with, to protect human, animal and plant life and health or to avoid serious prejudice to the environment;
- the package containing it or the label on the package bears the name of a fictitious individual or company as the dealer of the kind or variety; or
- it is not labelled in accordance with the requirements of this Act or the rules made thereunder;

(15) "Notification" means a notification published in the Official Gazette;

(16) "Prescribed" means prescribed by rules made under this Act;

(17) "Producer" means a person, group of persons, firm or organisation who grows or organizes the production of seeds;

(18) "Registered kind or variety", in relation to any seed, means any kind, or variety thereof, registered under section 13;

(19) "Registration Sub-Committee" means the Registration Sub-Committee constituted under sub-section (1) of section 7;

(20) "Regulation" means a regulation made by the Committee under this Act;

(21) "Seed" means any type of living embryo or propagule capable of regeneration and giving rise to a plant of agriculture which is true to such type;

(22) "Seed Analyst" means a Seed Analyst appointed under section 33;

(23) "Seed Inspector" means a Seed Inspector appointed under section 34;

(24) "Seed processing" means the process by which seeds and planting materials are dried, threshed, shelled, ginned or delinted (in cotton), cleaned, graded or treated;

(25) "Spurious seed" means any seed, which is not genuine or true to type;

(26) "State Government", in relation to a Union territory, means the administrator thereof;

(27) "State Seed Testing Laboratory", in relation to any State, means the State Seed Laboratory established or declared as such under sub-section (2) of section 32 for that State;

(28) "Transgenic variety" means seed or planting material synthesized or developed by modifying or altering the genetic composition by means of genetic engineering;

(29) "Variety" means a plant grouping except micro-organism within a single botanical taxon of the lowest known rank, which can be

(i) defined by the expression of the characteristics resulting from a given genotype of that plant grouping;

(ii) distinguished from any other plant grouping by expression of at least one of the said characteristics; and

(iii) considered as a unit with regard to its suitability for being propagated, which remains unchanged after such propagation,

and includes propagating material of such variety, extant variety, transgenic variety, farmers' variety and essentially derived variety.

Footnote: "essentially derived variety", in respect of a variety (the initial variety) shall be said to be essentially derived from such initial variety when it-

(a) is predominantly derived from such initial variety, or from a variety that itself is predominantly derived from such initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety;

(b) is clearly distinguishable from such initial variety; and

(c) conforms (except for the differences which result from the act of derivation) to such initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety;

(30) "Extant variety" means a variety available in India which is-

(a) notified under section 5 of the Seeds Act, 1966; or

(b) farmers' variety as defined in PVP Act; or

(c) a variety about which there is common knowledge; or

(d) any other variety which is in public domain.

The central seed committee, registration and other sub-committees

3. Constitution of central seed committee

The Central Government shall, by notification, constitute, for the purpose of this Act, a Committee to be called the Central Seed Committee.

4. Composition of the committee

(1) The Committee shall consist of a Chairperson, members, ex-officio and other members, to be nominated by the Central Government.

(2) The Secretary to the Government of India in the Department of Agriculture and Co-operation, Ministry of Agriculture, shall be Chairperson, ex officio.

(3) The Committee shall consist of the following members, ex officio namely:-

(i) the Agriculture Commissioner, Department of Agriculture and Co-operation, Government of India ;

(ii) the Deputy Director General (Crop Sciences), Indian Council of Agricultural Research;

(iii) the Deputy Director General (Horticulture), Indian Council of Agricultural Research;

(iv) the Joint Secretary in charge of seeds in the Department of Agriculture and Co-operation, Government of India

(v) the Horticulture Commissioner, Department of Agriculture and Co-operation, Government of India;

(vi) a representative of the Department of Bio-technology, Government of India, not below the rank of Joint Secretary to the Government of India;

(vii) a representative of the Ministry of Environment and Forests, Government of India, not below the rank of Joint Secretary to the Government of India.

(4) The Committee shall consist of the following other members to be nominated by the Central Government, namely:-

(i) the Secretary (Agriculture) from five States, one each from three out of the five geographical zones of the country as mentioned in the Schedule on rotation basis;

(ii) Director, State Seed Certification Agency from one State which is not represented under clause (i);

(iii) Managing Director, State Seeds Corporation, from one State which is not represented under clause (i) or clause (ii);

(iv) two representatives of farmers;

(v) two representatives of seed industry;

(vi) two specialists or experts in the field of seed development.

(5) The Committee may associate with it, in such manner, on such terms and for such purposes as it may deem fit, any person whose assistance or advice it may desire in complying with any of the provisions of this Act, and a person so associated shall have the right to take part in the discussion of the Committee relevant to the purposes for which he has been associated, but shall not have the right to vote and shall be entitled to receive such allowances or fees as may be fixed by the Central Government.

(6) A Member nominated under sub-section (5) shall, unless his seat becomes vacant earlier by resignation, death or otherwise, be entitled to hold office for two years from the date of his nomination but shall be eligible for re-nomination provided that the said member shall hold office only for so long as he holds the appointment by virtue of which his nomination was made.

(7) Save as otherwise provided, the terms and conditions of service of the members shall be such as may be prescribed.

(8) A member other than an ex officio member may resign his office by giving notice in writing to the Central Government and on such resignation being accepted, he shall be deemed to have vacated his office.

(9) A person shall be disqualified for being nominated or appointed as a member if he-

(i) has been convicted and sentenced to imprisonment for an offence which, in the opinion of the Central Government, involves moral turpitude; or

(ii) is an undischarged insolvent; or

(iii) is of unsound mind and stands so declared by a competent court.

(10) No act or proceeding of the Committee shall become invalid merely by reason of –

(i) any vacancy therein, or any defect in the constitution thereof; or

(ii) any defect in the appointment of a person acting as the Chairperson or a member of the Committee; or

(iii) any irregularity in the procedure of the Committee not affecting the merits of the case.

(11) The Central Government may, at any time, remove from office any member other than member, ex-officio after giving him a reasonable opportunity of showing cause against the proposed removal.

5. Powers and functions of the Committee: The Committee shall be responsible for and shall have all the powers for the effective implementation of this Act and shall advise the Central Government and the State Governments on matters relating to-

(a) seed programming and planning;

(b) seed development and production;

(c) export and import of seeds;

(d) standards for registration, certification and seed testing;

(e) seed registration and its enforcement;

(f) such other matters as may be specified by the Central Government.

6. Powers of Committee to specify minimum limits of germination, purity, seed health, etc.

The Committee may, by notification, specify–

(a) the minimum limits of germination, genetic and physical purity, and seed health, with respect to any seed of any kind of variety;

(b) the mark or label to indicate that such seed conforms to the minimum limits of germination, genetic and physical purity, and seed health specified under clause (a), and other particulars, such as expected performance of the seed in accordance with the

information provided by the producer under section 14 which such mark or label may contain.

7. Registration and other Sub-Committees of the Committee and their functions

(1) The Committee shall constitute a Sub-Committee to be called the Registration Sub-Committee consisting of a Chairman and such number of other members, to assist him in the discharge of the functions of the Committee, as may be prescribed.

(2) it shall be the duty of the Registration Sub-Committee-

(a) to register seeds of varieties after scrutinizing their claims as made in the application in such manner as may be prescribed;

(b) to perform such other functions as are assigned to it by the Committee.

(3) The Committee may appoint as many other Sub-Committees including a Sub-Committee on Seed Certification as it deems fit consisting wholly of the members of the Committee or wholly of other persons or partly of members of the Committee and partly of other persons as it thinks fit to exercise such powers and perform such duties as may be delegated to them.

8. Procedure of the committee and its sub-committees

The Committee may, subject to the previous approval of the Central Government, make regulations for the purpose of regulating its own procedure and the procedure of any Sub-Committee thereof.

9. Secretary and other officers of the committee The Central Government shall –

(a) appoint a person to be the Secretary of the Committee; and

(b) provide the Committee with such technical and other officers and employees as may be necessary for the efficient performance of the functions of the Committee under this Act.

10. Meetings of the committee

(1) The Committee shall meet as and when necessary at such time and place and shall observe such procedure in regard to transaction of business at its meetings (including the quorum at meetings) as may be provided by regulations.

(2) The Chairperson or, in his absence, the Agricultural Commissioner or, in the absence of both the Chairperson and the Agriculture Commissioner, any member chosen by the members present from amongst themselves, shall preside at a meeting of the Committee.

(3) All questions at a meeting of the Committee shall be decided by a majority of votes of the members present and voting and in the case of an equality of votes, the Chairperson or, in his absence, the Agriculture Commissioner or, in the absence of both the Chairperson and the Agriculture Commissioner the person presiding shall have and exercise a second or casting vote

11. State seed committee Every State Government shall establish a State Seed Committee to

(a) advise the Committee on registration of regional or local seeds of any kind or variety;

(b) advise the State Government on registration of seed producing units, seed processing units, seed dealers and horticulture nurseries;

(c) maintain, in each district, a list of seed dealers, seed producers, seed processing units and horticulture nurseries;

(d) seek information from persons engaged in the production, supply, distribution, trade or commerce in seeds of any kind or variety regarding stocks, prices, sales and other information in the manner as may be prescribed;

(e) advise the State Government and the Committee on all matters arising out of the administration and implementation of this Act; and

(f) carry out other functions assigned to, by, or under this Act.

Registration of kinds and varieties of seeds, etc

12. Maintenance of national register of seeds of kinds and varieties

(1) For the purposes of this Act, a register of all kinds and varieties of seed to be called the National Register of Seeds shall be kept by the Registration Sub-Committee wherein all specifications, as may be prescribed, shall be maintained.

(2) Subject to the directions of the Committee, the Register shall be kept under the control and management of the Registration Sub-Committee.

(3) The Registration Sub-Committee shall, within such intervals and in such manner as it thinks appropriate, publish the list of kinds and varieties of seed which have been registered during that interval.

13. Registration of seeds of any kind or variety

(1) No seed of any kind or variety shall, for the purpose of sowing or planting by any person, be sold unless such seed is registered under sub-section (2) by the Registration Sub-Committee in such manner as may be prescribed.

(2) Subject to the provisions of sections 14 and 15, the Registration Sub-Committee may register, or refuse any kind or variety of seed on the basis of information furnished by the producer on the results of multi-locational trials for such period as may be prescribed to establish the performance of that seed.

(3) The Registration Sub-Committee may grant provisional registration as prescribed to the varieties of seeds which are available in the market on the date of commencement of this Act.

(4) Registration made under this Act shall be valid for a period of fifteen years in the case of annual and biennial crops, and eighteen years for long duration perennials.

(5) At the expiry of the period granted under sub-section (4), the kind or variety of seed may be re-registered for a like period by the Registration Sub-Committee on the basis of information furnished by the producer on the results of such trials as may be prescribed under sub-section (2) to re-establish performance of the kind or variety of seed.

(6) The Registration Sub-Committee shall have the power to issue such directions to protect the interests of a producer against any abusive act committed by any third party during the period between the date of filing of application for registration and the date of decision by the Committee on such application.

14. Procedure for registration

(1) Every application for registration under sub-section (1) section 13 shall be made in such form and contain such particulars and be accompanied by such fees as may be prescribed.

(2) On receipt of any such application for the registration of a kind or variety of seed, the Registration Sub-Committee may, after such enquiry as it deems fit and after satisfying itself that the kind or variety of seed to which the application relates conforms to the claims made by the importer or by the seller, as the case may be, as regards the efficacy of the kind or

variety of seed and its safety to human beings and animals, register the kind or variety, as the case may, of the seed on such conditions as may be specified by it and allot a registration number thereto and issue a certificate of registration.

(3) The Registration Sub-Committee may, having regard to the efficacy of the seeds and its safety to human beings and animals, vary the conditions subject to which a certificate of registration has been granted and may, for that purpose, require the certificate holder by notice in writing to deliver the certificate to it within such time as may be specified in the notice.

15. Special provision for registration of transgenic varieties

(1) Notwithstanding anything contained in section 14, no seed of any transgenic variety shall be registered unless the applicant has obtained clearance in respect of the same as required by or under the provisions of the Environment (Protection) Act, 1986:

Provided that the Registration Sub-Committee may, subject to clearance under the said Act, grant provisional registration, for a period not exceeding two years on the basis of information furnished by the producer on the results of multi-locational trials in the prescribed manner.

(2) Save as otherwise provided in sub-section (1), the form and manner in which and procedure for registration of transgenic variety of seed and the fee payable thereto shall be the same as applicable in case of registration under section 14.

16. Cancellation of registration of seeds of kinds and varieties

(1) The Registration Sub-Committee may cancel any registration granted under section 13 or section 15 or any one or more of the following grounds, namely:-

(a) that the holder of the certificate has violated any of the terms and conditions of the registration; or

(b) that the registration has been obtained by misrepresentation or concealment of essential data; or

(c) that the variety is not performing in accordance with the information provided by the producer under sub-section (3) of section 14 or has become obsolete or has outlived its utility; or

(d) that prevention of commercial exploitation of such variety of seeds is necessary.

(i) In the public interest;

(ii) To protect public order or public morality; or

(iii) To protect human beings, animal and plant life and health to avoid serious prejudice to the environment.

(2) No order of cancellation of registration under this section shall be made unless the holder thereof or the affected person concerned has been given a reasonable opportunity of showing cause in respect of the grounds for such cancellation.

17. Notification of cancellation of registration of seeds of kinds and varieties

The Registration Sub-Committee shall notify the cancellation of registration of a seed of any kind or variety made under section 13 or any registration made under section 15 in the Official Gazette

18. Exclusion of certain kinds or varieties of seed from registration

1. Notwithstanding anything contained in this Act, no registration of any kind or variety of seed shall be made under this Act, if prevention of commercial exploitation of such kind or variety is necessary to protect public order or public morality or human, animal or plant life and health, or to avoid serious prejudice to the environment.

2. A kind or variety of seed containing any technology, which is harmful, or potentially harmful, shall not be registered.

Explanation: For the purposes of this sub-section, the expression "technology" includes genetic use restriction technology and terminator technology.

19. Evaluation of performance

The Committee may, for conducting trials to assess performance, accredit centers of the Indian Council of Agricultural Research, State Agricultural Universities and such other organizations fulfilling the eligibility requirements as may be prescribed, to conduct trials to evaluate the performance of any kind or variety of seed.

20. Compensation to farmer

Where the seed of any registered kind or variety is sold to a farmer, the producer, distributor or vendor, as the case may be, shall disclose the expected performance of such kind or variety to the farmer under given conditions, and if, such registered seed fails to provide the expected performance under such given conditions, the farmer may claim compensation from the producer, distributor or vendor under the Consumer Protection Act, 1986.

21. Seed producers and seed processing units to be registered

(1) No producer shall grow or organize the production of seed unless he is registered as such by the State Government under this Act.

(2) No person shall maintain a seed processing unit unless such unit is registered by the State Government under this Act.

(3) The State Government shall register a producer or seed processing unit if he or it meets the specifications prescribed by the Central Government in terms of infrastructure, equipment and qualified manpower.

(4) Every application for registration under sub-section (3) shall be made in such form and manner and shall be accompanied by such fee as may be prescribed.

(5) The State Government may, after making such enquiry and subject to such conditions as it thinks fit, grant a certificate for maintaining a seed producing or a seed processing unit in such form as may be prescribed.

(6) Every seed producing and processing units shall furnish periodic returns to the Seed Certification Agency in such form and at such time as may be prescribed on the quantity of seeds of different kinds or varieties processed by them.

(7) The State Government may, after giving the holder of certificate of registration under sub-section (1), or sub-section (2), as the case may be, suspend or cancel the registration if.

(a) such registration has been obtained by misrepresentation as to a material particular relating to the specification in terms of infrastructure, equipment or availability of qualified manpower; or

(b) any of the provisions of this Act or the rules made thereunder has been contravened.

22. Seed dealers to be registered

(1) Every person who desires to carry on the business of selling, keeping for sale, offering to sell, bartering, import or export or otherwise supply any seed by himself, or by any other person on his behalf shall obtain a registration certificate as a dealer in seeds from the State Government .

(2) Every applicant for dealership under sub-section (1) shall be required to furnish information about seed stocks, sales and other related information as may be prescribed.

(3) Even application for registration under sub-section(1) shall be made in such form and manner and shall be accompanied by such fee as may be prescribed.

(4) The State Government may, after making such enquiry and subject to such conditions as it thinks fit, grant a certificate of registration as a dealer in seeds in such form as may be prescribed.

(5) Every dealer registered under this section shall furnish such information and returns regarding seed stocks, seed lots, expiry date of seed lots and other related information as may be prescribed to the State Government.

(6) The State Government may, after giving the dealer an opportunity of being heard, suspend or cancel a certificate granted under this Act if-

(a) such registration had been obtained by misrepresentation of any material fact;

(b) contravenes any of the provisions of this Act or the rules made thereunder.

23. Horticulture nursery to be registered

(1) No person shall conduct or carry on the business of horticulture nursery unless such nursery is registered with the State Government.

(2) Every application for registration under sub-section (1) shall be made in such form and contain such particulars and shall be accompanied by such fee as may be prescribed.

24. Duties of registration holders of horticulture nursery: Every person who is a holder of a registration of a horticulture nursery under section 23 shall-

(a) keep a complete record of the origin or source of every planting material and performance record of mother trees in the nursery;

(b) keep a layout plan showing the position of the root-stocks and scions used in raising the horticulture plants;

(c) keep a performance record of the mother trees in the nursery;

(d) keep the nursery plants as well as the parent trees used for the production or propagation of horticulture plants free from infectious or contagious insects, pests or diseases affecting plants.

(e) furnish such information to the State Government on the production, stocks, sales and prices of planting material in the nursery as may be prescribed.

Regulation of sale of seed and seed certification agencies

25.Regulation of sale of seeds of registered kinds and varieties: No person shall himself, or by any other person on his behalf, carry on the business of selling, keeping for sale, offering to sell, bartering, import or export or otherwise supply any kind of seed of any registered kind or variety unless-

(a) such seed is identifiable as to its kind or variety;

(b) such seed conforms to the minimum limit of germination and genetic, physical purity, seed health specified under clause (a) of section 6;

(c) the container of such seed bears in the prescribed manner, the mark or label bearing the correct particulars thereof, specified under clause (b) of section 6;

(d) the container of such seed, in the case of transgenic varieties, bears a declaration to this effect as specified in sub-clause (2) of section 15;

(e) he complies with such other requirements as may be prescribed.

26. State seed certification agency: The Committee may, in consultation with the State Government, by notification, establish a State Seed Certification Agency for the State to carry out the functions entrusted to the State Seed Certification Agency by or under this Act:

27. Accreditation of seed certification agencies

(1) The Committee may in consultation with the State Government and the State Seed Committee, accredit –

(a) organizations to carry out certification, on the fulfillment of such criteria, as may be prescribed, or

(b) individuals or seed producing organisations to carry out self- certification, in such manner as may be prescribed.

(2) The accredited individuals and seed producing organisations shall be subject to such inspection and control of the Committee, the concerned State Government and State Seed Certification Agency, as may be prescribed.

(3) The accreditation may be withdrawn by the Committee, for reasons to be recorded in writing and after giving to the concerned organization or individual, as the case may be, a reasonable opportunity of being heard.

28. Grant of certificate by the state seed certification agency

(1) Any person selling, keeping for sale, offering to sell, bartering or otherwise supplying any seed of any registered kind or variety may, if he desires to have such seed certified by the State Seed Certification Agency, apply to that Agency for the grant of a certificate for the purpose.

(2) Every application under sub-section (1) shall be made in such form, shall contain such particulars and shall be accompanied by such fee as may be prescribed.

(3) On receipt of an application under sub-section (1), the State Seed Certification Agency may, after such enquiry as it thinks fit and after satisfying itself that the seed to which the application relates conforms to the prescribed standards, grant a certificate in such form and on such conditions as may be prescribed:

Provided that such standards shall not be lower than the minimum limit of germination, genetic and physical purity specified for that seed under clause (a) of section 6.

29. Revocation of certificate: If the State Seed Certification Agency is satisfied, either on a reference made to it in this behalf or otherwise, that-

(a) the certificate granted by it under section 28 has been obtained by misrepresentation as to an essential fact; or

(b) the holder of the certificate has, without reasonable cause, failed to comply with the conditions subject to which the certificate has been granted or has contravened any of the provisions of this Act or the rules made thereunder,

then, without prejudice to any other penalty to which the holder of the certificate may be liable under this Act, the State Seed Certification Agency may, after giving the holder of the certificate an opportunity of showing cause, revoke the certificate.

30. Recognition of seed certification agencies in foreign countries

The Central Government may, on the recommendation of the Committee and by notification, recognise any seed certification agency established in any foreign country, for the purposes of this Act.

31. Appeals

(1) Any person aggrieved by a decision of the Registration Sub-Committee under section 14, section 16 or section 27 or of the State Seed Certification Agency under section 28 or section 29 may, within thirty days from the date on which the decision is communicated to him prefer an appeal to such authority (hereinafter referred to as the appellate authority) as the Central Government may think fit to constitute:

Provided that the appellate authority may entertain an appeal after the expiry of the said period of thirty days if it is satisfied that the appellant was prevented by sufficient cause from filing the appeal in time.

(2) An appellate authority shall consist of a single person or three persons as the Central Government may think fit, to be appointed by that Government.

(3) The form and manner in which an appeal may be preferred under sub-section (1), the fee payable for such appeal and the procedure to be followed by the appellate authority shall be such as may be prescribed.

(4) On receipt of an appeal preferred under sub-section (1), the appellate authority shall, after giving the appellant and the other party an opportunity of being heard, dispose of the appeal as expeditiously as possible.

Seed analysis and seed testing

32. Central and state seed testing laboratories

(1) The Central Government may, by notification, establish a Central Seed Testing Laboratory or declare any seed-testing laboratory as the Central Seed Testing Laboratory to carry out the functions entrusted to the Central Seed Testing Laboratory by or under this Act in the prescribed manner

(2) The State Government may, in consultation with the Committee, and by notification, establish one or more State Seed Testing Laboratories or declare any seed testing laboratory in the Government or non-Government sector as a State Seed Testing Laboratory where analysis of seed of any kind or variety shall be carried out under this Act in the prescribed manner.

(3) Every Seed Testing Laboratory referred to in sub-section (1) shall have as many Seed Analysts as the Central Government may consider necessary.

(4) Every Seed Testing Laboratory referred to in sub-section (2) shall have as many Seed Analysts as the State Government may consider necessary.

33. Seed analysts

(1) In case of the Central Seed Laboratory, the Central Government and in other cases the State Government may, by notification, appoint such persons as the Government thinks fit and having the prescribed qualifications to be Seed Analysts and define the local limits of their jurisdiction.

(2) Every Central Seed Testing Laboratory established or declared under sub-section (1) of section 32 and every State Seed Testing Laboratory established or declared under sub-section (2) of that section shall have as many Seed Analysts as the Central Government or the State Government, as the case may be, specify.

34. Seed inspectors

(1) The State Government may, by notification, appoint such persons as it thinks fit, having the prescribed qualifications, to be Seed Inspectors and define the areas within which they shall exercise jurisdiction.

(2) Every Seed Inspector shall be subordinate to such authority as the State Government may specify in this behalf.

35. Powers of seed inspectors

(1) The Seed Inspector may-

(a) take samples of any seed of any kind or variety from-

(i) any person selling such seed; or

(ii) any person who is in the course of conveying, delivering or preparing to deliver such seed to a purchaser or a consignee; or

(iii) a purchaser or a consignee after delivery of such seed to him;

(b) send such sample for analysis to the Seed Analyst of the area within which such sample has been taken;

(c) enter and search, at all reasonable times, with such assistance, if any, as he considers necessary, any place in which he has reason to believe that an offence under this Act has been or is being committed and order in writing the person in possession of any seed in respect of which the offence has been or is being committed, not to dispose of any stock of such seed for a specific period not exceeding thirty days or, unless the alleged offence is such that the defect may be removed by the possessor of the seed, seize the stock of such seed;

(d) examine any record, register, document or any other material object found in any place mentioned in clause (c) and seize the same if he has reason to believe that it may furnish evidence of the commission of an offence punishable under this Act; and

(e) exercise such other powers as may be necessary for carrying out the purposes of this Act or any rule or regulation made thereunder.

(2) The power conferred by this section includes the power to break-open any container in which any seed of any kind or variety may be contained or to break-open the door of any premises where any such seed may be kept for sale:

Provided that the power to break-open the door shall be exercised only after the owner or any other person in occupation of the premises, if he is present therein, refuses to open the door on being called upon to do so.

(3) Where the Seed Inspector takes any action under clause (a) of sub-section (1), he shall, as far as possible, call not less than two persons to be present at the time when such action is taken and take their signatures on a memorandum to be prepared in such form and manner as may be prescribed.

(4) The provisions of the Code of Criminal Procedure, 1973, or in relation to the State of Jammu and Kashmir, the provisions of any corresponding law in force in that State, shall, so far as may be, apply to any search or seizure under this section as they apply to any search or seizure made under the authority of a warrant issued under section 94 of the said Code, or, as the case may be, under the corresponding provisions of the said law.

Export and import of seed

36. Import of seeds

(1) All import of seeds –

(a) shall be subject to the provisions of the Plants, Fruits and Seeds (Regulation of Import into India) Order, 1989, or any corresponding order made under section 3 of the Destructive Insects and Pests Act, 1914;

(b) shall conform to minimum limits of germination, genetic and physical purity, and seed health as prescribed under section 6; and

(c) shall be subject to registration as may be granted on the basis of information furnished by the importer on the results of multi-locational trials for such period as may be prescribed to establish performance.

(2) The Central Government may, by notification, permit to import an unregistered variety in such quantity and subject to fulfilling such conditions as may be specified in that notification for research purposes.

37. Export of seeds

The Central Government may, on the advice of the Committee, restrict, by notification, the export of seeds of any kind or variety if it is deemed that such export may adversely affect the food security of the country, or if it is felt that the reasonable requirements of the public will not be met, or on such other grounds as may be prescribed.

38. Offences and punishment

If any person –

(a) contravenes any provision of this Act or any rule made thereunder; or

(b) imports, sells, stocks or exhibits for sale or barter; and or otherwise supplies any seed of any kind or variety deemed to be misbranded ; or

(c) imports, sells, stocks or exhibits for sale or barter, or otherwise supplies any seed of any kind or variety without a certificate of registration; or

(d) obstructs the Committee, Registration Sub-Committee or Seed Certification Agency or Seed Inspector or Seed Analyst or any other authority appointed or duly empowered under this Act in the exercise of its powers or discharge of their duties under this Act or the rules made thereunder, he shall, on conviction, be punishable – with fine which shall not be less than five thousand rupees but which may extend to twenty five thousand rupees.

(2) If any person sells any seed which does not conform to the standards of physical purity, germination or health or does not maintain any records required to be maintained under this

Act or the rules made thereunder he shall, on conviction, be punishable with fine which shall not be less than five thousand rupees but which may extend to twenty- five thousand rupees.

(3) If any person furnishes any false information relating to the standards of genetic purity, misbrands any seed or supplies any spurious seed or spurious transgenic variety, sells any non-registered seeds he shall, on conviction be punishable with imprisonment for a term which may extend to six months or with fine which may extend to fifty thousand rupees or with both.

39. Forfeiture of property

When any person has been convicted under this Act for the contravention of any of the provisions of this Act or the rules made thereunder, the seed in respect of which the contravention has been committed shall be forfeited to the Central Government.

40. Offences by companies

(1) Where an offence under this Act has been committed by a company, every person who at the time the offence was committed was in charge of, and was responsible to the company for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

Provided that nothing contained in this sub-section shall render any such person liable to any punishment under this Act if he proves that the offence was committed without his knowledge and that he exercised all due diligence to prevent the commission of such offence.

(2) Notwithstanding anything contained in sub-section (1), where an offence under this Act has been committed by a company and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any director, manager, secretary or other officer of the company, such director, manager, secretary or other officer shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Explanation. – For the purpose of this section,-

(a) "company" means any body corporate and includes a firm or other association of individuals; and

(b) "director", in relation to a firm, means a partner in the firm.

41. Power of central government to give directions to the state governments

The Central Government may give such directions to any State Governments as may appear to the Central Government to be necessary for carrying into execution in the State any of the provisions of this Act or of any rule made there under.

42. Power of central government to issue directions to the committee

(1) Without prejudice to the foregoing provisions of this Act, the Committee shall, in the discharge of its functions and duties under this Act, be bound by such directions on questions of policy as the Central Government may give in writing to it from time to time.

(2) The decision of the Central Government whether a question is one of policy or not shall be final.

43. Exemption from registration

(1) Nothing in this Act shall restrict the right of the farmer to save, use, exchange, share or sell his farm seeds and planting material, except that he shall not sell such seed or planting material under a brand name or which does not conform to the minimum limit of

germination, physical purity, genetic purity prescribed under clause (a) or clause (b) of section 6.

(2) The Central Government may, by notification, and subject to conditions, if any, as it may specify therein, exempt from all or any of the provisions of this Act or the rules made thereunder, any educational, scientific or research or extension organization.

Miscellaneous

44. Protection of action taken in good faith

No suit, prosecution or other legal proceeding shall lie against the Government or any person for anything which is in good faith done or intended to be done under this Act.

45. Power to remove difficulties

(1) If any difficulty arises in giving effect to the provisions of this Act, the Central Government may, by order published in the Official Gazette, make such provisions not inconsistent with the provisions of this Act as may appear to be necessary for removing the difficulty:

Provided that no order shall be made under this section after the expiry of two years from the date of commencement of this Act.

(2) Every order made under sub-section (1) shall be laid before each House of Parliament.

46. Power of Central Government to make rules

(1) The Central Government may by notification, make rules to carry out the provisions of this Act.

(2) In particular and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely:-

(a) the terms and conditions of service of members of the Committee under sub-section (7) of section 4;

(b) the matters to be specified under clause (f) of section 5;

(c) the functions of the registration sub-committee under sub-section (1) of section 7;

(d) the manner of scrutinizing applications under clause (a) of sub-section (2) of section 7;

(e) the specifications which shall be maintained in the National Register of Seeds of kinds or varieties under sub-section (1) of section 12;

(f) the manner of registration of seed of any kind or variety under sub-section (1) and (3) of section 13;

(g) the period for which multi-locational trials shall be conducted under sub-section (2) of section 13;

(h) the form of application and the particulars which should be furnished in such application under sub-section (1) of section 14;

(i) the eligibility requirement which an organization shall fulfil for accreditation under section 19;

(j) the specification required to be fulfilled for registration as a producer or seed producing unit under sub-section (3) of section 21;

(k) the form and manner in which an application for registration under sub-section (3) of section 21 shall be made and the fee with which such application shall be accompanied under sub-section (5) of said section 21;

(l) the form in which a certificate for maintaining a seed producing or seed processing unit may be granted under sub-section (5) of section 21;

(m) the form in which and time within which periodic returns shall be filled under sub-section (6) of section 21;

(n) the information which an application for dealership in seeds shall be furnished under sub-section (2) of section 22;

(o) the form and manner in which an application for registration as seed dealer under sub-section (1) of section 22 shall be made and the fee which shall accompany such application under sub-section (3) of that section;

(p) the form in which a certificate of registration as a dealer in seeds shall be granted under sub-section (4) of section 22;

(q) the information and return which a registered dealer shall furnish to the State Government under sub-section (5) of section 22;

(r) the form in which an application for registration of a horticulture nursery shall be made, the particulars which such application shall contain and fee which shall accompany such application under sub-section (2) of section 23;

(s) the information on production, stocks, sales and prices of planting material in a nursery shall be furnished to the State Government under section 24;

(t) the requirement which a person carrying on business of selling, etc. of any registered kind or variety of seeds shall comply with under clause (e) of section 25;

(u) the criteria to be fulfilled under clause (a) and the manner of carrying out self-certification under clause (b) of sub-section (1) of section 27;

(v) the inspection and control of the Committee, the concerned State Government and the State Seeds Certification Agency for accrediting individuals and seed producing organizations under sub-section (2) of section 27;

(w) the form of application and the particulars to be furnished in such application and the fee which shall accompany such application under sub-section (2) of section 28;

(x) the form in which and the conditions subject to which a certificate shall be granted under sub-section (3) of section 28;

(y) the form and manner in which an appeal shall be preferred and the fee which such appeal shall accompany under sub-section (3) of section 31;

(z) the manner in which a Central Seed Testing Laboratory established or declared under sub-section (1) of section 32 shall carry out its functions;

(za) the manner of carrying out analysis of seeds shall be made under sub-section (2) of section 32;

(zb) the qualifications which a person to be appointed as Seed Analysts shall possess under sub-section (1) of section 33;

(zc) the qualifications which a person to be appointed as Seed Inspector shall possess under sub-section (1) of section 34;

(zc) the form and manner in which the memorandum shall be prepared under sub-section (3) of section 35;

(zd) the grounds on which the Central Government may restrict export of seeds under section 37;

(ze) any other matter which is to be or may be prescribed.

47. Power of Committee to make regulations

(1) The Committee may, with the previous approval of the Central Government, by notification, make regulations not inconsistent with the provisions of this Act and the rules made thereunder, to provide for all matters for which provision is necessary or expedient for the purpose of giving effect to the provisions of this Act.

(2) In particular and without prejudice to the generality of the foregoing power, such regulations may provide for all or any of the following matters, namely:-

(a) the procedure for conduct of business to be transacted by the Committee or any Sub-Committee thereof under section 8;

(b) the procedure in regard to transaction of business at meetings of the Committee (including the quorum at meetings)under sub-section (1) of section 10.

48. Rules and regulations to be laid before parliament

Every rule and every regulation made under this Act shall be laid as soon as may be after it is made, before each House of Parliament, while it is in session, for a total period of thirty days which may be comprised in one session or in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid, both Houses agree in making any modification in the rule or regulation or both Houses agree that the rule or regulation should not be made, the rule or regulation shall, thereafter, have effect only in such modified form or be of no effect, as the case may be; so, however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that rule or regulation.

49. Repeal and savings

On the commencement of this Act, the Seeds Act, 1966 shall stand repealed;

Provided that such repeal shall not affect,-

(a) the previous operation of the law so repealed or anything duly done or suffered thereunder; or

(b) any right, privilege, obligation or liability acquired, accrued or incurred under the law so repealed; or

(c) any penalty, forfeiture or punishment incurred in respect of any offence committed against the Act so repealed; or

(d) any investigation, proceeding, legal proceeding or remedy in respect of any such right, privilege, obligation, liability, penalty, forfeiture or punishment as aforesaid; and any such investigation, proceedings, legal proceeding or remedy may be instituted, continued or enforced; any such penalty forfeiture or punishment may be imposed as if this Act had not been passed:

Provided further that, subject to the first proviso and any saving provisions made elsewhere in this Act anything done, any action taken, any rule made, any notifications or orders issued under the provisions of the Act so repealed shall, in so far as they are not

inconsistent with the provisions of this Act, be deemed to have been done, taken, made or issued under the corresponding provisions of this Act, and shall continue to be in force accordingly, unless and until expressly or implied repealed by any thing done, action taken, rules made or, notification or orders issued under this Act.

(2) Notwithstanding such repeals any kind or variety of seeds that has been notified under the law as so repealed shall be deemed to have been registered under this Act, and any seed certification agency established under section 18 of the Seeds Act, 1966 shall be deemed to have been established or recognized, as the case may be, under this Act.

Geographical zones

- ✓ ZONE-I: Andhra Pradesh, Karnakata, Kerala, Lakshadweep , Pondicherry and Tamil Nadu.
- ✓ ZONE-II: Andaman and Nicobar Islands , Bihar , Chhatisgarh, Jharkhand, Madhya Pradesh, Orissa And West Bengal .
- ✓ ZONE-III: Arunachal Pradesh , Assam , Manipur, Meghalaya, Mizoram, Nagaland , Sikkim And Tripura.
- ✓ ZONE-IV: Dadra And Nagar Haveli, Daman And Diu , Goa , Gujarat , Rajasthan And Maharashtra .
- ✓ ZONE-V: Chandigarh, Haryana, Himachal Pradesh, Jammu And Kashmir, National Capital Territory Of Delhi, Punjab, Uttranchal And Uttar Pradesh.

Economics of Quality Seed Production- A Case Study

Agriculture and Indian economy

- Agriculture accounts 13.9 % of national GDP
- Provide livelihood for > 60% population
- Source of food: Food grains production was 252.56 mt during 2011-12.
- Agriculture sector supplies raw material to industrial sector
    - Agro-produce processing units (rice, oil mills)
    - Agro-produce manufacturing units (bakeries, sugar factory)
    - Agro-input manufacturing units (fertilizer, pesticide, seed)
    - Agro-service centres
- It has bigger role in capital formation
- Agriculture accounts for 11% in total India's exports and is net exporter of agricultural commodities

Importance of seed

Seed is an important contributor to the targeted four per cent growth in Indian agriculture. Seed is the basic and most critical input for sustainable agriculture and a steady availability of quality seed is necessary for targeted growth in agricultural sector. The response of all other inputs depends on quality of seeds to a large extent. It is estimated that the direct contribution of quality seed alone to the total production is about 20 per cent depending upon the crop and management of other inputs. A strong positive correlation exists between Seed Replacement Rate (SRR) and productivity, elucidating the importance of regularly replacing seed with new quality seed[1]. Estimated commercial world seed market is around 45 billion USD and Indian seed market is around 2 billion USD. Indian seed market is the 5th largest market in the world[2]. The availability of certified / quality seed in India reached to the level of 330.41 lakh quintals[3]. Through the supply of quality seed, Indian seed programme could play an important role in sustained agricultural production. The private seed companies are mostly concentrating on production of varieties/ hybrids in high value-low volume crops and garnering maximum share in the domestic seed market. The public sector produces and distributes high quality seeds of high volume- low value crops for the resource poor farmers.

Why quality seed

- Seed alone contributes around 20 per cent in total production
- Varietal purity
- Higher productivity, absence of other crop seeds and certain diseases
- It is scientifically processed, treated, packed and labelled with proper lot identity

[1] Government of India (2008) National Seed Plan
[2] International Seed Federation, 2012
[3] Agricultural Statistics at a Glance, 2011

- Seed is tested for planting qualities viz. germination, purity admixture of weed seed and other crop seeds, seed health and seed moisture content

Economics of quality seed production

Cost and return analysis of grain and seed production of paddy has been presented in Table 1 (case study in UP). The total cost of cultivation per hectare of paddy grain and seed production estimated to be Rs. 44000.00 and Rs. 51000.00 respectively. The gross return per hectare in production of paddy grain and seed estimated Rs. 60000.00 and Rs. 88000.00 respectively. The net profit per hectare in production of paddy grain and seed was Rs. 16000.00 and Rs. 37000.00 respectively. The BC ratio for grain and seed production of paddy worked out to 1.36 and 1.73 respectively.

Cost and return in production of Paddy (Rs. pr ha.)

Particulars	Grain production (Rs.)	Seed production (Rs.)
Variable cost	28000	35000
Fixed cost	16000	16000
Total cost	44000	51000
Gross return	60000	88000
Net profit on variable cost	32000	53000
Net profit on total cost	16000	37000
BC ratio	1.36	1.73

Cost and return analysis of grain and seed production of wheat has been presented in Table 2. The total cost of cultivation per hectare of wheat grain and seed production estimated to be Rs. 39000.00 and Rs. 45000.00 respectively. The gross return per hectare in production of wheat grain and seed estimated as Rs. 54000.00 and Rs. 77000.00 respectively. The net profit per hectare in production of wheat grain and seed was Rs. 15000.00 and Rs. 32000.00 respectively. The BC ratio for grain and seed production of paddy worked out to 1.38 and 1.71 respectively.

Cost and return in production of Wheat (Rs. per ha.)

Particulars	Grain production (Rs.)	Seed production (Rs.)
Variable cost	23000	29000
Fixed cost	16000	16000
Total cost	39000	45000
Gross return	54000	77000
Net profit on variable cost	31000	48000
Net profit on total cost	15000	32000
BC ratio	1.38	1.71

Economics of hybrid seed production in vegetables

There has been increasing trend in the adoption of hybrid seed technology in vegetables like tomato (40%), cabbage (68.6%), brinjal (82%) and Okra (10%) during the past two decades. This technology, though capital and labour intensive, has increased the profitability of farmers through enhanced productivity. The commercial seed production in vegetables undertaken in India not only meets much of the requirement of domestic demand but also fetches foreign exchange for the country and thus adds substantially to the economic development of the farm families.

Sudha *et al.* 2006 in her study in Karnataka reported that the total cost of cultivation per hectare of tomato and okra hybrid seed production estimated to be Rs. 49775.00 and Rs. 38548.00 respectively. The gross return per hectare in production of tomato and okra seed

estimated Rs. 138118.00 and Rs. 77995.00 respectively. The net profit per hectare in production of tomato and okra seed was Rs. 88343.00 and Rs. 39447.00 respectively. The BC ratio for tomato and okra seed production worked out to 2.77 and 2.02 respectively.

Cost and return in hybrid seed production of Tomato and Okra (Rs. per ha.)

Particulars	Tomato (Rs.)	Okra (Rs.)
Variable cost	48566.00	37474.00
Fixed cost	1209.00	1074.00
Total cost	49775.00	38548.00
Gross return	138118.00	77995.00
Net profit on variable cost	89552.00	40521.00
Net profit on total cost	88343.00	39447.00
BC ratio	2.77	2.02

Seed pricing

Seed pricing policies in public sector

The objective in Government seed pricing is as follows:

- To induce farmers to use certified seed of improved varieties in order to increase national agricultural production.
- To provide adequate incentives to seed producers to supply seed in sufficient quantity to meet demand.
- To encourage the development of private distribution channels
- To implement government agro-economic policies.

The breeder seed pricing of field crops is uniform across the country. This is one of the unique systems of seed pricing in the developed countries. The sale rates of breeder seed is being decided every year in Annual Breeder Seed Review meeting of ICAR under the chairmanship of DDG (crop science) in consultation with SAUs and Project Co-ordinator of crops. The basis of breeder seed price is 50 per cent higher than the price of foundation seed of NSC. The basis of foundation seed is 25 per cent higher than certified seed. There will be five per cent increment every year in the sale price of breeder seed due to inflation. The prices of foundation seed are being decided by the MoA for NSC and SFCI on the basis of proposals received from these two organisations. There is variation in pricing with respect to different states in both the organizations. These rates are generally decided on the basis of local procurement price and minimum support price declared by GoI.

The pricing policies of certified seed in different states are highly variable. However, prices of seed decided under the chairmanship of APC/ Agricultural Secretary of each state. The basic criterion followed is more or less same in all the states. In general, grain procurement price of Krishi Upaj Mandi is being taken from the prominent production areas as the base price and then additional overhead charges added to decide the procurement price from the farmers.

Seed pricing policies in private sector

Policy is often decided by top level management, prices of seed decided by taking opinions of sales team, production and finance. Various components of cost submitted by finance department to the management with a recommendation as to what should be the price. The pricing policy rarely delegated to the lower level management. Only suggestions and some ideas will be delegated to lower level management. The lowest selling price of a product in any market should at least cover the prime cost (prime cost means direct wages,

direct material and direct expenses) and variable overheads. The corresponding fixed overhead may or may not be recovered if it is not practicable to do so. Such fixed overhead may be recovered in more favourable market.

Availability of quality seed at an affordable price is essential for increase in agricultural production. Quality seed production requires about 30 per cent more labour than the grain production. The labour intensiveness of quality seed production has created employment opportunities in rural areas. Since the benefit cost ratio of quality seed production in paddy and wheat came to 1.73 and 1.71, similarly benefit cost ratio for tomato and okra hybrid seed production came to 2.77 and 2.02 respectively, it can be considered as an economically viable option. Quality seed production provides higher income and employment generation which help farmers to reinvest into the agriculture, thereby enabling better living and health conditions to the family and attaining better status in the society.

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