Seed Quality Control System - Indian Perspective

Agriculture is a way of life in India for nearly seventy per cent of the population and it is the backbone of Indian economy, accounting for approximately 15.7 % of the National Gross Domestic product (GDP). India ranks second only to USA in sheer size of agriculture arable area (140 million ha). By virtue of its large arable land area, sizeable irrigated area, rich agro-biodiversity, diverse agro climate and well-developed research system, the country has all the potential to emerge as a global power in agriculture. The impressive growth registered in agricultural production in general and food grains in particular during the last 50 years have made the country self-sufficient in food grain production. However, India will be home to 1.8 billion populations by 2050, requiring about 430 million tonnes of food grain to feed as per present consumption level (www.nih.ernet.in/water/htm). This will pose a big challenge to our Scientists and Planners in the context of population growth and climate change. India has one of the biggest and strong public sector Agricultural Research Systems with ICAR Institutes, State Agricultural Universities and large number of agricultural extension stations and Krishi Vigyana Kendra's (KVKs') spread across the country to develop and deliver the best agricultural solutions to the farmers' needs.

In the significant advances that India made in agriculture in the last five decades, the role of the Seed Industry has been substantial. It is well established fact that the success of green revolution in India was a combination of high yielding varieties of seed and improved fertilizer usage. Globally this is an exciting time to be in agriculture, particularly in the Seed Industry as seed being the foundation of successful agriculture, the demand for quality seeds of improved varieties is growing fast and adoption of new technologies around the world by the farmers is happening at an amazing pace. Therefore, production and supply of high quality seeds of improved varieties to the tiller of the land is a high priority in agricultural growth and development.

Indian Seed Programme

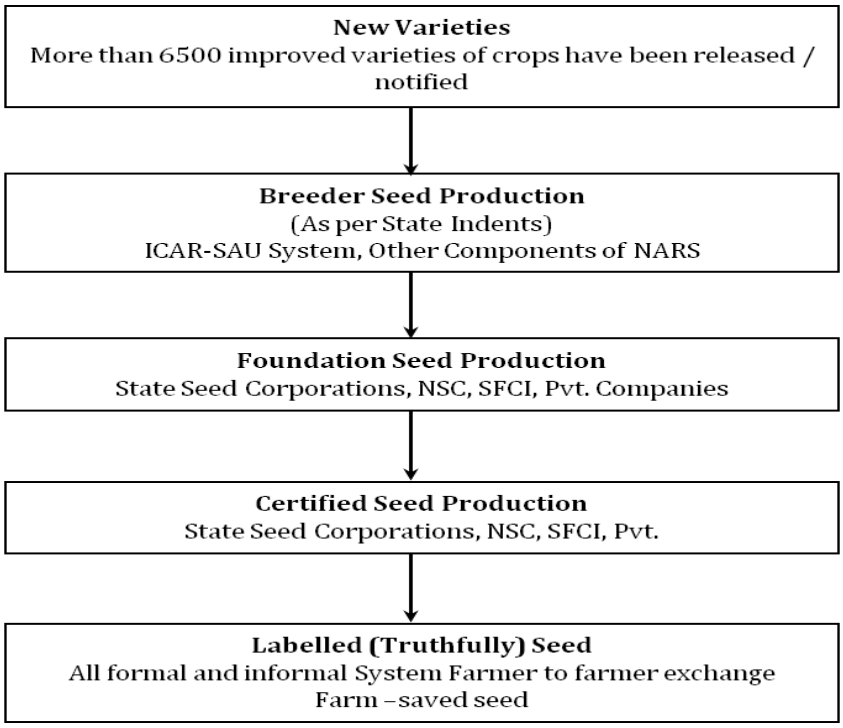
Among all inputs in agriculture seed is the critical, vital and most important input. India has made significant advance in agriculture in the last four decades, in which role of the seed sector has been substantial. The Indian Seed Industry is currently valued about Rs. 6,500 crores ($ 1475 Million) and approximately 321 lakh quintals of seeds in volume. There are about 150 - 200 organized seed companies existing in India today. Several companies have recognized Research and Development Units by Government of India and have developed a large number of varieties and hybrids in several crops.

The Indian seed programme is one of the biggest seed markets in the world, with annual sales at around US $920 million. Of this, domestic off take accounts for US $900 million and sales in the global market accounts for the remaining US $ 20 billion. The New Policy on Seed Development (NPSD), established in 1988 with the objective of augmenting productivity and output quality, stimulated major growth in the Industry as it attracted a lot of investment in seed business from major domestic seed companies.

The present Seed Replacement Rate (SRR) is around 15-20 % for various crops. This SRR level has to be increased to 35 % in self pollinated crops, 50 % in cross pollinated crops and 100 % for hybrid crops, in order to increase sustainable agriculture production and productivity for achieving the food, nutritional and social security. Making quality seeds available is going to be one of the most important challenges before us. India has sizeable public and private sector seed businesses. Giant public sector players include the National Seeds Corporation (NSC), the State Farms Corporation of India (SFCI) and State Seeds Corporations (SSCs). NSC was the first public sector organization, established in 1963. The Central Government is playing major role by extending support to several State Government programmes in seed sectors through Seed Village scheme, capacity building, quality control and extension activities in seeds for creation of Infrastructure and strengthening seed production and marketing of varieties and hybrids of various kinds of seeds.

Seed Production System in India

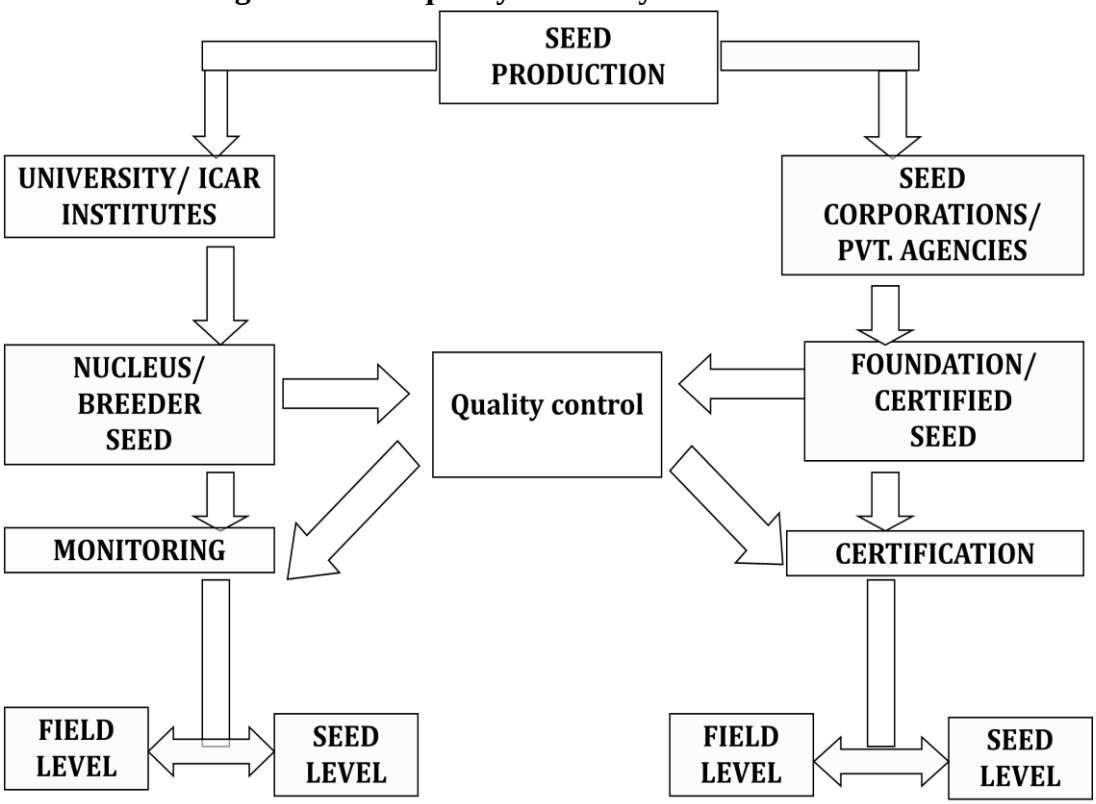
Seed planning generally adheres to the limited seed generation system in multiplication chain in a phased manner. Generally the system recognized 3-4 generations comprising breeder, foundation & certified seeds.



Seed quality control

Quality control is an important component of the seed programme. A seed programme without the provision of regulating the seed quality control measures may affect badly. There are two aspects of quality control. Firstly the genetic purity of the seed maintained during the production and marketing. Secondly it should have adequate qualities like high Germination and Physical purity, free from weed seeds, disease and have optimum moisture content.

Fig. 1: Schematic Diagram of seed quality control system in India



Seed Regulation: Seed laws aim to promote varietal and seed quality, thereby 'protecting' farmers from planting sub-standard seed. At the same time, they set the rules of the market for different seed suppliers thus intending to create a 'level play ground'. Seed laws therefore establish the institutional framework of national seed councils and certification agencies and regulate the procedures and standards for:

- **Variety release systems** aim to make only those varieties of proven value available to farmers through the formal seed system.
- **Seed certification** aims to control the varietal identity and purity throughout the seed chain.
- **Seed quality control** checks on other seed characteristics such as viability, purity and seed health. Seed quality control also aims at protecting *bona fide* seed producers from competition by less scrupulous colleagues.

From a legal point of view, seeds are regulated from at least three different perspectives. Firstly, the quality of seeds is regulated to ensure that seeds purchased conform to the characteristics that have been prescribed. Secondly, the safety of seeds is regulated through bio safety measures to ensure that new or imported seeds do not create unwanted environmental harm. Thirdly, in recent years, the intellectual property protection regime has rapidly expanded to include new seeds or new micro-organisms inserted in seeds as products which can be protected under different types of Intellectual Property Rights. The regulation of seeds has been and remains of tremendous importance because of the direct implications that it has on the majority of the population engaged in agriculture as well as on the fulfilment of basic food needs.

The Indian government regulates the Seed Industry and the Seed Trade in various aspects. At present, Indian Seed Industry is governed by Seeds Act (1966), Seed Rules (1968), Seeds Control Order (1983) under Essential Commodities Act-1955, Package Commodities Act (1986), Standards Weights And Measures Act (1976), Consumer Protection Act (1986), The Environment Protection Act (1986), Export Regulation and Quarantine- Plants, Fruits and Seeds (Regulation of import into India) Order (1989), The Destructive Insects and Pests Act (1914), State Acts for the control / movement of crops and seeds (1976), Protection of Plant Varieties and Farmers' Rights Act (2001), Biological Diversity Act (2002), Plant Quarantine Order (2003), Proposed New Seeds Bill (2004), Patents (Third Amendment)Act (2005) and Agricultural Produce Marketing Law (Amendment, 2009).

Policy initiatives in Seed Sector

The important policy initiatives taken by the GOI in seed sector are Seed Review Team (1968), National Commission on Agriculture's Seed group (1972), National Seeds Programme (1974-75), Creation of the Technology Mission on oil seeds and pulses (TMOP-1986) now called as ISOPOM (Integrated scheme of oil seeds, pulses, oil palm and maize), Production and Distribution subsidy, Distribution of Seed Mini-Kits, Seed Transport Subsidy Scheme (1987), New Policy on Seed Development (1988), Seed Bank Scheme (2000), National Seed Policy (2002), Seed Import And Export Policy (EXIM policy, 2002/2007), Formulation of National Seed Plan (2005), National Food Security Mission (2007), and Rashtriya Krishi Vikas Yojana (2007).

Mechanism of enforcement

It is the responsibility of the government to enforce the measures for controlling the quality of the seed being marked in the country. This can be achieved through legislation in the form of an Act. Government of India enacted the seeds Act in 1966. It is basically regulatory in nature and mainly ensures that seeds of notified varieties offered for sale conform to certain minimum limits of germination and purity. There are two systems in seed quality control and one of which is seed certification and the other is labelling which is compulsory under the seeds Act.

The salient features of the Seed Act 1966 are:

- Regulating the quality of certain seeds for sale and matters connected therewith.
- Constitution of central Seed committee to advise the Central & State governments on the matters arising out of administration of the Act and to carry out the other functions assigned to it under this Act.
- Establishment of Central & State Seed Testing laboratory.
- Establishment Seed Certification Board, Agency and other Committees.
- Investigation and prosecution of the offences under the Act and Rules.
- Implementation of the Act is the joint responsibility of the Central & State Governments.

To impose certain penalties for the offences committed under the Act

Proper implementation of the Seed Act is necessary for maintaining quality and production, distribution, supply, trade and commerce of seeds.

Seed Rules, 1968

The Seed Rules are framed in the year 1968 giving wider scope for understanding various provisions of the Seeds Act 1966. The functions of the Central Seed Testing Laboratory, Seed Certification Agency are elaborately dealt with labelling of any notified kind of variety of seed is made compulsory. It provides certain requirements to be complied with the person carrying on the business of selling seed, these rules are dealt with the following issues;

- Categorized the certified in to three distinct classes.
- Certification procedures are dealt in detail.
- Qualification of seed Analysts and his duties are specified
- Qualification of seed inspectors and his duties are widely defined.
- Procedures for dealing with a written complaint lodged to the seed inspector are laid down.
- Seed sampling procedures are dealt in detail.
- Maintenance of various records and issuing of memorandum in form – VII by Seed inspector to the dealer.

Seed Control Order, 1983

The Seed Control Order 1983 is promulgated under Essential Commodities Act of 1955 mainly with a view to evolve a mechanism for registration of seed dealers, get regular flow of information of seed production and sales and to ensure supply all over the country.

- ❖ This order provides for drawing of samples of seed including truthful labelled seeds.
- ❖ It envisages the obligations on the part of the dealer to obtain incense (clause-3)
- ❖ Display stock board and price list (clause-8)
- ❖ Give memorandum of cash or credit to the purchaser (clause-9)
- ❖ Maintain records and submission of reports (clause-18)
- ❖ Ensure suitable distribution of seeds (clause-10).

It empowers the State Governments to:

- Call for any information from the dealer (clause-13)
- Cancel the license in case of any violations (clause-15)
- Give directions for regulations of marketing of seed (clause-10)
- To enter upon and search any premises where any seed is stored or exhibited for safe.

- To make samples, seize/confiscate/details seeds stock to ensure compliance.
- Take criminal action against the dealers who contravene the provisions.
- Under this order samples drawn should confirm to the standard of quality claimed on the label.
- It discourages the activities of unscrupulous dealer.

Seed Certification

Government of India established Certification Agencies for the states under Section 8 of the Seeds Act 1966 and registered under the Societies Act, 1886. At the national level, Central Seed Certification Board h established (1972) under Section-8(a) of Seeds Act, primarily to render advisory services on scientific and operational to the Central Government and State Seed Certification Agencies (SSCA'S). The SSCA'S so established in India discharge their duties as per Section-9 and 10 of Seeds Act. The Section-9 refers to grant or issuance of certificate, Section-10 refers to revocation or withdrawal of certificate issued, based on breach of trust or non - accomplishment of procedure prescribed. The purpose of seed certification is to maintain and make available to public through certification of high quality seeds and propagating materials of notified kind/ variety so grown and distributed, as to ensure genetic identity and purity. Seed certification is also designed to achieve prescribed field and seed standards as per Indian Minimum Seed Certification Standards (Revised in 2013). So far 22 seed certification agencies have been established in India, out of which 17 are independent / autonomous and five are under Department of Agriculture. In India three classes of seeds are being followed viz., Breeder seed, Foundation and Certified seed, out of which only Foundation and Certified seed classes are under the purview of Certification Agency. The seed subjected to certification is labeled. Thus, all certified seed must be labeled, but all labeled seed is not necessarily certified. Agency after confirming all the prescribed field and seed standards issue white and Azure blue (ISI 104) colour tags foundation and certified seed class respectively. While, Truthfully Labelled Seed should carry Opal green colour tag.

Certification shall be completed in six broad phases:

- Receipt and scrutiny of application
- Verification of seed source
- Field inspections to verify conformity to the prescribed field standards.
- Supervision of post harvest stages including processing and packing
- Analysis of seed samples including genetic purity & seed health test.
- Grant of certificate and certification tags, tagging and sealing

Refusal of Certification

The Agency shall have the authority to refuse certification of any seed production field or any seed that does conform to the minimum standards prescribed for that particular crop either for field or for seed or for both.

Validity Period of the Certificate

The validity period of the seed lot will be nine months from the date of test at the time of initial certification. The validity period may be further extended for six months (amendment for 3 months as per notification in 2016) provided the seed conforms to the prescribed standards on retesting. A seed will be eligible for extension of the validity period as long as it conforms to the prescribed standards.

Appeal

As per Seeds Act, 1966 there is a provision under Section-11, to make an appeal to an Appellate Authority by aggrieved persons (seed producers and grower), if they are not satisfied with the decision of Certification Agency.

Seed Certification Standards

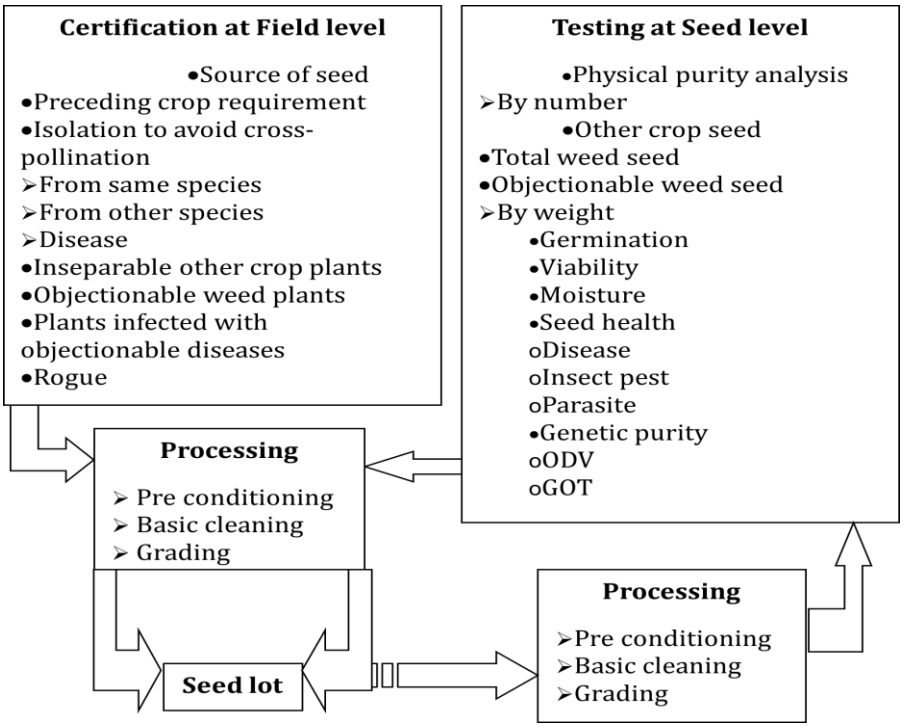
In India seed certification standards were originally developed by the Central Seed Committee in collaboration with National Seeds Corporation Limited, in the form of Minimum Seed Certification Standards, 1971, which contains General Seed Certification Standards applicable to all the crops and Specific Seed Certification Standards applicable to 56 crops, and since then standards have been amended from time to time. In the year 1988, Indian Minimum Seed Certification Standards were updated which contain Specific Seed Certification Standards for 102 crops and in the year 2013, Specific Seed Certification Standards for 199 crops have been published.

The statutory bodies to consider and suggest Certification Standards are:

1. Central sub-committee on crop standards, notification and release of varieties.
2. Central Seed Committee
3. Central Seed Certification Board
4. State Seed Sub-committees

These bodies are constituted for a specific period and are represented by all interests with the seed programme at central / state government level so also private seed enterprises and farmers' representatives.

Fig 2: Steps of Seed Certification / Seed Quality Testing



Enforcement Authority:

1. Licensing authority: the state government may be notification in the official gazette appoints such number of persons as it thinks necessary to licensing authority and may also define in the notification the area within which each licensing authority shall exercise his jurisdiction.

Application for license: **E**very person desiring to obtain a license for selling, exporting & importing of seeds shall make an application in duplicate in Form-A together with a fee of Rs.50/- to the licensing authority.

Grant of license: Licensing authority may after making detailed enquiry as it thinks fit grant a license in Form-B, the terms and conditions are enumerated in **Form-B (I to V)**

The Validity of license: Every license under this order shall unless previously suspended or cancelled remain valid for three years from the date of its issue.

Renewal of License: Every holder of license desiring to renew the license shall before the date of expire of the license make an application for duplicate to the licensing authority in Form-C together with Rs.20/- fee. If any application is not made before expiry but it is made within one month from the date of the license by paying additional fee of Rs.25/-.

2. Appointment of seed Inspectors: The State Government may by notification in the official Gazette appoint such number of persons as it thinks necessary to be inspectors and such notification depend the local area within which each such inspector shall exercise is jurisdiction.

Qualification of Seed Inspector: Seed inspector should be a graduate in Agriculture and one year experience in seed production or analysis or development.

Duties of the seed Inspector: The seep inspector has to perform all the duties as contemplated under Rule 23 & 23A he shall

a. Inspect all places used for growing storage or sale of any seed of notified kind/variety.
b. Satisfy himself that that conditions of the certificates are being observed.
c. Drawing of seed samples which he has suspected or being produced stocked or sold or exhibited for sale in contravention of the provisions of the act.
d. Investigate any compliant made to him in writing.
e. Maintain records of all inspection made and action taken by him in the performance of his duties including the taking of samples and seizure of stock and submit copies of such records. To the director of Agriculture or the seeds certification Agency
f. He shall detain Imported containers which he has reason to suspect
g. Institute prosecution in respect of breaches of act and rules.
h. Performs other duties entrusted by state Govt.

Duties of Seed certification Inspector

- Verification of seed source.
- Conducting field inspections
- Supervision of seeds processing
- Drawing of seed samples
- Supervision of bagging & tagging.
- Grant of certificate.
- Other duties entrusted by certification Agency.

3. Seed Analyst: the State Govt. can appoint the seed analyst. Rule 20 makes it mandatory that the person shall be eligible for appointment as seed analyst, only if he/she posses master to equivalent degree in Agriculture or Agronomy or Botany or Horticulture of a recognized University and one year experience in Seed Technology.

Duties of Seed Analyst:

- On receipt of seed samples for analysis he shall ascertain that the mark and the seal are intact.
- The seed analyst shall analyze the seed samples as per the procedures drawn in the seed testing manual.
- Seed Analyst deliver in form-VII a copy a report of the result of analysis within 30 days from the date of receipt of Samples sent by Seed Inspector.

- Seed Analyst shall forward to the State Govt. The reports giving the results of analytical work done by him.

3. (a) Appellate Authority for hearing appeals against State Seed Certification Agencies

Decisions:

In exercise of the power conferred under Sub Section (1) of Section 11 of the Act the State Govt. Appoints the Appellate Authority to entertain or render decisions on the appeals field by the person, refusal, suspension and revocation of certification agency under section 13 & 14 in the matters of grants, refusal, suspension and revocation of certificate.

Time limit for entertaining appeal: Sub-Section-1 contemplates that the appeal should be preferred within 30 days from the date on which decision in communicated to him. However the Appellate Authority may entertain an appeal after the expiry of said period if it is sufficient that the appellant was prevented by sufficient cause shown for not filing the appeal in time. Every memorandum of appeal shall be written accompanied by a copy of decision given and treasury receipt of Rs.100/-

(b) Appellate Authority for hearing cases against refusal/cancellation of seed license

Any person aggrieved by an order:

a. Refusing to grant, amend or renew the license for sale, export or import of seeds.

b. Suspending or cancelling any license, may within 60 days from the date of order, appeal to such authority as the State Govt. May specify on this behalf and the decision of such authority shall be final.

Provided that an application for appeal shall accompany an appeal fee of Rs. 50/-

Dealers to comply with Seeds Act & Rules:

- The holder of license shall from time to time report to the licensing authority any change in his business premises.
- Every dealer of seeds shall display in his place of business.
- Opening and closing stocks on daily basis.
- Price list of different seeds.
- Every dealer shall maintain books, accounts and records relating to his business.
- Dealer shall submit monthly return in his business in form – C to the licensing authority by 5th day of every month.
- No dealer shall sell such seed of notified variety which is false or misleading in any particular concerned in the seed contained in the container.
- Dealer should sell such seed is identifiable of kind/variety.
- Seed conforms to the minimum limits of germination and purity.

- The dealer shall not alter, obliterate or deface any mark or label attached to the container.
- Dealer should not sell or supply after the expiry date of seed stock.
- Dealer should maintain all records of seed sold for a period of three years.
- No dealer should prevent a seed inspector from taking sample any other power conferred on him.
- The dealer shall give every facility to the licensing authority for the purpose of inspection is stock in shop/godown/storage etc.
- The dealer shall display the license at the prominent and conspicuous place in his business premises open to public.

2. Legal Measure:

I. Penalties Under Section 19 of the Seeds Act 1966 if any Person

a. Contravenes any provision of this Act or any rule made under of

b. Prevents seed inspector from taking samples under this Act.

c. Prevents a Seed inspector from exercising any other power conferred on him but or under this Act shall on conviction be punishable.

1. For the first offence with fine which may extend to Rs.500/-
2. In the event of such person having been convicted of an offence under section with imprisonment for a term of six months or with fine to Rs. 1000/- or with both.

II. Penalties under Seed Control order 1983 (Under essential Commodities act 1955)

1. If any person contravenes any order made under section-3

- He shall be punishable
- In case of an order made to clause (h) or (i) of sub-section-(2) with imprisonment for a term which may extend to one year and shall also be liable fine.
- In case of any other of imprisonment shall not be less than three months but may extend up to seven years and liable to fine.
- Any property shall be forfeited to the Government.

2. If any person fails to comply with the direction he shall be punishable with imprisonment which shall not be less than three months but may extend up to seven years liable to fine.

3. If any person convicted under the sub clause – ii of sub-section-I or under Sub-section-2 is again convicted of any offence under the same provision he shall be

punishable with imprisonment which shall not be less than six months but may extend up to seven years and liable to fine.

4. Where a person having been convicted of an offence under sub-section-I is again convicted of an offence under the sub-section for contravention of an order in respect of an essential commodity, in addition to penalty the court may impose that such person shall not carry on any business in that essential commodity for such period as may be specified by court in the order.

Present Problems in seed law enforcement and future needs

- The existing seed laws in India are being implemented to ensure quality of seed to farmers. However, the degree of success varies from state to state. There are many issues that are considered as impediments for effective implementation of the seed laws. The most important bottle necks are discussed below.
- Presently the country does not have a single and comprehensive act/rule in place to regulate the development and release of crop verities and their subsequent seed multiplication, processing, marketing and quality check etc, we have several seed laws and associated laws which are either overlapping or inadequate, in other words, not focusing exclusively on seed quality assurance. Hence, there is an urgent need for evolving / enactment of a comprehensive law. There is need for convergence of existing laws which have relevance to seed development, production, distribution/marketing and including import/export.
- Even with the existing laws, implementation has been the biggest causality due to the inherent systems failure / institutional failure. It calls for a review and revision in the seeds standards, seed testing procedures, creation of enforcement authorities and other related laws.
- The quality regulation of vegetatively propagated crop verities has not received the same attention that has been now given to field crop seeds. It is needless to mention that this needs to be focused in terms of an enactment of suitable laws with appropriated enforcement mechanism.
- Though seed certification is voluntary, there is need to evolve a mechanism adequately supported by law to facilitate certification of all the notified varieties / popular or ruling varieties of both public and private sector.
- The emergence of vibrant private seed industry in the Country through is necessary, has thrown up new challenges in several areas including quality regulation. Hence, the issues relating to public-private partnership, development and release of private varieties and quality related subjects need to be reviewed and revised. There should be a level playing ground provided for both public and private sectors, so much so that farmers interest and national priorities of food security are not jeopardized.
- Establishment of separate enforcement authority/wing in each state for the effective enforcement of existing seed laws / future enactments or comprehensive laws would

go a long way in ensuring the availability of quality seeds to the farming community in the country.

- The existing penal provisions do not deter the habitual offenders of law/fly by night operators. Hence, there is an urgent need for enhancing the penalties for contravention of any seed laws / related laws.

New Seeds Bill, 2004:

The Seeds Bill, 2004 is generally proposed as a replacement for the existing Seeds Act, 1966. The rationale for a new Act can be traced back to the relatively rapid changes that have been taking place in the Seed Sector in the past couple of decades with the adoption of the Plant Variety Act, Biodiversity Act and amendments to the Patents Act which also contributes to following Intellectual Property Protection, participation of MNC's in a big way and the progressive introduction of transgenic seeds.

The stated objective of the proposed law is to "regulate the seed market and ensure seeds of quality". With the proposed changes, the Seed Law would be harmonized with other Seed Laws around the world and ensure the Indian seed market is open to big business. India's New Seeds Bill constituted in 1998, a Seed Policy Review Group in India recommended a long awaited shakeup and reform of the Indian Seed Laws; a new seed law would need to be passed for amalgamating and overcoming the deficiencies in the existing Seeds Act of 1966.

The salient features of the bill are;

1. Making Registration of varieties obligatory.
2. Creation of a National Register of seeds.
3. Regulating (make easier) the imports and exports of the seeds.
4. New regulation on GM crops.
5. Improving the market conditions for private seeds companies.
6. Compensation to farmers.
7. Registration of seed producers, seed processing units, horticultural nurseries.
8. Evaluation of performance of varieties.
9. Accreditation of Seed Certification Agencies.
10. More penalties on offences.
11. Individuals or Seed Producing Organizations to carry out Self Certification.
12. Declaring any Seed Testing Laboratory even under Non-Government sector as a State Seed Testing Laboratory to carry out seed quality analysis.

Table 1. Comparison between Seeds Act 1966 Vs Seeds Bill 2004

Particulars	Seeds Act 1966	Seeds Bill 2004
Coverage	Agriculture & Horticulture	Agriculture, horticulture, forestry, plantation crops, medicinal and

		aromatic plants
Registration of transgenic varieties	No provision	Special provision
Registration with PVPFR authority	Not required	Required
Period of protection	Not defined	Defined
Penalty for violation of act	Rs. 100-1000/- / six months imprisonment	Rs. 5000-5,00000/-one year rigorous imprisonment
Self certification	Not permitted	Permitted
Representatives in central seed committee	From all states	From five states only
Involvement of private seed sector	No	Yes

The genesis of the Indian legislation on Plant Variety Protection (PVP):

In India, agricultural research including the development of new plant varieties has largely been the concern of the government and public sector institutions. Earlier, India did not have any legislation to protect the plant varieties and, in fact, no immediate need was felt. However, after India became signatory to the Trade Related Aspects of Intellectual Property Rights Agreement (TRIPs) in 1994, such a legislation was necessitated. Article 27.3 (b) of this agreement requires the member countries to provide for protection of plant varieties either by a patent or by an effective s*ui generis* system or by any combination thereof. Thus, the member countries had the choice to frame legislations suiting their own system and India exercised this option. The existing Indian Patent Act, 1970 excluded agriculture and horticultural methods of production from patentability. The *sui generis* system for protection of plant varieties was developed by the Indian Government in 2001 by enacting "The Protection of Plant Varieties and Farmers' Rights Act" in the Parliament, integrating the rights of breeders, farmers and village communities, and taking care of the concerns for equitable sharing of benefits. It offers flexibility with regard to protected genera/species, level and period of protection, when compared to other similar legislations existing or being formulated in different countries. The Act covers all categories of plants, except micro-organisms. Further, the GOI passed the Biological Diversity Act in 2002 for protection of biological materials from exploitation. According to this Act, if foreign countries want to utilize our material either for research or trade, they should obtain prior permission from National Biological Diversity Authority of India. The Authority has the head quarters at Chennai, Tamil Nadu. Farmers and community rights are embodied in this Act and give protection to natural materials, but did not deal with the sovereign rights of breeders on their varieties.

Objectives of the PPVFR Act:

(i) To provide for the establishment of an effective system for protection of plant varieties.

(ii) To provide for the rights of farmers and plant breeders.

(iii) To stimulate investment for research and development and to facilitate growth of the seed industry.

(iv) To ensure availability of high quality seeds and planting materials of improved varieties to farmers.

This Act has 11 chapters and is divided in 97 clauses. The first chapter has title, and the definitions used in context of the Act. The last chapter is on miscellaneous clauses. The other nine chapters deals with PPVFR authority, registration of plant varieties, duration and effect of registration and benefit sharing, surrender and revocation of certificate, farmer's rights, compulsory license, plant varieties protection appellate tribunal, finance, accounts, audit, infringement, offences and penalties, etc.

Salient features of the PPVFR Act:

Authority

The Central Government shall establish an Authority to be known as the Protection of Plant Varieties and Farmers' Rights Authority (Established in 2005 with head quarter at New Delhi). It consists of a chairperson and fifteen members as representatives of different concerned ministries and departments, seed industry, farmers organizations, tribal communities and State-leve1 women's organization, etc.

Eligibility

For a variety to be eligible for registration, it must conform to the criteria of novelty, distinctiveness, uniformity and stability (NDUS), as described below [Section 15 (l)-(3)].

For the purposes of the Act, a new variety shall be deemed to be:

(a) *Novel*, if, at the date of filing of the application for registration for protection, the propagating or harvested material of such a variety has not been sold or otherwise disposed of by or with the consent of its breeder or his successor for the purposes of exploitation of such variety (i) in India, earlier than one year.(ii) or outside India, in the case of trees or vines earlier than six years, or, in any other case, earlier than four years, before the date of filing such applications, provided that a trial of a new variety which has not been sold or otherwise disposed off shall not affect the right to protection.

(b) *Distinct*, if it is clearly distinguishable by at least one essential characteristic from any other variety whose existence is a matter of common knowledge in any country at the time of filing of the application.

(c) *Uniform*, if subject to the variation that may be expected from the particular features of its propagation, it is sufficiently uniform in its essential characteristics.

(d) *Stable*, if it's essential characteristics remain unchanged after repeated propagation or, in the case of a particular cycle of propagation, at the end of each such cycle. The variety will be subjected to such distinctiveness, uniformity and stability tests as shall be prescribed.

Period of protection

The certificate of registration issued under section 24 or sub-section 98 of section 23 shall be valid for nine years in the case of trees and vines and six years in the case of other crops, and may be reviewed and renewed foe the remaining period on payment of such fees as may be fixed by the rules made on this behalf subject to the conditions that the total period of validity shall not exceed

(i) in the case of trees and vines, eighteen years from the date of registration of the variety;

(ii) in the case of extant varieties, fifteen years from the date of the notification of that variety by the Central Government under Section 5 of the Seed Act, 1996. and

(iii) in the other case, fifteen years from the date of registration of the Variety.

Breeders' rights:

The certificate of registration for a variety issued under this Act shall confer an exclusive right on the breeder or his successor or his agent or licensee, to produce, sell, market, distribute, import or export of the variety [Section 28 (I)].

Researchers 'right

The researchers have been provided access to protected varieties for bonafide research purposes [Section 30]. This Section states, 'Nothing contained in this Act shall prevent (a) the use of any variety registered under this Act by any person using such variety for conducting experiments or research; and (b) the use of a variety by any person as an initial source of a variety for the purpose of creating other varieties provided that the authorization of the breeder of a registered variety is required where the repeated use of such Variety as a parental line is necessary for commercial production of such other newly developed variety',

Farmers' rights

The farmers' rights of the Act define the privilege of farmers and their right to protect varieties developed or conserved by them [Chapter VI]. Farmers can save, use, sow, re-sow, exchange, share and sell farm produce of a protected variety except sale under a commercial marketing arrangement (branded seeds) [Section 39 (I) (i)-(iv)]. Further, the farmers have also been provided protection of innocent infringement when, at the time of infringement, a farmer is not aware of the existence of breeder rights {Section 42 (1)]. A farmer who is engaged m the conservation of genetic resources of landraces and wild relatives of economic plants and their improvement through selection and preservation, shall be entitled in the prescribed manner for recognition and reward from the Gene Fund, provided the material so selected and preserved has been used as donor of genes in varieties registrable under the Act. The expected performance of a variety is to be disclosed to the fanners at the time of sale of seed/propagating material. A farmer or a group of farmers or an organization of farmers can claim compensation according to the Act, if a variety or the propagating material fails to give the expected performance under given conditions, as claimed by the breeder of the variety.

Communities rights

The rights of the communities as defined, provide for compensation for the contribution of communities in the evolution of new varieties in qnantums to be determined by the PPVFR Authority [Section 41 (1)].

Registration of essentially derived varieties

The breeder of the essentially derived variety shall have the same rights as the plant breeder of other new varieties, which include production, selling, marketing and distribution, including export and import of the variety. The other eligibility criteria for award of registration are also the same as for new variety registration under the Act [Section 23(1), (6)].

Compulsory license

The authority can grant compulsory license, in case of any complaints about the availability of the seeds of any registered variety to public at a reasonable price. The license can be granted to any person interested to take up such activities after the expiry of a period of three years from the date of issue of certificate of registration to undertake production, distribution and sale of the seed or other propagating material of the variety [Section 47(1)].

Benefit sharing

Sharing of benefits accruing to a breeder from a variety developed from indigenously derived plant genetic resources has also been provided [Section 26(1)]. The authority may invite claims of benefit sharing of any variety registered under the Act, and shall determine the quantum of such award after ascertaining the extent and nature of the benefit claim, after providing an opportunity to be heard, to both the plant breeder and the claimer.

National Gene Fund

The National Gene Fund to be constituted under the Act shall be credited thereto:

(a) The benefit sharing from the breeder.

(b) The annual fee payable to the authority by way of royalties.

(c) By the compensation provided to the communities as defined under Section 41(1).

(d) Contribution from any national and international organization and other sources.

The fund will be applied for disbursing shares to benefit claimers, either individuals or organization, and for compensation to village communities. The fund will also be used for supporting conservation and sustainable use of genetic resources, including in situ and ex situ collection and for strengthening the capabilities of the panchayat in carrying out such conservation and sustainable use [Section (45)]. The Indian PVPFR Act thus appears to be an effective sui generic system providing a balance between plant breeders' rights along with farmers' rights and researchers' rights. The impact of the Indian *sui generis* system will be felt only after its effective implementation, and later in the areas of research and development, and ultimately in the national food and nutritional security.

Status of the total applications received crop wise up to dated 25.10.2013 were 5384 out of which Public varieties -1183, Private varieties- 2618 and Farmers varieties - 1583

International Seed certification and quality control:

OECD Seeds Scheme for Varietal certification or for the control of seed moving in International Trade. Seed Certification goes hand in hand with seed quality control in which the most important seed qualities -- viability, purity and health -- are tested in a laboratory, commonly using internationally harmonised procedures of the Organisation for Economic Cooperation and Development (OECD) or International Seed Testing Association (ISTA).

Back ground Information

- The Organization for Economic Co-operation and Development (OECD) an inter-governmental organization founded in 1961, Secretariat at Paris, France provides a multilateral forum to discuss, develop and reform economic and social policies.
- The OECD's mission is to promote for sustainable economic growth and employment, a rising standard of living and trade liberalization.
- The OECD brings together its member countries to discuss and develop domestic and international policies during its Technical Working Group and Annual Meetings.
- It analyses issues, identifies good policy practices and recommends action in a unique forum in which countries can compare their experiences, seek answers to common problems and work to co-ordinate policies.

OECD Seed Schemes

- The OECD Seed Schemes provide an international framework for the certification of agriculture seed moving in international trade.
- The schemes were established in 1958 driven by a combination of factors including a fast-growing seed trade, regulatory harmonization in Europe, the development of off-season production, the seed breeding and production potential of large exporting countries in America (North and South) and Europe, and the support of private industry. Membership of the Schemes is voluntary and participation varies.

There are seven Agriculture Seed Schemes in OECD viz.,

- Grasses and Legumes
- Cereals
- Crucifers and other oil or fibre species
- Fodder beet and sugar beet
- Subterranean clover and similar species
- Maize and sorghum
- Vegetables

Participating countries

- With the recent inclusion of ***INDIA, MOLDOVA's*** *and* ***Ukraine*** 58 countries from Europe, North and South America, Africa, the Middle-East, Asia and Oceania currently participating in the OECD Seed Schemes.

Objectives

- The objectives of the OECD Schemes for the varietal certification of seed are to encourage the use of "quality-guaranteed" seed in participating countries.
- The Schemes authorize the use of labels and certificates for seed produced and processed for international trade according to agreed principles ensuring identity and purity.
- The Schemes facilitate the import and export of seed, by the removal of technical trade barriers through internationally recognized labels (passports for trade).
- They also lay down guidelines for seed multiplication abroad as well as for the delegation of some control activities to the private sector ("accreditation").
- The quantity of seed certified through the OECD Schemes has grown rapidly in recent years and reached 5, 90,000 tonnes.

How do the Seed Schemes operate?

- The success of international certification depends upon close co-operation between maintainers, seed producers, trades and the designated authority (appointed by the government) in each participating country.
- Frequent meeting allow for a multi-stakeholder dialogue to exchange information, discuss case studies prepare new rule and update the Schemes. The UN family of bodies, a vast range of non-government organizations (UPOV, ISTA) and seed industry networks participate actively in the Schemes.

Benefits of the Schemes

- To facilitate international trade by using globally-recognized OECD labels and certificate.(e.g. they are required to export seeds to Europe).
- To build a framework to develop seed production with counties or companies.
- To participate in the elaboration of international rules for seed certification.
- To develop collaboration between the public and private sectors.
- To benefit from regular exchanges of information with other national certification agencies and observer organizations.

Rules and Directions of OECD Seed Schemes

- Since 1958, the **OECD Seed Schemes** are open to OECD countries as well as other U.N. Members. 58 countries participate. The OECD certification is applied to varieties satisfying Distinction, Uniformity and Stability conditions, having an agronomic value,

and published in official lists. The annual List of Varieties eligible for OECD Certification includes about 42,000 varieties from 194 species.

- The Schemes ensure the **Varietal identity and purity of the seed** through appropriate requirements and controls throughout the cropping, seed processing and labelling operations. Eg: Generation control (Pre-basic, Basic and Certified seed), isolation distances, purity standards, field inspections, lot sampling, post-control plots, compulsory official laboratory analysis for each certified seed lot.
- The OECD certification provides for official recognition of **"quality-guaranteed"** seed, thus facilitating international trade and contributing to the removal of technical trade barriers.

Government of India's Participation in the OECD Seed Schemes

- The Government of India, Ministry of Agriculture submitted a formal application to the Secretary General of the OECD on 21st September 2007, requesting membership of the OECD Seed Schemes. In the application, the Ministry requested to participate in the following seed schemes:
  - Cereal seed.
  - Maize and sorghum seed.
  - Vegetable seed.
  - Grass and legume seed.
  - Crucifer seed and other oil or fibre species seed.
  - Flower plant material

Details of the OECD Annual meeting and India's participation

- The recommendation of the annual meeting for India to join the OECD Seed Schemes (therefore becoming the 56th participating country) was forwarded by the Secretariat to the OECD Committee for Agriculture and the council accepted the India's participation in the OECD Seed Schemes during October, 2008.

- **Kinds of OECD tags / labels are:**
  i. Pre-Basic seed – **white tag with a diagonal violet stripe**
  ii. Basic seed - **White tag**
  iii. Certified 1st Generation - ***Blue Tag***
  iv. Certified 2nd Generation, or subsequent generations **– Red tag**
- Not Finally Certified – **Grey Tag** -This is not to be used with the statement "EC rules and standards".

Table 2. Seed laws in Asian countries at a glance:

Country	Seed Law	What it Does	What it Set Up
India	1966 Seed Act,	Regulates the sale of	Central Seed

	amended in 1972 (New Seed Bill, 2004, still to clear Parliament)	seeds of notified varieties	Committee Central Seed Laboratory and Central Seed Certification Board
Korea	1970 Major Agricultural Seed Law	Requires that seeds of eight crops be sold only with a valid seed sale license	National Seed Council
Indonesia	1997 Presidential Decree on Seed and 1999 Plant Cultivation Act and its 95PlantSeed Management Regulation	Says that farmers' varieties do not fall under the regulation (they are considered 'natural varieties' and as such, are not controlled by the government)	National Seed Board
Thailand	1975 Seed Act revised in 1999	Prescribes seed labelling requirements and minimum allowable germination requirements for 20 species of seed	Plant Committee
Pakistan	1976 Seed Act (Seed Amendment Bill 2000, still to clear Parliament)	Prohibits sale, offer for sale, advertising or holding in stock for sale, bartering, or 'otherwise supplying' seed of notified varieties that is not as per prescribed standards	National Seed Council, Provincial Seed Councils, National Registration Agency and Federal Seed Certification Agency
Bangladesh	1977 Seed Ordinance, followed by Seed Act of 997 and its Seed Rules 998	Requires that the seed dealer be registered and the seed certified prior to sale for five notified varieties	National Seed Board, Government Seed Laboratory and Seed Certification Agency
Nepal	1988 Seeds Act	Restricts the sale and distribution of seeds without conformity to prescribed standards	National Seeds Board
Philippines	1999 Seed	Promotes the	National Seed

	Industry Development Act	development of the seed industry	Industry Council replacing the Philippines Seed Board
Vietnam	1996 Decree on the Management of Plant Seeds	States that seed producers must be licensed	Seed Reserve Fund

Table 3. PVP laws in Asian countries at a glance

Country	UPOV Member	PVP Law	Impacts on Farmers
Thailand	No	1999	Cultivation or propagation from the PVP-protected seed by a farmer may be made not more three times
China	Yes	1999	The use for propagating purposes by farmers, on their own holdings, of the propagating material of the protected variety harvested on their own holdings shall not require authorization from or payment of royalties to the variety rights holder. Uses other than those mentioned above will require
Indonesia	No	2000	Allows farmers to use the protected variety as long as not for commercial purposes.
Pakistan	No	2000 Ordinance	Nothing shall affect a farmer's traditional right to save, use, exchange, share or sell his farm produce of a protected variety, except where a sale is for the purpose of reproduction under a branded marketing arrangement
Pakistan	No	Draft PVP law 2009	A farmer shall be deemed to be entitled to save, use, sow, re-sow, exchange, share or sell his farm produce provided that the farmer shall not be entitled to sell seed of a variety protected under this Act on a commercial basis.
India	No	00	Farmers can save, use, exchange, share and sell their produce of the protected variety with the restriction that they cannot sell branded seed of the protected variety for commercial purposes.
Korea	Yes	00	The Minister of Agriculture and Forestry may restrict the breeder's rights to a variety, if a farmer collects the seeds of the variety for himself for the purpose of self-production.

Philippines	No	00	The traditional right of small farmers to save, use, exchange, share or sell their farm produce of a variety protected under this Act, is maintained except when a sale is for the purpose of reproduction under a commercial marketing
Malaysia	Yes	004	Small farmers can only use seeds of a protected variety on their own field and exchange with small farmers only in 'reasonable amount'. The sale of farm-saved seeds is allowed only in situations where a small farmer cannot make use of the farm-saved seeds on his own holding due to natural disaster or emergency or any other factor beyond the control of the small farmer, and if the amount sold is not more than what is required in her/his own field.

Seed Formation, Structure and Importance

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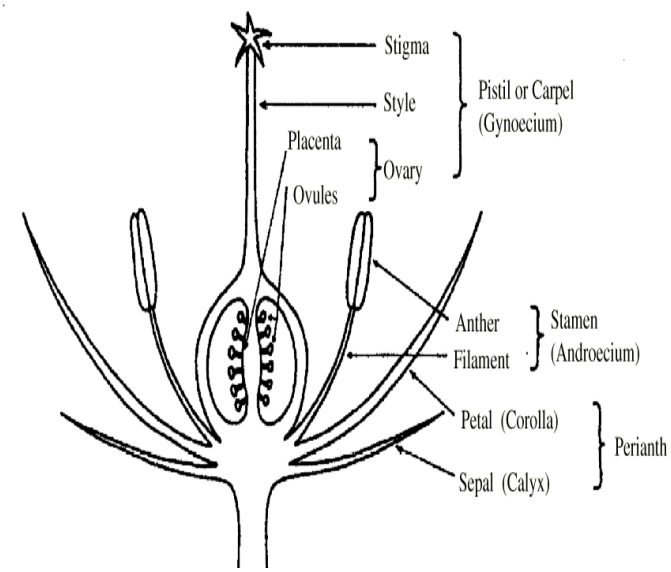
Botanically, seed is a ripened ovule containing an embryo in arrested state of development, usually with food reserve and a protective coats. In seed technological term, the part of the plant use for sowing purpose to raise the crop is considered as seed.

Floral structure:

Flower is a reproductive organ bearing pistil, stamen and usually sepals and petals. Male part of a flower is androecium consisting of anther sac, anthers and pollen grains. Female part is gynoecium consisting of ovary, style and stigma.

The flower is said to be perfect, when they contain both male and female parts. A flower with both functional male and female is called as bisexual or hermaphrodite. Sometimes male or female mature slightly at different times. This nature is called dichogamy which favours cross pollination. If male matures first it is called as protandry, if female – protogyny.



Imperfect flowers have either male (staminate flower) or female (pistillate flower) part. Such flowers are called as unisexual flowers. When both type of flowers occur in same plant – monoecious, if they occur in different plants – dioceious.

Seeds usually developed from the fertilized flower for which pollination (transfer of pollen from anthers to stigma) is pre requisite. For successful fertilization viable pollen and receptive stigma are two pre requisites.

Seed formation: It consists of four stages

1. Gametogenesis
2. Pollination
3. Fertilization
4. Development of seed

1. Gametogenesis

Formation of male and female gametes with haploid chromosome number for fertilization is known as gametogenesis. Gamete formation takes place separately in male (anther) and female (ovule) part of the flower. It involves two steps i.e., sporogenesis followed by gametogenesis in both male and female reproductive parts.

Sporogenesis: It is the formation of spore in reproductive part i.e., spores of male (microsporogenesis) and female (megasporogenesis).

Gametogenesis: It is the formation of gamete in reproductive part i.e., gamete of male (microgametogenesis) and of female (megagametogenesis).

Formation of male gamete

It has two steps microsporogenesis and microgametogenesis. Androecium (stamen) is the male part of the flower with anther and filament as its parts. Anther is a four chambered structure placed on a filament. Each chamber is known as pollen sac (microsporangia).

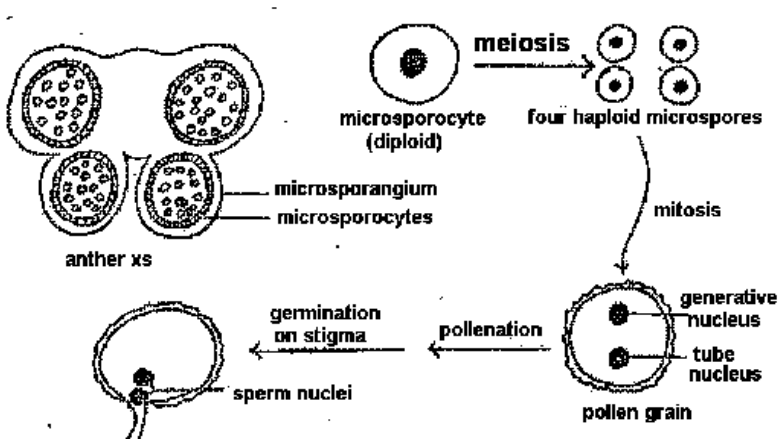
Microsporogenesis: In the pollen sac, pollen grains are formed. Inner most of layer of pollen sac is known as Tapetum that provides nutrients for development of pollen mother cells (2n) in each pollen sac. The diploid pollen mother cell undergoes meiosis (reduction) cell division, first to form dyad and then four haploid cells (tetrad). Each one is known as microspore.

Microgametogenesis: Haploid nucleus of microspore forms two haploid nuclei by mitotic (equational) cell division. Out of two haploid nuclei only one nucleus again divides by mitotic cell division and forms two haploid nuclei. Second nucleus remains as such (no further division). In this way total three haploid nuclei. Each one is known as micro gamete.

Pollen grain is a double walled structure, with hard outer cover (exine) and thin inner layer (intine). 3-5 germpores are present on the exine of the pollen grain. After pollination, pollen grain germinates on the stigma and forms a germ tube which protrudes out from any one germ pore. Through germ tube, all the three male gametes enter in the female reproductive part. The gamete present at the tip of the pollen tube is known as tube nucleus, whereas the remaining two are known as generative nuclei or sperm cells. Tube nucleus is responsible for growth and direction of pollen tube whereas generative cells take part in fertilization.

Genetic constitution of each microspore formed in a pollen sac differs from the other because of meiosis cell division that involves crossing over and recombination. Bu all the three micro-gametes are of same genetic constitution due to mitotic cell division.

Male sporangia



Formation of Female gamete:

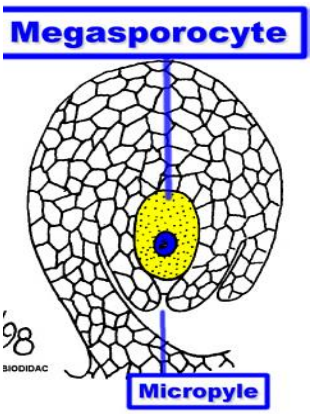
Gynoecium (pistil) is the female part of the flower with stigma, style and ovary as its parts. Ovary contains ovule (megasporangium) with embryosac surrounded by two layers of integuments. In the embryosac, female gametes are formed by the megasporogenesis and megagametogenesis in the nucellus.

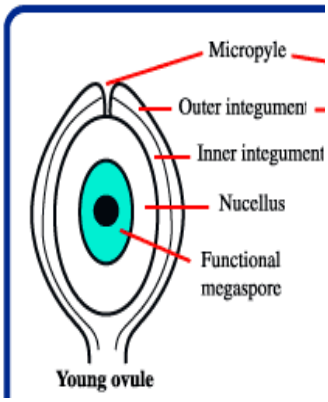
Megasporogenesis: A diploid nucellus cell differentiates into sporogenous cell towards micropylar end with nutrients from other nucellus tissues. It works as Megaspore mother cell. Megaspore mother cell undergoes meiosis (reduction) cell division to form four haploid cells. Each haploid cell is considered as Megaspore. Out of four megaspores, three are degenerated and only one remains functional.

Megagametogenesis: The functional megaspore develops into female gametophyte by three mitotic (equational) cell divisions. By first mitotic cell division two, by second four and by third eight haploid nuclei are formed. These eight archisporium haploid cells are arranged in three- two-three fashion in the embryosac, all surrounded by nucellus. Three towards chalaza end are termed as Antipodal, two at the centre as the Polar nuclei whereas out of three arranged at the micropylar end, the one present in the middle termed as egg cell and remaining two as synergids. The nucellus is the central portion of the ovule inside the integuments. It consists of diploid maternal tissue and has the function of megasporangium.

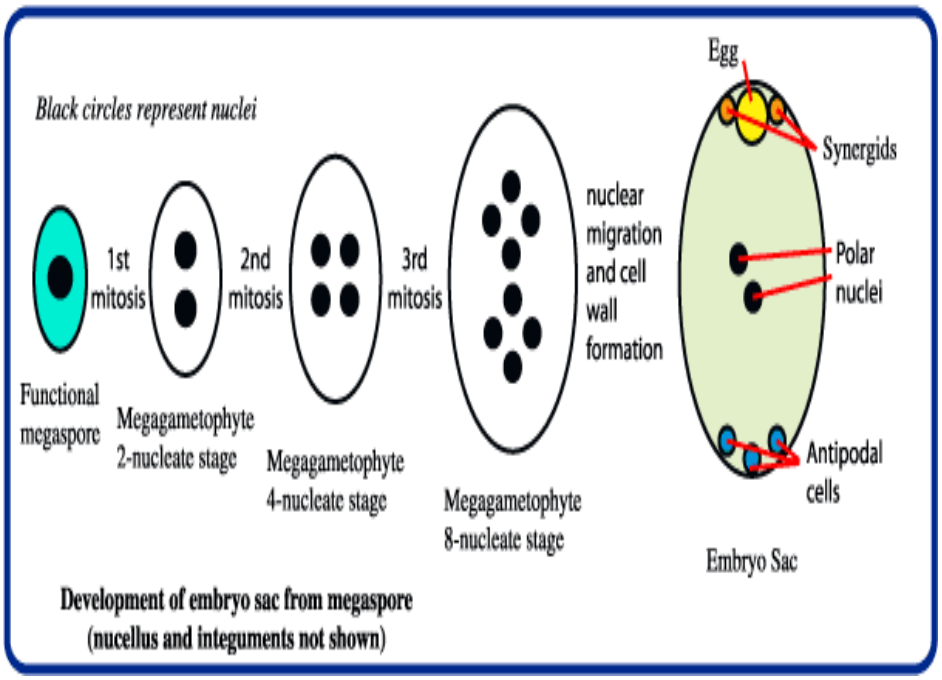
All the eight megagamets have same genetic constitution as they all originate from one spore by mitotic cell division.

Haploid cells found by meiosis are considered as spore. All the four spores formed by one mega mother cell have different genetic constitution. Gametes are found by mitotic cell division in micro or mega spore i.e., of haploid chromosome number. All the gametes formed by one spore have same genetic constitution.

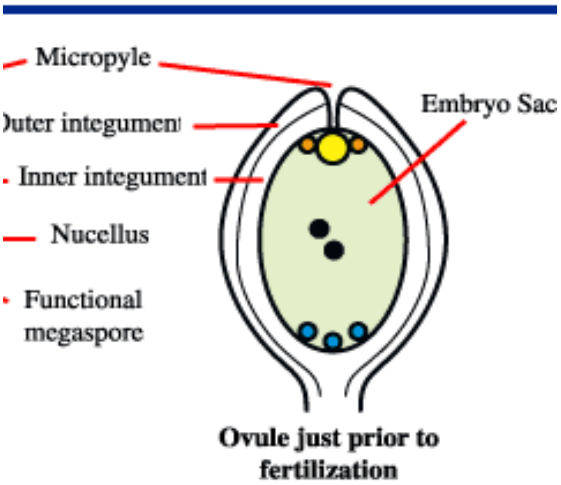




Angiosperm Ovule/Seed Development



Development of embryo sac from megaspore (nucellus and integuments not shown)



Ovule just prior to fertilization

2. Pollination

The mature anthers dehisce and release pollen -grains. When pollen grains are transferred from an anther to the stigma of the same flower the process is called self-pollination or autogamy. If they are transferred to the stigma of another flower, cross-pollination or allogamy is said to have occurred. Pollen is able to reach on stigma by various means viz., force of anther bursting, air, insect etc. Stigma become receptive for reception of pollen by releasing many enzymes that help in germination of pollen.

Pollen germinates on stigma and forms a pollen tube which comes out through any one germpore. The pollen tube enters in the stigma and travels through style up to ovule. The tube nucleus present at the tip of the germ tube directs the tube towards ovule. Whereas the generative cell present behind the tube nucleus undergoes mitotic cell division and forms two haploid generative nuclei.

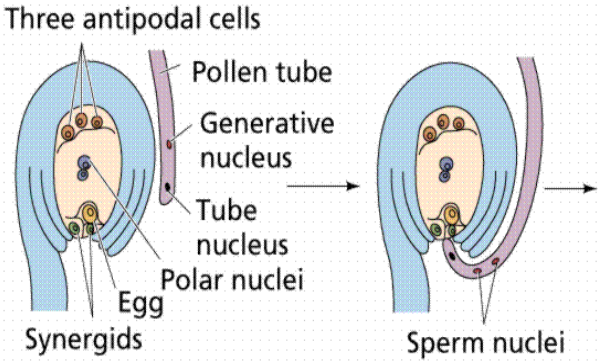
Self-pollination occurs in those plants where bisexual flowers achieve anther dehiscence and stigma receptivity simultaneously. The majority of angiosperms bear chasmogamous flowers i.e., flowers do not open before pollination. In some plants, flowers do not open at all such flowers is called cleistogamous, and this is the most efficient floral adaptation for promoting self-pollination.

Cross-pollination is ensured in plants which bear unisexual flowers. In bisexual flowers also self-pollination may be prevented by self-sterility, dichogamy (maturation of male and female organs at different times), herkogamy (where the structure of male and female sex organs proves a barrier to self pollination) and heterostyly (where flowers are of different types depending on the length of the style and stigma and pollination occurs only between 2 dissimilar types).

The important self-pollinated crops are wheat, rice, barely, mungbean and cowpea and cross pollinated are maize, rye, forage legumes and vegetables like carrot, cauliflower and onion. There is yet another category of crops called often cross pollinated crops such as cotton and pigeon pea where there may be 10-40 % cross pollination.

3. Fertilization

After landing on the stigma, the pollen grain germinates and pollen tube grows through the style. After traversing the style, the pollen tube enters embryosac of the ovule through micropyle. The embryosac consists of 7 cells. The end near the micropyle has the egg apparatus, which consists of egg cell and 2 synergids. There are 2 polar nuclei in the centre and the chalazal end has 3 antipodal cells. In angiosperms, fertilization involves the participation of 2 male nuclei. One fuses with the egg nucleus to form the diploid zygote and the other with 2 polar nuclei to produce a triploid nucleus, which is the primary endosperm nucleus. This process is called double fertilization.



Apomixis

Development of seed without fertilization. When the seed formation occurs without sexual fusion, the process is known as Apomixis. This occurs by several mechanism, however, all apomitic seed have genetic material only from the female plant. Apomixis may or may not require pollination and pollen tube germination to initiate seed formation, however sexual union never occurs.

Parthenocarpy: Development of fruit without fertilization.

Seed Development

After fertilization, development of fertilized ovule into a mature seed involves several different stages. Seed formation begins within the minute embryo sac with certain expectations, which is about the same in shape, size, and arrangement. In spite of initial similarities, the seed develops according to the genetic specification for each species, which are coded in the nucleus (chromosomes) of each cell.

After fertilization, seed develops through following physiological stages.

a). Histo-differentiation: Formation of embryo from egg cell and endosperm from polar nuclei after fertilization are considered as histo-differentiation.

b). Cell expansion: After formation of embryo and endosperm, the photosynthates are transferred in simple form (sucrose and glucose) from mother plant (source) and stored in complex form i.e., carbohydrate, lipid and protein in the cells of storage (sink) organs i.e., cotyledon or endosperm. It results in expansion of cell size.

c). Dehydration: After completion of photosynthate transfer, the seed reaches at physiological maturity which is defined as no active connection of seed with mother plant. From physiological maturity, dehydration starts as physical process in the seed and its completion is considered as physical maturity.

i) The integument of the ovule becomes the seed coat of the mature seed.

ii) Normally the nucellus is absorbed and is absent. The nucellus may persists in some genera such as Nutmeg, Clove, Rubber, Papaya, Pepper, Beet root, etc. as a thin layer called Perisperm, lying inside the seed coat and supplies food material to the embryo.

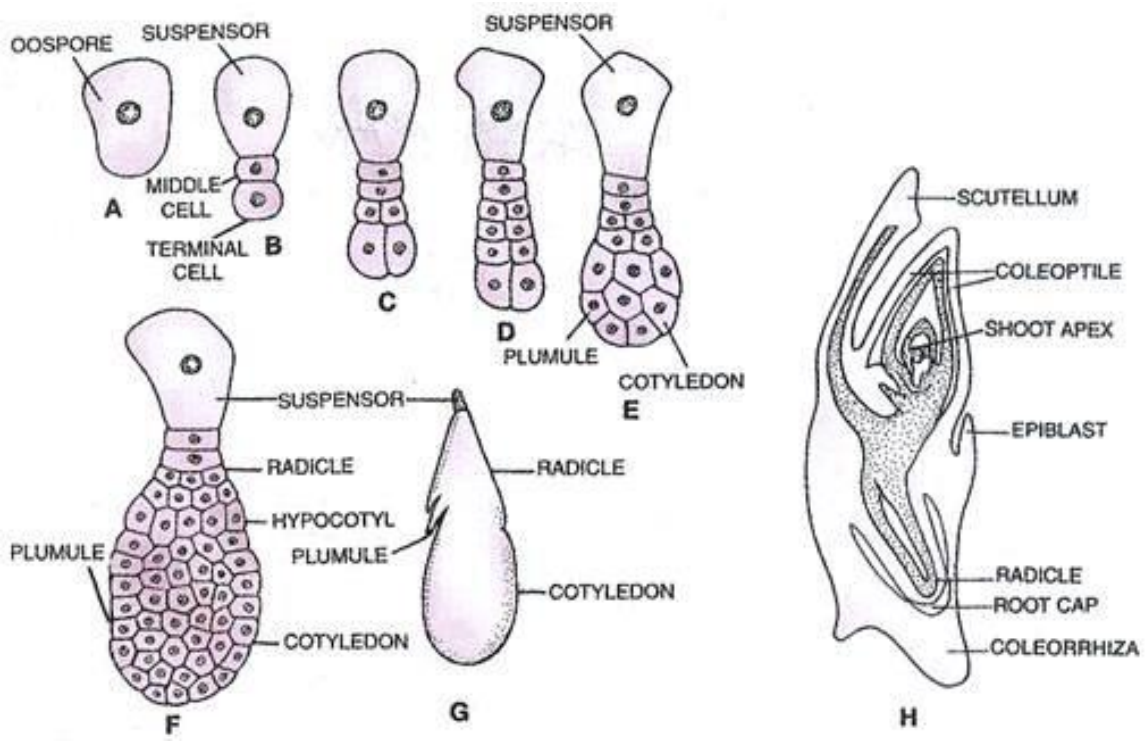
iii) The Endosperm serves as a principal nutritive support for the embryo of many species (especially monocotyledons) during both seed development and germination. The endosperm normally grows more rapidly than embryo.

- ❖ In Monocotyledons, endosperm usually reach the maximum morphological development at physical maturity and persists to comprise a major part of the seed.
- ❖ In Dicotyledonous spp., the endosperm may not develop or may be used up by the developing embryo and comprise none or a small part of mature seed.

iv) Embryo: The first few cell division from the zygote forms the Pro-embryo. Although the mature embryo of monocotyledons and dicotyledons appears considerably different, their pattern of embryogeny are similar. The Pro-embryo is divided into Suspensor and Embryo proper. The suspensor forms into a chain of cells, pushing the embryo proper into the center of the ovule thus making it in contact with the available food supply. The pro-embryo may vary greatly in size and shape.

Development of a monocot seed

The formation of monocot embryo consists of three stages i.e., proembryo, globular and scutellar.



The fertilized egg cell (n+n) undergoes mitotic cell division to form a structure of two diploid cells via transverse section known as proembryo. The upper cell is known as apical (distal or axial), while lower one as basal cell.

The basal cell of the pro-embryo forms the structure known as suspensor, but the structure is not well developed in monocots.

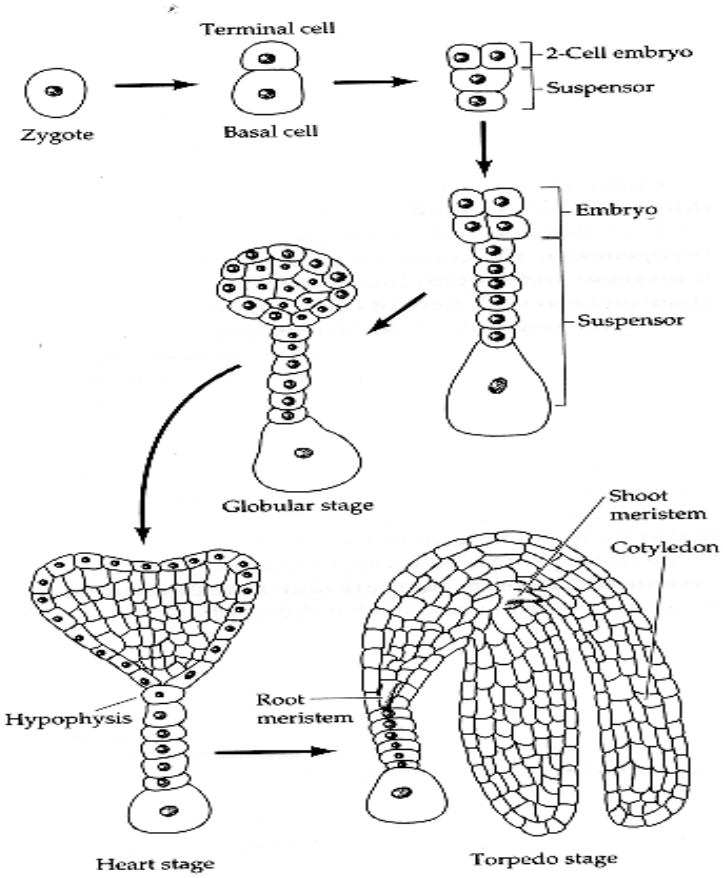
The apical cell divides mitotically and forms a globular structure of 16 diploid cells. At globular stage, one side of the globular structure divides more rapidly than the other cells and forms embryonic axis. Whereas, other cells form the single cotyledon known as scutellum. The stage is known as scutellar stage.

In the seed, scutellum is formed in between endosperm and embryonic axis. It is formed by the diploid apical cell of proembryo, therefore its chromosomal constitution is same as of embryo. The embryonic axis differentiates into plumule (shoot) and radicle (root) with covering of specialized tissues coleoptile on plumule and coleorhiza on radicle.

The initial triploid endosperm cell undergoes several mitotic cell divisions prior to cell wall formation. The photosynthates are transferred from source via transfer cells to store predominantly as a complex form (starch) in triploid cells of endosperm (sink). The structure of funicle is not well developed and functional in monocot seed. With the accumulation of food material, the size of cell gets enlarged. Many enzymes and hormones are stored in scutellum.

Development of a dicot seed

The development of monocot and dicot seed is similar upto globular stage. In dicot, the basal cell of proembryo develops into a suspensor that pushes the globular structure deep into the embryosac cavity and absorbs and transfers the food material for storage in globular cells.



Formation of cotyledon in the globular structure starts with a depression at the tip (heart shaped stage). Elongation of cotyledon by deepening of depression starts at torpedo stage. At cotyledonary stage radical and hypocotyls are well defined with rudimentary suspensor. Removal of one cotyledon shows presence of plumule in between both the cotyledons.

The food material is absorbed by the suspensor from the surrounding tissue and transferred to the cotyledons. In dicot seeds, the food material is predominantly stored in the form of protein and/ or lipids. To transfer the photosynthate, a vascular strand runs from mother plant through funicle upto one part of seed coat. From the seed coat it is diffused in the nucellus tissues and then absorbed by suspensor. It shows that mother plant is not directly connected with the developing seed.

At physiological maturity, the bridge present in the form of funicle between ovule and ovary is broken down with a scar on the seed coat known as hilum. The rapid water loss from the seed starts as physical process upto physiological maturity.

Seed ripening: After transfer of photosynthates (food material) from source (leaves) to sink (seed), abscission layer is formed at the base of the ovule at the connection of ovule with ovary i.e., funicle. It shows that now seed with new plant (embryo) has no relation with the mother plant. Formation of abscission layer cut down the supply of water and photosynthates. Seed starts conversion of food material in complex structure and minimize metabolic activities to remain viable for longer period of time (upto favorable conditions of germination). To achieve both the objectives, the best option is to minimize presence of water by physical process. The colour of the seed before ripening is usually green due to presence of active chlorophyll. With the gradual loss of moisture, the colour of the testa changes generally to yellow- brown- black or variegated according to crop.

Seed structure and histology

Seed Coat: Integument's of the ovule undergo marked reorganization and histological changes during maturation to form seed coats. It is a protective coat of diploid maternal tissue made up of two layers testa (outer thick layer) and tegmen (inner thin membrane). The seed coat is present as an envelope to protect the embryo and endosperm from desiccation, mechanical injury, effect of environmental fluctuations and damage due to insects and microorganisms.

The seed coat bears a scar called hilum, marking the point at which seed is attached to stalk. The funicle or the stalk forms a ridge called raphe along the margin of the seed. At one end of the hilum, there is a small hole called micropyle. There is an outgrowth below the hilum in leguminous seeds, which is called strophiole. Certain other seeds (castorbean, nutmeg) have outgrowths called arils. Arillar contents may important in attracting animals, which aid in seed dispersal.

Embryo: It is a rudimentary plant made up of an axis bearing one or more cotyledons. Embryo is present in axis form with one tip known as plumule responsible to form shoot portion and the other axis known as radicle (embryonic root) to form the root. The portion of embryonic axis extended above the cotyledon is known as epicotyls and below the cotyledon

as hypocotyl. The shape of the embryo and their position within the seed are variable between species. In the monocot species that have a substantial endosperm (endospermic seeds), the embryo occupies proportionately less of the seed.

Embryo of monocot seed is a small structure which lies at one end of the seed. Organs of the monocot embryo are coleoptile (shoot sheath), the plumule, the radicle and coleorhizae (root sheath). The coleoptile is the leaf sheath of the cotyledon that protects the plumule during field emergence. The coleorhiza is a protecting cover on radicle to protect radicle during germination. The portion in between plumue and radicle is mesocotyl. It is responsible for growth of embryo during germination in monocot seeds.

Store of food

Endosperm: It is a thick and massive structure made up of elongated cells containing abundant starch present in the mature seed and serves as food storage organ. Cells are triploid (3n), result of double fertilization. Two out of three genomes are of maternal origin. Testa and endosperm are the two covering layers of the embryo.

Seeds are categorized as endospermic or non-endospermic in relation to the presence or absence of a well developed endosperm within the mature seed. The relatively massive endosperm is the major source of stored seed reserves in cereals. As a rule endosperm lack intercellular space. In cereals, the storage cells of the endosperm are nonliving with replacement of cytoplasmic contents by starch and protein.

(i) Albuminous: It means well developed endosperm is present as store of food. The amount of endosperm in mature seeds is highly species- dependent and varies form an abundant endosperm layer (Nicotiana tabaccum) to a single layer (Arabidopsis thaliana).

(ii) Exalbuminous: Fusion among polar nuclei and sperm cell occurs and 3n endosperm is initially formed but during the process of development, the cotyledons absorb the food reserves from the endosperm. The cotyledons serve as sole food storage organs. The endosperm is almost degraded in the mature seed and the embryo is enclosed by the testa. The endosperm was initially present but now it is not visible therefore the seed is designated as exalbuminous.

On the outside of the endosperm one to few layers of diploid living cells known as aleurone layer are present. Aleurone layer is responsible to synthesize enzymes to convert food material in available form during germination.

Cotyledon: It is the extension of the embryo originates from zygote as embryonic axis with similar genetic constitution. On the basis of number of cotyledons, the crop species are divided into two groups (I) monocotyledonous - presence of one cotyledon (ii) dicotyledonous – two cotyledons are present. In monocot, the scutellum situated in between the endosperm and the embryo is the single cotyledon. The cotyledons of non- endospermic seeds are much bulkier and are storage tissues, and in peas and beans account for over 90 percent of the mass of the seed in comparison to monocot endospermic seeds.

Perisperm: (Part of nucellus that become a storage tissue). Diploid maternal food storage tissue originates from the nucellus. In most of the species, the maternally derived perisperm

fails to develop and is quickly absorbed by the developing embryo. It does present in mature seeds of many Caryophyllales (Centrospermae) including the Amaranthaceae (Beta, Chenopodium) among the eudicots, but also in basal angiosperms like blak pepper (piper nigrum), Piperaceae.

Fruit structures considered as seed

Fruits are mature, ripened ovaries containing seeds. The pericarp (fruit wall) is made up of diploid maternal tissue. Following single seeded fruits are usually considered as seed:

Caryopsis: Single seeded fruit with fused fruit and seed wall e.g. wheat, sorghum, pearl millet etc. The fruit of cereals use for sowing as seed are of following types.

Caryopsis without husk: Maize, pearl millet, sorghum, wheat etc.

Caryopsis with husk: Rice, barley, oat etc.

Husk is not the part of fruit/seed. It is a part of flower present as an attachment i.e., lemma and palea that covers the caryopsis.

Achene: Single seeded indehiscent fruit where pericarp can be removed from the mature seed, e.g., sunflower, safflower etc.

Schizocarp: A dry fruit, which is separated into two or more units at maturity, e.g. coriander, carrot etc.

Nut: Fruit with thick and hard shell like fruit wall, e.g. ground nut.

Examples of different categories of seeds:

	Albuminous	Ex- albuminous
Monocot	Cereals	Onion
Dicot	Castor, Sunflower	Pulses

Seed structure of crops

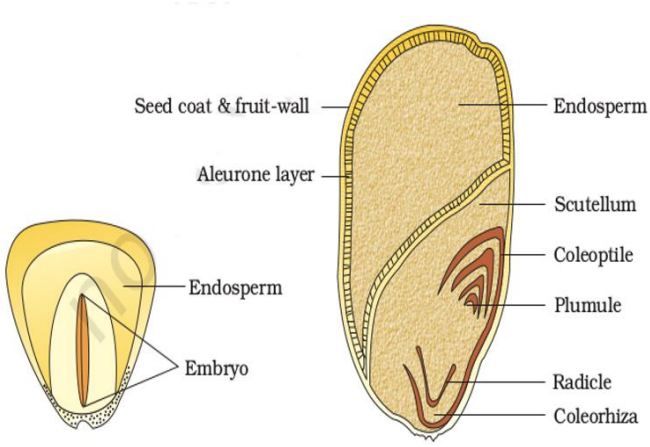
Monocot seeds of crops from family Gramineae

These are single seeded fruits with fused seed coat and fruit wall known as caryopsis. The endosperm of these seeds is made up of non- living starchy endosperm (starch grains, food storage, dead cells, and flour) and the aleurone layer i.e., living cell layer surrounding the starchy endosperm. The epithelium layer separates the embryo and endosperm.

Organs of the cereal embryo are coleoptile (shoot sheath), scutellum (cotyledon), the radicle and coleorhiza (root sheath). A very small embryo made up of shield shaped single cotyledon know as scutellum and a short axis lies in a groove at one end of the endosperm. The coleoptile is the leaf sheath of the cotyledon. During germination, the scutellum absorbs nutrients from the starchy endosperm and makes it available to embryo to form seedling. Coleoptile protects the shoot meristem and plumule during field emergence. The coleorhizae protects radicle during germination. The coleorhiza is the first structure that grows through the pericarp, it is then ruptured by the radicle (the completion of germination).

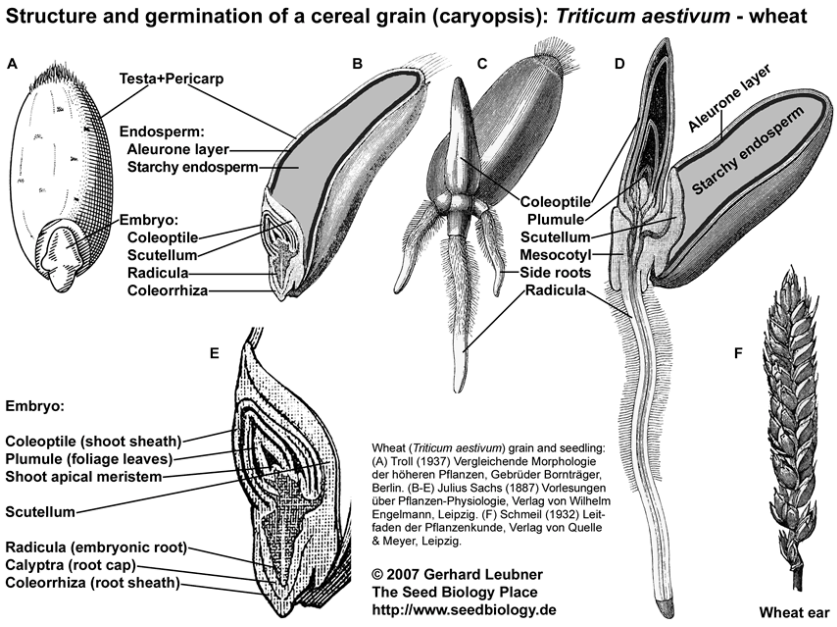
Germination and seedling establishment of cereal grains are hypogeal. After emergence of primary root, the coleoptile is pushed upward by elongation of the mesocotyl.

The coleoptiles elongates and reaches the soil surface then leaves of the plumule emerge through an opening at the tip of the coleoptile. Mobilization of the food storage in the starchy endosperm is a post- germination event and requires an embryo signal (gibberellins), which induces the production and secretion of hydrolytic enzymes from the aleurone layer.

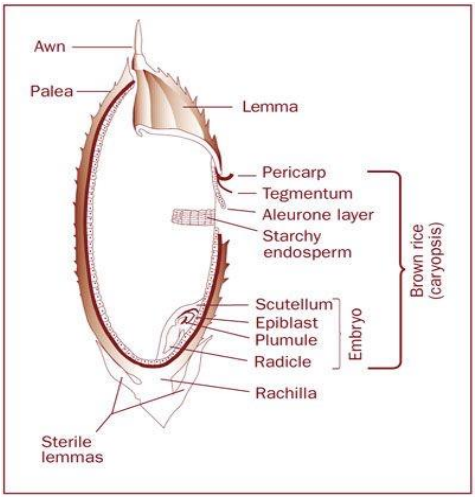


Structure of a monocotyledonous seed

Wheat: It is humped at dorsal and creased at ventral side. Embryonic end of the seed is known as collar end, whereas, other end with hairs is known as brush end.



Rice: It is a caryopsis, tightly closed in lemma and palea. The endosperm of rice is of two types (i) mealy- high breakage during milling and (ii) vitreous- less breakage and non sticky.



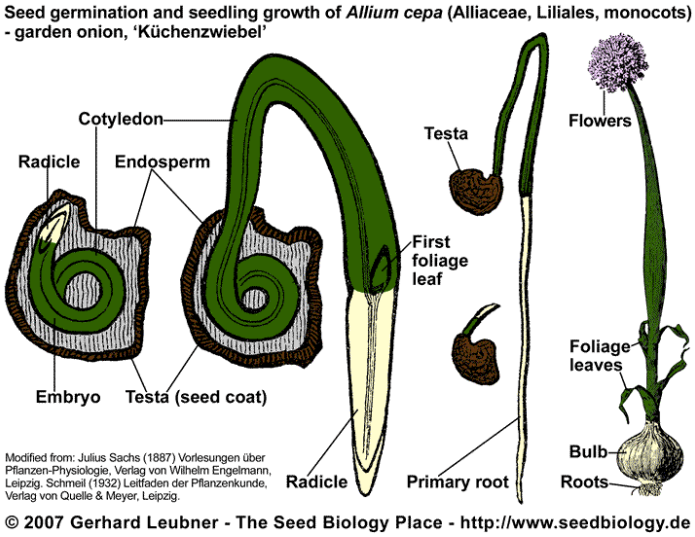
Sorghum: Pericarp consists of an epicarp, mesocarp and endocarp. The attachment of fruit with plant turns black at physiological maturity. The endosperm consists of a layer of aleurone cell and an outer corneous endosperm surrounding a central floury or starchy endosperm.

Maize: Seed is conical in shape with broad and rounder upper end and a sharply pointed lower end embedded in the cob. White and oval area contains a ridge like structure, which indicates the position of embryo. The yellow part of the grain is endosperm.

Finger millet: It is a crop with naked seed of family Graminenae, known as utricle with thin papery pericarp. The brownish colour seed is round at the top and flattened at the end.

Others

Onion: It is a monocotyledonous endospermic seed. Embryo is spirally twisted and cylindrical in shape. Most of the part of embryo is made up of single cotyledon. The tip of cotyledon towards the pointed end of seed is radicle. Endosperm is present as thin whitish mass. The testa and endosperm remain temporally attached to single cotyledon on the seedling. The developing seedling obtains nutrients from the endosperm by way of the cotyledon.

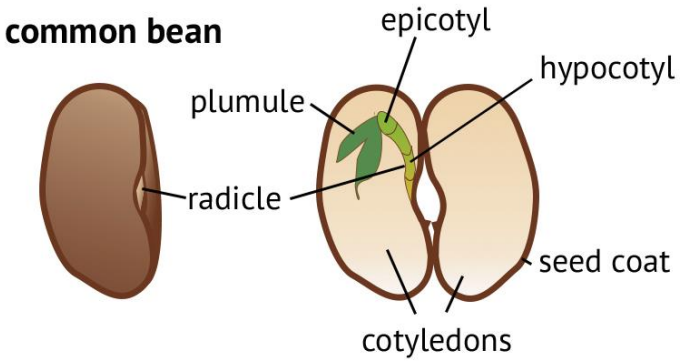


In addition, the green cotyledon of onion functions as a photosynthetic leaf, contributing significantly to the food supply of the developing seedling. The plumule (young foliage leaves) emerges from the protective, sheath like base of the cotyledon, elongates, and forms the foliage leaves of the seedling. The crop is an example of monocot seed with epigeal germination.

Dicot seeds from crops of family Leguminoseae

These are the ex- albuminous (non- endospermic) dicotyledonous seeds. The embryo is made up of embryonic axis with two fleshy cotyledons. The cotyledon is sole food storage organ as it absorbs the food reserves from the endosperm completely during seed development. Seed is round to oval surrounded by a protective seed coat with scar of hilum and micropyle. Radicle portion of embryonic axis projects beyond the cotyledons.

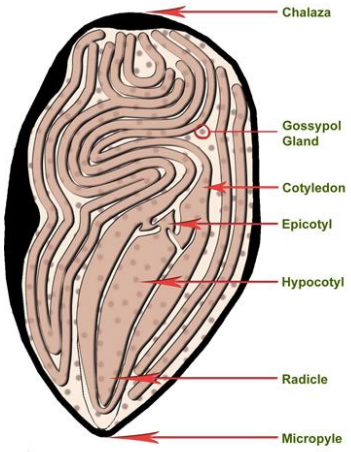
The other end of the embryonic axis is the plumule present in between both the cotyledons. In some species, wart like outgrowth is present below the hilum called strophiole.



Chickpea: It is a crop from family Leguminoseae with a beak like structure in the seed. The beak has micropyle and hilum structure. In the seed of chickpea, chalaza end is prominent. Many varieties have puckering at both the cotyledonary side of the seed. Seed surface of many varieties is rough with the expression as deposition of sand like particles.

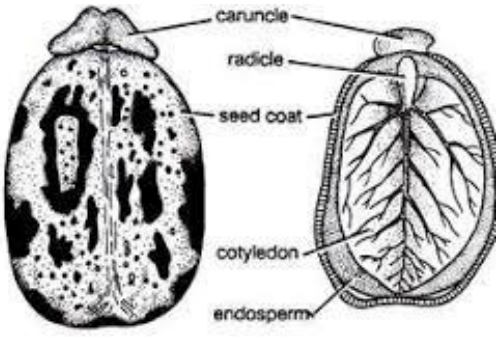
Others

Cotton (*Gossypium sp*.): A dicot seed with dark coloured hard seed Coat. Endosperm present below the seed coat as thin light brown layer covers the folded cotyledons. The fruit of cotton is known as boll. In cotton, the epidermal cells of seed coat elongate into hairs.



Achene (Sunflower, safflower, Niger): These are the albuminous dicot single seeded fruit covered with a fruit wall with some ridges. Usually, a very thin layer of endosperm is present in between the outer covering of seed and cotyledons. The cotyledons are flat with clear nerves. The embryonic axis is short and radical is present in extended form at one side of it.

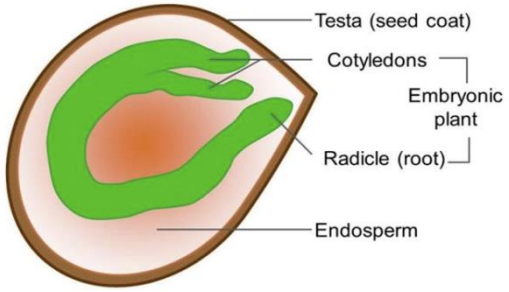
Castor: It is a large seed covered with a hard seed coat. At one end of the seed, caruncle is present as whitish outgrowth of integument. The hilum is present at the base and partly hidden due to the caruncle, whereas the micropyle is located in between the caruncle and the hilum. Testa has white and brown spots. It is an endospermic dicotyledonous seed. On the removal of the testa, a white oblong flattened endosperm covered with a thin tegmen layer becomes visible. The spatulate axile embryo is embedded in the endosperm. The cotyledons are thin, flat and broad with clear veins and the endosperm is the major storage tissue. The cells of the endosperm of castor bean seeds undergo programmed cell death after their oil and protein reserves have been mobilized. The plumule bears a number of minute leaves near its apex end remains hidden between the two cotyledons.



Mustard: Seeds are spheroid to irregularly globose, dark reddish brown to brownish black non- endospermic present in siliqua (fruit). The cotyledons serve as sole food storage organ. A scar (pit) is visible on seed coat formed by partial dilution in outer layer of epidermis with thickened and sculptured lateral walls. Whereas, scar of hilum is not noticeable.

Tomato: Small, compressed thin seed with minute aligned depression on the seed coat. Seed of tomato has only one integument. Its lateral epidermal wall is transformed in spurious hairs. Scar of hilum is compressed. Embryo is curved and linear in shape with two cotyledons at one end and flattened, semitransparent and fleshy layer of endosperm.

Tobacco: Embryo is straight or slightly bent with abundant endospermic layer and prismatic to subglobose seeds.



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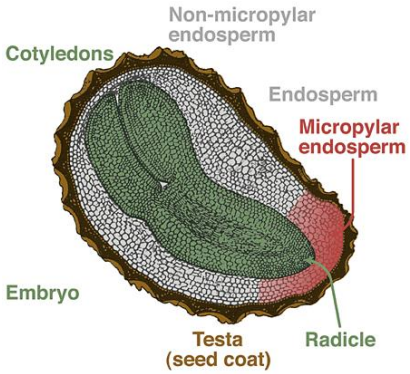
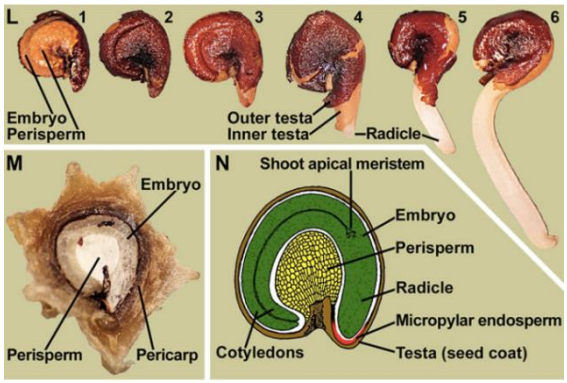
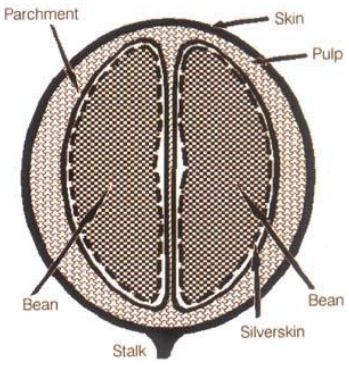


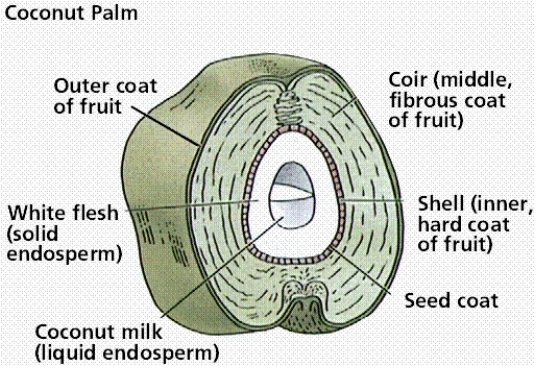
Beet (*Beta vulgaris*): Seeds with endosperm, cotyledon and nucellus tissues as store of food. The seed may be mono or multi germ. The seed is sectored irregularly with rough hairy seed coat and large scar of hilum. Seed coat is hard; curved/ bent embryo with poorly developed two cotyledons. Endosperm is hard and semi transparent. On wetting becomes mucilaginous. Well developed perisperm is present at the center as store of food.



Coffee (*Coffea Arabica*): The nucellus of the ovary after fertilization becomes perisperm and stores the food reserves. An endosperm tissue envelops the embryo of coffee. The endosperm is surrounded by endocarp, which resembles a seed coat. The fully differentiated embryo lies inside an embryo cavity.



Coconut: It has an unusual endosperm with part of it as liquid and acellular.



Coriander: It is a fruit known as schizocarp that splits into two, known as mericarp at maturity. The coat of mericarp has 5-10 ribs, with spines protruding outside and calyx frequently persistent at apex. The fruit wall is not fused with seed coat. Embryo is small and linear with inferior radical. Closely apprised dicotyledonous seed from family Umbelliferae contains relatively large amount of living endosperm, which completely surrounds a small embryo located at the micropylar end of seed.

Seed Growth and Maturation

Wheat and soybean representing monocots and dicots may illustrate the changes in the pattern of accumulation of reserve materials at different stages of seed maturation. In wheat, the dry weight of the seed increases rapidly in about 35 days after anthesis. The water content of the grain is maximum between 14 and 21 days after anthesis, and then it declines rapidly. The amounts of reducing sugar and sucrose are high between 7 and 14 days and decline rapidly thereafter due to conversion to starch. Since in wheat, starch is the major reserve material of the seed, the pattern of starch accumulation is similar to that of dry matter accumulation.

The speed of germination is faster in wheat varieties that begin to lose water early during seed development. The seed is said to have physiologically matured only when it attains maximum dry weight, germinability and vigour. Normally the seed is harvested at field maturity, a stage when the moisture content is reduced to about 6-10 % in wheat. Field maturity is a crop specific character.

A soybean seed attains maximum dry weight between 48 and 54 days after flowering. Oil accumulation is less during 12-18 days after fertilization; maximum oil accumulates between 24 and 42 days after flowering, after which the rate decreases. The protein content in the seed is maximum during 12-18 days after fertilization and decreases subsequently. The initial high percentage of protein may be due to the high content of non-protein nitrogen, which decreases with seed age. Oil accumulation picks up only after protein accumulation completes in the seed.

Importance of Seed Structure

1. For identification of cultivars, it can be done based on the morphological, inheritable physiological and biochemical characters

2. To decide the shelf life potential of seeds -by determining how much storage organ the seed has

3. To decide about the various post-harvest operations namely drying, threshing , processing ,cleaning, grading to prevent or minimize the mechanical damage

4. To design post-harvest handling equipments.

5. To decide about mechanized sowing.

Basic Principles of Quality Seed Production

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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 the seed 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 Breeding in Self and Cross Pollinated Crops

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Introduction

Seed is the first critical input needed by farmers to improve and maintain their crop productivity. It is critical that any seed sold is the correct stated variety, for two reasons. Firstly, the target of plant breeders is to introduce new varieties, the general purpose being to improve the cultivation and/or the yield and/or the quality of the derived products. It is interesting to remember that around 40 per cent of the total increase in agricultural production registered in the last 50 years at a global level has derived from the introduction of new varieties. Secondly, the farmer decides to select a variety on the basis of its agricultural characteristics, such as resistance to stress or disease, or its productivity and the recognized value of its products. 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 mis-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.

Why maintenance breeding important in crop production?

After the release of a variety, its seeds have to be multiplied in sufficient quantity which takes 3-4 generations before it reaches to the farmers for commercial use. During these multiplication cycles, care has to be taken so that the variety does not degenerate but maintains its original characteristics. For achieving this goal, the seed production programme becomes an exhausting task requiring high technical skills, financial investments and proper methodology and care. It is expected that the nucleus/breeder seed should be of high purity in subsequent generations will largely depend upon the quality of nucleus /breeder seed. The important factors, which affect the genetic purity of varieties, are developmental variations, mechanical mixture, mutations, out-crossing, minor genetic variations, selective influence of diseases and the technique used by the plant breeder.

To ensure sufficient quantity of quality seed to the stake holders particularly to the farmers it is necessary to strengthen and further to maintain the generation system of seed production. Because of the generation system of seed production the decline in genetic potential as well as deterioration of genetic purity of the cultivar can be reduced or minimized during the multiplication of sufficient quantity of seed from the handful of nucleus seed stock. Further, this system also ensures the availability of quality seed to the farmers for commercial use. However, the sufficient quantity of seed production at final phase (certified seed) depends on the preceding generations (Foundation/Breeder/Nucleus seed). Besides quantity, the quality of seed also largely depends on genetic purity of breeder/nucleus seed. Hence the nucleus and breeder seed are the back-bone of the seed production system.

Therefore, to maintain the genetic purity/original characteristics of any variety, maintenance breeding is essential.

How maintenance breeding enhance the seed quality of a variety?

Maintenance breeding efforts were highly successful in improving grain quality and maintaining yields in the face of substantial increases in disease and insect pressure and significant environmental and climatic changes. Peng *et al*., 2010 suggest that the low yield of IR8 was resulted from the lack of adaptation to changed environmental conditions, and maintenance breeding plays a critical role in improving adaptation of newly developed varieties to environmental changes that have a negative impact on older varieties. Further, their study provides strong justification for continuous maintenance breeding efforts to preserve rice yield potential through improved resistance to rapidly evolving biotic and abiotic stresses.

Most germplasm improvement work will continue to focus on both maintenance of yield gains and increasing yield potential (Evans and Fischer, 1999). The maintenance breeding places particular emphasis on stress tolerances associated with anticipated environmental and climatic changes (Cassman *et al*., 2003). Maintenance breeding refers to germplasm improvement for overcoming diseases, improving grain quality, or eliminating other defects that may constrain production and grain marketability (Richards, 1996). Further, it is also essential or prerequisite to purify the old or admixture varieties. Maintenance breeding not only improves the cultivars traits besides it also maintains the original characteristics of particular variety. Thus it ensures the quality of seed of particular variety irrespective old or newly released variety. The genetic purity of foundation and certified classes will depend on the type of nucleus/breeder seed use. Therefore, the maintenances of original characteristics of the variety/parental lines at the nucleus and breeder seed level is very-very important.

Breeder involved in nucleus/breeder seed multiplication should know to ensure the seed quality assurance through maintenance breeding:

- 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.

The maintenance breeding procedure or methodologies are varies from crop to crop and mainly depends on the breeding behaviour or mode of pollination. Therefore, maintenance breeding in self pollinated crops is vary from that of out crossing or cross pollinated crops.

Maintenance breeding in self and cross pollinated crops

Maintenance of seed quality (particularly genetic purity) in self pollinated crops is easier compare to cross pollinated crops. This is mainly due to the breeding behaviour of self pollinated crops, where there is less chance of out crossing and thus very less/no genetic contamination at flowering stage (pollination) if maintain proper isolation distance. However,

irrespective of mode of pollination (self/cross pollinated crops), it is absolutely necessary to select single panicle or single plants 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 (Chowdhury and Lal, 2003). Maintenance breeding in cross pollinated crops and parental lines of hybrids is somewhat different and complex. The procedure of maintenance breeding (maintenance of nucleus seed) of cross pollinated crops and self pollinated crops described below with example.

Maintenance of nucleus seed of varieties in self pollinated crops (Example: wheat)

Nucleus seed: It is the seed stock available with the breeder, which he multiplies for supply at the time of varietal testing and notification or maintain in a systematic way to avoid any sort of variation in the variety to retain the identity of the variety and to feed it in the seed chain for the purpose of production of breeder seed of the variety. Maintenance of nucleus seed involves following steps (Fig. 1).

● Raise basic seed sample procured from original breeder along with its 'DUS' features in isolation of five meters by sowing through dibbling method. Select more than 500 spikes/ear-heads of the variety true to its varietal descriptors and thresh them individually to avoid any type of genetic variation in the variety.

● Examine the seeds for uniform colour, shape and size and reject the seeds of those lots where there is variation for these traits appear.

● The seed from selected ear-heads should be shade dried to bring down the seed moisture to about 8% and packed air tight in small tin foil pouches. For relatively important varieties, it is even suggested to keep adequate quantity of these seeds in pouches at -4^0C, to serve as seed bank. Such stored seeds retain viability for 5-7 years. This seed sample constitutes the material for Stage-I for nucleus seed production.

Stage-I (NSS-I): In the next cropping season, the seeds obtained from each selected ear-head are space planted in rows of 3 m length in isolation of 5 m from other varieties and examined critically throughout the growing season particularly at early vegetative growth stage, ear emergence and at near maturity for their genetic purity. To enable proper inspection, sow in paired rows by dibbling method. Reject the entire ear row that shows any sort of genetic deviation. To ensure high quality seed production ruthlessly reject the row-progenies even if the variation appears in a single plant in the row. If variation is detected in the progeny at or after the flowering stage, reject the progenies on both sides of the rejected progeny to avoid any source of variation in the subsequent progenies which might have occurred due to outcross with the rejected progeny. Each ear-head progeny is to be harvested and threshed separately, labeled and stored in small cloth bag safely. It is expected to harvest about 200g seed from each such ear-row progeny.

Stage-II (NSS-II):

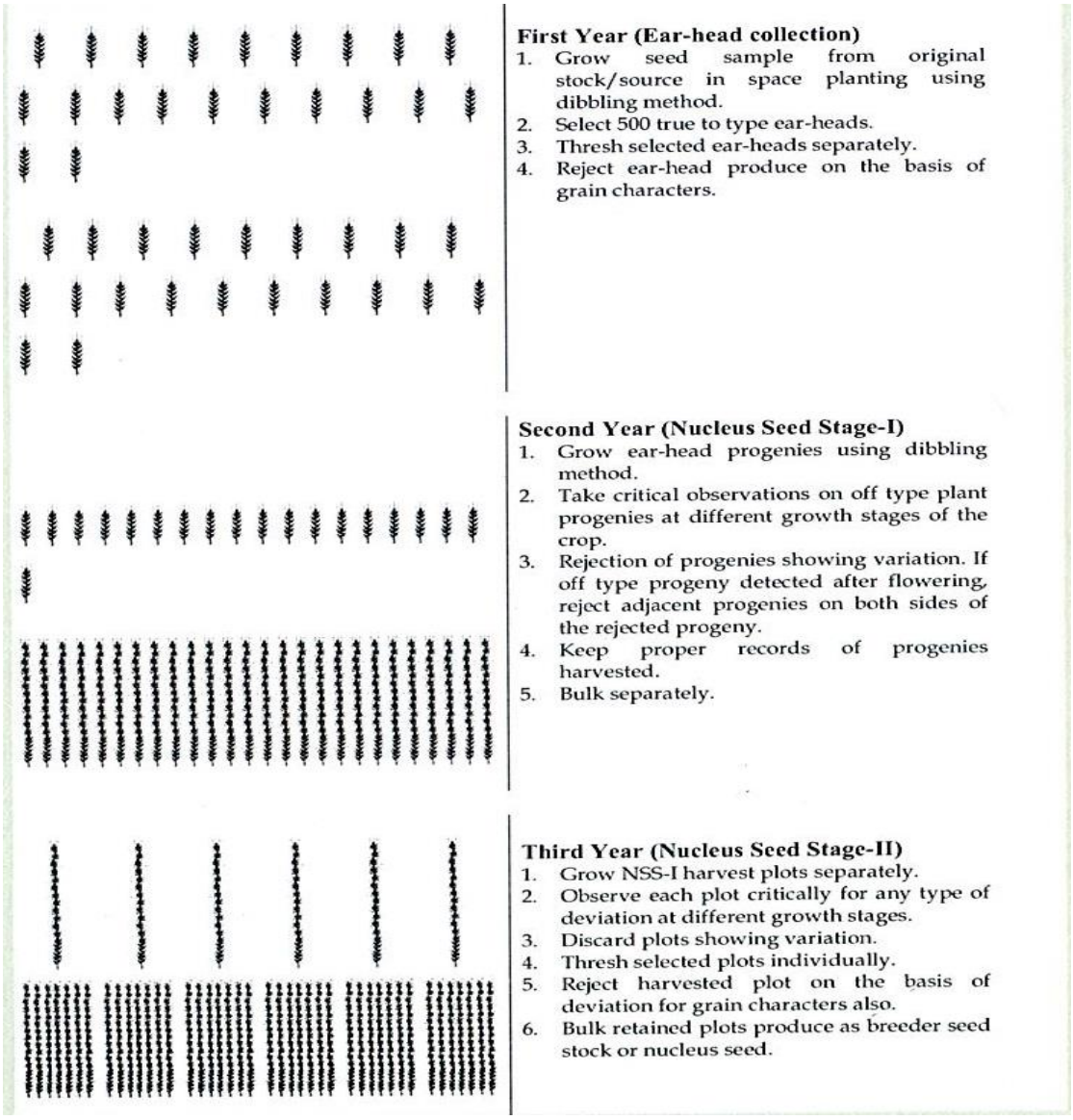
Whenever the demand for breeder seed requirement is more than 10q, it is necessary to go for stage II. Even otherwise for a high quality seed production, NSS II is followed prior to breeder seed production. This ensures the nucleus seed quality by double check and enhanced seed multiplication as the seed starts multiplying in larger plots at this stage.

The following steps are involved for the maintenance of seed at stage II.

● Seed harvested from each ear-row progeny of NSS I is drilled separately in a plot (3m x 1.38m). The production of NSS-II stage may vary depending upon the nucleus seed requirement and availability of NSS I seed stock.

● These plots are re-examined for any type of deviation from varietal descriptors. This second cycle of nucleus seed multiplication provides yet another opportunity to eliminate any offtype in the ear-row progeny, which might have escaped during NSS-I. The plot having any deviation from the varietal descriptors should be rejected.

● The true to type plots are harvested and threshed separately. Seed from these plots are examined for seed colour, shape and size for genetic uniformity of the variety and the plots true to their genotype are bulked to constitute nucleus seed or breeder seed stock.



First Year (Ear-head collection)

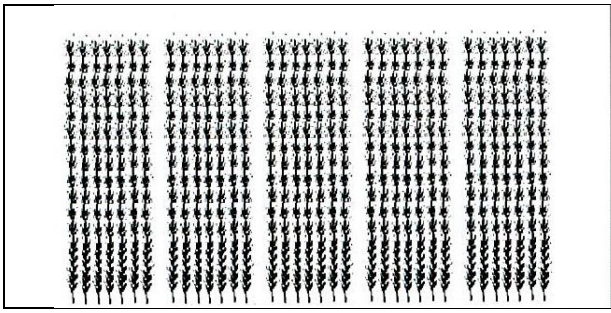
1. Grow seed sample from original stock/source in space planting using dibbling method.
2. Select 500 true to type ear-heads.
3. Thresh selected ear-heads separately.
4. Reject ear-head produce on the basis of grain characters.

Second Year (Nucleus Seed Stage-I)

1. Grow ear-head progenies using dibbling method.
2. Take critical observations on off type plant progenies at different growth stages of the crop.
3. Rejection of progenies showing variation. If off type progeny detected after flowering, reject adjacent progenies on both sides of the rejected progeny.
4. Keep proper records of progenies harvested.
5. Bulk separately.

Third Year (Nucleus Seed Stage-II)

1. Grow NSS-I harvest plots separately.
2. Observe each plot critically for any type of deviation at different growth stages.
3. Discard plots showing variation.
4. Thresh selected plots individually.
5. Reject harvested plot on the basis of deviation for grain characters also.
6. Bulk retained plots produce as breeder seed stock or nucleus seed.



Fourth Year (Breeder Seed)

1. Sow breeder seed plots in one direction with seed drill.
2. Leave one row unsown after every 8th row.
3. Follow roguing norms in removing the off type plants.
4. Harvest the seed plots with utmost care to avoid any mechanical mixture.
5. Keep proper records of each lot separately.

Fig. 1 Schematic diagram for the maintenance breeding of wheat varieties.

Maintenance of breeding in cross pollinated crops:

A. Maintenance of composites / OPV's

Open pollinated varieties (OPVs) refers to collection of individual, which share a common gene pool. Synthetic have been derived through interbreeding of lines with goods general combining ability, while composite varieties are interbred populations in advanced generation of promising genotypes without any knowledge of their combining ability. Open pollinated varieties (OPVs) are easier to develop than hybrids, their seed production is simpler and relatively inexpensive and are adapted to local environment. The subsistence farmers who grow them can save and exchange own seed for planting the following season, reducing their dependence on external sources. OPV's 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 (Maize) as described in Fig. 2.

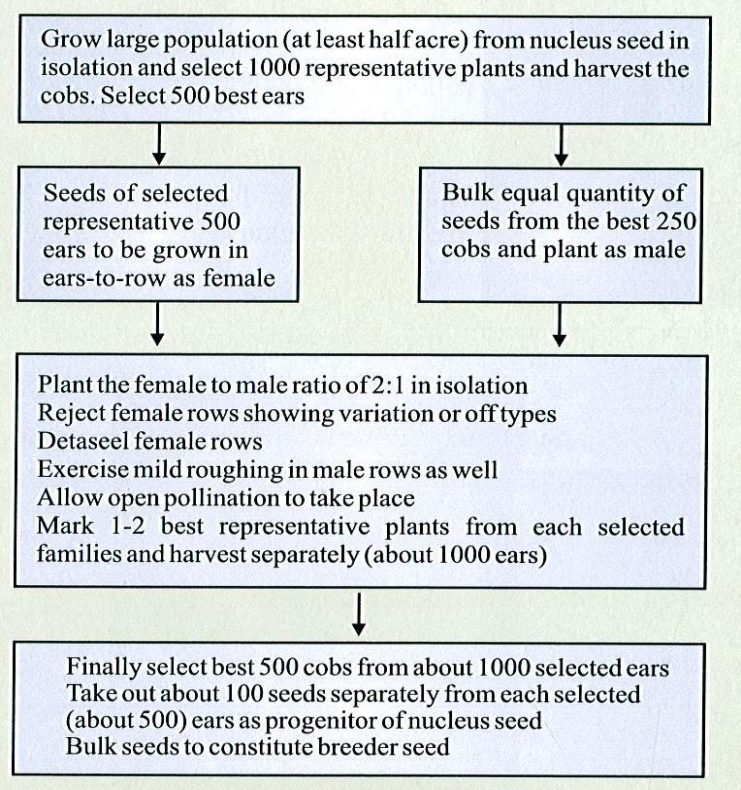


Fig.2 Varietal maintenance and seed production programme of composite OPVs (Maize)

B. Maintenance and production of nucleus seed of inbred lines

Maize is a cross pollinated crop, however, it is self compatible as a result naturally up to 5% selfing occurs in maize. Practically, it is possible to encourage inbreeding in maize by pollinating with pollen from same (selfing) or related plants (sibbing). Inbreeding leads to homozygosity. This is attainted much faster in case of selfing, while to a lesser extent by sib mating. Maize being cross-pollinated exhibits inbreeding deficiencies. However, over past few decades population improvement programme especially recurrent selection has increased the vigour of inbreds to a considerable extent. Inbred lines are derived through rigorous selfing / and or sib mating (7-8 cycles). They are considerable homozygous. The goal in inbred line maintenance is to maintain the performance, appearance (Physical and genetic purity) of original lines. This includes proper isolation, rigorous elimination of off-types (roguing), care in pollination procedures (selfing or sibbing) and using accurate pedigree records and labels. Limiting the number of line reduces risk of out crossing and genetic drift.

Inbred line maintenance involves self pollination, sib-pollination or a combination of these. Selfing aids in maintaining inbreds in condition, while sibbing tends to prevent excessive loss of vigour. A inbred line may be maintained in either of two alternatives, self pollination and sib mating. In first, alternative plants of the inbred lines are self pollinated and those with uniform characteristics with the inbred description are harvested individually. Ears consistent with inbred characteristics are shelled separately. In next year, part of the seeds of individually shelled ears are sown as ear to progeny rows. Off type rows are eliminated and rows with characteristics consistent are selected and self-pollinated. Self pollinated cobs are harvested individually and off-tyeps are rejected. Ears are shelled

separately. Portion of seeds are retained separately, to be used for future progeny testing and the rest is bulked as breeder seed. Alternatively, out of bulked seeds inbred line is planted. Off type plants are rogued out before flowering. This is followed by sib-pollination, that is pollination between plants. Both plant-to-plant as well as bulk sib-pollination is practiced. Plant-to-plant sib-pollination is safer. In bred lines can also be maintained by growing in isolation, allowing for open pollination after through roguing of off types. Plants true to type are retained and involved in sib mating. Off type ears are rejected after harvest. True-to-type cobs are shelled in bulk. Seeds from best cobs are retained and used as nucleus seed and rest is used as breeder seed.

Most convenient way of maintaining inbred lines is to grow them in a big seed plot in isolation and execute rigorous roguing at four stages of crop growth, i.e. at knee high stage, flowering, post flowering and at harvest. Cobs of all plants are covered with silk bag before silk emergence. Once the breeder is sure that all off type plants are rogued out of the seed plot, the silk bags are removed and open pollination is allowed to take place. After harvest, selection is made on the basis of ear and grain characters. One hundred best representative ears are selected to constitute breeder's seed after bulking the seeds. Fifty to 75 seeds are taken out of the selected 100 ears are bulked to make up nucleus seed. Rest of the ears harvested from the seed plot are bulked to constitute breeder seed. In this whole process extreme care is to be taken to rogue out off type plants to encourage homogeneity in the material.

Nucleus seed production of parental lines of hybrids

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 stock 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.

Rice hybrids are developed by using cytoplasmic – male sterility (CMS) – fertility restoration system which involves three lines.

1. CMS line or A line (male sterile)
2. Maintainer line or 'B' line (male fertile)
3. Restorer line or 'R' line (male fertile)

Hybrid rice seed production involves two stages

a) Multiplication of 'A' line, which involves crossing of A x B lines.

b) Seed production of hybrid, which involves crossing of A x R lines.

Before actually producing the seeds of A, B, R and hybrid seed, purification of the parental lines is very important. It is necessary to purify the parental lines at least once in three years. Purification process involves four steps:

1. Source Nursery – Growing of source material
2. Test cross nursery – Test crossing of selected lines
3. Identification nursery – Evaluation of test crosses
4. Multiplication nursery – Multiplication of identified lines

1. Source Nursery (Season I)

- Large number of A, B and R lines are grown side by side for convenience.
- 'B' line is sown 4-5 days after 'A' line and 'R' line is staggered depending on the flowering difference between A & R line.
- The individual plants are observed and the off types are carefully removed.
- At flowering, 200-250 typical CMS plants which are completely sterile and also typical maintainer and restorer lines are selected.

2. Test Cross Nursery (Season II)

- Approximately 200-250 paired crosses are made between selected plants of CMS line with those of maintainer lines / plants.
- Two or three panicles of the same CMS plant are used for crossing with the selected 'R' line plants.
- Lable the crossed panicles of A x B as A1 x B1, A2 x B2 ... An x Bn and similarly the A x R crosses are labeled as A1 x R1, A2 x R2 ..... An x Rn

3. Identification nursery (Season III)

- The purpose of identification nursery is to identify those progenies, which are not uniform and true to type.
- 10-20 seeds from each of the A x B crosses and all the seeds of A x R crosses are used for raising the nursery.
- The paired crosses of A x B and A x R are planted in the main field without isolation.
- Observe the progenies of A x B crosses for stable male sterility, true to type and uniformity.
- The off-types, partial fertilie plants in A x B crosses and those with proor restoration in A x R crosses are identified.
- It is very important to identify those, which deviate from normal standard characteristics in identification nursery so as to reject them in multiplication nursery.

4. Multiplication nursery (Season III)

- After sowing a part of A x B crosses seed in identification nursery, remaining seed is sown 21 days later along with corresponding 'B' lines. This material is planted in isolated plots of more than 500 m.
- Based on the observations made in A x B crosses in the identification nursery, deviants are removed before flowering along with their corresponding 'B' lines in multiplication nursery.
- Remaining A x B pairs are allowed to cross-pollinate.
- 'B' lines are harvested first, threshed separately and bulked. This forms the source seed for nucleus seed production of 'B' lines.
- Then 'A' lines are harvested and threshed separately. This forms the source for nucleus seed production of 'A' line.

Restorer line multiplication

- The restorer lines are grown as panicle to row progenies in a separate block, 21 days after transplanting of A x R progenies in identification nursery.
- Those lines which are found to be deviant in A x R progeny as observed in identification nursery are removed before flowering.
- After assessing spikelet fertility of the corresponding A x R progenies, the seeds of the corresponding 'R' lines with good restoration are bulked as source seed for nucleus seed production of 'R' line.

Nucleus seed production of 'A' line

- Isolation of 500 m is necessary for nucleus seed Production of 'A' line.
- Seed rate : 15 kg/ha for 'A' line, 5 kg/ha for 'B' line
- Staggered sowing of 'B' line is necessary. Half the quantity of 'B' line is sown 3 days after the sowing of 'A' line and the remaining half of the 'B' line is sown 5 days after the sowing of 'A' line.

While transplanting, the following steps may be followed.

- Spacing between A and B lines : 30 cm; Spacing between A lines : 15 cm;
- Spacing between two 'B' lines : 30 cm; Plant to plant spacing : 15 cm
- Row-ratio of (A : B) : 6:2
- Plant single seedling / hill.
- Row direction should be perpendicular to the wind direction to facilitate higher our crossing.

- Apply GA_3 (60 g/ha) mixed in 500 litres of water to enhance panicle exsertion and seed set, GA_3 is sprayed at 5-10% flowering on two consecutive days with 40% on the first day and 60% on the second day.
- Off-types i.e., pollen shedders in 'A' lines and any other plants that do not conform to the characteristics of A line are removed. Rogueing is done at all critical stages such as vegetative, flowering and maturity stage.
- Supplementary pollination through rope pulling or rod shaking is done to enhance the crosspollination.
- Monitoring by competent personnel is essential to produce the genetically pure seed.
- At the time of harvest, 'B' line is harvested first and then only 'A' line.
- Seed is cleaned and dried to 10-12% moisture content and treated before storing in cool any dry place.

Nucleus seed production of B and R lines

It is similar to the nucleus seed production of inbred varieties. Initially seed of purified B and R lines is used to produce nucleus seed and subsequently single plants are selected for further use.

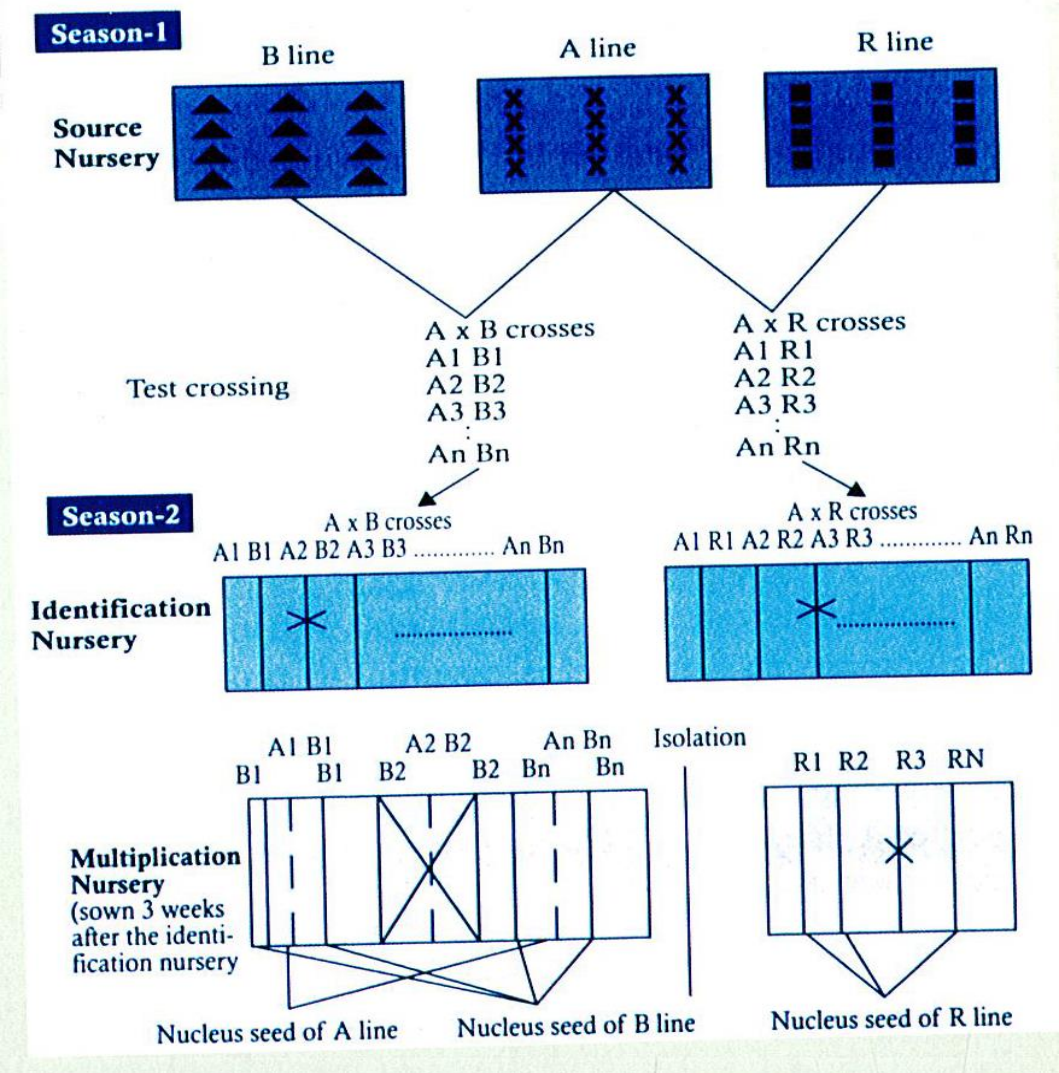


Fig.3 Procedure for nucleus seed production of A, B and R lines.

Conclusion

Maintenance breeding is a prime most task in ensuring the high seed quality production in seed supply chain. Because during the maintenance breeding programme, the breeder strictly selecting and advancing only the true to type plant/ear of particular variety based on original characteristics of the variety. Therefore, maintenance breeding during or prior to nucleus/breeder seed production is very-very essential in seed quality assurance. Besides preserving yield potential, improving adaptation of newly developed varieties to environmental changes, the continuous maintenance breeding 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.

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Seed Production Technique in Rice

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Rice (*Oryza sativa*) is a well known cereal belonging to the family Gramineae. It is the second important cereal next to wheat in Asia. It is a staple food for more than 60% of the population. The seed production can be taken up in both the seasons.

Method of seed production

Rice is a self-pollinated crop with cross-pollination to the extent of 0-5%. The crop should be raised in isolation and seeds are allowed to set by open-pollination. To maintain the varietal purity an isolation distance of 3 metres is maintained in both certified and foundation stage of seed production.

Seed production stages

Breeder seed → Foundation seed → Certified seed

Land requirements

Land to be required for seed production shall be free of volunteer plants, weeds, soil borne, diseases, insects, etc. The selected plots should be levelled and the soil preferably clay loam. Land should be fertile with good irrigation and drainage facilities and with good sunlight and aeration.

Seed selection and sowing

Seeds used for the seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with good germination percentage. The seed rate required is 30-40 kg/ha. The spacing adopted is 10x15 cm for early duration varieties and 15x15 and 20x15 for medium and late duration varieties. The following factors should be considered while purchasing the seeds.

- Should be related to appropriate seed class
- Tags, labels and seals on seed bags are intact
- Validity period has not been expired

Seed treatment

Seeds must be treated with appropriate fungicide and insecticide before sowing. The seeds treated before sowing by fungicides like Carbendazim or Thiram @ 2g/kg is recommended.

However, seed biopriming with *Trichoderm aharzianum* and/ or *Pseudomonas fluorescens* (@5 g/kg) is an ecofriendly biological control method. Seed biopriming not only suppresses the seed borne diseases but also results in better seed germination and seedling growth.

Cultural practices of rice

For seed production, the cop should be grown by direct sowing or by transplanting. But it is desirable to grow under puddle and transplanting systems.

Nursery

Prepare the seed bed 35-40 days prior to the scheduled transplanting time. Plough the field twice in the dry condition and puddle later in standing water (2-3 cm) two to three times within 5 days. Sowing of late maturing varieties in the nursery should be done from 25th may to 10th june and that of early duration varieties from 10th to 25th june. About 50 to 60 beds of size 6.0 x 1.5 m are sufficient for raising seedlings to transplant one hectare.

Time and method of sowing

Seed crop should be sown one week advance to the normal crop sowing. Some adjustment may be made to avoid pest and disease incidence. Sufficient moisture should be ensured during sowing to get better germination and optimum plant stand. Seed crops should invariably be sown in rows on ridge bed. Row planting helps in conducting proper field inspections, facilitates rouging and plant protection measures. Depth of sowing is most important to get good plant stand in nursery which depends on soil type, soil temperature and moisture. The seeds should be sown 2 to 3 cm deep in the soil.

Source of seed

Obtain nucleus/breeder/foundation seed from a source approved by the certification agency to raise the nursery

Classes and Sources of Seed

A. Breeder seed: Breeder seed is seed material directly controlled by the originating or sponsoring-plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed. Breeder seed shall be genetically must pure as to guarantee that in the subsequent generation i.e. certified Foundation seed class shall conform 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.

Preparation of main field

The main field should be ploughed and irrigated many times to obtain a fine tilth and a soft soil with fairly impervious subsoil, so that the transplanted seedling established quickly. A plough field should be kept flooded for a week before transplanting, if possible.

Transplanting and Management of Crop

The optimum age of seedlings for transplanting is 18 – 22 days for short, 25 – 30 days for medium and 35 – 40 days for long duration varieties. One to two seedlings per hill are transplanted at a depth of 3 cm. Before transplanting, clip off the tips of the seedlings to facilitate uniform growth.

Isolation Distance

For pure seed production the field must be isolated atleast 3m from other fields. Isolation is an act of keeping the seed crop away from the source of contamination. Main objective is to avoid mechanical admixtures. The three types of isolation are Distance isolation, Time isolation and Barrier isolation.

Weed management

Weed out the plots twice or thrice as needed before heading. The problem of weeds and their management assumes greater significance in seed production programme because of stringent seed standards and high value for seed. Weeding should be done manually and the weeds removed should be trampled into the field for the conservation of nutrients and for organic matter as mulch. The weed plants have the mechanism of wide adaptability to adverse conditions, high growth rate compared to cultivated species. They compete with the seed crop for space, nutrients, moisture, light and gases and thereby reduce the seed yield considerably. It is very essential to keep the seed crop free from weeds in the early stages (up to 20-25 days) by doing one or two hand manual weeding. Alternatively, chemical weedicides can be applied to control the weeds. The pre-emergence spray of weedicides is to be selected based on the crop growth stage. There should be sufficient moisture in the soil at the time of spraying of weedicide.

Irrigation

Water is stagnated in the field at a depth of 2 – 5 cm till the transplanted seedlings are well established. Then 5 cm of water is maintained upto the stage when the milky portion of the grain turns into soft dough. Flooding is not necessary if the field is saturated with rains. In this case irrigation should be done during initial seedling period covering about 10 days, during tillering to flowering, a critical stage and panicle initiation stage to flowering (heading).

Pest and disease control

It is essential to control the insect pests and diseases so as to raise healthy seed crop. Rice crop is commonly affected by pests and diseases like leaf eating caterpillars, leaf folders, case worm, green leaf hopper, yellow stem borer, blast, brown leaf spot, sheath blight, stem rot, bacterial leaf blight, tungro virus etc., at different growth stages. The management techniques for these pests and diseases are essential.

Rouging

Rouging should be done from vegetative phase to harvesting phase. The seed production field should be checked and off-types and diseased plants should be removed. Major rouging is done before flowering stage to assure the genetic purity of the seeds. It is the process of removing undesirable plants from the seed crop and the rogues may be weeds, off types, other variety plants, plants affected with diseases etc. It is necessary to avoid genetic contamination, disease transmission, mechanical admixtures to meet the certification requirements with respect to off types, diseases, inseparable other crop plants and objectionable weed plants. Rogues can be identified based on the morphological characters

besides variations in flowering. Number of rouging depends upon the crop, however a minimum of three rouging starting from sowing to maturity stages are necessary. Rouging can be done at any time of the crop stage. Maximum percentage of off-types permitted at the final inspection is 0.050% for foundation seed production and 0.20% for certified seed production. Off-type rogues can be removed from the crop whenever they appear.

Off-types to be removed

During maximum tillering

- Remove any plants outside the rows.
- Remove plants that are considerably taller or shorter than the original variety.
- Remove plants that are off-type in leaf blade size or shape.
- Remove plants that are off-type in colour of the leaf sheath or leaf collar.

During flowering

- Remove off-type plants that flower very early or very late.
- Remove plants that are off-type in leaf size, leaf angle, and panicle shape and size.

Before harvest

- Remove off-types that have different grain characters from the original plants. Look for differences in grain shape, grain size, or the presence or absence of awns.

Field inspection

A minimum of three field inspections should be done from flowering to harvesting stage by the seed certification inspectors from SSCA to examine the seed crop in the field and to determine its suitability for certification. During inspection parameters such as isolation requirement, offtypes, volunteer plants, diseased plants etc., are checked. In case of rice the maximum permissible limit for the presence of off-type plants, objectionable weed, and infected plants by designated disease is 0.05 and 0.2, 0.01 and 0.02 and 0.1 and 0.5 % for foundation and certified seed production, respectively.

Harvesting and Threshing

Harvest is done soon after the maturation of the seeds that turns from green to straw yellow colour. Ear heads should be harvested when the seeds have attained their maximum physiological maturity i.e., 90% of the seeds are straw yellow in colour. At this stage the moisture content varies between 17 and 23 percent. Seed crop harvested should be threshed, winnowed, cleaned and dried to safe moisture level before processing.

Seed yield

Seed yield depends on the crop varieties, agronomic principles followed in raising seed crop, besides control of pests and diseases.

Seed processing and packaging

After drying the seeds to the prescribed level of seed moisture content, the seeds are to be processed by using air screen cleaner with the appropriate sieve sizes approved by the Seed Certification Agency. After grading, the seeds are to be treated with suitable fungicides before packaging.

Seed Storage

After packaging, the seeds are to be stored in well ventilated, damp proof, insect free seed godowns until (controlled) storages are to be used for storing the seeds for more than one season.

Seed Production Aspects of Millets and Soybean

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Millets

Finger miller or ragi (*Eleusine coracana*) is a robust tufted annual with a good tillering ability growing to a height of 40-100cm. finger millet and all small millets are essentially self pollinated. The extent of out crossing is less than 1%. This is an advantageous feature during seed production in ensuring high level of genetic purity. The salient features of floral biology and mode of pollination are briefly given below crop-wise.

Floral biology and pollination

The inflorescence of finger millet consists of a group of digitately arranged spikes in terminal umbel form. The spikelets are arranged on side of the rachis each alternating with other spikelet and contain 4 to 10 hermaphrodite flower, whereas terminal ones may be staminate or sterile. For all the florets of a spikelet two glumes are common. Each floret consists of a lemma and a palea, which enclose three stamens and one ovary having two styles with plumose stigma and two fleshy truncate lodicules. The anthers dehisce longitudinally and self pollination is the rule. The flowers open from middle of the spike and progress towards both the directions. Within the spikelet also, the florets in the middle first open then the florets in the top and the basal florets open at the last. Seeds are about 1 to 2 mm in diameter, globose, smooth or rugose, varying in colour from orange red, reddish brown, dark brown to nearly black, a white-seeded form is also known. The pericarp remains distinct during development and at maturity appears as a papery structure surrounding the seed.

Foxtail millet (*Setaria italica*) is an annual grass growing to a height of 1.0-1.5 m. inflorescence is a spike like panicle, varies in length and breadth with ribbed and ciliate rachis carrying 6 to 12 two flowered sub-sessile spikelets and each subtended by 1 to 3 bristles. Bristles vary in colour and length in different cultivars. Spikelets are elliptic with two glumes, often purple in colour and two broad lodicules. Stamens are three in number with white or orange anthers. Ovary is smooth with two long styles and plumose stigma. Grain is oval, shiny, 2 mm in length and tightly enclosed by lemma and palea varying in colour from cream to orange, yellow, brown or black.

Kodo millet (*Paspalum scrobiculatum*) is an annual with stems 60-90 cm long and showing profuse tillering. Spikes are 2 to 6 in number, and 3 to 15 cm long. Spikelets are usually sessile or with short pedicilate on a flattened rachis. The spikelets are arranged in two or more regular or irregular rows, flat, broadly elliptic, awnless with two florets of which the lower is reduced to a valve and upper is rounded. Being highly cleistogamous. Self pollination is the rule. The grain is enclosed in hard horny persistent husks which are difficult to remove.

Little millet (*Panicum sumatranse*) is an annual grass with slender culms of 30-90 cm height and showing low to very high tillering in different cultivars. Panicle is compound, 15

to 45 cm long with spikelets mostly beared on unequal pedicels but solitary at the end of the branches. The hermaphrodite flowers open in basipetal pattern with a brief and rapid anthesis period. The glumes open for a short while and self-pollination is the rule. The seeds are small, about 0.2 cm long, oval in shape with varying colours from dark grey to cream.

Proso millet (*Panicum miliaceum*) is an annual growing to a height of 90-120 cm. the inflorescence is a drooping panicle varying for degree of compactness with more or less naked branches bearing ovate pointed spikelets. The main rachis of the panicle is glabrous. Laterals being ribbed and hairy and swollen at the tip where the spikelets are born. The spikelets are about 0.5 cm long and contain two flowers, partially enclosed by glumes. The outer glume is short, while the inner glume is as long as spikelet. The lower flower of the spikelet is sterile consisting of a lemma and very much reduced palea, while the upper flower is perfect bearing grain. The perfect flower contains two lodicules, three stamens and an ovary with two long styles and feathery stigma. The flowers are normally self fertilized and produce a nearly globular grain enclosed tightly in the persistent lemma and palea. The grain is variously coloured (cream, red, grey or yellow) and very smooth. The inner grain is normally white or green in colour.

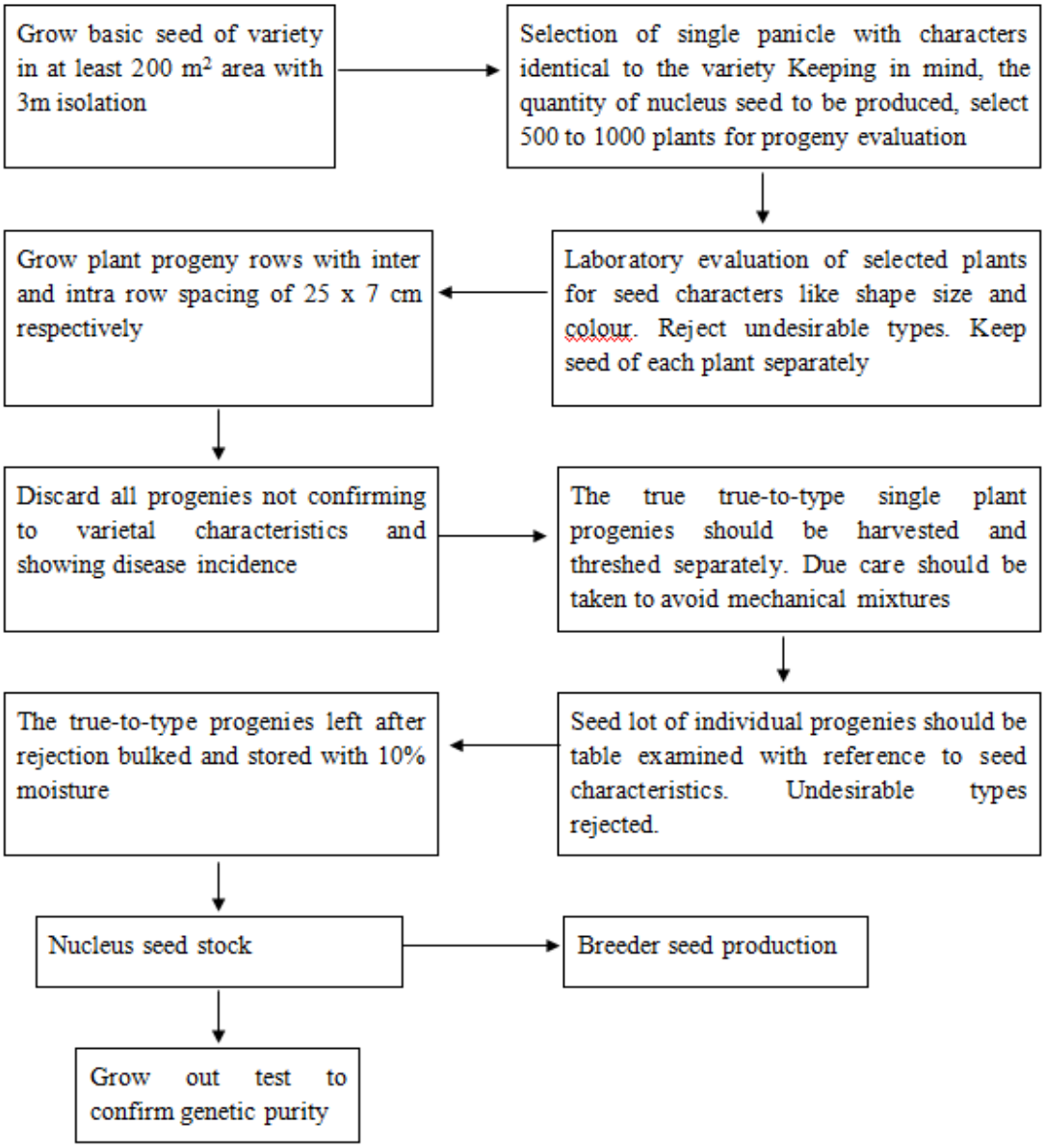
Barnyard millet (*Echinochloa frumentacea*) is an annual with erect stem growing to a height of 60-120 cm Spikelets are two flowered, awnless and placed on short rough pedicels subtended by two glumes. Lower floret is sterile with lemma and small palea and upper floret is hermaphrodite with well-developed lemma and palea and two lodicules. Stamens are three in number with purple anthers. Ovary contains two distinct styles with plumose stigma. Grain is enclosed in white shinning hardened lemma and palea.

Nucleus seed production

As already mentioned the very high self pollinated nature of these crops is an advantage during seed production in ensuring high level of genetic purity. In view of its very high inbreeding nature the required isolation distance is less, around 3-5 mts.

Nucleus seed is the first stage in the seed multiplication chain of a released variety and is the only seed used to produce its own seed class. To produce nucleus seed of a variety the basic seed maintained by the breeder is a pre requisite. Nucleus seed is directly produced by the original plant breeder and required to have cent per cent genetic purity. Although, ragi and small millets are highly self pollinated, it is desirable to self individual panicles of the selected single plants in the first stage of nucleus seed production. The detailed scheme of nucleus seed production is given in the flow chart.

Schematic diagramme of nucleus seed production in small millets



Breeder seed production

Breeder seed is produced from the nucleus seed stock and production is supervised either by the original breeder or the sponsored plant breeder. Breeder seed must have maximum genetic purity and form the material for production of other classes of seeds in the seed chain. The breeder seed should be produced as far as possible in absolute isolation. In case, breeder seed of more than one variety is produced, a minimum isolation distance of 5 m should be followed.

- The agency for breeder seed production is required to have nucleus seed of the variety for the concerned breeder/ institute along with a list of characteristics features of the variety

- The nucleus seed is planted in a disease free, well prepared and homogenous plot having an isolation distance prescribed for respective crop. The planting should be done as per sowing time prescribed for each zone and indicated in the next
- Planting is done with the required seed rate leaving 1 m space after each bed for easy monitoring of the field. The plot should be managed as per the recommended package and practices
- The breeder should visit the plot at regular intervals to rouge out off-type plants before flowering
- Harvesting should be done at the proper maturity. Precautionary measures should be taken at the time of harvesting and threshing to avoid mechanical mixtures. The simultaneous threshing of the two varieties should not be done. The seed should be dried to 10% moisture level before storage, if required.
- Grow out test should be carried out after taking samples from different lots to confirm the purity of the seed.
- The seed should be treated with insecticide to protect it from the store pests and be packed in properly labeled gunny bags
- All the BSP Performa except BSP I should be sent to PC, ADG, DAG at the schedule timing so as to complete the process effectively

Package of practices of raising the crop of Kodo and Kutki for nucleus and breeder seed

Planting time	**:**	25 June to 15 July
Seed rate	**:**	10 kg/ ha
Spacing	**:**	20-25cm x 5-7 cm
Fertilizer	**:**	40kg N/ha; 20kg P_2 O_5/ha; 10kg K_2O/ha for Kutki 60kg N/ha; 40kg P_2 O_5/ha; 20kg K_2O/ha for Kodo
Irrigation	**:**	
Weed management	**:**	Isoproturon @ 0.5kg a.i./ha at pre-emergence stage 2,4-D @0.6kga.i./ ha at 25 days after sowing
Insect pestmanagement	**:**	For the control of bristle beetle application of Chlorophyriphos @ 1.5-2ml/ liter of water
Disease	**:**	To minimize the damage from loose and covered smut, the seed reatment with fungicides Carbendazim+Thiram (1g +2g/kg) at the time of sowing is useful.

Seed multiplication ratio (SMR)

In all small millets seed multiplication ratio is very high and is of the order of 1:150. under good management seed multiplication ratio can go up to 1:500. This is a distinct advantage, small millets as a group enjoy over many other group of crops.

Storability of seeds

All small millers in general have very good storability with few storage pest problems. Seed can remain viable for 2-3 years even in ambient conditions. In storage structures where, temperature and humidity are controlled the seed viability easily gets prolonged to 5-10 years. These advantages should be harnessed while producing nucleus/breeder seed, by minimizing frequent production. The breeder/nucleus seed produced can be stored and use up to 5 years or even more depending upon the kind of storage facility available. Thus avoiding seed production every year is helpful in saving manpower and in minimizing the cost of seed produced.

Table 1: Field and seed standards for Small millets

Standard Parameters	**Minor millets**	
	Foundation seed	**Certified seed**
Field standards		
Isolation	3.00m	3.00 m
Off types	-	-
Plants affected by seed borne diseases	-	-
Seed standards	-	-
Seed standards		
Pure seed (min)	97	97
Inert matter (max)	-	-
Other crop seed (max)	10	20
ODV (max)	-	-
Weed/ seed (max)	10	20
Germination (min)	75	75
Moisture (max)	12	12
Vapour proof containers (max)	8	8

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Mahalinga S. Kannan, R. Abarna Thooyavathy,Ragul T Kasiyapa, K. Subramanian and K. Vijayalakshmi (2013) Seed Production Techniquesfor Cereals and Millets. Centre for Indian Knowledge Systems, ChennaiRevitalising Rainfed Agriculture Network

Soybean:

Soybean (Glycine max (L.) Merrill) ranks first among the oil seed crops in the world and in India both. India is the fourth ranking country in the world after United States of America, Brazil, and Argentina regarding area and fifth ranking after China regarding production. Soybean has unprecedented expansion in India by recording 15-20% annual growth rate. It has emerged very fast since early eighty's and occupied vital place in agriculture, edible oil economy, foreign exchange and upliftment of social status of soybean farmers. It contributes 20 per cent of total edible oil pool of the country. The export earnings reached to the tune of Rs. 7000 crores (Director's Report, DOSR, 2008-09). In addition, soybean offers good prospects for alleviation of wide spread protein mal nutrition.

It is the matter of special mention that, in the phenomenal revolution of soybean farming in India, Madhya Pradesh contribution has always been largest and substantial in respect of area and production of country's total. This fact has established Madhya Pradesh as synonym of SOYA STATE**.** Soybean is a major oilseed crop of the country covering an area of 6 million hectares. Owing to phenomenal spread of soybean cultivation in India, the demand for its seed has increased tremendously. The seed requirement for the present area is 45 lakh quintals while the availability of quality seed is only about 3.7 lakh quintals. The percent seed replacement rate is about 8%. The average annual breeder seed production of soybean under the aegis of AICRP on soybean, during the last five years is nearly 6000 quintals. There are 30-40 varieties in the seed chain.

Seed production in soybean has several problems. Soybean seed is classified in the least storable group. Besides its inherent low viability, soybean seed is also highly prone to mechanical injury during processing and transportation. The seed is so sensitive that even before its harvest; it can be adversely affected by field weathering. These factors affect seed germination and vigour severely and at times even maintaining the minimum germination standards (70%) till next season becomes difficult. The seed multiplication ratio in soybean is very low (1:10) and this coupled with high seed requirement, forms the major bottleneck in augmenting the availability of quality seed. Further, large quantities are prone to be rejected as either being undersized or on the basis of the presence of other distinguishable varieties (ODVs).

Floral biology and pollination

Soybean has a typical papillionaceous flower with a tubular calyx of five unequal sepal lobes and a five-parted corolla consisting of posterior banner petal, two lateral wing petals and two anterior keel petals in contact with each other but not fused. The androecium consists of 10 stamens arranged in diadelphous manner. The single pistil is unicarpellate and has one to four campylotropous ovules alternating along the posterior suture.

The elevated stamens form a ring around stigma. The pollination often occurs before the opening of flowers. The pollen is shed directly on stigma. Due to presence of cleistogamy, there is a very high percentage of self-fertilization. The natural out-crossing is generally less than 1.0%. The time from pollination to fertilization is S-10 hours. The day of opening of flowers is likely the day of fertilization or one day after it.

Important diagnostic characteristics

The morphological characteristics of plant and seed detailed in Table1 helps the soybean breeder/seed men to identify true-to-type plants of a particular variety and to rogue out off-types or undesirable types.

Table 1. Important morphological characteristics and stages of observation

S.No.	Characteristics	States	Stage of observation
1	Hypocoty 1: anthocyanin colouration	Absent/ present	Seedling
2	Plant growth habit	Erect/ semi-erect/ semi-erect to horizontal	Vegetative
3	Shape of lateral leaflets	Lanceolate/ triangular/ pointed ovate/ rounded ovate	Vegetative
4	Size of lateral leaflets	Small/ medium/ large	Vegetative
5	Time of flowering	Early/ medium /late	Start of flowering
6	Plant: growth type	Determinate/ semi-determinate/ indeterminate	Reproductive
7	Flower colour	White/ violet	Start of flowering
8	Presence of hairs on pod	Absent/ present	Reproductive
9	Pod: colour of hairs	Grey/ tawny	Reproductive
10	Plant height	Short/ medium/ tall	Vegetative/ reproductive
12	Seed size	Small/ medium/ large	Harvest maturity
13	Seed shape	Spherical/ spherical flattened/ elongated/ elongated flattened	Harvest maturity
14	Ground colour of testa (excluding hilum)	Yellow/ yellow green/ green/ brown/ black	Harvest maturity
15	Seed coat lusture	Shiny/ intermediate/ dull	Harvest maturity
16	Seed: hilum colour	Grey/ yellow/ brown/ imperfect black/ black	Harvest maturity

Nucleus seed production

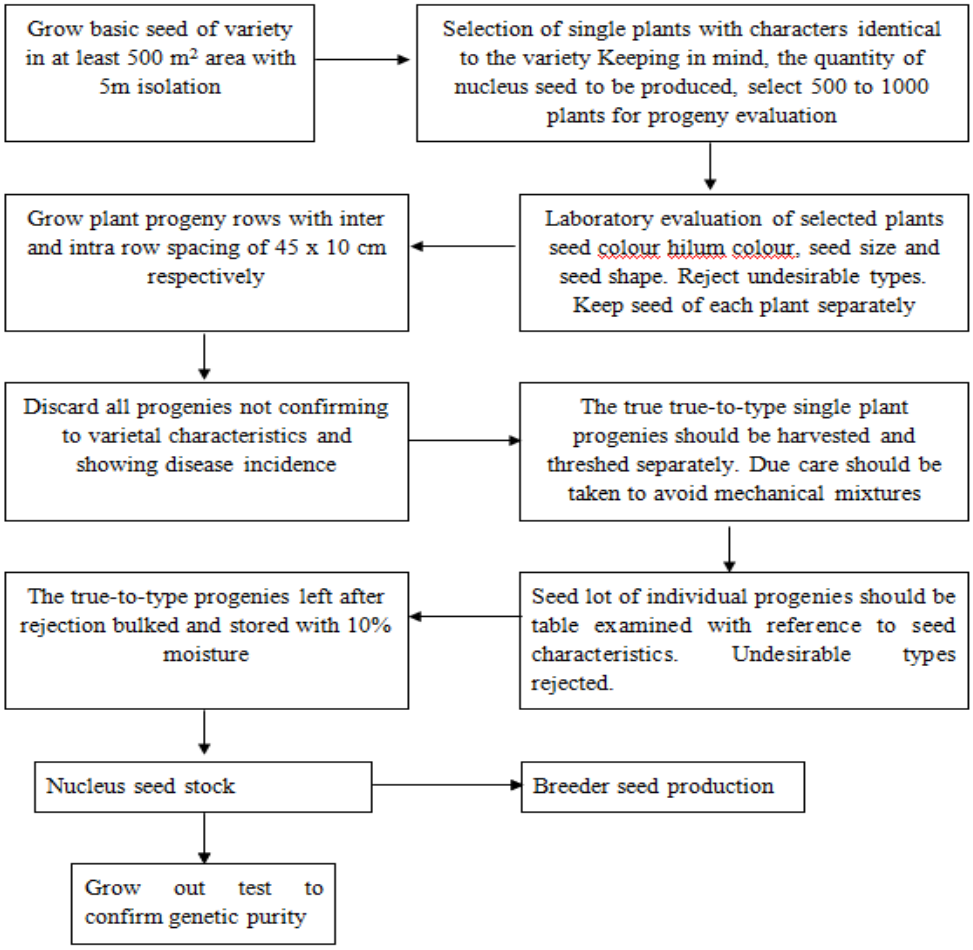
Base population: In soybean, a minimum of 500 plants should be selected for planting progeny rows. The plants should be selected uniformly from the entire population of breeder or nucleus seed plot. The actual number of plants to be selected will depend upon seed multiplication ratio and targeted quantity of breeder seed. The source of base population for pre-released varieties may be plots of Advanced Varietal Trial II.

Selection from base population: The selection of plants from base population should be on the DUS characteristics of the variety supplied by originating institute or breeder.

Harvesting/threshing of single plants: The plants are harvested at the time of maturity and dried for two days in the field. Individual plants are threshed manually to avoid mechanical damage to the seed. The seed is kept in paper packets and dried to 9-10% moisture before storage.

Table examination of seed: Individual plant seeds are examined for seed colour hilum colour, seed size and seed shape. The seed of any plant not conforming to the standard is rejected. Hilum colour in soybean is subject to occasional variation; therefore, any variation from the original variety should be specially looked for and discarded. The seeds with poor appearance and showing symptoms of seed borne diseases should also be discarded. Properly labeled seed packets are kept in cloth/gunny/polythene bags and stored at 25^0C and 50-60% RH.

Schematic diagramme of nucleus seed production in chickpea



Nucleus seed stage I

The nucleus seed plot should be well drained, clean and fertile. It should be free from volunteer plants. The single plants should be sown in single rows of 3 to 5 meter length. The distance between rows should be 45-60 cm.

Planting season: The normal planting season for soybean is kharif. The plot should be sown during the optimum period recommended for respective locations (Table 2). Soybean is a photo-sensitive and short-day crop. Delayed sowing results in poor growth and early flowering in determinate varieties.

Agronomic practices: The plot should receive farm yard manure @ 10 tons/ha. It should be fertilized with 20:60:20:20:: N: P_2 O_5 : K_2 O:S and Phorate 10G @ 10 kg/ha be applied in the furrows at the time of sowing (Table 2). Seed should be treated with Thiram +Carbendazim (2:1) @ 3g/kg seed followed by inoculation with rhizobial culture. The seed should be hand dibbled at 5 cm distances in the rows. Preventive measures should be taken to control insect pests and diseases. To control the seed borne fungi, Carbendazim @ 0.05% or Mancozeb 70WP @ 0.25% should be sprayed at R2 and R6 stages.

Observation of progeny rows: The progeny rows are continually examined for various characters throughout the growing season. The characters, their stage of observation and the variations expected are given in Table 1. The rows with off type plants are rouged. If off type is detected after flowering, adjoining rows are also removed. The purified single plant progenies are harvested separately.

Harvesting and threshing: The crop should be harvested when the seed moisture is 17-18% without delay to avoid shattering and prevent seed deterioration due to field weathering. It should be threshed manually at 13-15% seed moisture to minimize mechanical injury to seed during threshing. The seed of each progeny is table examined for seed characters and undesirable types should be rejected. The cleaned seed of selected rows should be bulked to make it nucleus seed stock. The seed should be dried to moisture of 8-9% before storage.

Nucleus seed stage II

The bulk of individual plant progenies in soybean are often designated as G0. When the demand of breeder seed is limited, this seed can be used directly for growing breeder seed. In case large quantities of breeder seed are required, this seed should be used to grow nucleus seed stage II. The seed is sown in plots of 5 meters width with a tract of 1 meter. The seed rate is kept at 80% of recommended rate for commercial crop. The crop is grown with standard package of practices. The plot is regularly examined throughout growing season. The rest of the practices are same as in nucleus seed stage I.

Breeder seed production

Seed source: The seed source for breeder seed is nucleus seed. It could be nucleus seed stage I i.e. bulk of single plant progenies or nucleus seed stage II. In exceptional circumstances, breeder seed stage I can be used to produce breeder seed stage II provided the genetic purity is maintained.

Isolation: Soybean being a highly self-pollinated crop without crossing of less than 1 % and therefore the minimum isolation distance required is 3 m for avoiding physical mixture.

Seed rate, agronomic management, plant protection measures: Seed rate is directly related to plant population which determines the yield. The seed rates to obtain optimum plant population are dependent upon seed index and germinability. The requirement is 65, 80 and 100 kg/ha for small, medium and bold seeded varieties respectively. For seed purpose, however, a population of 3.2 to 3.6 lakhs/ha is appropriate. Hence, only 80% of the commercial seed rate is to be used. The details of agronomic management and plant protection measures are detailed in Table 2.

Land: The field for breeder seed production should preferably be one compact block, well leveled and well drained. The field should be free from volunteer plants.

Sowing: The seed should be treated with Thiram + Carbendazim (2:1) @ 3g/kg seed to prevent seedling rot and ensure good stand. It should be followed by inoculation with rhizobial culture. The seed plot is sown with a cleaned seed drill in rows 45cm apart. The seed should be placed at a depth of 3-5 cm. A gap of 1 m is kept after every 18-20 rows for inspection of the plants. The agronomic practices, like weed management, inter-culture operations, disease and pest management should be as per the local recommendations.

Rouging: The breeder seed plot should be monitored minutely throughout the crop season specifically at flowering stage, pod filling and maturity stages. The off-type plants are identified on the basis of cultivar character. The rouging should be carried out under the supervision of plant breeder and rogued plants should be removed from the field.

Diseases management: Among the diseases, root rot, YMV, rust, aerial blight and other foliar diseases, pod blight etc. are the important diseases causing considerable loss in soybean. The following recommendations should be followed.

Root rot: crop rotation with cereals, deep summer ploughing, if serious incidence of disease is observed do not cultivate soybean on that piece of land.

Yellow Mosaic Virus: Control white fly (vector) by any of the recommended insecticides. Uproot plants as soon as they show the symptoms of YMV, immediately and destroy them.

Foliar diseases:

i. **Leaf spots:** Spray twice (at 35 & 50 DAS) with Carbendazim 50 WP @ 0.1%or thiophenate methyl 70 WP @ 0.05% after 35 day of sowing
ii. **Bacterial pustule:** Kasugamycin 0.2%+ Copper oxychloride 0.2% or Streptocycline 200 ppm Copper oxychloride 0.2%.
iii. **Rust: Hexaconazole** 5 EC @ 0.1% or Propiconazole 25 EC @ 0.1%or Oxycarboxin 20 EC 0.1% or Triadimefon 25 EC 0.1% At 35 and 50 DAS.

Insect management: Among the insect pests, stem borer (stem fly and girdle beetle), defoliators (semi looper, tobacco caterpillar and linseed caterpillar) and sucking (white fly, jassids and aphids) are most damaging insect - pests. Following recommendations have been given for insect- pests control.

For defoliators: Installation of Pheromone traps

Soil application:ForStem fly & White fly: Phorate 10 G @ 10 kg. / ha.

Seed treatment: ForStem fly & White fly: Thiamethoxam 70 WS@ 3g / kg seed

Foliar spray: ForGirdle beetle and defoliators: Triazophos 40 EC @ 0.8 Lit. / ha.

ForDefoliators: Rynaxypyr 20 SC @ 100 ml/ha Or Spinosad 45 SC @ 125 ml/haOr Chlorpyrifos 20 EC @ 1.5 Lit. / ha. or Quinolphos 25 EC @ 1.5 Lit. / ha.

ForMites: Ethion 50 EC @ 1.5 Lit. / ha.

ForStem fly & White fly: Ethofenprox 10 EC @ 1.0 Lit. / ha. or Thiamethoxam 25 WG @ 100 g / ha.

ForGirdle beetle: Monocrotophos 36 SL @ 0.8 Lit. / ha.

Bio insecticide for defoliators control: Breauveria bassiana@ 1.0 Lit. / ha.Or Bt @ 1.0 Lit or./ ha. Or Ha NPV or SINPV @ 250 LE / ha.

Harvesting: The soybean crop reaches harvestable maturity when the pods have lost their green color and attain the mature pod color characteristic of the variety and seed has become hard. The crop should be promptly harvested at this stage to avoid seed shattering and field deterioration. The soybean seed is highly prone to mechanical damage during harvesting if the seed moisture is below 13%. Therefore, desiccation should be avoided for the seed crop. After a few days drying when the seed moisture reaches 13-15%, the crop should be threshed either by tractor treading or by a multi crop thresher at 300-400 rpm. For direct combining, the seed moisture should be around 14%, the combine should be set carefully to avoid seed damage.

Processing: The processing should be carried out at seed moisture of 12-13%. An air screen cleaner is the most effective for soybean seed. The recommended sieve size for processing is 8.0 mm round for top screen and 4.0 mm oblong for bottom screen.

Grow out test: The breeder seed must confirm to the strict standards of genetic purity and subjected to grow out test as per the standard procedure. For ensuring genetic purity, the minimum population required for grow out test and standard procedure should be followed. The plants should be observed for various characters throughout the growing season. The off-type plants are tagged and their number is recorded.

Packaging, labeling and storage: The breeder seed should be dried to 8-9% moisture content and packed in moisture proof bags of 30-40 kg capacity. Polylined (400 gauge) jute canvas bags or HDPE bags are most suitable. It should be properly labeled and stitched. Soybean seeds deteriorate rapidly under high temperature and high humidity conditions of tropics. The seed therefore need special storage conditions to maintain their viability. A cool and dry store is recommended. The temperature in storage room should be between 20-25^{0}C and relative humidity 50-60%.

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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 Techniques in Pulses

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Seed is the basic and most critical input for sustainable agriculture. 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 15 – 20% depending upon the crop and it can be further raised up to 45% with efficient management of other inputs. The proverb "As you sow, so you reap" applies in letter and spirit to the vocation of agriculture. Thus, the quality seed is of paramount importance for sustainable growth of agricultural production. Further, Pulses have been an integral part of Indian Agriculture since time immemorial. They provide protein of high biological value in vegetarian diets overcoming malnutrition in masses. In India over a dozen pulse crops including chickpea, pigeonpea, mungbean, urdbean, cowpea, lentil, lathyrus, frenchbean, horsegram, fieldpea, moth etc. are grown in one or the other part of the country. However, the most important pulse crops grown are chickpea (48%), pigeonpea (15%), mungbean (7%), urdbean (7%), lentil (5%) and fieldpea (5%). The growth in pulse production has not kept pace with the requirements in the country. Consequently over a period of time, per capita availability and use of pulses in diet have reduced considerably. Lack of quality seed continued to be one of the greatest impediments in bridging the vast yield gap between the one realizable and being realized at the farmer's fields. It is widely felt that pulses productivity can substantially be increased if the availability of right kind of seed in time is ensured. In this endeavor, advance planning and execution of seed production programmes right from breeder seed are considered important. Also inadequate care right from seed production to its processing, storage and supply has created a vast gap between what is being actually realized and what is realisable.

With the establishment of National Seeds Corporation (NSC) in 1963 and the introduction of Seed Act in 1966, formal seed supply system in India was established that formed the backbone of the seed industry in the country. Through Seed Act it was mandatory that the seeds should meet the minimum prescribed standards of physical and genetic purity and assure percentage germination either by compulsory labelling or voluntary certification. A major re-structuring of the seed industry by Government of India through the National Seed Project Phase-I (1977-78), Phase-II (1978-79) and Phase-III (1990-1991), was carried out, which strengthened the seed infrastructure that was most needed and relevant around those times. This could be termed as a first turning point in shaping of an organized seed industry. Introduction of New Seed Development Policy (1988) was yet another significant mile stone in the Indian Seed Industry, which transformed the very character of the seed industry. The policy gave access to Indian farmers of the best of seed and planting material available anywhere on the world. The establishment of Protection of Plant Varieties and Farmers Rights Act in 2001

Seed replacement rate (SRR)

The SRR for different pulse crops in different states during the year 2011 is given in Table 1. It is apparent that against the 30%target set for different pulse crops by the end of 11th five year plan, achievements vary from 1.89 to 89.7 in case of chickpea, 3.5 to 79.7 in urdbean, 3.6 to 107.1 in mungbean, and 4.8 to 94.8 in pigeonpea in different states. All India average has been 19.4 in chickpea and 22.2 in pigeonpea which is quite low for the major pulse crops.

Table 1 : Seed replacement rate (SRR) during the year 2011

State	Chickpea	Urdbean	Mungbean	Pigeonpea
Andhra Pradesh	78.0	43.0	48.0	55.0
Karnataka	42.2	24.7	15.8	11.5
Tamil Nadu	81.7	46.7	21.5	94.8
Gujarat	16.2	34.2	18.8	21.9
Maharashtra	-	50.8	35.1	30.7
Rajasthan	12.5	6.9	18.3	21.7
Madhya Pradesh	9.9	10.3	21.2	17.2
Uttar Pradesh	16.6	-	20.8	25.5
Odisha	5.7	3.5	2.4	4.8
Bihar	15.8	18.5	20.2	11.3
Chattisgarh	15.9	8.1	3.6	20.8
Assam	-	79.7	107.1	35.6
Jharkhand	1.3	7.0	21.2	23.6
All India	19.4	34.4	30.3	22.2

Categories of Seed

The following four classes of seed are recognized in India:

1. Nucleus seed: It is the initial seed obtained from the selected individual plants of a particular variety/parental line for the purpose of purifying and maintaining that variety/ parental lines by the originating breeder and its multiplication under his own supervision or the supervision of a qualified breeder. It is used to produce breeder seed and forms the basis of the total seed production chain. True to type plants are selected individually from the space-planted basic seed stock.

2. Breeder seed: It is produced from nucleus seed under direct supervision of concerned breeder. Breeder seed shall be genetically so pure as to guarantee that in the subsequent generations *i.e.* foundation and certified classes shall confirm to the prescribed standards of genetic purity. The breeder seed is labeled with a golden yellow colored tag (Colour No. 356, IS : 5-1978) of 12 x 6 cm size and serves as the source for the initial and recurring increase of foundation seed.

3. Foundation seed: This is the progeny of breeder seed or be produced from foundation seed stage Iwhich can be clearly traced to the breeder seed. The production of foundation seed shall be supervised and approved by the certification agency and so handled as to maintain specific genetic identity and genetic purity and shall be required to confirm certification standards specified for the crop. Foundation seed produced directly from the

breeder seed is designated as foundation seed stage-I, while foundation seed produced from foundation seed stage-I is designated as foundation seed stage-II. White color tags of 15 x 7.5 cm size are used for both classes of foundation seed.

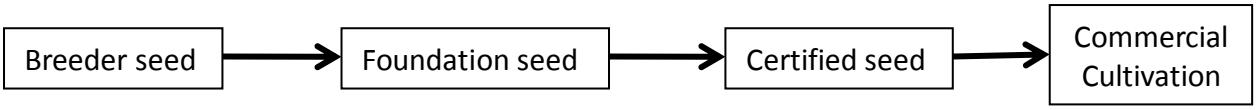
4. Certified seed: This is the class of seed produced from foundation seed and certified by a seed certification agency. Certified seed can be used to produce certified seed, provided its reproduction does not exceed three generations beyond foundation seed stage I, or can be planted by the farmers for commercial cultivation. Only notified varieties are eligible for entering into formal seed system and production of certified seed. Certified seed production is mainly undertaken by the National and State Seed Corporations. However, state agricultural universities, public and private sector seed enterprises, authorized farmers' organizations and registered seed growers can also produce certified seed from the stock of foundation seed. The color of tag for the certified seed is azure blue (shade ISI No. 104) of 15 x 7.5 cm size..

5. Truthfully labeled seed

Progressive seed growers produce the seed of released varieties, maintaining a sufficient level of genetic purity by adopting the recommended package of practices and sell it to the farmers as 'Truthfully labeled (TL) seed'.

Generation system of seed multiplication

In India, we follow 3- generation system:



The production of breeder seed is the mandate of the ICAR along with SAUs while the production of foundation and certifies seeds is the mandate of the seed industry.

Seed Certification Procedure

Seed certification is a legally sanctioned process to maintain and make available to the public high quality seeds and propagating materials of notified kind and varieties so grown and distributed as to ensure genetic identity and genetic purity.

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 seed 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; and

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

Steps involved in a seed certification programme

The following steps are involved in a standard seed certification programme in India:

Application for the grant of certificate

Every application for the grant of a certificate under Sub Section (1) of section I is required be made in Form 1 in accordance with the procedure outlined by the certification agency for submission of an application and contains the following particulars:

(a) The name, profession and place of residence of the applicant

(b) The name of the seed to be certified, it's notified kind/variety

(c) Class of seed

(d) Source of seed

(e) Limits of germination and purity of the seed

(f) Mark or label of the seed

Certificate

Every certificate granted under sub section (1) of section (9) shall be in form II and shall be granted by the certification agency, after making enquires and satisfying itself in accordance with the provision of the said sub-section on the following conditions, for the period specified by the certificate agency.

(i) The person to whom the certified is granted under sub section(3) of section (1) shall attach a certification tag to every container of the certified seed and shall follow the provisions in respect of marking or labeling provided under the Seed Act.

(ii) Certification tag shall contain the following particulars:

(a) Name and address of the certification agency

(b) Kind and variety of the seed.

(c) Lot number or other mark of the seed

(d) Name and address of the certified seed producer

(e) Date of issue of certificate

(f) Appropriate sign to designate certified seed

(g) An appropriate word denoting the class /designation of the seed

(iii) The colour of the certification tag shall be yellow for breeder seed, white for foundation seed and blue for certified seed.

(iv) The container of the certified seed shall carry a seal of such material and in such form as the certification agency may determine and no container carrying a certification tag shall be sold by the person if the tag or seal has been tampered with or removed.

(v) The holder of the certificate shall keep record of the details of each lot of the seed which is issued for sale in such form as to be available for inspection and to be easily identified by reference to the number of the lot as shown in the certification tag of each container and such records shall be contained in the case of seed for which expiry date is fixed for a period of two years from the expiry of such date.

(vi) If the certification agency so directs, the holder of the certificate shall not sell or offer for sale any lot in respect of which a sample is furnished under the proceeding clause until the agency authorize the sale of such lot.

(vii) The holder of the certificate shall on being directed by the certification agency that any part of a seed lot has been found by the said agency not to conform the prescribed standards of quality or purity of that lot from sale and so far as may in the particular circumstances of the case, be practicable, recall all issues already made from that lot.

(viii) The holder of the certificate shall comply with the provisions of the Act and Seed Rules and with the directions given after not less then one month notice by the certification agency to such holder.

(g) Inspection of seed field

Seed crops are controlled by various inspections which may be confined to standing seed crop or may also extend to drying cleaning, storage and procedures. Field inspections are done to achieve the following objectives:

I. To verify seed source and identify seed lot.

II. To collect information on cropping history of seed field.

III. To check crop and cultivation conditions

IV. To check freedom from impurities namely other crop plants and weed plants.

V. To check isolation distance.

VI. To check freedom from other cultivars and off types.

VII. To check freedom from seed borne disease.

Minimum Seed Certification standards

Quality seed is critical to agricultural production. Poor seed limits the potential yield and reduces the productivity. It is a widely accepted that seed should be tested when it is ready for sale to control verifiable qualities. In India a minimum standard is set for each attribute and a ban is enforced on the sale of seed that falls short of any minimum standard. For various activities, the corresponding factor for which standard is required, is as follows:

Activity	Standard
Field inspection	Varietal purity, isolation, seed-borne diseases, weeds
Pre- and post control tests	Varietal purity, seed-borne diseases

Seed quality test in the Laboratory	Varietal purity, analytical purity, seed health, germination and moisture content.

Specific crop standards

Specific crop standards for maintaining genetic purity and quality of seeds have been established for different crops. These specific standards are of two kinds:

1. Field standards
2. Seed Standards

Field Standards:

Field standards have been established for all those factors which affects the purity (genetic and analytical) and seed health of standing crop. The various field standards can be grouped into four categories.

(a) Land requirement (Selection of field)

(b) Minimum isolation requirements

(c) Minimum specific number of field inspections

(d) Minimum specific crop standards for

(i) Off types

(ii) Designated diseases

(iii) Objectionable weeds (designated weed species only)

(iv) Inseparable crop plants (designated species of crop plants only)

Selection of field

While selecting the field for seed production, the history of previous crop should be kept in mind

Crop	**Rotation between previous crop**
Mungbean, Urdbean,	Two seasons unless previous crop is the same variety
Pigeonpea	One seasons unless previous crop is the same variety

Isolation distance

To ensure that the pollination occurs only among plants of the desired variety, fields must be isolated either by distance or flowering time from potentially contaminating pollen sources. Isolation required depends on flower characteristics, sexual compatibility with neighbouring crops, pollen quality and viability, mode of pollen dissemination and purity standards required from specific class of seed. Recommended isolation distances may need to be increased depending upon the economic impact of contamination. Certifying agencies must inspect fields and the surrounding areas to ensure that isolation standards are met.

Table 2 : Isolation distance in different pulse crops

Crop	Isolation Distance (m)	
	Foundation seed	**Certified seed**
Chickpea, Lentil, Fieldpea Mungbean, Urdbean and Rajmash	10	5
Pigeonpea	200	100

Eliminating off-types

In field off-type plants be appropriately eliminated at different stages of seed production and utmost attention is required to rogue out plants affected particularly due to seed borne diseases and viruses. Various seed standards are presented in Table 3.

Table 3: Quality seed standards in Pulses

Crop	Plants affected by seed borne disease		Off type (%)		Other crop seed (per kg)		ODV per kg	
	F	C	F	C	F	C	F	C
Chickpea	0.1	0.2	0.1	0.2	None	5	5	10
Fieldpea	-	-	0.1	0.2	None	5	5	10
Lentil	-	-	0.1	0.2	5	10	10	20
Pigeonpea	-	-	0.1	0.2	5	10	10	20
Mungbean	0.1	0.2	0.1	0.2	5	10	10	20
Urdbean	-	-	0.1	0.2	5	10	10	20
Cowpea	0.1	0.2	0.1	0.2	None	10	5	10
Rajmash	0.1	0.2	0.1	0.2	None	None	5	10

F = Foundation seed, C = Certified seed

Designated Seed borne diseases

A number of seed borne diseases of pulses are known which are major constraints in theirproduction. Such diseases are given in Table 4. Heavily infested/contaminated seeds have adverse effect on germination leading to poor stand of crop. Therefore, growing seeds certified to be diseases free becomes indispensable for healthycrop production. Central Seed Certification Board has fixed standards for seed borne diseases of a few pulse crops viz., cowpea (stem blight, anthracnose, ascochyta blight), mungbean (halo blight), Dolichos (bacterial blight) and french bean (bacterial blight anthracnose, ascochyta blight, mosaic).

Table 4 : Seed borne diseases of pulse crop

Crop	Diseases	Causal organism
(A) Fungal		
Chickpea	Grey mold	*Botrytiscinerea*
Fieldpea	Leaf & pod spot	*Ascochytapisi*
Mungbean/Urdbean	Leaf spot	*Cercosporacanescens*
	Collar rot	*Rhizoctoniabataticola*
Cowpea	Dry root rot	*Macrophominaphaseosina*

***(B)* Bacterial**		
Mungbean	Halo blight	*Pseudomonas syringaepv. Pheseolicola*
cowpea	Blight	*P. syringaepvpisi*
	Blight	*Xanthomonascampestrispv. vignicola*
(C) Viral		
Mungbean /Urdbean	Urdbean leaf crinkle virus	
Cowpea	Cowpea severe mosaic virus	
	Cowpea aphid borne mosaic virus	
Pea	Pea seed borne mosaic virus	
French bean	Bean Common mosaic virus	
Broad bean	Broadbean stain virus	

Seed Standards

Seed standards which affect the quality of seed such as purity percentage, inert matter, other crop seeds, weed seed, other distinguishable variety seed, germination percentage, seed moisture content etc. are presented in Table 5-6

Table 5 : Seed Standards for foundation and certified seeds of Kharif pulse crops

Factor	Pigeonpea		Black gram		Green gram		Cowpea		Horse gram		Moth bean	
	F	C	F	C	F	C	F	C	F	C	F	C
Pure Seed (Min.)	98.0%	98.0%	98.0%	98.0%	98.0 %	98.0 %	98.0 %	98.0 %	98.0 %	98.0 %	98.0 %	98.0 %
Inert matter (Max.)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Other crop seeds (Max.)	5/kg	10/kg	5/kg	10/kg	5/kg	10/kg	None	10/kg	None	10/kg	5/kg	10/kg
Weed seeds (Max.)	5/kg	10/kg	5/kg	10/kg	5/kg	10/kg	N0ne	10/kg	None	None	5/kg	10/kg
Other distinguisha ble var. seed (Max.)	10/kg	20/kg	10/kg	20/kg	10/kg	20/kg	5/kg	10/kg	5/kg	10/kg	10/kg	20/kg
Germination including hard seed (Max.)	75.0%	75.0%	75.0%	75.0%	75.0 %	75.0 %	75.0 %	75.0 %	80.0 %	80.0 %	75.0 %	75.0 %
Moisture (Max.)	9.10%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%
Moisture for vapour proof Container (Max.)	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	7.0%	7.0%	8.0%	8.0%

F = Foundation Seed

C = Certified Seed

Table 6 : Seed Standards for foundation and certified seeds of Rabi pulse crops.

Factor	Chickpea		Pea		Lentil		Rajmash		Chick ling vetch	
	F	C	F	C	F	C	F	C	F	C
Pure Seed (Min.)	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
Inert matter (Max.)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Other crop seeds (Max.)	None	5/kg	None	5/kg	5/kg	1o/kg	None	None	5/kg	1o/kg
Weed seeds (Max.)	None	5/kg	None	None	1o/kg	2o/kg	None	1o/kg	5/kg	1o/kg
Other distinguishable var. seed (Max.)	5/kg	1o/kg	5/kg	1o/kg	1o/kg	2o/kg	5/kg	1o/kg	1o/kg	2o/kg
Germination including hard seed (Max.)	85.o%	85.o%	75.o%	75.o%	75.o%	75.o%	75.o%	75.o%	75.o%	75.o%
Moisture (Max.)	9.1o%	9.o%	9.o%	9.o%	9.o%	9.o%	9.o%	9.o%	9.o%	9.o%
Moisture for vapour proof Container (Max.)	8.o%	8.o%	8.o%	8.o%	8.o%	8.o%	7.o%	7.o%	8.o%	8.o%

F = Foundation seed

C = Certified seed

Characteristics of a Good Quality Seeds

Physical Purity

The seeds should be devoid of inert matter like dust, stones, seeds of other crop varieties, broken seeds, weed seeds, etc. After harvest, seeds should be separated from chaffy seeds and insect or disease affected seeds in order to maintain the physical purity of the seeds.

Pure seed (%) = $\frac{weight\ of\ pure\ seeds}{total\ weight} X\ 100$

Genetic Purity

Genetic purity of the seed should be maintained in order to ensure the quality of the seeds. The traditional and inherent characteristics of the seed should be maintained from generation to generation and is referred as genetic purity. The characteristics of the progeny should exactly resemble its mother plant.

Moisture Content of the Seeds

Seeds with high moisture content will loose its germination vigour and viability soon. Hence, it is necessary to maintain correct moisture content of the seeds in order to ensure the good

germination capacity and viability. It is also essential to protect the seeds from pest infestation and attack by diseases. Seeds should be stored at a safe moisture level of 9 – 10%. Moisture content of the seeds is measured directly using digital moisture meter.

Seed Health

Seeds with good germination capacity and seed vigour are considered as quality seeds. Seeds should be devoid of insect damage and infestation by any microbes like bacteria and fungi.

Seed viability

Standard laboratory germination or tetrazolium test are the most commonly used methods to predict the viability percentage. Germination test is conducted in 400 pure seeds in 100 X 4 or 50X 8 or 25 X 12 as per the ISTA rules (Table 7).

$$\text{Germination (\%)} = \frac{Number\ of\ normal\ seedlings}{total\ number\ of\ seeds\ plated} X\ 100$$

However, interpretation of data through this method requires atleast a week or 10 days. Tetrazolium test is a quick way to predict the viability percentage of a seed lot. It requires only about 24 hrs to estimate the viability percentage. After soaking the seeds in water for 24 hrs, seed coats are removed and seeds are soaked in the solution of tetrazolium. The viable seeds stains red colour while dead sees do not stain at all.

$$\text{Viable seed} = \frac{number\ of\ red\ stained\ seeds}{total\ number\ of\ seeds} X\ 100$$

Table 7 : Methods of testing for germination of pulse crop seeds (based on ISTA rules)

Common name	Botanical name	Substrata	Temp. (ºC)	Light	First count (days)	Final count (days)	Recom m-ended
Chickpea	*Cicerarietinum*L.	BP,S	20-30*20	-	5*	8	-
Pea	*Pisumsativum*L.	BP,S	20	-	5	8	-
Lentil	*Lens culinaris*Medik	BP,S	20	-	5	10	Prechill
Rajmash	*Phaseolus vulgaris*	BP,S	20-30 25-20	-	5	9	-
Chickling vetch	*Lathyrussativus*	S, BP	20	-	5	14	-
Pigeon Pea	*Cajanuscajan*L. Millsp	BP,S	30	-	4	6	-
Black gram	*Vignamungo*L.Hepper	BP,S	20-30, 25-20	-	4	7	Diffuse light
Green gram	*VignaradiataL.* Wilezek	BP,S	20-30, 25	-	5	7	KNO_3
Cowpea	*Vignaunguiculata*L.	BP,S	20-30, 25	-	5	8	-
Moth bean	*Vignaaconitifolia*L.	BP,S	20-30, 25	-	5	9	-
Horse	*Macrotylomauniflor*	BP	30	-	3	5	-

gram	*um*						
Broad bean	*Viciafaba*	BP,S	20	-	4	14	Prechill

- BP is the 'between paper' method and S is sand method.
- Alternate temperature of 20-30ºC i.e. 20º for 16 hours and 30ºC for 8 hours.
- Alternate temperature of 25-20ºC i.e. 25ºC for 16 hours and 20ºC for 8 hours.
- First count is taken only in paper substratum and not in sand.

Table 8: Tetrazolium testing methods for different pulse crops

Crop	Pre-conditioning	Preparation	Treatment
Chickpea (*Cicerarietinum* L.)	20ºc-16 hrs soak in water	Remove testa 0.5%TZ	3 hrs at 38º c
Field pea (*Pisumsativum)*	25 ºc-16 hrs soak-in water	Remove testa0.5% TZ	3 hrs at 38º c
Lentil (*Lens culinaris)*	20 c-16 hrs soak in water	Lateral cut/remove testa0.5% TZ	4 hrs at 38º c
Rajmash (*Phaseolus vulgaris*)	25º c-16 hrs soak in water	Remove testa 1.0%TZ	4 hrs at 38ºc
Pigeonpea (*Cajanuscajan*)	25º c-16 hrs soak in water	Remove testa0.5% TZ	3 hrs at 38º c
Black gram (*Vignamungo)*	25º c-16 hrs soak in water	Remove testa0.5% TZ	2 hrs at 38º c
Green gram (*Vignaradiata*)	25º c-16 hrs soak in water	Remove testa 0.5% TZ	3 hrs at 38ºc
Cowpea (*Vignaunguiculata)*	25º c-16 hrs soak in water	Remove testa 0.5% TZ	4 hrs at 38º c
Faba bean (*Viciafaba)*	25º c-16 hrs soak in water	Remove testa 1.0 % TZ	4 hrs at 38º c

Seed Processing

It is a process of upgrading the quality of seed by removing foreign material and undesirable seeds, improving the planting value and applying chemical protectants to seed.

Seed processing helps in following manner in quality improvement of the seed:

(i) It makes possible more uniform planting rates by proper sizing and by removing seed appendages which hinder planting.

(ii) Improves seed crop marketing by improving seed quality and maintaining dependable standards for planting seed.

(iii) Prevents the spread of weeds by removing weed seed from crop seed.

(iv) Improves crop quality by removing seeds of other crops from the pure seed of a variety

(v) Protects crops from insects-pests and diseases by chemical protectants.

(vi) Reduces seed losses by removing high moisture-foreign material and by drying seeds which are too high in moisture.

(vii) Facilitates uniform marketing by providing storage from harvest until the seed is needed for planting.

The seeds are dried and cleaned to remove the undesirable contaminants like soil particles, chaff, stones, weed seeds, other crop seeds, shriveled broken or damaged seeds. The seeds are initially cleaned by winnowing follows by grading and cleaning through a series of sieves. In addition to air screen cleaners, gravity separators, indented cylinder separators, spiral separators are also used.

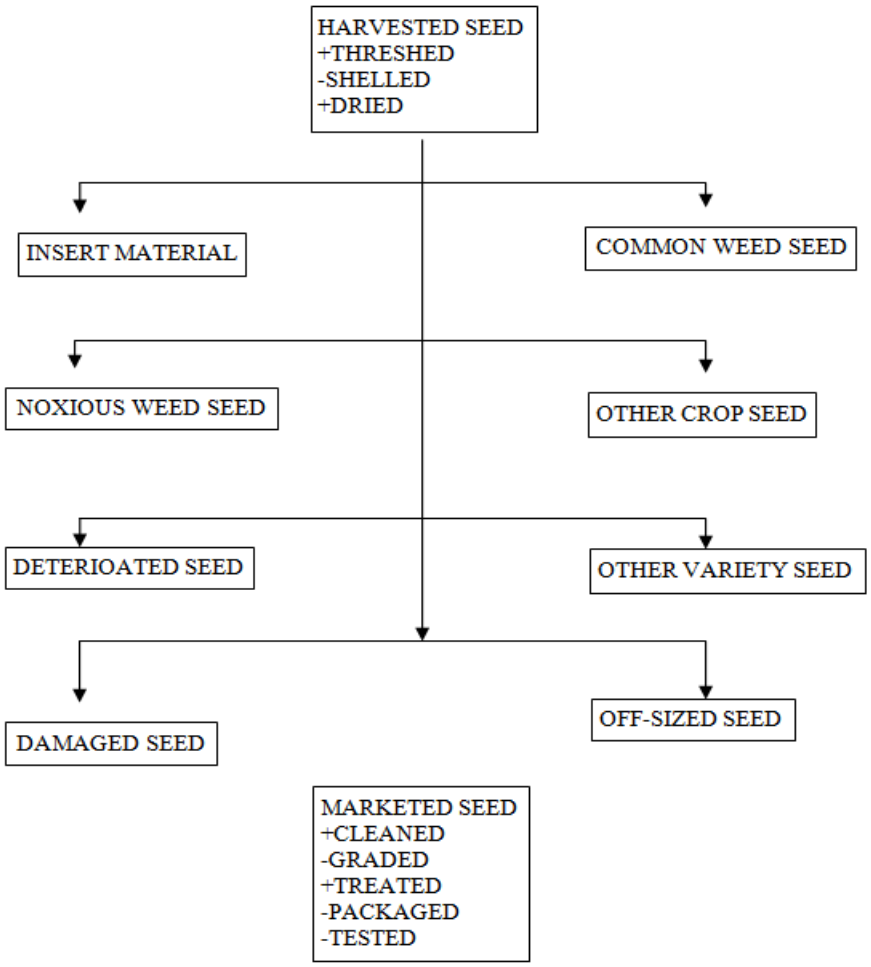


Fig. 2 : Undesirable materials removed during processing of seed

Steps Involved in seed processing

The following are the important steps of seed processing:

(i) Drying

(ii) Conditioning and pre-cleaning

(iii) Cleaning

(iv) Separation and grading

(v) Treatment

(vi) Bagging

Seed drying

In pulses, the moisture must be removed upto 9% before these are packed under air moisture proof bags. The drying characteristics of seed depend upon the structure and chemical composition of seeds and RH of air. High temperature causes decomposition of protein, necrosis of protoplasm and destruction of seed as a living organism. High protein content in pulses make these seeds having moisture content more than 30% shriveled and crack open even at low temperature of 28-30^{0}C resulting in poor quality seed. Such seeds, therefore, should be dried at low temperature restricting the drop in moisture content to not more than 3%in one cycle of drying.If the moisture content is very high then the seeds should be dried 2-3 times before it is brought to proper moisture content for storage.Generally the seed should be dried according to temperature given in following table :

Moisture content before drying	**Max. temp. (^{o}C) of hot air**
Below 18%	30-35 ^{o}C
Above 18%	22-25 ^{o}C

Separation and Grading

Separation and grading improves the quality of seeds in following ways:

(i) Seeds become free from inert matter, weed seed, other crop seed, other variety seed, deteriorated seeds and off-size seed.

(ii) Seed lots become attractive due to uniformity in seed size. Pulse seeds are generally separated and graded by using size, length, weight and shape based separators viz. specific gravity separator and spiral separator. Selection of separator depends upon the nature and kind of seeds.

Table 9 : Screen aperture size recommended for processing of pulse seeds.

Crop	**Screen aperture size in millimeter**	
	Top screen	Bottom screen
Chickpea	9.00r*, 10,00r	5.00r, 5.50r,6.00r
Pea	10.50r	6.75r
Lentil	7.00r	3.20s**, 4.00r, 4.75
Rajmash	11.0r	4.75s
Pigeonpea	9.50r	3.20s,4.00r,4.75r

Blackgram	5.00r	2.80s
Green gram	5.50r	2.80s, 3.20s
Cowpea	7.00r	3.50r, 4.00

*r = Screen with round perforations; **s = Screens with slotted (oblong) perforation

Seed Treatment

All the graded seeds are treated with suitable chemical protectants for protecting them from any damage that may be caused due to storage or soil insects and microorganisms (pathogens).

Characteristics of a good seed fungicide:

1. Effective against all seedling diseases which normally attack that crop
2. Cost-effective and easy to apply
3. Non–injurious to seed, even when applied in excess, and with prolonged storage.
4. Non injurious to the user, and non-corrosive to machinery
5. Stable in the package, on the seed and in the soil
6. Compatible with inoculants
7. Non-toxic when fed to animals

Labeling Treated Seed:

All the treated seed with toxic substances should have a special label. Regulations for labeling seed treated with toxic substance require the words 'Treated Seed" or other appropriate warning, together with the common name of the treating substances, to be shown clearly on the analysis tag or label, printed on the seed container or shown on a separate tag or label in each container. This can be shown as 'This seed treated with ---------- (Common name of the substance)' or 'Treated with --------- (common name of the substance) or Treated : or similar wording.

Bagging

To maintain the quality, bagging of seed should be strictly done in view of following consideration:

(i) Kind of seed (ii) Duration of storage

(iii) Seed rate basis (iv) Demand from purchaser

Generally, pulses may be packed in 5,10,20 and 50 kg bags according to demand. If seeds are to be carried over to the next 2-3 years, then moisture proof packing material with 8 per cent moisture content in stored seed will be ideal. The packing material should be printed and contain necessary information in respect of kind of seed, crop, variety, year of production, lot number, germination per centage, information on treated or untreated, etc.

Seed Storage

Proper storage conditions for pulse seeds are must. Storage of breeder seed at commercial level requires elaborate arrangement to protect them from damage caused due to (i) unfavourable atmospheric conditions (temperature and humidity), (ii) insect-pests, (iii) fungus and (iv) mechanical injury caused due to excessive piling of the bags. The viability of seed in storage is greatly influenced by moisture content at which the seed is stored. Seed moisture is influenced by ambient relative humidity and temperature. The seed should be stored at moisture lower than equilibrium moisture only in moisture proof bags otherwise it will absorbed moisture from the atmosphere. The seeds have minimal biological activity at moisture lower than 9-10% moisture content. Dried seeds are less affected at higher temperature in godown and therefore can be easily stored (Table 10).

Table 10 : Biological activity of seeds at different moisture contents

Moisture content of the seeds (%)	**Effect on seed**
6-12	Suitable for storage in godowns with little chances of insect damage
12-14	Seed susceptible to insect and fungal attack
18-20	Temperature and moisture of seed increase due to respiration
45-50	Germination starts

Insect-pests attack the seed at favorable moisture and temperature if these are present in the grain from the pre-harvest or in the gunny bags or present in the storage godown itself. The gunny bags should be treated with insecticides and storage godowns may be fumigated before use.

Quality Seed Production in Rapeseed and Mustard

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Rapeseed and Mustard is a rather complex group of oilseeds which comprised *Brassica rapa* (syn. *B. campestris*) var. *toria*, *Brassica rapa* var. *yellow sarson*,*Brassica rapa* var. *brown sarson; Brassica napus (*gobhi sarson*), Eruca sativa (*taramira*); Brassica juncea* (Indian mustard),*Brassica carinata* (Ethiopean musrard) and *Brassica nigra* (black mustard). Rapeseed and Mustard are phenotypically distinguished from each other on the basis their sessile and petiolated leaves, respectively. Other details are briefed as below

Species	Genome	Chromosome Number (n)	Mating System
Rapeseed			
Brassica rapa (syn. *B. campestris*) var. *toria*	A	10	Self incompatable
Brassica rapa var. *yellow sarson*	A	10	Self compatable
Brassica rapa var. *brown sarson*	A	10	Self incompatable
Brassica napus	AC	19	Self compatable
Eruca sativa	E	11	Self incompatable
Mustard			
Brassica juncea	AB	18	Self compatable
Brassica carinata	BC	17	Self compatable
Brassica nigra	B	08	Self incompatable

Morphology: Rapeseed and Mustard belong to the family Brassicaceae (Cruciferae). The plants of this grouphave a lengthy tap root system. Leaves are dark green, serrate, pinnatified and ether sessile (rapeseed) or petiolated (mustard). In *B. rapa*, the upper leaves are auriculate and clasp the stem closely, while in *B. napus* only the lower leaves are partially clasping whereas *B. juncea* they are petiolated. The inflorescence is elongate receme. The stamens are tetradynamous, means there are four long stamens and two short stamens in each flower. The flowershave four petals in the form of a cross hence the family name was previously as Cruciferae. The pods or siliqua are long narrowusually consisting of two carpels separated by a false septum, which shatters after maturity.

Diagnostic Characteristics: Rapeseed and Mustard is a very heterogeneous group therefore the diagnostic characteristics are also differed accordingly. However, the following

characteristics may be helpful for identifying the true as well off type's plants while monitoring is critically done at appropriate stages in seed production plots.

Trait	**Type**				**Growth stage**
Leaf hairiness	absent	sparse	dense		Vegetative
Leaf type	Sessile	Petiolate			Vegetative
Leaf colour	Light green	Medium green	Dark green	Purple green/ Purple	Vegetative
Leaf: Lobes number	Absent	Low	Medium	High	Vegetative
Leaf: Dentation of margin	Entire	Dentate	Serrate		Vegetative
Timeofflowering	Early	Medium	Late		Flowering
Calyx colour	Light green	Green			Flowering
Corolla colour	Yellow	Dark yellow	Cream yellow	White	Flowering
Petal shape	Narrow	Broad			Flowering
Plant height	Dwarf	Medium	Tall	Very tall	Maturity
Main raceme length	Short	Medium	Long		Maturity
Siliqua length	Short	Medium	Long		Maturity
Siliqua beak length	Short	Medium	Long		Maturity
Siliqua locule	Unilocular	Bilocular	Trilocular	Tetralocular	Maturity
Siliqua arrangement	Appressed	Semi appressed	Open		Maturity
Siliqua surface	Smooth	Undulated	Constricted		Maturity
Maturity period	Early	Medium	Late		Maturity
Seed colour	Yellow	Brown	Reddish brown	Dull grey/ Black	Maturity
Seed size	Small	Medium	Bold		Post harvest

Selection of field: Field should be properly isolated from other field of any Brassica species and also be free from volunteer plants and weeds particularly, Satyanashi *i e.,* Argemone Mexicana L. (Mexican prickly poppy) which is categorized as Objectionable weed for rapeseed-mustard seed production. The field must be well labeled and fertile. Sandy loam and loam types soils are most suitable.

Indian minimum seed certification standards prescribe a minimum isolation distance of 100 meters and 50 meters for foundation seed and 50 meters and 25 meters for certified seed production for self incompatable and self compatable types, respectively from fields of other varieties of the same species ,and fields of the same variety not confirming to varietal purityrequirements of certification; *Eruca sativa* (taramira) and any of the following species of Brassica.

Table: Brassica species from which seed fields should isolated as per IMSCS

Botanical name	Common name
Brassica juncea (L.) Czern & Coss.	Indian mustard or Rai or Bangla sarson
Brassica juncea (L.) Czern & Coss. Subsp.integrifolia (West) Thell (syn. *B.juncea* (L.) Czern & Coss.var.cuneifolia Roxb.	Vegetable mustard or Rai
Brassica juncea var. rugosa (Roxb)	Pahadi rai
Brassica chinensis Juslen non Duthie & Fuller. (syn. *B.campestris*(L.) var. dichotoma Watt.)	Brown sarson or Kali sarson
Brassica rapa(L.) var. glauca (Roxb.) Schulz. (syn *B.campestris* var. sarson prain.)	Yellow sarson or Pilli sarson or Sarish
Brassica rapa (L.) var. toria (syn. *B. campestris*(L.) var. toria Duth. &Full.)	Toria or Rai or Lahra or Maghi or Achara rai.
Brassica tournefortii Gouan	Punjabi rai or Jangali rai
Brassica nigra (L.) Koch	True mustard or Black mustard or Banarasi rai
Brassica alba (L.) Robenh	White mustard
Brassica pekinensis (Lour) Rupr	Chinese cabbage (heading)
Brassica chinese(L.)	Chinese cabbage (non-heading
Brassica rapa(L.)	Turnip

Preparation of Land: Usually one ploughing followed by three to four harrowingand

Levelingis sufficient to prepare land to desired tilth. Toria in particular requires a fairly moist seed bed for good germination.

Source of seed: Seed as per requirements either nucleus/breeder or foundation should be obtainedfrom reliable source preferably approved by a seed certification agency.

Sowing: Sowing of mustard should be done in first fortnight of October and of toria during second fortnight of September, however optimum sowing time in northern state is mainly September. Seed drill should be thoroughly cleaned before filling the nucleus/ breeder seed in it. Row to row spacing of 45 cm and plant to plant spacing of 15 cm in mustard (*B. Juncea* and *B. carinata*) and gobhi sarson (*B. napus*) and 30 cm row to row and 10 cm plant to plant spacing in toria and yellow sarson should be maintained.

Two meter space after every 25m should be left as path for monitoring, management operations and roughing of off type plants.

Fertilizer: Recommended dose of N:P:K for mustard are 80:40:40 kg/ha and for toria 50:25:25 kg/ha, respectively. Half dose of nitrogen and full dose of phosphorus and potash should be applied at sowing and remaining nitrogen should be applied at first irrigation. Application of sulphur @ 40 kg/ha and 1 kg boron should also be made at the time of sowing. Application of 25 kg zinc sulphate per hectare also gives good response in addition to the normal dose of fertilizer.

Thinning and intercultural: Thinning should be done at about 3 weeks after sowing to maintain optimum plant population followed by intercultural operation for controlling the weeds.

Irrigation: The number of irrigation depends upon the type of soil. Normally two irrigations are required first at 30-35 days after sowing and second at seed filling stage.

Roguing: The removal of off type plant should be carried out at three stages. The off type plants are distinguished on the basis of morphological characteristics which should be removed before flowering. Thereafter, the off type plants which are identified at flowering should be removed before pod formation. At late stage the off type plants should be removed on the basis of siliqua and seed characteristics and also on the basis of maturity duration. Disease infected plants should also be removed. The field should be kept free from all kinds of weed particularly from Argemone maxicana which should be uprooted altogether before it flowers.

Field monitoring: The seed production plots are being critically monitored at different stages particularly before flowering, at flowering and at maturity by the monitoring team comprising the crop/ seed breeders, representative of State/ National Seed Cooperation and State Seed Certification Agency.The monitoring report as per prescribed IMSCS should be submitted to seed producing institution which must be produced before the buying agency, if demanded.

Hybrid seed production: Hybrids have very recently been developed in mustard using different cytoplasmic genetic male sterility systems. The seedproduction technology for hybrid seed productionhas always been realized for their refinements. However, a wider row ratio of 10A and 2R/B may be adopted for hybrid seed production or for multiplication of A line. Parental lines are multiplied in different plots. The seed parent (A line) is maintained by growing the rows of A and B lines in a specific ratio. At harvesting the maintainer rows (B line) are harvested first. Later on the remaining rows of seed (A line) parent are harvested and bulked.Strict rouging is advised during flowering to rouge out the fertile plants from seed parents The seed production of B and R line is similar to any other varietal seed production The commercial F1 hybrid seed is produced by growing seed parents (A-line) and restorer line (R line) in 10:2 row ratio as followed in case of maintenance of seed parents. The rows of restorer parents (R line) are harvested first and bulked followed by harvesting of seed parent The seed from the seed parent is processed and packed as hybrids seed. Honey bee play important role in enhancing the transfer of pollen hence 3-4 honeybees boxes/ha may be kept to ensure proper pollination for good seed set.

Major diseases and their control measures:

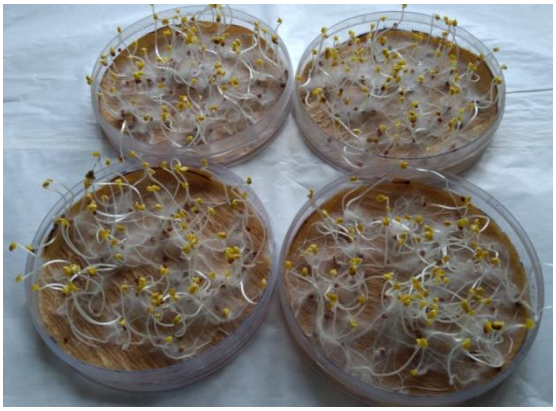
Disease	Main Symptom	Control measure
Alternaria blight caused by *Alternaria brassicae*	Brown coloured rounded spots appear on all the parts of plant with black outer ring.	Spraying of Iprodione or Mancozeb @ 0.2% at 15 days interval on disease appearance.
White rust caused by *Albugo candida*	White pustules appear on the lower surface of the leaves.	Seed treatment by Apron 35 SD@ 6g/kg seed. Spray of Ridomil M.Z. @ 025% at 50 days after sowing.
Downy mildew caused by *Peronospora parasitica*	Small creamy white spots on cotyledons at 10-15 days after sowing. Mixed infection of white rust and downy mildew is also found on leaves and stem.The most conspicuous and pronounced symptom is the infection of inflorescence causing hypertrophy of the peduncle of inflorescence and develop stag head structure.	Spraying of Mancozeb or Rodomil MZ 72 WP @0.2%at 15 days interval on disease appearance.
Powdery mildew caused by *Erysiphe cruciferarum*	• Dirty white, circular, floury patches on either sides of the leaves.Under favourable environmental conditions, entire leaves, stems, floral parts and pods are affected.The whole leaf may be covered with powdery mass.	Spraying of Mancozeb or Rodomil MZ 72 WP @0.2%at 15 days interval on disease appearance.
Sclerotinia stem rot	• It is soil borne disease.Elongated water soaked lesions appear on stem near to the crown region, covered with cottony mycelial growth later on.Brown to black sclerotial bodies may also be seen in the later stage on the infected plant parts.	Seed treatment with 0.1% a.i. Carbendazim. Foliar spray of Carbendazimm @ 0.1% at 50 and 70 days after sowing

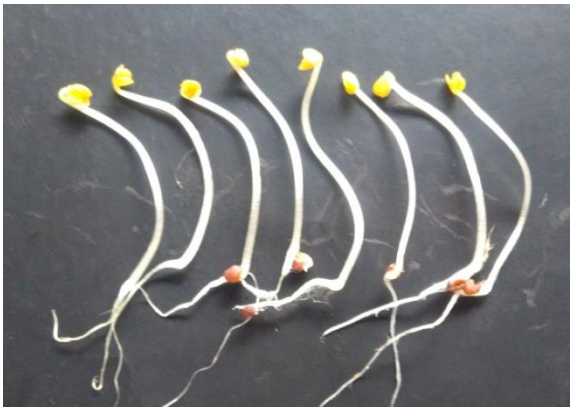
Insect-pests: Painted bug, saw fly and mustard aphid are the major insect-pests of the crops. Painted bug and Mustard saw fly may be controlled by spraying of Endosulphan 35 E.C. @ 0.035% (1 ml/litre of water). Mustard aphid causes very heavy damage to the crop. Spray of 0.025% of Metasystox 25 EC (1ml/ litre of water) is recommended for the control of aphids at 15 days interval after its first appearance on the crop.

Harvesting and threshing: Border row plant of 1 m area from all sides of the plots should first be harvested separately to maintain genetic purity. The seed plots should be harvested at the stage where 70-80% plants turn yellow. The harvested crop is staked and dried before threshing. Staking of crop is important to obtain good luster of seed. Threshing may be done either manually or by thresher. Essential precautions should be taken to avoid mechanical mixture during threshing.

Seed testing: After threshing a sample of seed is taken for seed testing laboratory for the examination in respect of seed standards. The seed purity, germination percentage and moisture content in seed are thoroughly checked in seed testing laboratory. Breeder seed is considered of high quality because it is produced under direct supervision of breeder. There are fixed seed standards for foundation and certified seed. These seed standards must be fulfilled to produce good quality seed.

Particular	**Foundation**	**Certified**
Pure Seed (minimum)	97%	97%
Inert matter	3%	3%
Other crop seed (maximum)	10/kg	20/kg
Other distinguished varieties (maximum)	0.10% (by number)	0.50% (by number)
Total weed seeds (maximum)	10/kg	20/kg
*Objectionable weed seeds (maximum)	5/kg	10/kg
Germination	85%	85%
Moisture (maximum)	8%	8%
For vapour – proof containers (maximum)		
-Mustard	5%	5%
-Rapeseed	7%	7%





Seed processing and packaging: After threshing the seed should be dried either in direct sunshine or in mechanical seed drier to bring the seed moisture down to 8%. The temperature of air in seed dried should not exceed 40^{o}C. A random sample from the dried seed is taken and analyzed for quality characters before the grading. The India Minimum Seed Certificate Standard recommends the size of screen aperture as given below for seed grading of rapeseed-mustard which vary according to the seed size of a variety.

Top screen with round perforations: 2.75, 3.00, 3.25

Bottom screen with slotted (oblong) perforations 0.90, 1.00, 1.10, 1.40 mm

The graded seed is treated with Apron 35 SD @ 6g/kg or with Thiram @2g/kg to provide protection against disease during emergence. The treated seed is packed in cloth bag and each bag is labelled. Breeder seed shall be supplied in sealed containers duly stiched and sealed. The seed should be packed in small packing because the seed rate for sowing these crops is less. The label in golden yellow colour (B/S), White (F/S) and Opel (C/S) containing information of quality attributes of the seed standards is affixed on the packing.

Storage: Seed should be dried to bring the moisture content up to 8% before storage. Seed should be stored at less than 20^{o}C and at less than 30% relative humidity (RH). The stores should be properly fumigated to avoid storage losses.

Quality Seed Production in Sunflower and Safflower

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Sunflower (*Helianthus annuus* L.) is principally a *kharif* oilseed crop. With the advent of advancements in its genetics and breeding, it is now being grown successfully in all agricultural calendar globally. It is one of the three important edible oilseed crops grown in the world, after soybean and groundnut. In India, sunflower was introduced in commercial cultivation around 1969 and being covered of 335 thousand ha with the annual production 270 thousand million tones of seed. Besides, Safflower (*Carthamus tinctorius* L.) being more or less day neutral crop but thermo-sensitive so grown as *Rabi* crop. India occupies first position in area and production in the world with about 60% area and 66% production. Maharastra and Karnatka are the major growing states with 94% area and 80% of the production. The productivity of safflower is highest in Mexico with 12 q/ha and India with 6.30 q/ha. Its oil contains 90% polyunsaturated fatty acids (PUFA) so it is good for heart patients. Suitably its dried flowers are used to treat circulatory, inflammation and muscular problems. Its petals are used for dye extraction. This crop can be grown as guard crop because of its spiny nature. Poor quality of seed is one of the serious impediments responsible for low productivity in India, which necessitates maintenance of genetics purity of varieties and parental line of hybrids to realize maximum possible yield of cultivars/ hybrid.

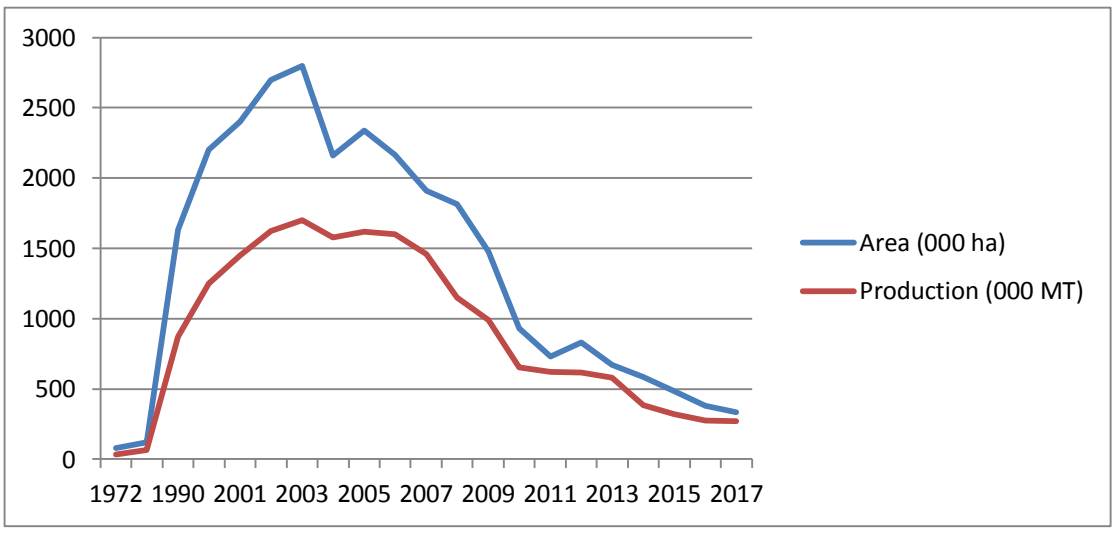

Fig.1: Area and production of Sunflower over years in India

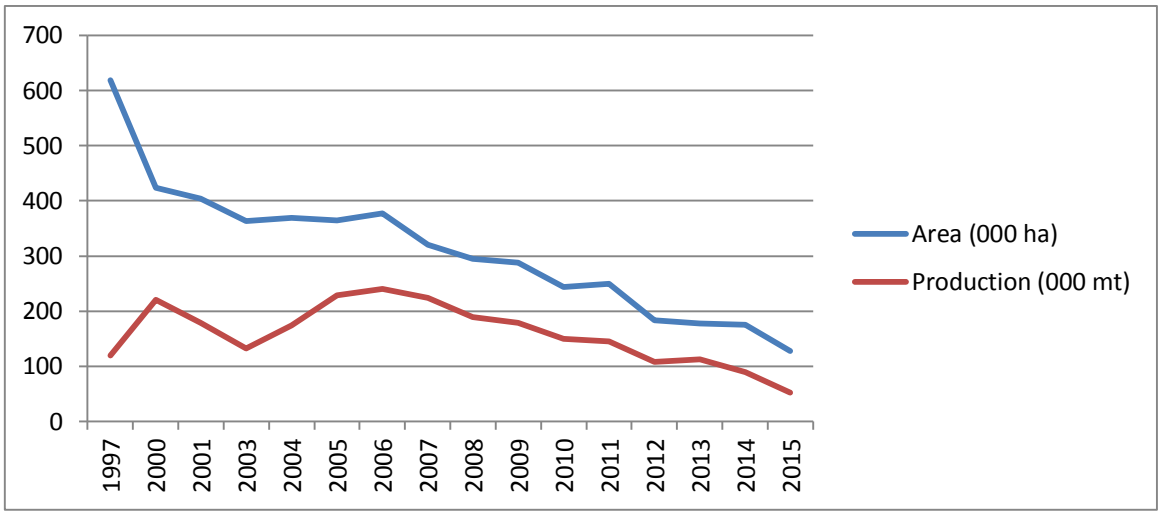

Fig.2: Area and production of Safflower over years in India

Floral biology and pollination: Sunflower: The flowering process beings with unfolding of outer rat florets. The outer whorl of disc flowers open first proceeding gradually towards the centre of the head. In general, 2 to 4 whorls open daily and complete flowering within a head in 5-8 days. Anthesis takes place in the morning hours between 06-08 h on warm sunny days. Anthesis is delayed if weather is cool, cloudy or wet. The sunflower is protandrous. Pollen is dehisced within anther tube. As the style elongates and pushes up through the anther tube, the pollen is mechanically forced out. The style continues to elongate until the stigmas emerge from the anther tube and the lobes separate, exposing their pollen receptive surfaces. Pollination and fertilization occur when the spiny viable pollen is transferred to stigmatic surface. Cross-pollination is favoured by insect, in particular, honeybees.

Safflower: Safflower is predominately a self-pollinated crop but cross-pollination generally occur to an extent of 5-40% through insects, mostly through honeybee. The inflorescence is a capitulum or head borne terminally on the main stem, secondary branches, tertiary branches and other higher order branches. Each head consists of a group of small individual flowers called florets ranging from 20-200. Flowering beings first at the inflorescence that terminates at the main plant axis. Florets at the periphery of the capitulum/flower head open first and proceed centripetally. Three to five days are required for completion of florets opening in a capitulum. The total flowering period of a whole plant varies from 3 to 4 weeks and usually takes about 25-30 days. The disc florets usually begin to open in the morning and the process continues till mid-day. A few, however, open in the afternoon also. Those remain open for one or two days before fading. The stigma remains receptive for three days.

Important Diagnostic Characteristics:

Sunflower: The following major characteristics should be taken into consideration for identification of true-to-type plants/rows and elimination of off-type in seed production plots.

Table: Important Diagnostic Characteristics in sunflower

Characteristic	State	Stage of observation
Leaf size	Very small/ small/ medium/ large/ very large	Vegetative
Leaf colour	Light green / medium green/ dark green	Vegetative
Leaf blistering	Absent/ medium/ strong	Vegetative
Fineness of serration	Fine/ medium/ coarse	Vegetative
Flowering	Early/ medium/ late	Vegetative
Ray floret colour	Ivory/ pale yellow/ yellow/ orange/ purple/ red brown/ multi coloured	Flowering
Head (Capitulum) diameter	Small/ medium/ large	Maturity
Head shape	Concave/ flat/ convex/ mis-shape	Maturity
Plant height	Very small, small/ medium/ tall/ very tall	Matutity
Seed type	Short/ medium/ long	Post harvest
Seed base colour	White/ grey/ brown/ black	Post harvest
Stripes on seed	Absent/ present	Post harvest

Safflower: With the availability of both open-pollinated varieties and hybrids in sunflower, the seed production methods followed in the two types, are distinct. Therefore identification of true –types is essential in varieties, parents as well as hybrids seed production plots. The descriptors of each variety , parental lines of hybrids and hybrids are differed distinctly. Attempt has been to elaborate such information very precisely (Table).

Table: Important Diagnostic Characteristics in safflower

Characteristic	State	Stage of observation
Plant nature	Spiny/ non-spiny	Vegetative
Growth habit	Spreading/ semi-spreading	Vegetative
Days to 50% flowering	Early/ medium/ late	Flowering
Plant height	Dwarf/ medium/ tall	Maturity
Margin of lower stem leaves	Serrate/ deeply serrate/ entire	Vegetative
Margin of upper stem leaves	Serrate/ deeply serrate/ entire	Vegetative
Colour of upper stem leaves	Dark green/ green/ light green	Vegetative
Stem colour	Green/ greenish white/ yellowish white	Vegetative
Nodes number on main stem	Less/ medium/ high	Vegetative
Internodes' length of main stem	Short/ medium/ long	Vegetative
Main stem thickness	Low/ medium/ high	Vegetative
Leaf hairiness	Non-hairy/ hairy	Vegetative
Location of branches on main stem	Predominantly basal/ upper half/ upper 2/3rd of the plant	Flowering/ maturity
Number of primary branches/ plant	Less/ medium/ high	Flowering/ maturity
Number of secondary branches/ plant	Less/ medium/ high	Flowering/ maturity
Number of tertiary branches/ plant	Less/ medium/ high	Flowering/ maturity
Corolla colour (bloom stage)	Creamy white/ white/ light orange/	Flowering

	yellowish to pale orange/ yellow/ dark yellow	
Corolla colour (Drying)	White/ dirty whitish pink/ red/ light orange/ orange/ orange red/ yellow/ pale yellow/ red yellow/	Maturity
Seed (achene) shape	Conical/ conical with taper at one end/ obpyramidal	Post- harvest
Seed (achene) colour	White/ yellowish white/ creamy white/ brownish white/ whitish yellow	Post- harvest
Pappus on seed (achene)	Absent/ mild/ medium	Post- harvest

Selection of Field: Seed multiplication should be done in its area of adaptation and under proper management to produce greater quantities of high quality seed. Both crops can be grown on variety of soils but well drained, neutral and fertile soils are best suited for seed production. The land selected should not have been raised with respective crops during the previous year. The extent of cross-pollination varies 17 to 62 % in sunflower and 5 to 40% in safflower depending insects' activity. Accordingly, the seed field must be ensured at least 1000 m and 500-600 m isolation for nucleus and breeder seed categories of open pollinated varieties and parental lines or hybrid cultivars for sunflower and safflower, respectively, 400 meters for foundation seed and 200 meters for certified seed for field of other varieties, same variety not conforming to variety purity requirements in both the crops..

Preparation of land: Usually one deep ploughing, two to three harrowing followed by leveling are adequate to prepare the field to the desired tilth.

Sowing time: Sunflower, unlike most other crops, is not season bound crop. Barring the periods of extreme freezing temperatures the sowing time can be adjusted as per availability of land for planting. However, sowing should be so adjusted that the maturity of the crop does not coincide with the rains, since rains during maturity period adversely affects the seed quality. Post rainy (*Rabi*) and summer season in the conventional sunflower growing areas (Peninsula India) and spring in northern parts have been identified as best for seed multiplication. The best sowing time of safflower seed crop is October.

Source of seed: Obtain nucleus/breeder/ foundation seed from the source approved by the seed certification agency.

Method of sowing: The crop should be sown in rows. The depth of seeding should be 2 to 4 cm.

Spacing: Row to row spacing of 45- 60 cm and 25-30 cm within a row is prescribed for varieties and parental lines of a hybrid cultivar.

Seed rate: 6 kg/ha for variety; 3.75kg/ha of 'A' line and 1.25kg/ha of 'B' line for 'A' x 'B' seed production and 5 kg/hg for 'R' line (pollen parent).

Fertilizers and their application:

Sunflower: The fertilizers required for raising a good sunflower crop is 80 kg nitrogen, 40 kg phosphorus and 40 kg potash per hectare. At the time of planting 50 kg nitrogen and the full amount of phosphorus and potash should be applied as a basal dose and the remaining 30 kg nitrogen at the time of earthing *i e.*, after 40 to 45 days of crop growth.

Safflower: Basal application of 10-25 kg N per hectare and 30-50 kg Phosphorus (on Phosphorus deficient soils); and top dressing of 10-25 kg N per hectare at the time of flowering results in substantial increase in seed yield.

Irrigation: Pre-sowing irrigation is necessary in the spring to summer season, and desirable for rabi sowing for uniform germination and better stand. Sunflower is comparatively drought-tolerant and yields higher than sister oilseed crop under moisture stress conditions.In rabi and zaid planting two and four irrigation respectively, are necessary for higher yield. In kharif, if rainfall distribution is favourable, no irrigation may be required. One irrigation between the flowering and grain filling stages must be applied. In the case of safflower, after weeding and hoeing one or two irrigations improves seed yield. Irrigation is more important at bud stage. Late irrigations or too much nitrogen delays harvesting.

Weeding and intercultural operations: One to two weeding during the first six weeks after germination are necessary. Thereafter growth rate is higher and the crop covers the ground and smothers most of the weeds. Wild *Helianthus* spp. And Carthmus spp. Are the objectionable weed in sunflower and safflower, respectively.. Care should always been taken to keep the field free from such weeds.

Earthing: The sunflower plants may root lodge because of large heavy heads. Earthing, preferably before and, if needed after irrigation around 48 days after sowing is highly desirable. 10 to 15 cm high earthing is sufficient.

Supplementary Pollination: Placing of bee-hives on the field periphery or on blank strips approximately at 200 meter intervals has been found beneficial for cross-pollination and seed set.

Hand-pollination may also be restored to. Sunflower heads are gently rubbed with bare palm or covered with muslin cloth during the anthesis period between 7am to 11am alternate days for about two weeks.

Plant protection:

Sunflower:

Diseases: Alternaria blight may assume serious proportions in the rainy season and may reduce yields drastically. The dark brown and black coloured spots, if seen on any plant part, should be immediately sprayed with 0.25 % of Dithane M-45 or Dithane Z-78 at one to two weeks intervals. Other diseases of minor importance are: Sclerotium wilt in July and August planting; Sclerotinia wilt in winter; and charcoal rot in March planting. The affected plants

should be uprooted and burnt. Growing of sunflower in longer duration rotational cycles is recommended.

Pests and birds:

Insects: No serious pest of sunflower has been noticed. The crop should be watched against attack by cur worms during the seeding stage, for head borer damage at the bloom stage and for jassid attack all the time. Mixing of 5 % Heptachlor dust in soil at 15 kg per hectare will control cut worms and one to two sprays of 0.025 % Metasystox (25E.C.) will take care of the other two insects.

Bird damage: In lonely maturing fields of sunflower, birds may cause extensive damage, particularly when no other seasonal crop is in the grain stage. Bird watching in such cases is imperative. In planting with or after the seasonal crops the bird damage is minimal.

Safflower: Spray the crop with 0.1 % Fenithion for control of aphids, with 0.03 % Dimathoate for thrips; and with 0.07 % Endosulfan for safflower bud fly. For control of bacterial blight spray the crop with Streptocycline 500 ppm two to three times.

Roguing: Roguings are required at pre-flowering, flowering and before harvesting stages. Before flowering, tall, very early, very late, branched as well as weak, wild and diseased plants should be roughed out. At the time of 75 % crop maturity; wild, ornamental, diseased, damaged and all those plants which do not conform to the characteristics of the variety/ hybrids under seed production, should be roughed out. In addition to these, plant affected by wilt, charcoal rot, blight, etc. should also be removed from time to time as required. In the case of safflower, the best time to remove off-type plants is just before the spines appear. All off-types including those of collar are removed.

Precautions in Roguing: Sunflower head continues to develop and shed viable pollen even after removal from stalk. It is therefore, important that the heads after removal from stalks are turned down (face down on the soil) while throwing them on ground.

Sunflower is phototropic until the early stage of flowering. After ray florets are fully developed, the head generally faces the east. This feature makes rouging inefficient, if the row direction is east/west. If the direction is north-south, this problem is eliminated. It is therefore important that roguing is always done looking westward at the heads.

Harvesting and Threshing: The crop is ready for harvesting when the top leaves are dry and flowers are shriveled. Heads may be removed with shears or knife. Heads cutting are sun dried in the threshing floor. Hand threshing can also be done by rubbing seed heads on a metal sheet or beating with sticks. Threshed seed must be dried to eight to ten % moisture before storage.

Seed yield: A good crop may give an average yield of 15q per hectare

Production of Hybrid Seed:

Sunflower: Hybrid Sunflower is produced by using cytoplasmic male sterility and genetic fertility restoration system. The male sterile line A line) contains sterile cytoplasm and recessive genes for fertility restoration. This is maintained by a male fertile counterpart (B line) which also contains recessive genes, but has fertile cytoplasm. Hybrid seed production is involved the crossing of a male sterile line (A line) with a fertility restoring line (R line) which has the dominant gene for fertility restoration, but may have either sterile or fertile cytoplasm. The restorer line (R line) should nick well with A line to produce hybrid seed. The production of seed either A line (A x B) or Hybrid (A x R) seed is done in an isolated field as mentioned earlier in preferably 3:1 planting ratio. The first two border rows around the field of male parent (B or R) may be sown in order to ensure enough pollen supply. The male fertile plants should be removed each day during the entire flowering period. This could be best done in the morning hours before the bees have removed the pollen. Supplementary pollination may be done by gentle rubbing of palm on the male parent flowers and thereafter on the stigmas of the female line to transfer the pollen. The male parent rows should be harvested first prior to harvest of female rows to avoid any sort of contamination. No heads of male parent should be left intermingled with the female parent rows.

Sunflower: Hybrid of safflower is developed using genetic male sterility system (GMS) which is recessive in nature. Since female parent is a GMS line, it segregates in to 50% male sterile (MS) and 50% male fertile (MF) progenies in seed production plots. The identification of MS and MF plants in GMS lines is only possible at flowering stage from the pinched brush like capitulum opening in MS plants and normal capitulum in case of fertile plants. Besides, no pollen production is observed in sterile plants whereas; abundant pollen is produced in the fertile plants. Florets of fertile plants are big and fully opened whereas those of sterile plants are small and not wide opened. Style of fertile plants is longer than that of sterile flower. The marking of MS plants is necessary and done by tagging all MS plants at the time of perfect bloom. Delay may cause confusion in differentiating MS and MF plants. Harvest seed only from male sterile plants. Rigorous monitoring is done throughout growing season for any variation or off-types. Undesirable rows, if noticed should be rogued out immediately. Harvesting of MS plants is done first in order to avoid any physical mixing of the seed with seeds from fertile plants. While threshing the MS plants, check the tag on the plants to avoid mechanical mixing of fertile plants. The seed from sterile plants should be screened for the seed characteristics described pertinent to respective hybrid and its parental lines.

Seed testing: After threshing, a sample of seed is taken for seed testing laboratory for the examination in respect of seed standards. The seed purity, germination percentage and moisture content in seed are thoroughly checked in seed testing laboratory. Breeder seed is considered of high quality because it is produced under direct supervision of breeder. There are fixed seed standards for foundation and certified seed. These seed standards must be fulfilled to produce good quality seed.

Table: Indian Minimum Seed Certification Standards for foundation seed (F/S) and certified seed (C/S) in sunflower and safflower

Particular	**Sunflower**		**Safflower**	
	F/ S	**C/ S**	**F/ S**	**C/ S**
Pure Seed (%, minimum)	98	98	98	98
Inert matter (%minimum)	2	2	2	2
Other crop seed (no./kg, maximum)	None	None	None	None
Other distinguished varieties (maximum)	-	-	-	-
Total weed seeds (no. /kg, maximum)	5	10	5	10
*Objectionable weed seeds ((no. /kg, maximum)	None (wild Helianthus spp.)	None (wild Helianthus spp.)	None (wild safflower)	None(wild safflower)
Germination (%)	70	70	80	80
Moisture content (%, maximum)	9	9	9	9
For vapour – proof containers (%, maximum)	7	7	7	7
Maximum husk less seeds	2	2	-	-

Seed processing and packaging: After threshing the seed should be dried either in direct sunshine or in mechanical seed drier to bring the seed moisture down to 9%. The temperature of air in seed dried should not exceed 40^{o}C. A random sample from the dried seed is taken and analyzed for quality characters before the grading.

The graded seed is treated with Apron 35 SD @ 6g/kg or with Thiram @2g/kg to provide protection against disease during emergence. The treated seed is packed in cloth bag and each bag is labeled. Breeder seed shall be supplied in sealed containers duly stitched and sealed. The seed should be packed in small packing because the seed rate for sowing these crops is less. The label in golden yellow colour (B/S), White (F/S) and Opel (C/S) containing information of quality attributes of the seed standards is affixed on the packing.

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www.sopa.org/india-oilseeds

Seed Processing – Brief Overview

Udaya bhaskar K., Radhika C., Ramesh K. V., Govind Pal and Dinesh K. Agarwal

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.

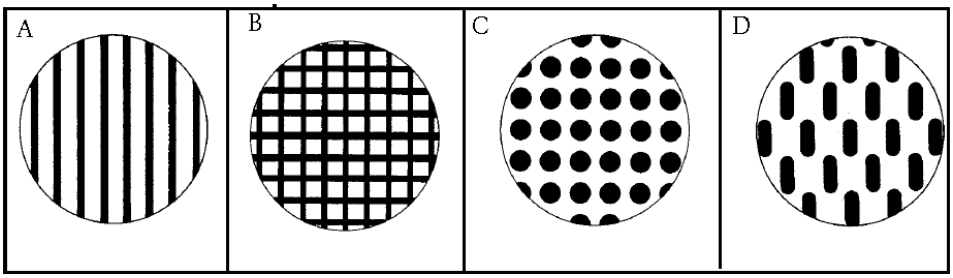
2. A sieve with openings smaller than the seed retains the seeds while smaller debris passes through. The holes are adjusted to retain the smallest viable seeds. Sometimes several screens with gradually decreasing mesh or hole sizes may be used and the seeds graded according to size. The grading may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

Sripathy K. V., Udaya bhaskar K., Vijayakumar H. P. and Dinesh K. Agarwal

Introduction

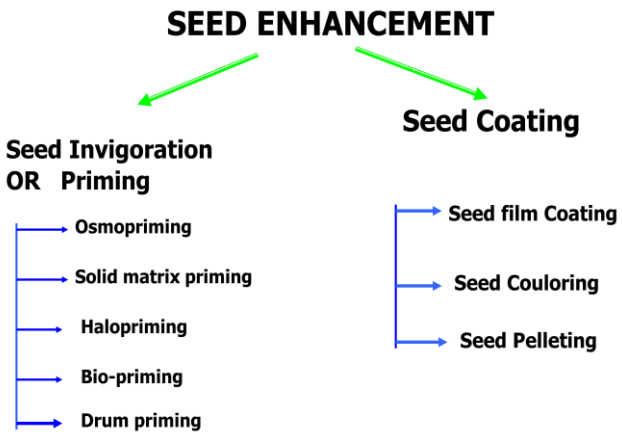
Any post harvest treatment that improves germination/seedlings emergence or facilitate the development of more number of normal, rapid, uniform and healthy seedlings in the field condition is termed as seed enhancement (M C Donald, 2000).

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).

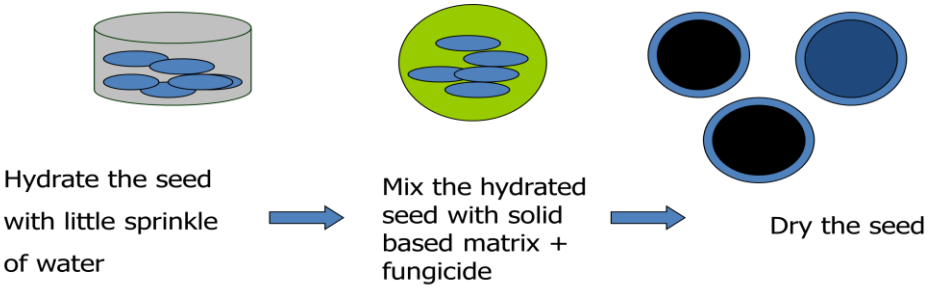
In priming osmotic potential of the solution is lowered due to solute accumulation in the embryo, which might generate sufficient turgor pressure to overcome endosperm/seed coat restraint (Bradford, 1986).

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

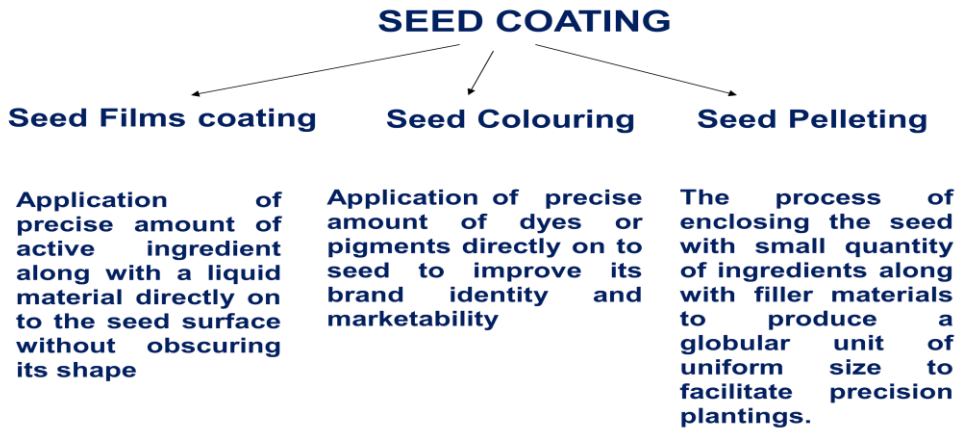
- Accelerates rapid germination and growth rate of seedling
- Plants recover much more quickly from abiotic stress than those from untreated plants.
- Flowering is slightly accelerated.
- Induces resistance to salinity / alkalinity and drought.
- Seeds are able to withstand high temperature [80-105 c) 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	Sherin Susan jhon 2003.

	(1ml diluted in 5ml of water) improved plant stand, establishment, crop growth and yield potential compare to uncoated seeds.	

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

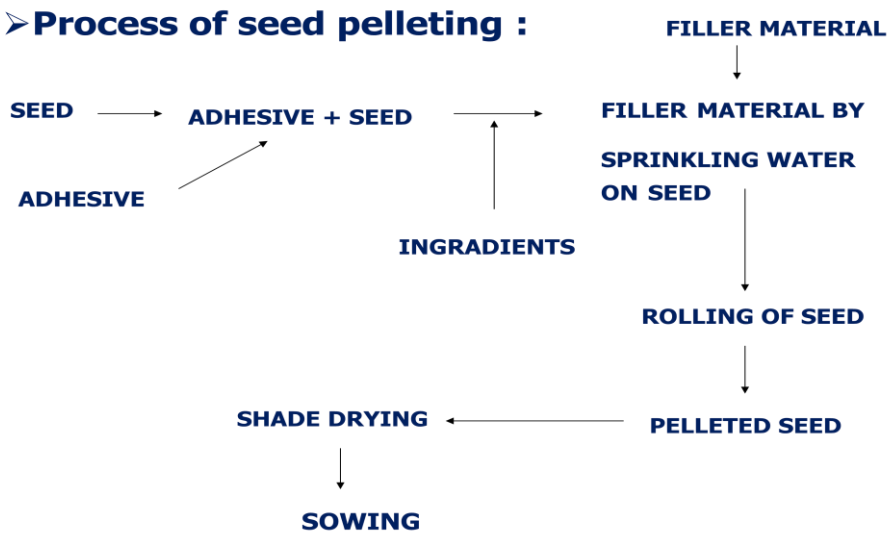
Seed pelleting is the mechanism of applying needed materials in such a way that they influence the seed or soil and the seed- soil interface (Scott 1989).

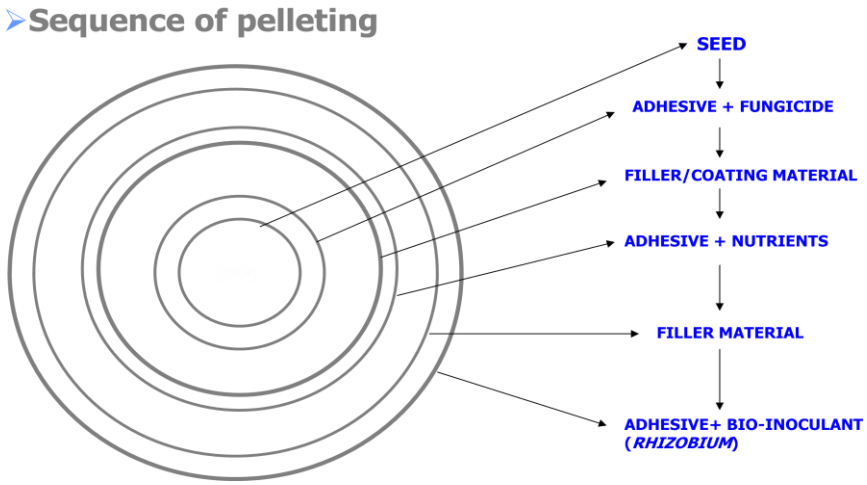
Seed pelleting technique: Three basic steps

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.

Basic Principles of Seed Storage: Accentuation on Community Seed Banks

Udaya bhaskar K., Radhika C., Vijayakumar H.P., Sripathy K. V. and Umesh R. Kamble

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.

Seed Quality Assurance during Storage–Seed Health Management

Heavy losses have been recorded in the course of seed storage throughout the world. Importance of the additional seed that can be made available for production and consumption by pest free/ pest controlled storage is intensely felt during unfavourable agricultural years. Surplus grains produced in the country only aggravate storage problems. Increasingly, attention is being focused on minimizing storage losses depending on available knowledge. In the past fifty years, a number of research reviews and books have been published in the filed of biology, bionomics and control in stored seeds through various gadgets.

More than 65 per cent of the total grain produced is retained and stored by the farmers for food, feed and seed purposes till the next harvest. It is estimated that about 5-8 per cent of grains are retained for seed, about 20 per cent is hand pounded and the rest is milled.

To the present level of production, an additional 150 million tonnes food grain production has to be achieved to feed almost 1.5 million people by 2040. Thus, our effects to augment production of food grain, have to be supported with strategies to lower the storage losses.

Many think, the damage to the seeds occur during storage only; hence management of insect pests in storage only is targeted. Inspite of proper management, the damage in storage continues to be enormous. This is so, because some of he major storage pests have been observed to infest/multiply under field conditions, which are carried over to storage along with the harvested grains. The losses during threshing (1.68%), transportation (0.15%), processing (0.92%) and storage (6.58%) amount to almost 8-9 per cent.

Seed security is key to the attainment of household food security among resource poor farmers in developing countries. Seed is a valuable commodity. Like most biological materials, seed is also vulnerable to many factors that can cause deterioration during storage. Temperature and relative humidity of the storage environment, damage from insects or rodents can all contribute to loss of seed quality.

Majority of storage pests recorded in India belong to orders Coleoptera and Lepidoptera. Based on the nature of damage and their feeding habit, they are grouped as internal feeders and external feeders.

A. Internal feeders

1. Weevils : **Family**: Curculionidae **Order**: Coleoptera

Scientific names	Common names
1. *Sitophilus oryzae* (L.)	Rice black Weevil
2. *S. Zeamais* (Motsch)	Maize weevil
3. *S. granaries* (L.)	Granary weevil

Rice Weevil, *Sitophilus oryzae* (L.)

Identification

- Size of an adult is around 3 mm with long snout or beak
- The body colour appears to be brown or black
- On close observation, four orange / red spots are arranged in cross on the wing covers
- It can able to fly.

Maize Weevil, *S. Zeamais* (Motsch)

Identification

- Close relative of rice weevil with 2.5 to 4 mm size
- Small brown weevil has four reddish brown spots on the wing covers (elytra).
- It has a long, thin snout and elbowed antennae
- It appears similar to the rice weevil, but has more clearly marked spots on the wing covers and is somewhat larger.
- It can able to fly.

Granary weevil, *S. granaries* (L.)

Identification

- Adult weevils are about 3 to 5 mm size with elongate snout.
- The adults are radish brown in colour and lack distinguishing marks.
- It cannot able to fly

Commodities damaged

Wheat, rice, maize, sorghum and paddy (rarely)

2. Lesser Grain Borer

Scientific Name	**Common Name**	**Family**:	**Orde**r:
Rhyzopertha	Lesser Grain Borer,	Bostrichidae	Coleoptera

dominica (Fab.)	Hood Grain Borer, Paddy Borer Beetle		

Identification

- Adults are 3-4 mm in size
- Large pronotum appearing to have only two body sections
- It has got 3 distinct antennal clubs with last 3 segments are larger than the other segments.
- The shape of the posterior area of the elytra is rounded.

Nature of damage

Irregular holes (c.f.: Weevils) in bagged storage, irregular messy waste flour spots indicate infestation of this pest. Heating is very common. Localized infestation is almost a rule. Both adults and larvae cause damage and are voracious feeders. Seed kernels are reduced to mere shells. The damaged kernels remain engulfed in a film of waste flour.

Commodities damaged

Paddy, rice, wheat, maize, millets, coriander, oats, chilli and turmeric. It attacks paddy more easily than *S. oryzae.*

3. Pulse beetles **Family:** Chrysomelidae, Bruchinae **Order:** Coleoptera

Scientific names	Common names
Callosobruchus maculates (F.)	Pulse beetles
C. chinensis L.	
C. theobromae	
C. analis	

Identification

***Callosobruchus maculates* (F.)**

- Small, short, active with long conspicuous serrate antennae, 3 to 4 mm in size.
- Colour is reddish brown, slightly elongated beetle
- Wing covers are marked with black and gray with two black spots near the middle.

Pulse Beetle, *Callosobruchus chinensis* L.

- It is 3 to 4 mm in size long oval shaped chocolate coloured body it is pointed towards front.
- The size of the adult beetle depends on the size of the

infested pulse.

- There are dark patches on elytra and thorax.
- Elytra do not cover the abdomen completely.

Nature of damage

Larvae eat up the grain, kernel and make a cavity. Adults are short lived, harmless and do not feed on stored produce at all. The infestation starts from the filed its self because the beetle can actively fly.

Commodities attacked

Practically whole pulses such red gram, greengram, blackgram, bean, cowpea, soybean.

4. Grain moth

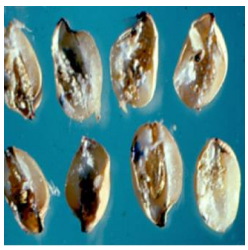
Scientific name	Common Name	Family	Order
Sitotroga cerealella (Olivier)	Angoumois grain moth	Gelechiidae	Lepidoptera

Identification:

- Size 8 to 10 mm. Moth yellowish brown with wings completely folded over back in sloping manner. Wing expanse 10-14 mm.\
- Hind wings with sharp pointing apical end and bearing heavy fringe of bristles.
- Leaves small dirty specks on window pans and walls.

Nature of damage

It is a primary pest. Only larvae damage grains, adults being harmless. Grains are hollowed out. It attacks in field and stores too. In stored bulk grains, infestation confined to upper 30cms depth only. Hole is circular with characteristic ‘flap’ or ‘trap door’.



Commodities attacked

Paddy, maize, sorghum, barley and wheat (rarely). It is not capable of attacking milled rice or other cereal products.

5. Tamarind beetle

Scientific name	Common Name	Family	Order
Caryedon serratus	Tamarind beetle,	Chrysomelidae,	Coleoptera

(Olivier)	Groundnut bruchid	Pachymerinae	

Identification:

- Adult beetle is robust brunched. Reddish brown cuticle densely clothed with grey brown setae but with dark markings on the elytra
- The pygidium in the female fully visible from above.
- Each hind femur bears a conspicuous ventral comb of one large spine and 8 to 12 smaller ones.
- The full grown larvae are migratory in nature and reddish brown and fleshy

Nature of damage:

Larvae bore into the groundnut is revealed by larval emergence holes and the presence of cocoons outside the pods. Feeding damage to the seeds can be seen when infested pods split open.

Commodities attacked

Tamarind pods, Groundnut pods, wild tree legumes like *Cassia*, *Acacia*, *Bauhinia*, etc.

B. External Feeders

1. Khapra beetle

Scientific name	**Common Name**	**Family**	**Order**
Trogoderma granarium Everts	Khapra beetle	Dermestidae	Coleoptera

Identification

- Adult size 1.5 to 3mm, convex, oval in shape with practically no distinct division of head, thorax and abdomen. Abdomen size is comparatively larger.
- Sexual dimorphism is well developed, males being smaller in size than females.
- Larvae are straw coloured with dark brown hairy bands on each segment and typical posterior tuft forming a trail of long hairs, size 0.5 to 5mm

Nature of damage

Being a primary pest, it damages the grain starting with germ portion, surface scratching and devouring the grain. Actually it reduces grain into frass. Excessive moulting creates public loss and market appeal due to insanitation caused by the cast skins, frass, and hair. Crowding of larvae leads to unhygienic conditions in warehouses. Damage is confined to peripheral layers of bags to a depth of 30 to 50 cm in bulk storage.

Commodities attacked

Wheat, maize, sorghum, rice, pulse, oilseeds and their cakes.

2. Rust red Flour beetle

Scientific name	Common Name	Family	Order
Tribolium castaneum (Herbst.) *T. confusum* Duval	Rust red flour beetle Confused flour beetle	Tenebrionidae	Coleoptera

Identification:

- *Tribolium castaneum* is reddish brown and antennae end with 3 segmented club.
- *T. castaneum* is same in colour, antennae end in a gradual club, the club consisting of four segments.

Nature of damage:

Both adults and larvae feed on milled products. Flour beetles are secondary pests of all grains and primary pests of flour and other milled products. In grains, embryo or germ portion is preferred for feeding.

Commodities attacked:

Groundnut, oats, lima bean, rice barley, walnuts, peas etc.

3. Saw toothed grain beetle

Scientific name	Common Name	Family	Order
Oryzaephilus surinamensis (L.)	Saw toothed grain beetle	Silvanidae	Coleoptera

Identification:

1. Narrow, flattened, 2.5-3.0 mm long
2. Thorax having teeth like serrations on each side
3. Antennae clubbed
4. Elytra cover abdomen completely
5. Adults are winged but they rarely fly

Nature of damage

Adults and larvae cause roughening of grain surface and off odour in grain. Grains with higher percentage of broken, dockage and foreign matter sustain heavy infestation which leads to heating of grain.

Commodities damaged

Rice, wheat, maize, cereal, products, and dry fruits.

4. Warehouse moth

Scientific name	Common Name	Family	Order
Ephesita cautella	Fig or almond moth	phycitidae	Lepidoptera

Identification:

- Size 13 mm, wings expanse 2.0- 2.5 mm
- Wings are dirty white in colour with distinct black bands about 4 mm from the head
- It rests with sloped wings over the body almost like the slanting roof of warehouses
- Being nocturnal, rests in dark places during day time. It sometimes files during day time also; usually it is active at dust when temperature and R.H. fluctuations occur.

Nature of damage

Only larval stage is harmful. It manly feeds on germ portion leaving the rest of the kernel undamaged. In bulk infestation, its damage is limited to peripheral top layers only. Web formation covers the bags, floor space and mill machinery thereby leading to clogging in mills.

Commodities attacked

Wheat, rice, maize, sorghum, groundnut, spices

5. Indian meal moth

Scientific name	Common Name	Family	Order
Plodia interpunctella (Hubner)	Meal worm moth	Phycitidae	Coleoptera

Identification:

- Fore wing basal half silver white or greyish, outer 2/3 portion is reddish, copper bronze lustre with irregular bands.
- Hind wings long, silvery, darker with reddish scales
- Thorax is slightly darker with reddish scale
- Hind tibia robust
- When the insect is at rest, antennae 2/3 of the body size cross and rest on the wings

Nature of damage

Primary pest, cause serious damage to ear and grains of maize, contaminates the grains with excrement, cast skins, webbing, dead individuals and cocoons; prefers to eat germ portion and hence grains lose viability.

Commodities Attacked

Maize, cereals, dry fruits, groundnuts and cereal products

6. Rice moth

Scientific name	Common Name	Family	Order
Corcyra cephalonica (Stainten)	Rice moth	Galleriidae	Lepidoptera

Identification:

- Spot free informally pale buff brown colour
- Wing expanse 25 mm
- Fore wings with dark views
- Cocoons dense white and tough
- Larvae with conical prolegs on abdominal segments

Nature of damage

Larva is only responsible for damage. It pollutes food grains with frass, moults and dense webbing, in case of whole grains, kernels are bound into lumps up to 2 kg .

Commodities Attacked

Rice, sorghum, other millets whole cereals, cereal products, dals, processed products of cereals, pulses, oil seeds, nuts, dry fruits and milled spices.

Sources of infestation of stored products by insects

The belief is that, the insect outbreak in stored products is spontaneous cannot be true as stored grain insects, originate chiefly from indigenous insect populations. The main sources of infestation are

i. Field infestation

ii. Infestation by migration

iii. Infestation through conveyance

iv. Infestation through storage building or structure, bird's nests and ant's, rodent burrows, etc.

Impact on Seed Quality:

Many of the storage insect pests were known to feed on the embryo of the seed which results in germination failure ultimately, the seeds are unfit for sowing. ISTA organisation has fixed minimum standard for insect infestation. They have fixed 0.5% damage for cereals and 1.0% damage for pulses. If it crosses more then the prescribed damage the lot will be rejected for seed purpose. However, experiments carried at our centre revealed that even after 4 percent damage, the germination was above 96% in both cereals as well as pulses, which clearly indicates their is need for modification of standards fixed by ISTA.

Management of insect pests of stored seeds

Control of insect pests

Amongst the present methods of insect control, following are the important methods which can help in safe storage of seeds particularly at farmer's level.

1. Preventive measures
2. Curative measures

Preventive measures

"Prevention is better than cure" hence the following preventive measures are recommended

Hygiene or sanitation

1. Threshing floor /yard should be clean, free from insect infestation and away from the vicinity of villages and granaries.
2. Clean the harvesting and the threshing machines before their use.
3. Trucks, trolleys or bullock carts which are used for transportation of seeds should be made free form insect infestation.
4. Clean the storage go downs / structures before storage of newly harvested crop.
5. All dirt, rubbish, sweepings and webbings should be removed from the stores and disposed / destroyed.
6. All the cracks, crevices, holes existing in the floors and ceilings should be plastered with mud or cement permanently.
7. All the rat burrows should be closed with a mixture of broken glass pieces and mud and then plastered with mud/ cement.
8. White wash the store rooms before storage of seeds.
9. Seeds should be kept in stores which are rat & moisture proof.
10. Proper stacking of bags also helps in seed protection.
11. Proper handling of seeds and avoiding hooks on storage bags help minimize exposure to insects.
12. Bags should be stacked on wooden dunnage 0.5 meter away from the wall.
13. Bags should be stacked in rows having space of nearly 2 to 3 meters in between height of a row should not be more than 15 bags leaving about $1/5^{th}$ space of total storage from the roof.
14. Bulk storage structures of seeds should also be kept away from the ventilators or doors.
15. Seed crop harvested at a moisture content ranging from 20 – 28 per cent should be dry to safe moisture content
16. Sun drying and use of mechanical dryers can be opted to bring down moisture.
17. Improper drying of seeds during post harvest operations enhances the insect infestation.
18. Staggered sun drying with short exposure to sun spread over large number of days (9 to 11 am for 8 days) reduces insect infestation.
19. Use of improved storage structures with gunny bags or jute bags with close weaves can reduce insect infestation.
20. Impregnation of gunny bags with insecticides can prevent entry of insects and polythene lined gunny bags were suggested by polyester-polythene 400 gauge lined canvas was found to be resistant to all types of insect attack.

Disinfestations of stores / receptacles

Before the use, the receptacles / store rooms should be disinfested with approved residual insecticides preferably by spraying a Malathion 50% EC, with a dilution of 1: 100

and applied at the rate of 3 lit /100 m^2 or dichlorovos @ 1ml/ litre of water and seal the store house for a week without allowing the air to enter.

Fumigation

- Decide the need for shed fumigation (entire store house or godown) or cover fumigation (only selected blocks of bags).
- Check the store house / godown and the black polythene sheets or rubberized aluminium covers for holes and get them ready for fumigation.
- Choose the fumigant and work out the requirement based on the following guidelines.
- Fumigation with Aluminium phosphide @ 3 tablets of 3 g each per tonne of seeds and for shed fumigation @ 21 tablets of 3 g each for 28 cubic meters for the period of 5 days.
- Insert the required number of aluminium phosphide tablets in between the bags in different layers. Cover the bags immediately with fumigation cover. Plaster the edges of cover all round with wet red earth or clay plaster or use sand snakes to make leak proof. Keep the bags for a period of 5-7 days under fumigation. Remove the mud plaster after specified fumigation period and lift cover in the corner to allow the residual gas to escape. Allow aeration and lift cover after a few hours. Follow similar steps in case of shed fumigation also.

Curative measures

The infestation of stored seed insect pests can be controlled by following methods.

I. Non- chemical control measures

II. Chemical control measures.

1. Non- chemical control measure

The measures where chemicals are not used for control of insect pests of stored seeds are

Ecological control measures

The infestation of stored seeds from insect pests largely depends on the proper management of three factors *viz.*,

i. Temperature

ii. Moisture content of seeds

iii. Availability of oxygen

All these factors are required for normal rapid development and multiplication of insects in the godowns and storage practices. These storage practices can be modified to create ecological conditions unfavourable for attack by insects.

Temperature

Temperature ranging from 20^0 C to 40^0 C, accelerates the development of insects but above 42^0C and below 14^0C retards reproduction and development, while prolonged temperature above 45^0 C below 10^0C may kill the insects. Heating of seeds at 50^0C will be lethal to insects but it is not advisable because the seeds are affected and lose their viability.

Moisture content of seed

Moisture is the critical factor in safe storage of seeds. The seeds stored at around 10 per cent moisture content escape from the attack of insects (except khapra beetle.)

Advisable moisture content of seeds for safe storage

Cereals	:	10-12%
Pulses	:	9-10 %
Oilseeds	:	7-8 %
Vegetable seeds	:	>7%

It is desirable to know the moisture content of seed lots just after harvest or before storage as an aid to seed trade. The role of moisture in life of a seed is given below

Seed moisture content (%)	Effect on Seed
18-40	Seed physiologically mature. Seed susceptible to field deterioration, moths and insects very active.
13-18	Moths and insects can be damaging seed
10-13	Seed store reasonably well for 6-18 months in open storage. Insects can still be a problem in susceptible seed.
8-10	Very little insect activity, seed very susceptible to mechanical damage.
4-8	Safe moisture content for sealed storage
0-4	Extreme desiccation can be damaging to seed

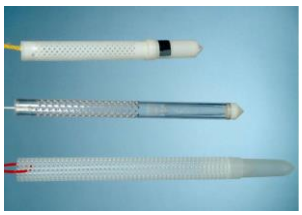
Availability of oxygen

In storage, oxygen is consumed by seeds and insects during respiration and carbon dioxide is produced. Insects respire at the rate of 20,000 to 1,30,000 times than that of the same weight of the seeds. Thus, O_2 level will reduce below 1 % and CO_2 level will automatically increase which will be lethal to all the stages of insects.

Traps to monitor the incidence of storage pests:

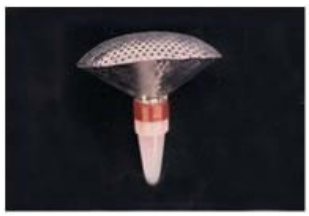
Probe Traps

The use of traps is a relatively new method of detecting insects in bulk stored seeds or in bag storage. Probe traps are used by keeping them under seed surface. The traps are simple to use, escape proof to many species and provide a mechanism for continuous monitoring of stored product insects. The trap can be inserted into the stored seeds and left for two weeks for best results. Insects like *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum*, *Oryzaephilus surinamensis* and *Sitotroga cerealella* can effectively be trapped and monitored by probe traps.



Pulse beetle trap

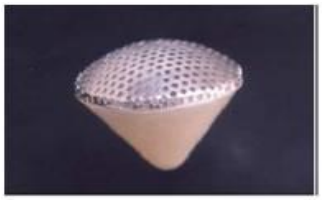
This is also a probe trap type model specially designed for pulse beetle. The traps can be kept with the cover lid alone protruding out of the seed. As generally, the emerging beetles come to the top for free movement and mating. Restricting the placement of traps on the side and centre of the storage bin or container will be sufficient to collect them.



Pitfall Traps

Pitfall traps have been used widely to capture soil inhabiting insects. These traps can logically be use in bulk stored seeds for capturing insects active on the seed surface.

Crawling insect pests enter the trap by crawling or falling through the holes in the top. Generally, special coatings with sticky material like tangle foot on the inside of the cone on which the insects cannot walk and holds the insect inside the trap.



Light Traps

Electrophysiological and behavioural studies have shown that majority of stored products insects responds to light of wave length between 300-700 nm. Stored product insects give their largest response to light of 350 nm (UV) and 500- 550 nm (Green light.) Green light is mostly preferred by stored product Lepidopterans. Lesser grain borer *Rhyzopertha dominica*, Red flour beetle, *Tribolium castaneum*, Cigarette beetle, *Lasioderma*, *Corcyra* etc., are attracted to UV light in large numbers. Lepidopterans like *Sitotroga cerealella*, *Corcyra cephalonica* etc., prefer green light source. UV light traps can be used for the beetles attacking paddy which are attracted in large numbers to UV light. Significant among them are *Rhyzopoertha and Tribolium castaneum*.

Sticky traps

Sticky boards, screens, paper strips, hollow tubes, wing traps have been used to trap stored product moths. Sticky traps have been widely used in food processing plants. Various models of sticky traps have been developed for use in monitoring aerial populations of stored product insects. However, sticky traps are generally used with pheromones. Several sticky trap models for monitoring stored product insects are available.

Pheromone traps

Pheromone traps of various models have been designed for use in pest management of various stored pests. Pheromone lures are available for many stored product insects namely, *E. cautella, S. cerealella, C. cephalonica, R. dominica*, T. *castaneum, O. surinamensis* and *T. granarium*. In general, in Lepidopteran moths, females produce chemical substance which attracts males. But fortunately, in major families of stored product beetles, the adult males release chemicals commonly termed as aggregation pheromones to which both females and males get attracted. Examples for this include *T. castaneum, T. confusum, R. dominica* and *O. surinamensis*. The value of these pheromones in stored product management has clearly been demonstrated by many workers.

II. Chemical control measures

a. Prophylactic treatments of seeds

- The produce is meant for seed purpose, mix 1.0 kg of activated kaolin or 1.0 kg of lindane 1.3 D or 1.0 kg of malathion 5 D for every 100 kg of seed and store / pack in gunny or polythene lined bags.
- To protect the pulse seeds, mix activated kaolin at the above dosage or any of the edible oils at 1.0 kg for every 100 kg seeds or mix 1.0 kg of neem seed kernel powder for every 100 kg of cereal or pulse seeds.

b. Curative seed treatments

1. Inorganic chemicals

- Treat the seeds of cereals or pulses used for seed with deltamethrin 40 mg/kg of seed by diluting insecticides in 5 ml of water before treating and shade dry for few minutes, and then store the seeds by packing them in polylined gunny bags.

National seed Project, University of Agricultural Sciences, Bangalore recommended the following seed treatment insecticides to manage the storage insect pests of seed

- Treat the seeds of cereals or pulses used for seed with bifenthrin 20 mg/kg of seed by diluting insecticides in 5 ml of water before treating and shade dry for few minutes, and then store the seeds by packing them in polylined gunny bags.
- Treat the seeds of pulses used for seed purpose with Emamectin benzoate 5 SG @ 40 mg or Spinosad 45 SC @ 0.4 ml diluted in 5 ml of water per kg of seed to control the pulse beetle in storage upto 12 months. Treat the seeds of maize used for seed purpose with spinosad 45 SC @ 0.4 ml mixed in 5 ml of water per kilogram of seed to control the storage insect pests of maize upto nine months.
- Treating the groundnut pods with deltamethrin 2.8 EC @ 1ppm (0.04 ml) or thiodicarb 75 WP @ 2 ppm (2.70 mg) or spinosad 45 SC @ 2 ppm (0.04 ml) by diluting in 15 ml of water, shade drying and storing the pots in gunny bags for management of groundnut pod borer under ambient conditions up to 9 months without affecting the seed quality parameters.
- The groundnut pods packed in High Density Poly Ethylene (HDPE) bags treated with deltamethrin 2.8 EC @ 100 ppm (3.5ml /liter) or spinosad 45 SC @ 100 ppm (0.2ml/liter) for management of pod borer *Caryodon serratus (Olivier)* upto nine

months of storage under ambient conditions without affecting the seed quality parameters.

2. Organic seed treatments

- Neem based insecticides containing 3000 ppm of azadirectin content for cereals and 10,000 ppm of azadirectin content for the pulses at the rate of 5 ml/kg seeds were also recommended for the management of storage pests.
- Maize seeds treated with vasambu (*Achorus calamus*) dry rhizome powder @ 10 g / kg seed and packed in 400 gauge polythene bags is recommended to store the seeds safely for more than one season.

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.

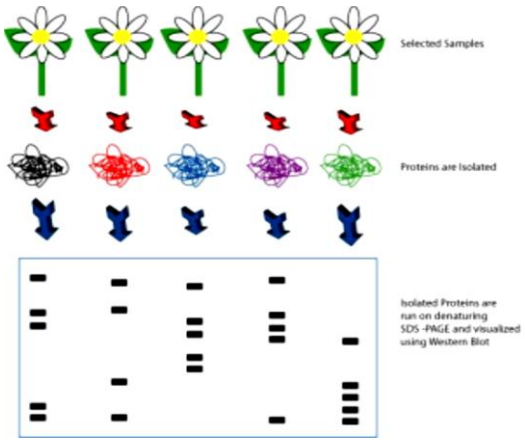


Fig.1: Sequential Summary of events occurring in isozymes analysis of plant samples. Although useful in some plant varieties, isozymes provide little variation in highly bred cultivars

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.

Physiological & Harvestable Maturity Indices in Seed Crops

Introduction

Plants, as sessile life forms, have evolved diverse mechanisms to circumvent unfavorable growth conditions, among them interruption of the life cycle is one of the most successful strategies. Spermaphyta, or seed plants, are characterized by the formation of the seed, a structure originated from the fertilized ovule that includes the embryo and other maternally derived tissues. Embryogenesis within the seed allows the entry into a quiescent state that represents an evolutionary advantage since it facilitates dispersal and resuming of growth under optimal environmental conditions. Seed formation is an intricate process that can be roughly divided into proper embryogenesis (cell division and morphogenesis), followed by a maturation phase, characterized by storage compound accumulation, acquisition of desiccation tolerance, growth arrest and the entry into a dormancy period of variable length that is broken upon germination (Harada, 1997). In essence, seed maturation involves all structures comprised within the seed, but predominantly the embryo and the endosperm originated by a double fertilization event. Maturation leads to a developmental end-point in the endosperm, whereas the embryo retains the regenerating capacity after germination. Despite these differences, both embryo and endosperm share many features concerning the physiological changes and underlying molecular mechanisms associated with maturation.

In this review, we will re-examine minor aspects of seed maturation as a physiological process opposed to germination and will focus on recent findings related to central transcriptional regulators that participate in gene expression programmes associated with embryo and endosperm maturation. In the past, the study of seed specific gene expression has led to the idea of different regulatory mechanisms in monocot- and dicotyledonous species. However, a closer watch uncovers a limited perception, probably sustained on a knowledge biased from the different prevailing tissues in the seed of the two phylogenetic groups. Current data, clearly points to the participation of similar and sometimes the same factors in both organs. Moreover, new roles, out of the seed, have been discovered for regulators considered to be seed-specific and new functions within the seed assigned to previously known regulators unrelated to this organ. Altogether, these findings are enabling to perceive seed maturation as an "intrusive phase" in the developing embryo, similar to other phases introduced in the course of evolution at different times and in different taxa to produce growth arrest in a reversible manner (Harada, 1999; Kaplan *et al.*, 1997). In addition, extensive studies of regulatory networks are facilitating the identification of master regulators, responsible for the "seed fate", which directly participate in transcriptional control during maturation or modulate the activities of other factors acting under their influence.

Seed maturity

Seed maturity refers to the morphological, physical, and functional changes that occur in the seed from the time of fertilization until seeds are fully formed and ready for harvest. (Delouche, 1973).

Seed development is the period between fertilization and maximum fresh weight accumulation. And seed maturation begins at the end of seed development and is continues up to harvest (Abdul - Baki *et al.* 1973).

Seed maturation is the crucial and the most important factor that determines the seed quality. (Delouche *et al.* 1973).

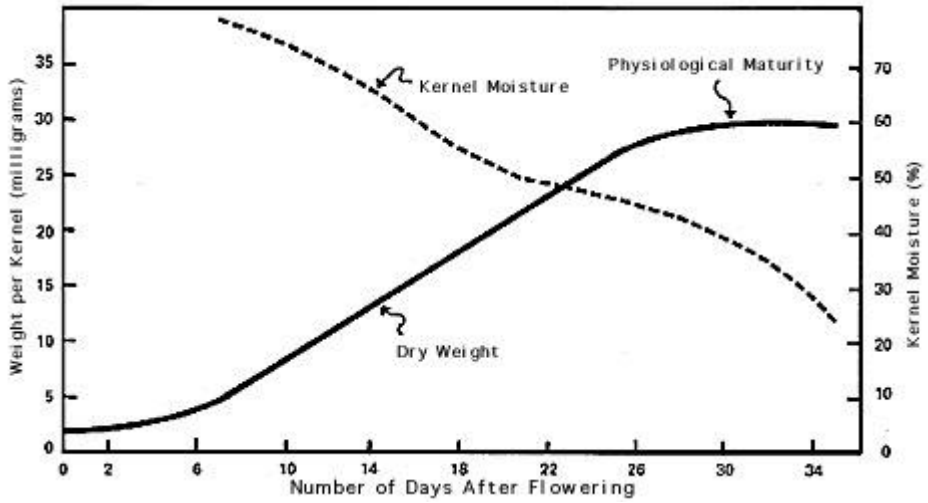
Why to Study Seed Maturation

- It helps in prevention of seed deterioration by timely harvesting of seed.
- Harvesting can be done at earlier stage then the effective yield control can be formulated by preventing weed seed to attain full germination.
- It contributes considerably in saving time, money, and labor by avoiding unnecessary delay in harvesting.
- It helps in reducing seed loss due to insect's pests and non insect's pest such as rodents, birds and animals.
- It helps in escaping from the various types of diseases.
- It helps in reducing seed losses due to shattering.

Physiology of seed maturation

The maturation phase is started once the embryo and endosperm have completed the morphogenesis and patterning stages (Wobus *et al.*, 1999). This phase is characterised by a growth arrest, followed by the synthesis and accumulation of reserves, whose degradation upon germination will provide nutrients to the growing seedling before the photosynthetic capacity is fully acquired (Baud *et al.*, 2002). Early and mid phases of maturation are dominated by the action of ABA, initially synthesised in the maternal tissues and later on, although to a lower extent, in the embryo and endosperm (Nambara *et al.*, 2003). Transcription of major seed storage protein genes occurs mainly during this period. Subsequently, ABA levels decline and late maturation follows characterized by the synthesis of LEA (Late Embryogenesis Abundant) proteins, associated to the dehydration process and acquisition of desiccation tolerance. During this stage, accumulation of storage metabolites prevails in the form of carbohydrates (endosperm) or lipids (embryo), a quiescent state is accomplished and dormancy, the inability to grow under otherwise favourable conditions, can be established (Holdswoth *et al.*, 1999). Maturation is not an obligatory process and if embryos are removed from the seed and the ABA effects eliminated, they can proceed through the germination phase and develop into normal seedlings (see Figs. 1A, 4). In certain plants, like mangroves, embryogenesis proceeds directly to the seedling state. Similarly, so-called viviparous mutants in other plants display an analogous behavior. In addition to ABA, other hormones are important in seed development, like auxins, cytokinins and gibberellins (GAs). In particular, the synthesis and requirement of active GAs during the maturation phase have been demonstrated in elegant experiments in maize embryos (White *et al.*, 2000). It is now widely accepted that maturation is not determined by ABA alone but instead by the ABA/GA balance. Exciting results on metabolites as signals, as well as metabolism and accumulation of nutrients during seed development have been extensively covered in recent publications (Baud *et al.*, 2002; Hills, 2004; Borisjuk *et al.*, 2004) and are outside the scope of this review.

Physical and physiological changes during seed maturation



Importance of understanding seed maturation

1. Unnecessary delay in harvesting seeds after they attain physiological maturity contributes considerably to deterioration.
2. Plant breeders can shorten the time required for growing crops by knowing the time of maximum germination.
3. Harvest can be done at an earlier date.
4. Effective weed control measures can be formulated by preventing weed seeds to attain full germination capacity.
5. Contribute considerably in saving time, labour and money by avoiding unnecessary delay in harvesting.
6. "Storing" of seeds commence in the field after the seed attain physiological maturity. Field deterioration of seeds can occur when subjected to adverse climatic conditions while still in the plant. Cottonseeds sprout in the boll, radicle growth of some grasses starts and legume seeds show water damage.

In general, seeds reach their peak germination and vigour at the time of maturation in the field. Once this peak is reached the seeds can only decrease in quality.

Physiological maturity of seed

At this stage normally the seed has more moisture content. The seed crop can be harvested at high moisture content at physiological maturity, provided artificial facilities for drying are available; otherwise the crop has to be left on the field for natural drying till the seed moisture comes down to around 18-20 per cent for threshing. However, the harvesting maturity is a crop-specific character.

For seed threshing the moisture content of 18-20 per cent is suitable. Anything-above 18 per cent, the seed will be damaged. Increased amount of moisture content in seed amounts to increase in respiration, thereby seed deterioration increases at faster rate. However, the processing can be done at safer level of moisture content.

Seeds of most crop species mature when they attain maximum dry weight. Most of the seeds are physiologically mature at this point, but there are exceptions. However, after fertilization seed start developing, seed begin to increase steadily as a result of translocation of food reserves associated with rapid cell division and elongation. Physiological maturity is the days taken to attain maximum accumulation of dry matter, germination and vigour.

Moisture Content (MC) at physiological maturity (PM)

	Moisture content per cent at		
	PM	HM	Days to PM
Groundnut	40-45	35-40	65-70
Rice	28	18-20	25-30
Sorghum	30	20-25	30-35
Corn	36-40	20-25	50-60
Cotton	50-55	30-35	-
Chilly	50	45-50	-
Soybean	20-25	16-18	60-65

PM = Physiological maturity; HM = Harvesting maturity

Percentage of food reserves in crop plants

	Starch	Protein	Fat
Cereals	70-75	10-13	2-8
Oil seeds	5-20	20-40	40-50
Pulses (beans & peas)	50-55	22-25	5-10
Soybean and cotton	15-26	37-39	17-33

Harvesting is the process of removal of entire plants or economic parts after maturity. The economic product may be grain, seed leaf, root or entire plant. The remaining portion of the stem that is left on the field after harvest is known as stubble.

Types of maturity

There are two types of maturity

- Physiological maturity.
- Harvesting maturity.

Physiological maturity can be defined as the stage at which the seed reaches the maximum dry weight.

A seed is dried when it has dried out to moisture content in equilibrium with atmosphere this stage is known as harvesting maturity. Harvesting maturity varies with crop to crop; it depends on the use of the crop. Such as vegetable purpose, seed purpose etc.

The basic seed development pattern is most likely to be similar in most agricultural crops and horticultural crops. Although some variation may vary in levels of seed moisture and dry weight, duration of each stage which depends on genotype and environment factors. However the sequence may remain unaltered then the different stages.

There are three stages or phases of seed maturation

- ✓ Phase 1 or lag phase.
- ✓ Phase 2 or food reserve or accumulation phase or linear phase.
- ✓ Phase 3 or ripening stage or desiccation stage.

Phase 1 or lag phase

- ➢ In this phase the seed growth is very rapid and marked at intensive cell multiplication.
- ➢ The moisture percent remains high and constant in this phase.
- ➢ This stage is important as it is the period when the frame work of future seed is being laid down.

Phase 2 or food reserve or accumulation phase

- ➢ In this phase there is a slow increase in the dry weight. Reaching maximum at the end of the phase.
- ➢ The amount of water changes very little but the percentage of water fall steadily.
- ➢ Seeds become viable early and acquired very rapidly.
- ➢ In this phase the substances which is served as food reserved such as protein sugar fat etc, are being transferred to the developing seed.

Plant nutrition is there fore is very important at this stage. Seed coat colour changes are the indices of approaching maturity which is gradually takes place during later half of the stage.

Phase 3 or ripening stage or desiccation stage

- ➢ This stage last for 4-21 days depending up on the genotype and also the environmental conditions.
- ➢ During this stage the moisture content falls from 40% to the level in equilibrium with surrounding atmosphere (12-16%).
- ➢ During this stage the dry weight of the seed remains relatively constant and the seed is normally termed as ripe and ready for harvest and it is described as harvest maturity.

Common indices of maturity

For most practical purposes a seed grower should consider a crop to be ripe when it is ready for harvest, when the crop is matured. But before the loss of seed due to shattering or shedding and decline the quality due to changes in various elements in environment.

The best point at which the seed should be harvested varies from area to area and year to year from farmer to farmer.

The common indices are as follows

1) Seed consistency:

Deciding harvest timing on seed consistency is offen hard to estimate the average

Effect of seed maturity on seed quality

There are three important aspects of seed quality greatly affected by the different stages of seed maturation.

1) Viability.
2) Vigour.
3) Storage potential.

Viability: express as the ability or capacity of seed to germinate completely when it is placed on a substrata with optimum conditions for germination.

Many seeds harvested 10 days after pollination are viable and more than 90% of seeds harvested 15 days after pollination are able to germination.

Germination can does takes place very soon after the embryonic tissues have been found and before maturity are attained.

The immature seeds will not help in successful seed ling establishment.

Vigour

It is the sum total of all those properties of seeds which determine the potential level of performance and activity of seed or the seed lot during germination and seedling emergence under varying conditions.

Table. Criteria for harvesting of crops

Crops	**Maturity symptoms and criteria for harvesting**
Rice	1. 32 days after flowering 2. Green grains not more than four to nine per cent 3. Percentage of milky grains less than one per cent 4. Moisture content of grains less than 20 per cent 5. 80 per cent panicles straw coloured and grains in lower portion of panicle in hard dough stage. At least five hills are to be studied at maturity
Sorghum	1. 40 days after flowering 2. Grain moisture content less than 28 per cent 3. Yellow coloured ears with hard grains
Pearl Millet	28 to 35 days after flowering Compact ears, on pressing hard seeds come out
Finger millet	Brown coloured ears with hard grains
Maize	1. Less than 22 to 25 per cent moisture in grain 2. Husk colour turns pale brown 3. 25 to 30 days after tasseling
Wheat	About 15 per cent moisture in grain Grains in hard dough stage Yellowing of spikelets

Redgram	1. 35 – 40 days after flowering 2. 80 – 85 per cent of pods turn brown
Blackgram Greengram	Pods turn brown or black with hard seeds inside pods
Groundnut	1. Pods turn dark from light colour. 2. Dark coloured patches inside the shell. 3. Kernels red or pink 4. On pressing the kernels, oil is observed on fingers
Cotton	Bolls fully opened

Moisture content of grains for safe storage

Crops	**Moisture Content (%)**
Paddy, raw rice	14
Parboiled rice	15
Wheat, barley, maize, sorghum, pearlmillet, finger millet and pulses	12
Groundnut pods, rape and mustard	6

Summary and conclusions

The following changes occur in seeds as they mature:

1. Moisture content decreases rather uniformly from 70-80 per cent to 15-20 per cent.
2. Dry weight increases to a maximum then may decrease slightly.
3. Seed size increases to a maximum then decreases somewhat as the seed dries.
4. A few seeds become capable of germination within a few days after fertilization; maximum germination is reached at a somewhat later date.
5. Seedling vigour increases as seed dry weight increases and reaches a maximum at the time of maximum dry weight (seed vigour is the sum of those properties which determine the potential level of activity and performance of the seed or seed lot during germination and seedling emergence).
6. In general, seeds reach their peak germination and vigour at the time of maturation in the field. Once this peak is reached the seeds can only decrease in quality.

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Rice

Sorghum

Pearlmillet

Finger millet

Maize

Wheat

Redgram

Blackgram

Groundnut

Cotton

Table. Maturity indices, number and time of harvesting in vegetable crops

Seed crop	Maturity indices	Harvestings			Remarks
		No.	Time		
A. Dry seeds					
Amaranthus	General brown yellowing of inflorescence indicate seed matuirty	1 to 2	Morning	Prone to shattering	
Onion	seeds become black on ripening in silver coloured capsules. Ten percent heads expose black seeds	1 to 2	Morning	Prone shattering	Jones nad Mann, 1963
Carrot Parsnip	Secindary and 3rd order head turn brown	1 to 2	Morning	Shattering on delayed harvesting	Gray, 1979
Spinach	Later ripening plants start to become yellow.	1	Morning	Shattering on delayed harvesting	Parlevliet, 1968
Cole group	On ripening plants start dry out and become orange brown in colour. Oldest pod will become brown first	2 to 3	Morning	Considerably shattering loss by birds. Strong tendency to siliqua shattering	Nieuwhof., 1969
Radish	Brown pods and parchment like when the seeds are near maturing	1	Daytime	Do not shatter easily	Watts and george, 1957
Garden peas	Majority of pods have become parchment like	1	During day	Do noy shatter easily	Biddle and king, 1977
Methi	Pods turns brown and leaves get dry	1	Morning	Delay in harvesting cause shattering	
Beans	Earliest pods dry and parchment like and remainder have turned yellow	1	During day	Over maturity leads to shattering and cotyledons cracking	Smith 1955

Broad Bean	Pods become relatively dry, sponginess and is usually preceded by a general blackening	1	during day		
Okra	Pods become gray or brown, hard according to cultivar	1 to 2	during day	Sequential ripening of pods and a tendency to split on ripening	
B. Fleshy fruit which are dried before seed extraction					
Chillies	Turning of fruit colour green to red, yellow or brown.	2 to 3	During day	dry methods of seed extraction	Mehta and Ramakrishan, 1986.
Bottle gourd	Rind becomes hard and colour	1	during day		
sponge gourd	Changes to light brown or yellow				
C. Wet fleshy fruits					
Capsicum	Green coloured changes to red or yellow depending on variety	1 to 2	during day	wet method of seed extraction	
Cucumber	fruit develops external ripening colour, stalk adjacent to the fruit withers. For comfirming actual seed maturity, several fruits are cut longitudinally and mature seeds separate easily from the interior flesh	1	during day	Seed extraction is done by scooping, acid/ alkali and fermentation methods	whitker and davis 1962
Watermelon	Tendrils withere on shoot bearing fruit. Skin colour undeside the fruit surface resting on the soil is pale yellow. Dull sound on thum ping fruit	1 to 2	Day time		
Muskmelon	fruits tend to separate (full slip) from stem. In winter melons, seed matuirty is indicated by rind colour change from green to yellow or yellow to white, blosoom end of fruit softens, skin become waxy and its aroma increases. Easy separation by	1 to 2	Day time	Melon seediis not fermented	

	abscission layer.				
Squashes, pumpkins and Marrows	Rind becomes hard and its colour changes from green to yellow, orange and yellow golden to straw colour.	1 to 2	Day time		
Asparagus	Berries become red or yellow and leaves turn brown	1	Day time	select from healthy crop	
Brinjal	Turning normal fruits colour to red and softnes of fruits	2 + 3	Day time	Seed is extracted by fermentation acid/alkali or while juice/pulp separation, wet seed extraction	Rick 1978
Tomato	Skin colour change to red and softness of fruits	2 to 3	Day time		
Bitter Gourd	Fruit and seed becomes red	1	Day time	Hard seeds separated, washed	
Summer squash	fruits become hard, its colour deep yellow or red	1	Day time		
Seed Potato	Haulms get dry, droop down turn dark brown in colour	1	Day time	Delay leads to spoilae of seed tubers.	

Seed Testing: Paramountcy of Sampling and Methodology of Purity Analysis

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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 - General Principles and Methodology

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Germination testing is considered as the most important quality test in evaluating the planting value of a seed lot. The ability of seeds to produce normal seedlings and plants later on 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 conceived wherein 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 nearly as possible as those determined by random sample variation.

Objective

The ultimate objective of seed germination testing is to obtain information with respect to the planting value of the seed and to provide results 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 or not it is able to develop further into a satisfactory plant under favourable conditions in the field (ISTA, 2015). A seedling, depending on the species being tested, consists of a specific combination of some of the following structures which are essential for its further development into a satisfactory plant.

- Root system (primary root; in certain cases seminal roots),
- Shoot axis (hypocotyl, epicotyl; in certain *Poaceae*,mesocotyl; terminal bud).
- Cotyledon (one or two cotyledons according to the species)
- Coleoptile (in all *Poaceae*).

Seedlings cannot be evaluated in a germination test until these essential structures are clearly identifiable and the reported percentage germination expresses the proportion of seeds which have produced normal seedlings under the conditions and within the period specified for each species.

General Principles

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 excepting those recommended in the following Table. 1

Table-1

Crop	Media	Temperature	1st count	Final count	Addl. Directions
Paddy	TP; BP; S	20<=>30, 25	5	14	Preheat(50°±2^{0}C); Soak in water or HNO_3(1N) 24 hours
Wheat	TP, BP, S	20	4	8	Preheat (30-35^{0}C), prechill, GA_3
Barley	BP, S	20	4	7	Prechill, GA_3, Preheat (30-35^{0}C)
Maize	BP, S	20<=>30, 25	4	7	-
Sorghum	TP, BP	20<=>30, 25	4	10	Prechill
Pearl Millet	TP, BP	20<=>30, 25	3	7	0.2% KNO_3(2 to 3 hours)
Ragi	TP, BP	20<=>30	4	8	0.2% KNO_3(2 to 3 hours)
Bengal gram	BP, S	20<=>30, 20	5	8	-
Blackgram	BP, S	20<=>30, 25	4	7	-
Cowpea	BP, S	20<=>30, 25	5	8	-
French bean	BP, S	20<=>30, 25,20	5	9	-
Greengram	BP, S	20<=>30, 25	5	8	-
Horsegram	BP	30	3	5	-
Peas	BP,S	20	5	8	-
Redgram	BP, S	30	4	6	-
Castor	BP, S	20<=>30	7	14	-
Groundnut	BP, S	20<=>30, 25	5	10	Remove shells, Pre heat 40° C
Gingelly	TP	20<=>30	3	6	-
Soybean	BP, S	20<=>30,25	5	8	-
Sunflower	BP, S	20<=>30, 25	4	10	Ethrel 25ppm for 48 hrs
Cotton	BP, S	20<=>30, 25	4	12	Hotwater(85°C-1 minute)
Sun hemp	BP, S	20<=>30	4	10	-
Cluster bean	BP	20<=>30	5	14	-
Oat	BP, S	20	5	10	Preheat30-35°c prechill
Dhaincha	TP,BP	20<=>30	5	7	Rub seed coat on paper
Sugar beet	TP,BP,S	20<=>30, 15<=>25, 20	4	14	Prewashmultigerm 2hrs,monogerm 4hrs
Ashgourd	S	30<=>35	5	14	Light
Bittergourd	BP,S	20<=>30, 30	4	14	-
Bottlegourd	BP,S	20<=>30	4	14	-
Cucumber	TP,BP,S	20<=>30,25	4	8	-
Pumpkin	BP,S	20<=>30,25	4	8	-
Ridgegourd	BP,S	30	4	14	-

Snakegourd	S	30<=>35	-	14	Dark,GA3 500 ppm 24hrs Remove seed coat
Watermelon	BP,S	20<=>30, 25	5	14	-
Brinjal	TP,BP	20<=>30	7	14	-
Chilli	TP,BP	20<=>30	7	14	Kno3
Bhendi	BP,S	20<=>30	4	21	-
Tomato	TP,BP	20<=>30	5	14	Kno3
Onion	TP,BP	20; 15	6	12	Prechill
Amaranthus	TP	20<=>30	-	8	Light
Coriander	TP,BP	20<=>30,20	7	21	-
Spinach	TP,BP	15;10	7	21	Prechill
Carrot	TP,BP	20<=>30,20	7	14	-
Radish	TP,BP	20<=>30,20	4	10	Prechill
Turnip	TP	20<=>30,20	5	7	Prechill,Kno3
Field bean	BP,S	20<=>30,25	4	10	-
Cabbage	TP	20<=>30,20	5	10	Prechill,Kno3
Knol-Khol	TP	20<=>30,20	5	10	Prechill,Kno3
Cauliflower	TP	20<=>30,20	5	10	Prechill,Kno3

*The symbols '<=>' indicate alternating temperature regimes. 1st temperature: 16 h; 2nd temperature: 8 h

Note:

1. **Prechilling:** The replicates for germination are placed in contact with the moist substratum and kept at low temperature(between 5° c and 10° c)for upto seven days for all agricultural and vegetable seeds.
2. **Preheating:**The non imbibed seeds of the replicates for germination are heated at a temperature of 30 to 35^0C with free air circulation for a period of up to 7 days before they are placed under the prescribed germination conditions. For certain tropical and subtropical species, preheating temperature of 40 to 50^0C may be used.
3. **Potassium nitrate(KNO_3):** Instead of water, 0.2%KNO_3 Solution (prepared by dissolving 2g KNO_3 in one litre of water) is used to saturate the germination substratum at the beginning of the test. Water is used for moistening thereafter.
4. **Gibberellic acid(GA_3):**The germination substratum is moistened with 0.05% solution of GA_3, prepared by dissolving 500mg GA_3 in 1 litre of water. When dormancy is weaker, 0.02% may be enough; when it is stronger, up to 0.1% may be used routinely. If it is necessary to use concentrations higher than 0.1 %, care must be taken to ensure that the development of seedlings is not adversely affected. When a concentration higher than 0.08 % is required, dissolving the GA_3in a phosphate buffer solution is recommended. The buffer solution is prepared by dissolving 1.7799 g of Na_2HPO_4. $2H_2O$ and 1.3799 g of NaH_2PO_4. H_2O in 1 L of distilled water.

The seeds arranged in replicates are tested under favorable moisture conditions and in accordance with the methods prescribed in the above Table. After the period indicated in the table, the replicates are examined and counts are made.

General Requirements for Germination

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

Suitable substratum

The substrata serve as a moisture reservoir and provide a surface or medium for which the seeds can germinate and the seedlings grow. The commonly used substrates are paper, pure sand or mixtures of organic compounds with added minerals.

Paper substrate

Most widely used paper substrates are filter paper, blotter or towels (kraft paper). The paper should be such that:

- The roots of the seedlings will grow on and not into it;
- It possesses sufficient strength to enable it to resist tearing when handled during the test.

Sand

It may be necessary to wash and sterilise the sand before use. For reuse of sand it must be washed, dried and resterilized. Sand which has been used for testing chemically treated samples, should preferably be discarded without being reused, if however, it is reused it should be ascertained that chemicals which may have accumulated in the sand do not cause phytotoxic symptoms.

Organic growing media

Organic media are defined as containing the following elements in known proportions and fitting the requirements.

Organic Compounds: fibres such as peat, coconut fibres or wood fibres, with a revommended size less than 5 mm.

Mineral particles: for example sand, perlite, dolomite or vermiculite. The proportion should be between 15 and 30% in volume. It is recommended that 90% of the particles should pass through a sieve with holes or meshes of 3mm width.

Soil

Soil is generally not recommended as a primary growing medium. However, it may be used as an alternative to organic growing media when seedlings show phytotoxic symptoms or if evaluation of seedlings is in doubt on paper or sand. Soil should be of good quality, non-caking and free from any large particles. It must be reasonably free from weed seeds, bacteria, fungi, nematodes or toxic substances, which might interfere with the germination of seeds, the growth of seedlings or their evaluation. Soil should allow adequate aeration for germination when water is added with a pH of 6.0-7.5.

Specification of Germination paper:

Germination paper should preferably possess a creaped surface. The paper should have an open, porous formation and free from impurities or toxic substances that may affect seed germination. It should be free of fungi or bacteria which might interfere with the growth or evaluation of seedlings. It should hold sufficient moisture during the period of test and should possess sufficient strength to resist wear and tear during handling. The texture should be such that the roots of germinating seedlings will grow on and not into the paper.

The paper shall meet the following requirements.

Type of Paper	BasisMass (g/m2)	Bursting Strength (kg/cm2)	Capillary rise (in mm)/ Min	PH	Ash % by Mass(Max.)
Filter paper	130-135	1.0	30	6.0 to 7.5	1.20
Towel paper	95-100	2.0	30	6.0 to7.5	1.50

In this test, comparison shall be made between germination papers of unknown quality and known acceptable quality. Pieces of paper should be cut to size and placed in petridishes or plastic boxes. Petridishes or plastic boxes should be lined with two thickness of such paper. The papers should be saturated with tap water and seeds of Brassica species or onion should be germinated. Evaluation may be done by comparing the development of the seedlings grown on unknown quality of paper and those grown on the known quality of paper. The evaluation of seedlings shall be made after 3 days in case of Brassica and after 6 days incase of onion. If paper of unknown quality contains toxic substances, the root tips will be shortened and sometimes discoloured, root hairs 'bunched' and sometimes plumules shortened.

Specification For Sand

Sand shall be clean and free from clay like material dirt, crushed stones or pebbles.At least 90% of the particles must pass through a sieve with holes or meshes of 2.0mm width. It should not contain toxic materials to cause injury to seedlings. The pH should be within the range from 6.0 to 7.5. The specific conductance should be within the range from 0.01 x 0.02 ms/cm2.

Biological Test for Toxic Materials:

In this test, comparison shall be made between sand of unknown quality and sand of known pre tested quality. Sand should be placed in petri dishes or boxes to form a uniform layer 2 cm deep. It should be moistured to its 50% water holding capacity, Seed of onion or Brassica species should be placed and cover to a depth of 1 cm of moist sand. Evaluation may be done by comparing the development of the seedlings grown on the unknown quality and those grown on known quality as described for testing the germination paper.

Adequate Moisture and aeration

High concentration of water at cellular level is necessary for the seed to start germination. Moisture is supplied to the seeds through the substratum. Precaution must be taken to ensure that the medium cannot dry out and sufficient water for the whole test period.

In the case of vegetable seeds, care is necessary in moistening the substrata. Too much water would allow fungal growth and decay of seeds.

Special measures for aeration are not necessary for Top of the paper and Pleated paper tests enclosed in boxes or petridishes. For Between paper test, however, care must be taken that envelops and rolled paper towels are loose enough to allow for sufficient air around the seeds. For the same reason, sand and organic growing media must not be compressed.

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. If the usual water supply in the laboratory is not satisfactory, distilled, de-ionised water may be used. To ensure the quality of water being used, an analysis should be obtained from time to time.

Favorable temperature

Seeds of most of agricultural and horticultural crops germinate in the temperature range of 10° C to 35° C. Some seeds germinate better at constant temperature. Others require an alternating temperature.Temperature control is also necessary to overcome dormancy wherever it occurs. Exposure of seeds to the temperature at 40°C or higher, alternation of temperature, low temperature applications are the easiest and safest method to overcome seed dormancy although methods to overcome dormancy by chemical treatments do exist.

Therefore, the temperatures prescribed in the above Table should be determined at the level of the seeds on the substrate.

Temperatures should be as uniform as possible throughout the germination apparatus and care should be taken that the temperature of tests does not exceed the level prescribed in the Table and should not be more than ± 2° C.

Where alternating temperatures are indicated, the lower temperature should usually be maintained for 16 hours and the higher for 8 hours. If alternation of temperatures cannot be controlled over week-ends or public holidays, the test should be kept at lower temperature

Light:

There are crops for which light is not required during germination test. However, presence of light is desirable to enable the evaluation of seedlings easier and with greater certainty. Other crops like lettuce and tobacco require light during germination on the test. In such cases, light should be between 750 and 1250 lux from cool white lamps.

Seeds of most of the species in the Table 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.

Specific recommendations for light or darkness, respectively, are given in the additionaldirections column of Table.

Procedures

Methods using paper:

Paper substrates are used for the following methods:

a) **TP (Top of paper)**: As the name indicates, the seeds are placed directly on one or more layers of moist filter or blotter papers in petridishes. These petridishes are tightly covered with lid and placed inside the germination cabinet. The relative humidity in the cabinet must then be maintained to 95-99% to prevent drying out during test period.

b) **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.

Methods using 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 be loosened by raking before sowing.

Sand may be used instead of paper, even if not prescribed in Table when the evaluation of a diseased sample proved impracticable because of the contamination of the paper substrate.

Moisture and aeration

The substrate must all times contain sufficient moisture to meet the requirements for germination. However, moisture content must not be excessive, or aeration maybe 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. 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.

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 pretreatments are recommended and given in Table. These pretreatments include dry storage, prechilling (treat the moist seeds at a temperature of 5° – 10 C 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 (GA_3 0.05 to 0.1 %) application etc.

For hard seeds, puncturing the seed with a needle away from embryo, mechanical scarification and acid scarification are recommended. Similarly for removing inhibitory substances, pre wash the seeds by running water at a temperature of 25^0 C and bring back these pre washed seeds to its original moisture content.

Duration of the Test

Duration of the test for individual species is indicated in table. The duration of the treatment required to break dormancy before or during the test is not taken as part the germination test period.The time of first count is approximate, but must be sufficient to permit the seedlings to reach a stage of development which allows for accurate evaluation. The time indicated in table refer to the highest temperatures. If lower temperature is choosen, the first count may have to be postponed. The tests lasting 7-10 days, intermediate counts to remove seedlings which are sufficiently well developed are recommended in order to make counting easier to prevent them from affecting the development of other seedlings. The first count may be omitted, if the first test is conducted in sand. 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 / labeling.

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 favourableconditions of water supply, temperature and light.

According to the International Seed Testing Association (2015) seedlings to be classified as normal seedling, must conform with one of the following categories:

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 seriously infected by fungi or bacteria are classified as normal, if it is evident that the parent seed is not the source of infection, and if it can be determined that all the essential structures were present.

a) Intact seedlings

An intact seedling, depending on the species being tested, shows a specific combination of some of the following essential structures:

i) A well-developed **root system,** consisting of: a long and slender **primary root**, usually covered

with numerous root hairs and ending in a fine tip; **secondary roots** when produced within the prescribed test period; several seminal roots instead of one primary root in certain genera, including *Avena, Hordeum, Secale, Triticum.*

ii) A well-developed **shoot axis,** consisting of: a straight and usually slender and 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 *Poaceae*.

iii) A specific number of **cotyledons**, i.e.: **one** cotyledon in monocotyledons or exceptionally in dicotyledons (it may be green and leaf-like or modified and remaining wholly or partly within the

seed); **two** cotyledons in dicotyledons (in species with epigeal germination: green and leaf-like, the size and form varying with the species being tested; in seedlings with hypogeal germination: hemisphericaland fleshy and remaining within the seed coat),

iv). Green, expanding **primary leaves**: **one** primary leaf, sometimes preceded by a few scale leaves in seedlings with alternating leaves, or **two** primary leaves in seedlings with opposite leaves;

v) A **terminal bud** or **shoot apex**, the development of which varies with the species being tested;

vi). A well-developed, straight **coleoptile** in *Poaceae*, containing a green leaf extending to the tip and eventually emerging through it;

vii) In seedlings of tree species with epigeal germination: when the primary root and hypocotyl together exceed four times the length of the seed, provided all structures which have developed are intact.

b). Seedlings with slight defects

The following defects are considered slight and therefore seedlings are classified as normal: – primary root with limited damage (e.g. not affecting the conductive tissue) or slight growth retardation;

– primary root defective but with sufficiently well developed secondary roots (in specific genera of *Fabaceae*, especially large-seeded genera such as *Phaseolus,Pisum*and *Vicia*, and *Poaceae*, e.g. *Zea*, and in all genera of *Cucurbitaceae*, e.g. *Cucumis, Cucurbita*and *Citrullus*, and *Malvaceae*, e.g. *Gossypium;* only one strong seminal root in *Avena, Hordeum, Secale, Triticum*

– hypocotyl, epicotyl or mesocotyl with limited damage(e.g. not affecting the conductive tissue);

– cotyledons with limited damage (if half or more ofthe total tissue area is left functioning normally and if there is no evidenceof damage or decay to the shoot apex or surroundingtissues);

– only one normal cotyledon in dicotyledons (if there isno evidence of damage or decay to the shoot apex orsurrounding tissues);

– fused cotyledons (provided that they comply with the50 % rule);

– primary leaves with limited damage (if half or moreof the total tissue area is left functioning normally [the 50 % rule);

–only one normal primary leaf, e.g. in *Phaseolus*(if there is no evidence of damage or decay to the terminal bud);

– primary leaves of *Phaseolus*which are properly formed but reduced in size, as long as they are larger than a quarter of the normal size;

– three or more primary leaves instead of two, e.g. in *Phaseolus*(provided that they comply with the 50 % rule);

– coleoptile with limited damage;

– coleoptile with a split from the tip extending downward not more than one third of the length (for *Zea mays*);

– coleoptile loosely twisted or forming a loop (because it is trapped under the lemma and palea or fruit coat);

– coleoptile with a green leaf not extending to the tip but reaching at least half-way up the coleoptile.

c). Secondary infection

Seedlings which are seriously decayed by fungi or bacteria are classified as normal, if it is evident that the parent seed is not the source of 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 favourable 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 handing.

b) **Deformed or unbalanced seedlings**: Seedlings with weak and unbalanced development which may be caused by internal disturbances of physiological biochemical character. Such internal disturbances, however, are often due to the earlier external disturbances such as unfavourable 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 so diseased or decayed as a result of primary infection that normal development is prevented. These may result from the external or internal seed borne diseases.

Multigerm seed units

Seeds which are capable of producing more than one seedling. Several types of seed units can produce more than one seedling e.g. unseparated schizorcarps of umbeliferae, clusters of *Beta vulgaris*, fruits of tectonagrandis, polyembryonic seeds. In such cases only one normal seedling is counted for determining the germination percentage.

Ungerminated seed

Seeds which have not germinated by the end of test period when tested under the conditions prescribed in Table 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.

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 Replicates performance is out of tolerance. Results being inaccurate due to wrong evaluating of seedlings or counting or errors in test conditions. Dormancy persistanceor phyto toxicity or spread of fungi or bacteria.

Reporting Results

The result of the germination 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.

Use of Tolerances:

For the use of tolerances, appropriate table given in hand book of seed testing should be used.

Seed Vigour Testing

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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.

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Seed Bio-Prospecting: Overview on Disease Management

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Introduction

Seed is a basic input material for agriculture and it is required as high quality in seed trading. There are many seed borne pathogens that have harmful effect on seed health. These pathogens are among the most important organisms causing serious losses to agricultural products. Plant diseases need to be controlled to ensure food safety. A number of different strategies are currently being employed to manage the plant diseases. There are various chemicals available for the seed treatment and management of seed borne diseases. But the use of chemicals is neither economical nor ecological. Apart from this there is a great risk of development of resistant races of the pathogen. So, there is a need to look into various bio-prospects of seed disease management. Biological control of the seed diseases is one of the important seed bio-prospects. The study and management of diseases affecting seed production is covered under seed pathology. In this chapter, we shall discuss the role of microorganisms in the management of the seed borne diseases.

Bio-prospect

Microbial seed treatment is an eco-friendly and economical approach to deliver beneficial microorganisms to soil, where they can multiply with plant roots. In terms of agriculture benefits microbes protect crops by increasing tolerance to various biotic and abiotic stresses. Microbial seed treatment is used as an alternative to pesticides owing to increasing demand for organic treatment in microbial seed treatment market. Microbial seed treatment segment holds the largest share in biological seed treatment followed by botanical treatment. Seed priming applied to commercial seed lots is widely used by scientist to enhance seed vigour in terms of germination potential and increased stress tolerance.

The term “biological control” has been used in different fields of biology, most notably entomology and plant pathology. In plant pathology the term applied to the use of microbial antagonists to suppress diseases. More broadly, the term biological control has also been applied to the use of natural products extracted or fermented from various sources. These formulations may be very simple mixture of natural ingredients with specific activities or complex mixture with multiple effects on the host as well as the target pest or pathogen.

Interaction and mechanism of biological control

Biological control of pathogens involves various interactions like mutualism, protocooperation and commensalism while hyperparasitism, antibiosis and competition are the mechanisms attributing to biological control.

Biological control of plant diseases

Most of the work on biological control of plant diseases has focused on soil borne diseases. However, seed-borne as well as air borne diseases have also caught attention of the

scientist. The bioagents used are various types of bacteria (*Psuedomonas and Bacillus*) and fungi (*Trichoderma* and *Gliocladium*). In india, the pioneering work done by Dr. Vasudeva and his team, involved the use of bacteria bio-agents *Bacillus subtillus* against fusarial wilt of pigeon pea. Other bacterial antagonist tried and found effective by various workers were, collar rot of lentil by *B. subtilis*. *Fluorescent pseudomonads* also become a focus of attention in 1980s. *Psuedomonas flourescens* was found to suppress rice sheath blight caused by *Rhizoctonia solani* and *Sclerotium rolfsii* in groundnut and cotton.

Biological control of plant diseases through seed bacterization has been reported to be successful in various other cases too. Streptomycin and Bacillus reduced the germination of *Tilletia indica* and *T. foetida*, the causal organisms of bunt of wheat. Hokeberg et al., (1997) screened about 400 bacterial strains isolated from roots of wild and cultivated plants against *Drechslera teres* (net blotch in barley). One isolate MA- 342 controlled diseases caused by *D. teres* and *T. caries* as a biological control agent. *Fluorescent pseudomonads* are also reported for the control of take all disease of wheat caused by *Gaeumannomyces graminis var. tritici*. Take all disease is an example of biological control by root associated microorganisms like rhizobacteria.

Bio-control agents also play a very important role in the management of seed borne diseases. Work done on the management of loose smut of wheat (*Ustilagi tritici*) and Karnal bunt (*Tilletia indica*) has opened up the possibilities of the use of *Trichoderma spp*. in combination with the reduced doses of the Carboxin (vitavax75WP) used as dresser for loose smut, and *T. harzianum* used as foliar spray, can be exploited successfully in managing these diseases of wheat under field conditions. These biocontrol findings have been validated through large scale on farm trials. Apart from these, not much information is available on the use of bioagents in controlling foliar as well as seed borne diseases of wheat. The seed borne infection of loose smut of wheat and covered smut of barley was reduced due to seed treatment with spore of *Trichoderma viride*. Seed coating with spores of *Trichoderma harzianum* and *Penicillium oxalicum* and cells of *Psuedomonas cepacia* and *Psuedomonas fluorescens* have been found effective biological control methods for damping off.

There are reports that seed treatment with crude extracts of *Vinca rosea*, *Oscimum sanctum*, *Allium sativum*, *Parthenium hysterophorus*, *Datura stramonium*, *Azadirachta indica* and *Thuja sinensis* reduces incidence of downy mildew of pearl millet.

Biological control and weather conditions

Most pathogens will be susceptible to one or more bio-control strategies, but practical implementation on a large scale has been constrained by a number of factors. The environmental factors such as temperature, rainfall, soil moisture and humidity play an important role in deciding the fate of biological control under field conditions. Yigal (1995) worked on biological control of *Botrytis cinerea* on tomatoes and strawberries in Israel with application of *Trichoderma harzianum* T39 (Trichodex) in glasshouse and in the field. Bio-control was more effective under conditions that were less favourable for the disease development.

The colonization of rhizosphere by *Gliocladium virens* and *Psuedomonas putida* was correlated with the suppression of *Fusarium* wilt in cucumbers. Microbial activity in soil increases with increase in soil temperature. The better colonization of bioagent at low temperature probably may be due to less competition from indigenous rhizosphere and other soil microflora. Good control of damping off of seedlings caused by *Pythium ultimera* and *R. solani* was obtained by strains of *Psuedomonas fluorescens* at low temperature. Likewise the control of bacterial wilt of tomato by avirulent strain of *P. solanacearum* was more at low temperature. Maximum reduction in *Fusarium* wilt of pigeon pea by inoculation of non pathogenic fungi was obtained at 20-30^0 C.

Time and mode of application of bio-control agents

The success of bio-control agents is mainly dependent on the time, crop growth stage, mode form and application or delivery system of bioagent**.** Same day inoculation of both *Trichoderma* isolates and *Curvularia eragrostidis* causing leaf spots in Yam.

Subsequent application of *Trichoderma* was also found preventive and curative towards Botrytis gray mold of chick pea and prevented the pathogen from invading and colonization of the plant. Inoculation of *T. harzianum* prior to Karnal bunt pathogen (*Tilletia indica* in wheat controlled *Pyricularia oryzae, Bipolaris sorokiniana* and *Alternaria alternate* infection in wheat seed by dipping these seeds in cell suspension of *Bacillus subtilis,* for five hours. The seed treatment is more effective to control *Sclerotium rolfsii* beans in fumigated soil under glasshouse conditions.

Inoculum load

Inoculum load of bio control agents decides the success or failure of the bio control agents. There is a recommended CFU for every bacterium, so one should treat the seed with the recommended concentration of the bacteria.

Effect of pesticides and fertilizers on bio agents

The use of pesticide in field affects the survival of antagonist micro-organisms and thus influences their efficacy to manage plant pathogens.

Bio safety and environment issue

Biological control deals with living organisms, so there may be non target effects of the bio control agents. So, utmost care should be taken while use of the bio -control agents.

Some of the diseases controlled by the antibiotics produced by the bio-control agents (BCAs) (Pal and Gardener, 2006; Singh, 2003)

Disease	**Pathogen**	**Target pathogen**
Damping off	*Psuedomonas fluorescens F13*	*Pythium spp.*
Aflatoxin	*Bacillus subtilis AU195*	*Aspergillus flavus*
Wilt	*Bacillus amyloliquefaciens FB42*	*Fusarium oxysporium*
Damping off	*Lysobacter sp. Strain SB-K88*	*Aphomyces cochliodes*
Root rots	*Trichoderma virens*	*Rhizoctonia solani*

Damping off	*Bacillus subtilis QST 713*	*Botrytis cinerea* and *R. solani*
Damping off	*Bacillus subtilis BBG100*	*Pythium aphenidermatum*
Damping off	*P.fluorescence pf-5*	*Pythium ultimum* and *R. solani*
Damping off and Rice blast	*Burkholderin cepacia*	*R. solani* and *Pyricularia oryza*
Ergot of bajra	*Fusarium roseum* *F. sambucinum* *Dactylium fusarioides*	*Claviceps purpurea*
	F. semitectum var.majus	*Claviceps fusiformis*
Powdery mildew of peas	*Ampelomyces,Cladosporium, Tilletiopsis* and *Verticillium*	*Erysiphe polygoni*

Conclusion

Healthy and disease free seed is a primary requirement for good agricultural produce. Seed is adversely affected by various biotic and abiotic stresses. Seed can be treated with various chemicals to control the pathogens, but chemical have their harmful effect on the environment and it is costly as well. Seed bio-prospecting or bio-control of the pathogen is a better alternative to control the plant diseases. Bio-control agents are economical and ecological. These are cost effective and user friendly. So there is a need to promote the use of bio-control agents in the field.

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.

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Seed Health Testing

Significance of seed health testing

One of the most important aspect of quality seed is the production of disease free seed, therefore, seed health testing is more important because

- Seed-borne inoculum secures the presence of a virulent strain of the pathogen along the seed.
- The presence of a pathogen with the seed favors the earliest possible establishment of the infection in seedlings.
- Un-infested soil may be inoculated by the introduction of infected seeds hence subsequent crop raised from healthy seed may in turn be infected from the soil.
- New physiological races/strains may be introduced with the seed so that varieties resistant to endemic races of the organism become affected.
- To know the health status of seed lots and keeping its quality under storage and consequently it's planting value.

Scope of seed health testing method

The seed health testing methods have become very critical and target oriented. The methods employed for the detection of seed borne viruses and bacteria are very sensitive and accurate, however, needs fairly good knowledge of microbiology, plant biotechnology and plant pathology considering the present set up of seed analysis. Tremendous scope exists for the application of these methods.

Seed health consciousness is gaining importance. Seed health awareness is increasing. Academically more and more methods are being evolved which are accurate and less time consuming but general adoption is far away due to the involvement of scientific infrastructure, manpower and expertise in our conditions.

Common methods employed

Techniques employed for detection of seed transmitted pathogens

The selection of a diagnostic method for evaluation of seed health depends upon the host to be tested as well as type of pathogen.

The purpose of the test are also very important.

Conventional Techniques

Naked eye dry seed inspection,
Seed wash test,
Whole embryo count test,
Incubation tests,
Grown on test,

Infectivity test,
X-ray radiography,
Electron microscopy based techniques,
Histopathological test
Seedling symptom tests

Serological techniques

ELISA (Enzyme linked immunosorbent assay) including Double Antibody Sandwich (DAS)-ELISA, Biotin-Avidin ELISA, Bead ELISA, Indirect F (ab')Z Fragments ELISA, Protein A coating (PAC) ELISA, Protein A-Sandwich ELISA,
Dot-Immuno-bidning Assay (DIBA),
Single Antibody Dot Immunoassay (SADI),
Immunosorbent Electron Microscopy (ISEM),
Immunofluorescence assay, solid phase immunosorbent methods,
Disperse dye-immuno Assay (DA),
Enzyme linked Fluorescent Assay (ELFA).

Nucleic Acid Based Techniques

Restriction Fragment Length polymorphism (RFLP) analysis,
Polymerase Chain Reaction (PCR) and its different modifications such as Reverse Trans Script ion PCR (RT-PCR), Combined Biological and Enzymatic Amplification (BIO-PCR), Taqman PCR, Immuno magnetic PCR (IMS-PCR), Multiplex PCR, Mimic PCR, Competitive PCR, Quantitative PCR, Spore-cracking PCR,
Nested PCR, Repetitive sequence based PCR (rep-PCR), Reverse transcript are PCR (PCR/RFLP), Magnetic Capture hybridization (PCR-MCH), Immunocapture RT-PCR, RT-PCR-ELISA.

Conventional Techniques

Inspection of dry seed

- Pour the sample on the purity analysis board on the top left surface
- With the help of spike, separate the pure seeds into the container placed on right side below the board.
- In other two small containers, separate the other crop seed (OCS) and inert matter (IM).
- The inert matter may consists of soil, sand, stones, various types of plant debris, sclerotia, smut balls, seed galls, bunt balls of fungi.
- The physical abnormalities may appear on seed and include shriveling of the seed, reduction or increased size, discoloration or spots on the seed coat.
- Abnormal seeds/inert matter may be tested with aided light under stereoscopic microscope.
- Seeds showing abnormalities and inert matter can further be tested by blotter or agar plate method.

- Make report on all the four components (pure seed, inert matter, weed seed and other crop seed) by weight.

Advantage:

The method provides quick information on seed health and purity. Very helpful for the detection of many diseases including grain smut of sorghum and pearl millet, ergot of sorghum, pearl millet, bunt of wheat, rice and Triticale, wheat seed gall etc.

Standard blotter method

Materials and testing facilities

Petri plates (plastic or glass, 90 mm diameter), blotting (filter) papers with superior water holding capacity already cut into 90 mm diameter, distilled water, forceps; trays (glass and plastic); growth (incubation) chamber with adjustable temperature and provision of NUV light system, deep freezer (-20°C), stereoscopic binocular microscope with magnification up to 60 times, compound microscope with magnification up to 400 times, glass micro slides and cover slip, electric oven, laminar air flow system.

Procedure

- Keep the cooled pre-sterilized glass Petri plates on the clean surface of the working table in required quantity (sterilization of glassware is done in an electric oven for 2 hrs at 180°C).
- Keep the filter papers near the Petri plates, count and make the sets of 3 filter papers for one plate.
- Disinfect the forceps tips (keeping it over the flame for few seconds, cool it).
- With the help of forceps, dip one set of filter paper in a glass tray containing distilled water. After complete soaking just, lift the set in air over the tray, allowing the extra water to run-off.
- Place the moist filter paper into lower half, holding the paper with the help of forceps in right hand. Set the papers, turning the plate clockwise.
- Prepare the plates in the same way. Wipe off and dry the working label.
- Place the seeds on a plain paper sheet (Number of seeds to be plated in one plate depends on the size of the seed. In a plate 5, 10, 25 or 60 seeds can be placed). Write the accession number and date of examination of the seed sample.
- Count and make small groups of 10 of 25 seeds for one plate. Do not touch the seed use spikes.
- Arrange the counted seeds on moist blotter (lined in plates) using forceps at equidistant from each other. Close the lid (for plating the 25 seeds, keep one seed in the center, 8 in middle and 16 in outer ring. Whereas for 10 seeds, one is plated in the center and 9 in the outer ring).
- Collect the plates in the plastic trays without disturbing the seeds.
- Incubate at 20-25°C for 7 days in alternate cycles of 12 hr dark and 12 hr light (The common source of light used is the near ultra-violet (NUV) supplied by black light

tubes or day light provided by cool, white, fluorescent tubes. In either case light is provided by two tubes hanging horizontally, 20 cm apart. Distance between tubes and plates should be 40 cm. Proper care for protection from NUV light must be taken wearing eye glass and hand gloves).

- After seven days of incubation, seeds are examined one by one under stereoscopic binocular microscope (associate mycoflora are identified based on habitat characters. These are also confirmed by making slides under compound microscope).
- Count the number of fungi on seeds and enter the observations in data-sheet. Also, make comments on symptoms on seed and seedlings.

Advantage

Blotter method is the most convenient, cheap and efficient method. The method was first adopted by Doyer (1938). A large number of mycoflora including *Alternaria solani, Stemphylium solani, Colletotrichum dematium, C. lindemunthianum, Macrophomina phaseolina, Fusarium oxysporum* etc. can be detected.

Modifications

2, 4-D Blotter dip method

Blotters (filter papers) are moistened with 0.1-0.2% solution of sodium salt 2, 4-dichorophenoxy acetic acid instead of plain distilled water. Rest of the method is same.

Advantage

The sodium salt retards the seed germination and seedling growth. Hence the seeds are not displaced; remain on the place where they were plated. Examination is made easy. In 1956, Neergaard found the method very effective for the detection of *Phoma lingam* associated with cabbage (Neergaard, 1977).

Deep freezing blotter method

- Seeds are plated as in blotter method.
- Incubate the plates initially for 24 hr under usual conditions in the growth chamber.
- Plates are transferred to deep freezer (-20°C) under complete darkness for 24 hr.
- Plates are retransferred to growth chamber for remaining 5 days.

Advantage

Exposure of imbibed seeds on moist blotters to low temperature (-20°C) kills the seeds matter. This provides the nutrients for better development of associated mycoflora. To avoid the contamination in deep freezer method can further be modified. Blotters may be soaked in streptopencillin (0.2%) solution. The antibiotic will be effective against gram positive and negative bacteria. The method was first adopted by Limonard (1968).

Standard agar plate method

Materials and testing facilities

Glassware, Petri plates, beakers, measuring cylinders, funnels, conical flasks. Chemical, agar-agar powder, sugar (sucrose or dextrose) distilled water. Equipment used are electric oven, autoclave, inoculation chamber (laminar-air flow system).

Procedure

- Prepare the potato dextrose agar medium (peeled potato slices 200 g boiled in 700 ml water, agar agar-powder 20 g dissolved in 300 ml with 20 g dextrose. Final mixing and making up volume to 1000 ml).
- Sterilize the media in autoclave (121.6°C for 20 min at 15 lb-pressure) and after semi-cooling, pour the melted medium in pre sterilized Petri plates (approximately 17-20 ml per 90 mm Petri plate) under aseptic conditions of laminar flow.
- After solidification of medium, invert the plate for 12 hr.
- Reject the contaminated plates (contamination refers to the development of bacterial, fungal, actinomycete or mix colonies on the medium. This also indicates the improper sterilization of glassware or media or preparation faults).
- Place 10 surface sterilized seeds (treated with NaOCl) on the media under aseptic conditions. One in center and 9 in outer ring.
- Incubate the plates containing seeds in the growth-chamber for 7 days.
- Examine the seeds for the developing associated mycoflora by naked eye and stereoscopic binocular on the basis of habitat characters.

Advantage

Method is most suitable for the detection of internally seedborne fungi e.g. species of *Ascochyta, Macrophomina, Phoma*. Muskett and Malone (1941) first used the method. The method can be modified in various ways either by changing basic media, its composition or addition of chemicals, as per need.

Modifications

Peptone-PCNB method

The basic medium (PDA) can be replaced by Malt-agar or Peptone-agar. Medium is supplemented by antibiotics (e.g. chloro-tetracycline, streptomycin sulphate) and / or fungicide (PCNB penta-chloro-nitro-benzene) in different concentrations.

Advantage

Medium containing antibiotics and fungicides needs no sterilization. The medium is advantageous for the detection of *Fusarium* spp., *Macrophomina phaseolina* (Limonard, 1968). Hag Borg *et al*. (1950) first used 2, 4-D in agar plate for *Colletotrichum lindemuthianum* on bean seed. Other selective medium includes e.g. Oxgall-PDA medium for *Septoria* sp., Guaiacol agar medium for *Pyricularia*.

Rolled paper towel method

- Take two sheets of standard germination testing paper (paper towel); enter the number, date and crop on the other side with waterproof ink.
- Mist first sheet with sterile-distilled water and stretch over clean surface of working table.
- Arrange 50 seeds in 5 rows of 10 seed at equidistant as in germination test on one sheet. Total 400 seeds are placed.
- Cover the seeds by second pre-soaked sheet carefully without disturbing the already arranged seeds.
- Roll and tie the sheets with rubber band at both the ends.
- To avoid water losses, use butter wax coated paper for rapping the sheets at one side.
- Place the paper towels, containing seeds in germinator with slightly tilting the bunch of towel.
- Incubate in dark.
- Observe the towels after 7-14 days by opening and removing the cover sheet.
- Examine the seeds by naked eye and stereo binocular for the presence of mycoflora and seed germination.

Advantage

The method is most suited for the detection of *Fusarium* spp. in cereals and *Ascochyta* spp. in pea. It is equally good for testing germination of seeds.

Seed washing test

- Take one gram of seed from a working sample in a clean and small conical flask.
- Add 10 ml of water and a drop of wetting agent (e.g. Tween 20).
- Make 10 replications
- Shake the flasks for 10 minutes with care.
- Transfer the water in tubes and centrifuge for 10 minutes at 2300-2500 rpm.
- Decant the supernatant liquid leaving the sediment at the bottom of the tube.
- Suspend the sediment in 2 ml of distilled water.
- Examine the water drops under compound microscope (200 x) for the presence for oospores. The oospores are yellow-brown, spherical, 3 layered thick walled spores.

Advantage

The method is best suited for the detection of downy mildew of sunflower (*Plasmopara halstedii*) and pearl millet (*Sclerospora graminicola*) pathogen. The viability of oospores associated with seeds can be determined. Oospores are subject to TTC (2.3-5 tri phenyl tetrazolium chloride) solution (1%) for 48 hr at 30°C. In complete darkness. Viable spore shows red color in their cytoplasm. The method has been used by Chahal *et al*. (1994) and Shetty *et al*. (1978).

Test tube water agar seedling symptom test

- Take clean, rimless glass test tubes of 16 mm diameter.

- Dissolve 10 g agar agar-powder in 1000 ml distilled water and autoclave at 15 lb for 15 min.
- Transfer 10 ml of water agar into each tube under aseptic condition.
- After solidification of agar place one seed in each tube. Cover the mouth of tube with a piece of aluminum foil.
- The tubes are placed vertically in a tray and incubated in growth chamber as in standard blotter method.
- As the seedling reaches the cover, the foil is removed.
- Symptoms caused by the associated mycoflora on the seed and developing seedling are observed after 14th day.

Advantage

The method is suited for most of the pathogen. Symptoms can be seed on roots and shoot portion. The method is also useful for quarantine stations as diseased seedlings of valuable crop scan be destroyed. Healthy seedlings can be retained and saved. The method was developed for *Septoria nodorum* associated with wheat seeds (Khare *et al*., 1977).

Sodium hydroxide seed soak method

- Dissolve 2 g NaOH in 1000 ml (for preparing 0.2% solution).
- Working seed sample consists of 4000 seed with 2 replication of 2000 seed each for foundation seed and 800 seeds with 2 replications of 400 each seed for certified wheat seed is prepared.
- Seeds are soaked in a small conical flask or beaker of 250 ml capacity for 24 hr at 25°C.
- A solution is decanted after 24 hr and washes the seeds in tap water.
- Seeds are placed on blotter to soak extra water.
- Spread the soaked seeds over white background and examine by naked eyes.
- Seeds exhibiting jet black shiny appearance with hollow or without hollowness are separated.
- Number of such seeds are counted as infected seeds and reported in percentage.
- Black seeds can be observed under compound microscope for the presence of teliospores.

Advantage

The method is well suited for Bunt of wheat and Triticale (*Neovossia indica*), rice (*Neovossia horrida*) (Agarwal and Verma (1983); Sharma and Agarwal (1996); Agarwal and Shrivastava (1981); Savitri and Sattar (1996). The method is very cheap and convenient. The method can be tested even for the seeds treated with (colored) fungicides (Agarwal and Mathur, 1992). Sodium hydroxide removes the other coatings, stain, dust; chemicals etc. from the seed and cause a bit swelling of the seed to exhibit clear symptom of the disease even in minute cases of infection.

Embryo count method

Embryo count method for the detection of loose smut infection in wheat seed is described by Agarwal *et al*. (1978); Gaur and Agarwal (1995). A cost effective suitable and modified technique is presented by Singh and Maheshwari (1995) consisting of the following steps.

Materials and testing facilities

Glassware/plastic wares; beakers, Petri plates, glass rod, plastic bucket, mugs, glass funnel attached with tube and stopper measuring cylinders. Chemicals; sodium hydroxide, trypan blue, rectified spirit, phenol, glycerol, lactic acid, Equipment; stereoscopic binocular microscope, precision balance, counter general; sieve mesh 10, 20 and 30 size, cheese cloth, seed sample, hot plate tap water system.

Procedure

- Soak 100 g (2200-2800 seeds) wheat seeds in 100 ml of 5 per cent solution of sodium hydroxide (NaOH) and 0.005 per cent trypan blue in a 2000 ml capacity beaker for 18-22 hr at 22-24°C.
- Pass the soaked seeds through a sieve set of 10 and 30 mesh and wash the seeds thoroughly with running tap water to separate the embryos.
- Agitate the soaked seed material to facilitate the separation of embryos. Collect the embryos over 30 mesh size.
- Wash the separated embryos into a tea strainer and dehydrate them with methyl spirit for 2-5 minutes.
- Pass the dehydrated embryos in solution of lactic acid + glycerol + water (1:2:1) in small beaker.
- Take a glass funnel; connect the stem of the funnel with rubber tubing provided with a stopper.
- Pass the mixture of lactic acid + glycerol + water through the tunnel. The embryo float at the top of the funnel and chaff sinks.
- The chaff can be run-off through a tea strainer and collect the solution in a beaker which can be reused for extracting the embryos for additional 3 samples.
- Repeat the process 4-5 times until embryos are separated from chaff. Heat the solution with embryos for 2 minutes until boiling.
- Allow the solution to cool for 30 minutes.
- Arrange the embryos in Petri plates in ring of individual embryo and pour solution of lactic acid and glycerol to facilitate examination.
- Evaluate the test by examining less than 12 to 15 x magnifications under stereoscopic binocular microscope. Infected embryo exhibit blue stained mycelium of loose smut pathogen in scutellum, plumule or whole embryo.

Seed Certification and Minimum Seed Certification Standards- Indian Paradigm

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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				

New Dimensions in Seed Certification: OECD Scheme

Improved varieties and good quality seeds are inevitable to confront the challenges of ever increasing population and food insecurity. Improved seed is a carrier of technological innovations and serves as an engine for agricultural advancement when available in the required quantities and of the right quality. Seed being a commodity of trade, seed production supply activities and seed quality constitutes a more serious source of concern than seed quantity. As the first input in the cropping process, high quality seed brings high genetic yield potential resulting in higher productivity and crop production.

Seed certification is a legally sanctioned system for the quality control of seed during seed multiplication and production. The main objective of the Seed certification is to ensure the acceptable standards of seed viability, vigour, purity and seed health. A well organized seed certification should help in accomplishing systematic increase of superior varieties, identification of new varieties and their rapid increase under appropriate and generally accepted names and provision for continuous supply of comparable material by careful maintenance

In India, certification is voluntary and labeling is compulsory. Seed certification is subjected to the Seeds Act, 1966 and the procedures are regulated by the 1968 rules for Certification and subsequent amendments. Certified seed must satisfy the standards as outlined in the 2013 edition of the Indian Minimum Seed Certification Standards (IMSC). Trade in seed is subject to bi-lateral and/ or multilateral agreement at local, regional and international levels. In general, the seed trade is one of the most regulated sectors in all countries, with a plethora of seed loss, testing and certification procedures. The simplification and harmonization of testing and certification procedures helps to improve farmers access to high quality seed in all regions of the world. Several international bodies were created for setting standards and regulations that provided an enabling environment for the seed industry: The International Seed Testing Association (ISTA); The International Plant Protection Convention (IPPC); The OECD seed schemes, and the International Union for the Protection of New Varieties of Plants (UPOV).

OECD Seed Scheme

The OECD Seed Schemes provide an international framework for the certification of seed with the aim of facilitating the growth in trade of seed by reducing technical barriers (providing 'seed Passport'). The Schemes were established in 1958 in response to a combination of factors including the rapidly growing seed trade, the increase in regulatory requirements in some countries, the development of off-season production, the large breeding and production potential of exporting countries. The purpose of the OECD Seed Scheme is to encourage the use of "quality-guaranteed" seed in participating countries. The Schemes authorize the use of labels and certificates for seed produced and processed for international trade according to agreed principles. The OECD Seed Certification Schemes are based on two key criteria; varietal identity and varietal purity. The OECD certification is applied to

varieties satisfying DUS tests (Distinction, Uniformity and Stability), and the Schemes aim to ensure varietal identity and purity through seed multiplication, processing labeling. They also provide specifications for seed multiplication outside of the country, which is becoming an ever-increasing practice. In 2008, over 500 000 metric tons of seed were OECD-certified, traded and used by farmers. In addition, the main OECD principles can also be applied to seed that is used on the domestic market. There are seven distinct and independent Seed Schemes and admission to each Scheme is voluntary. India became full members of the scheme in 2009. Presently, India participates in 5 schemes namely, Cereal seed; Maize and sorghum seed; Vegetable seed; Grass and legume seed and Crucifer seed and other oil or fibre species seed.

Varietal maintenance

The objective of maintenance breeding is to maintain and purify the pedigrees (parental lines) of hybrids or varieties. Thus, the genetic identity and purity of the hybrids can be preserved against various factors affecting the genetic deterioration *viz.*, genetic erosion, admixtures, selective influence of pests & diseases etc To achieve the goal of maintenance breeding *i.e.*, preserving the genes, traits, characters, hereditary factors which make one aspect of a breed or species different from another for the future. To minimize the contamination arising due to these factors, one has to take adequate care while producing seed more specifically at nucleus/breeder seed level in terms of land requirement, isolation, rouging, plant protection measures, harvesting, threshing and processing etc. The maintenance of the OECD variety is the sole responsibility of the institutes to which the variety belongs. The varietal maintenance is done through maintainer who is a person or an organisation responsible for maintaining the variety and ensuring that it remains true to type throughout its full life-span and in the case of hybrid varieties that the formula for hybridization is followed. Maintenance may be shared. For listing purposes, the maintainer can be the national office / the company/institute responsible/or the variety even when the maintenance process/or the variety lakes place at another location. The maintenance of variety done by adopting the normal maintenance breeding procedures. The maintainer code is a unique alpha-numeric code attributed to each maintainer by the National Designated Authority. The list of maintainers is compiled from the individual countries' lists and comprises the names and addresses, including the country, of each maintainer.

Approaches for maintenance for Self-pollinating Crops

- Produce enough breeder seed for the lifetime of the variety:
- Produce breeder seed every fifth year:
- Use basic seed as source for breeder seed without selection :
- Use Basic Seed as Source for Breeder Seed with Negative Mass Selection :
- Ear-to-row or Plant-to-row Selection for Self-pollinating Crops:

Approaches for maintenance for Cross-pollinating Crops

- Negative Mass Selection :
- Ear-to-row and Plant-to-progeny Selection

- Rest Seed Method:

Classes and Stages of Seed Multiplication

Breeders Maintenance Material

Checked against DUS characters. Carries Suppliers Labels. Controlled and maintained by the maintainer / breeder. Used for pre-basic seed multiplication.

Pre-Basic Seed

Carries White Label with diagonal Violet Stripe. Controlled by official certification authority (DA) and maintainer. Undertake pre- controlled test. Cannot be commercialized and not for sale. Produced officially by the recognized institute/ organization.

Basic Seed

It carries white label and is controlled by official certification authority (DA) along with the maintainer. Undertake pre-controlled test. Cannot be commercialized and not for sale. Produced officially by the recognized institute/ organization. Basic Seed shall be produced under the responsibility of the maintainer who will decide, in consultation with the Designated Authority, the number of generations from parental material before Basic Seed, which number must be strictly limited; and who will maintain a sufficient supply of seed for sowing to produce Basic Seed, ensure that it preserves the characters of the variety and supply the Designated Authority, when requested, with samples of this seed. If the Basic Seed is produced in a country other than the country of registration of the variety, technical conditions must be agreed in advance by the Designated Authorities of both countries concerned.

Certified Seed

Certified seed may be produced either inside or outside the country of registration of the variety it carries Blue Label (C 1) and Red Label (C 2). This seed is not under Breeder's / Maintainers control, however they are consulted for the number of multiplication. Designated Authority and Controlling Authorities undertake the quality control including post control test and provision of Patent Royalty to the Maintainers / Breeder's. This class of seed is used for the commercial multiplication or sale.

Not Finally Certified Seed

The seed which is to be exported from the country of production after field approval, but before final certification as basic or certified seed, shall be identified in fastened containers by the special label is referred as not finally certified seed. It carries grey label.

Standard Seed

This category mainly exists in vegetable seed scheme. Seed that is declared by the supplier as being true to the variety and of satisfactory varietal purity. It must confirm to

the appropriate conditions in the scheme. It carries dark yellow label.

Eligible Varieties and Parental Constituents

Country shall have national list of varieties under the OECD Seed Schemes, which include only those varieties tested and listed to be Distinct, Uniform and Stable following internationally recognized guidelines and in case of agricultural species, varieties also found to have acceptable Value for Cultivation and Use (VCU) in at least one country. Registered in National Catalogue of Varieties.

Control of the Production of the Seed

The Designated Authority [DA] in the country of production of the seed is responsible for implementing the Scheme in relation to that of production. For certified seed production in *OECD,* non-official inspectors are also allowed. Seed testing is done as per the International methods of Seed Testing recognized by the DA. The DA may authorize non-official laboratories to carry out seed analysis, but under official supervision.

The Designated Authority of the Country of Registration is responsible for

- Ensuring that the variety to be OECD listed has been registered on the National Official Catalogue
- Communicating the name of the person(s) or organisation(s) responsible for the maintenance of the variety
- Liaising with the maintainer of the variety
- Providing written agreement for the multiplication of seed outside the Country of Registration to the appropriate Designated Authority
- Supplying an authenticated standard sample of the variety to be multiplied in order that a control plot can be sown to provide an authentic reference of the variety
- Supplying an official description of the variety to be multiplied, and, in the case of a hybrid variety, a description of the parental components
- Authenticating the identity of the seed to be multiplied.

Requirements of the production and field inspection

- In each participating country requirements for the production of Basic and Certified Seed approved under the Scheme as being satisfactory for varietal identity and purity shall be officially applied. These requirements shall not be lower than the standards given.
- The Designated Authority must satisfy itself by inspection of the plants at an appropriate stage or stages during production that the lot is acceptable.
- In the case of production of seed of "Certified" category, the Designated Authority may, under official supervision, authorise non-official inspectors to operate field inspection with a view to seed certification, on the conditions or applicable treat and tThe Designated Authority which decides to use this method must define the operation scope (species; territories, areas and period concerned), ensure the official check inspections, sampling and post-control tests and other requirements or described and take all necessary measures to guarantee equivalent inspection in the sense of the Schemes for

field inspected by authorized inspector or by official.

- The designated Authority must take all practicable steps to ensure that the identity and varietal purity of the seed have been maintained between harvest and the fastening and labeling.

Seed Sampling

The Designated Authority is authorized to take seed lot sampling, fastening and labeling of container. He may authorize non-official persons to carry out, under official supervision of seed sampling, fastening and labeling of containers. The sample shall be large enough to meet the requirement as outlined and shall be drown according to current institutional methods for seed sampling recognized be the Designated Authority.

Seed Analysis

Seed Analysis of the sample shall be carried out in the official laboratory designated by the DA for analytical purity and germination according to current International Methods for seed testing recognized be DA. The Designated Authority may authorize non-official laboratories to carry out analysis under official supervision and under such situations the DA shall undertake officially check analysis and satisfy itself of verification and requirements.

Seed Sample Storage

For basic seed third part of each sample shall be stored as long as possible for comparison in control plots with future test samples of Basic seed. For certified seed a third part of each sample shall be stored for one year.

Pre and Post Control Tests

Pre control test is compulsory for Pre-Basic and Basic seed. A part of every sample of Basic Seed and 5 to 10 per cent of the certified seed shall be checked in a post-control test conducted immediately or in the season following the drawing of the sample

Issue of Certificates

The Designated Authority may issue certificates for each lot of Pre- Basic, Basic and Certified seed approved under the Scheme for varietal purity and for analysis results according to the procedures laid out. These two certificates shall carry the same OECD reference number.

Blending of Lots of Same Variety / Re-Packing and Re-labeling in Another Country

Two or more lots of certified seed of the same generation of one variety may be blended before or after export in accordance with the regulations of the country in which the seed is blended. A new reference number will be issued for blended lots. Records will be kept by the DA showing the reference numbers of the lot making up the blend and the proportion of each lot in the blend. Provision for Re-packing and Re-labeling in another country allowed.

Reference Numbers for Certificates and Seed Lots

In OECD the lot numbers are assigned based on Three letter country code as per ISO-3166-1 followed by initial letters of DA followed by reference number of the lot having uniform digits (for example, 0001 to 9999) and a code letter used to indicate harvest year. The code number is given for a year.

Specifications for Label or Marking of Seed Containers

Labels may be either adhesive or non-adhesive. The information may be printed on one side only or on both sides. Labels shall be rectangular is shape. The colors of the labels shall be white with diagonal violet stript for basic seed, white for certified seed, blue for first generation certified seed, red for second generation certified or successive generations. Not finally certified seed shall carry grey label. On all red labels and all grey labels for certified seed of 2nd or further generation the appropriate generation number must be stated. One end of the label shall be overprinted black for a minimum distance of 3 cm leaving the rest of the label colored.

The material used for labeling must be strong enough to prevent damage in ordinary usage. Statement of re- packing and re- labeling is given if applicable. In OECD all information shall be given in either English or French except reference to the Scheme which must be in both English and French. Label number is not given in OECD schemes.

Specimen Certificate and Analysis Results

In OECD, statement of re-packing and re-labeling is given additionally. In OECD only number of containers and declared weight of the lot is given and ISTA orange certificate is given.

Procedure for the Extension of the Scheme

Procedure for the extension of the scheme to include, for the purposes of field inspection, varieties under examination for registration on a National List.

Specific Crop Standards

Specific crop standards shall be followed in order to meet out the varietal purity.

Previous Cropping

Hybrids

Hybrid seed may not be grown in the same field for successive years.

Varieties

Grower requires furnishing particulars concerning the previous cropping in each seed field. There shall be minimum time interval at least 2 years between cereal crops of same species. Successive crops of the same variety and category of seed may be grown on the same field without any time interval provided that the satisfactory varietal purity is maintained. The growers shall furnish to the DA, particulars regarding, the previous cropping in each seed field. There shall be a minimum time interval between seed crops and any other crop of the same species as follows: for crucifer species: five years; for other species: two

years.

Isolation

Hybrids

For hybrids, female parent and cross pollinated OP varieties, prescribed distances from other variety of the same species except from a crop of male parent shall be maintained. Distances can be modified where there is sufficient protection from undesirable pollen or where the possibility of cross-fertilization is eliminated.

Varieties

The seed crops of self-fertilizing species shall be isolated from other cereal crops by a definite barrier or a space sufficient to prevent mixture during harvest.

Weed

Crops containing an excessive number of weeds shall be rejected.

Number of Harvest Years

The Designated Authority shall decide the number of harvest years to be permitted for a seed field, with particular attention when multiplying foreign varieties to the effects of changed ecological conditions on varietal purity.

Field Inspection

There shall be at least one field inspection of each seed crop after the emergence of the inflorescence. Control plots wherever possible be available for detailed examination at the time of field inspection of the seed plot. The DA shall decide whether or not approval can be given to the field following field inspections. For hybrids and parental lines minimum three inspections are followed. Official seed certification officer are authorized to inspect the plots. Non- official inspectors are also allowed to conduct inspections.

Varietal Purity in Seed Crop

The varietal genetic purity varies with class of seed. For basic seed it is 99.9 per cent are certified seed 1st generation and 2nd generation 99.7. This depends upon the species and ranges from 99.9 to 95 per cent.

Seed Sampling (Including Fastening and Labeling of Containers) **and Seed Analysis by Authorized Persons or Laboratories under Official Supervision**

The Designated Authority may authorize persons who are not under its direct and exclusive authority to draw samples under official supervision is called 'seed samplers'. Laboratories may also be authorized to carry out seed analysis as required under the Schemes. Sampling, fastening and labeling of seed containers may be entrusted to authorized persons.

Seed Lot Sampling

Sampling is done by samplers and supervised by official supervisors. And five

percent check sampling done by official seed samplers.

- DA may authorize non officials person to carry out seed sampling, fastening & labeling of container under official supervision (5 percent)
- DA may authorize Non-official laboratory for seed analysis.
- Model Label for container & printed information must be submitted for approval to OECD.
- White label for basic seed is not require if it is to be used in the same country.

Seed Analysis

In OECD Seed analysis is carried out in the laboratories authorized by DA and the laboratories shall carry out seed testing in accordance with current international methods. The laboratory shall be an independent laboratory, or a laboratory belonging to a seed company. In the case of laboratory belonging to seed company, the laboratory may carry out seed testing only on seed lots produced on behalf of the seed company to which it belongs, unless it has been otherwise agreed between the seed company, the applicant for certification and the DA.

Validity Period

No validity period is mentioned for Pre-Basic, Basic and Certified Seed.

Off-types in Field

Maximum number of plants of the same species being not true to variety is 1 in 30sq.mt for basic seed and 1 in 10sq.mt for certified seed. In OECD standard off type plants permitted all 0.22 percent in basic seed and 0.67 percent in certified seed.

Male Sterile Seed Parent

Male sterile seed parent may be mixed with fully fertile seed parent in the ratio of 2:1

Down-grading Seed Class

No provision is made to the OECD seed certification in this aspect.

Field Inspection Count

Crop Group	Crops	OECD Seed Standards	
		Basic	Certified
Pulse vegetables	Pea, Cowpea, Bean	100 plant per count	100 plant per count
Leafy crops	Lettuce, Spinach, Coriander, Methi	500 plant per count	500 plant per count
Fiber crops	Jute	200 plant per count	200 plant per count
Fruit crops	Tomato, Brinjal , Okra, Capsicum, Chilly	100 plant per count	100 plant per count

Future perspectives

The Indian Minimum Certification Standards were developed and is being adopted since 1974 for the domestic certification systems as per the need and requirement of Indian

farmers and stake holders of seed industry in India. Whereas the OECD Seed Schemes Rules and Guidelines are being developed for the benefit of 58 member countries for their Varietals Certification process to meet out the International seed standards and trading requirements. As these are two separate streams, we cannot harmonize the Indian Minimum Seed Certification Standards with the OECD Varietals Certification Rules and Guidelines. Whenever, a variety is being registered / offered for the OECD Seed Schemes then the OECD Rules and Guidelines need to be adopted and International varietal certification process has to be carried out. Similarly, the existing domestic seed certification with Indian minimum seed and field Standards will continue for the production of high quality seeds as per the Seeds Act. Both Indian Minimum Seed Certification Standards (IMSCS) and OECD Varietal Certification Systems, have agreeable level of general and specific crop standards requirements to meet the certification systems in these streams. However, certain variations have been found between IMSCS and OECD in general standards in case of: Classes and Stages of Seed Multiplication, Eligible varieties and Parental constituents, Control of the production of the seed, Seed sampling, Seed analysis, Seed sample storage, Pre- and Post Control tests, Issue of Certificates, Blending of lots of same variety, Provision of Re-packing and Re-labeling in another country, Reference numbers for certificates and seed lots, Specifications for the OECD Label or Marking of seed containers, Specimen certificate and analysis results, Procedure for the extension of the scheme, etc. The Specific crop standards namely: Previous cropping, Isolation, Off type, Varietal identification, Disease, Weed seeds, Number of harvest years, Field inspection count, Varietal purity in seed crop, Seed crop inspection, Field inspection of seed crops by Authorized Inspectors under Official supervision, Seed sampling (including Fastening and Labeling of containers) and Seed analysis by Authorized persons or laboratories under Official supervision, Validity period, Down-grading seed class, etc., are as mentioned in Table 5. In summary, we can say that even though India has become the member of OECD Seed Schemes, the two seed certification systems i.e. Indian Seed Certification and OECD Varietal Certification would move parallel in our country for the production of high quality seed as per the demand at Domestic and International trading requirements. As per the norms of OECD guidelines the Labels and Certificates designed and prepared by India as new member country shall need to be placed for the discussion and concurrence of OECD Secretariat. Multiplication of Indian Varieties in member countries for enhancing the International trading activities need to be explored by discussion with Officials of EU, ISF, ISTA, and AOSA for facilitation.

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.

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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- Case Study

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Importance of quality seed

Quality seed is an important contributor to the targeted four per cent growth in Indian agriculture. Quality seed is the basic and most critical input for sustainable agriculture and a steady availability of quality seed is necessary for the correct functioning of agricultural production. 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 for new quality seed. Estimated commercial world seed market is around 45 billion USD and Indian seed market is around 2 billion USD. Indian seed market is the 6th largest market in the world (2013). The distribution of certified / quality seed in India reaches all time high at the level of 380 lakh quintals (2016-17). 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 farmers.

The major factors contributed in market growth in seed industry are rising demand for food and feed and decline and scarcity of arable land across the world. There has been pressure to produce more from using same land along with other technologies on crop management measures such as plant protection, fertilizers, irrigation and other practices. Efficiency of other inputs highly depends on the quality of seeds used.It has been always major agenda globally to continuously improving seeds quality and these led inventions on hybrids and GM seeds. The two major technology measurement criteria associated with seed sector growth in agriculture are Seed Replacement Rate (SRR) and Seed Multiplication Ratio (SMR). Seed Replacement Rate (SRR) is the percentage of area sown out of total area of crop planted in the season by using certified/quality seeds other than the farm saved seeds by farmer. Productivity improvement initiatives invariably needs higher replacement rate with quality seeds of High Yielding Varieties (HYVs) and hybrids. However SRR is much below the required or optimum rate for most of the crops especially pulses and fodder crops. Also there has been low rate of hybrid adoption under Oilseed crops such as sunflower, castor and rapeseed and mustard.The Seed Multiplication Ratio (SMR) can be defined as the amount of seed harvested from each quantity of seed sown, which varies from crop to crop and largely dependent on genetic, climatic, soil and anthropogenic factors. Technological advancement helped a lot to improve SMR through yield gains and thus lowering of seed rate.

Why quality seed

- Seed alone contributes around 15-20 per cent in total production
- Varietal purity is known
- Higher productivity, absence of other crop seeds and certain diseases
- It is scientifically processed, treated, packed and labelled with proper lot identity
- Seed is tested for planting qualities viz. germination, purity admixture of weed seed and other crop seeds, seed health and seed moisture content

Global seed market

In global seed scenario, USA topped domestic seed market with value of US$ 12000 million followed by China (US$ 9950 million), France (US$ 2800 million), Brazil (US$ 2625 million), Canada (US$ 2120 million) and India (US$ 2000 million) during the year 2013. USA, China and France has more than 50% share of the total market.Globally private sector plays a major role in seed production. Top tenseed companies accounts for $14785 million or two thirds in global seed market share. Major companies are Monsanto, Du Pont and Syngenta, which together accounts for $10282 *i.e* 47 % of total seed market. Monsanto accounts for 23 % of total world's seed market.

Classification of items of cost

- Cost of production of any crop/ livestock product is the sum total of several components of cost.Costs incurred on a farm can be classified as cash cost or non-cash cost.
- **Cash costs** are the costs for which farmer spends money for acquisition of material inputs like seeds, fertilizer, chemicals and labour inputs like hired labour etc.
- **Non-cash costs** are attributable to items of cost, which do not require spending money. These may be items of cost like family labour, payments made in kind, home grown seeds, manures etc, exchange labour, depreciation, interest on operating capital etc.
- **Variable costs** vary directly with the production. The greater the production, greater are the variable costs. Variable costs may be either cash costs or non cash costs. Examples of variable cash costs are seeds, fertilizers, hired labour etc. Payments made in kind are the variable non-cash costs.
- **Fixed costs** are the costs incurred whether or not the production takes place. These could be cash or non-cash. Thus, land rent paid is an example of fixed cash cost. Land rent paid in kind, depreciation of farm machinery, tools, equipment and farm buildings are the examples of fixed non-cash costs.
- In short term some of the costs are variable while others are fixed. However, in the long run all costs are variable.

Methods to measure cost items

- **Purchase price** method of valuation of item of cost on the basis of current price as actual purchase price. It is used for those items of cost which have both short life span and whose values do not change substantially during short time periods. For example, inputs like fertilizers, chemicals, feeds, seeds and veterinary medicines.
- **Present market value:** Items, which are not purchased regularly but traded in the market, evaluated on present market value. Thus this method may be suitable for items like home grown seeds, manures, value of animals and man labour, products not sold but given away as gifts etc.
- **Net selling price:** It is the selling price minus cost of marketing. Used for farm products sold.
- **Imputed value:** There are certain items for which no money is actually spent but they do contribute towards the growth of a crop. Proper evaluation of such items in terms of money equivalent is important for correct assessment of production cost. E.g. family labour.
- **Replacement cost less depreciation:** It is generally used for property whose value changes appreciably from year to year.

Economics of quality seed production in important crops

Cost and return analysis of grain and seed production of paddy has been presented in Table 1 (case study in Uttar Pradesh). 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.

Table 1: Cost and return in production of Paddy (Rs. per 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 paddy hybrid seed production has been presented in Table 2 (case study in Telangana). The total cost of cultivation per hectare of paddy hybrid seed production estimated to be Rs. 73022.00. The gross return and net profit per hectare estimated was Rs. 124100.00 and Rs. 51078.00 respectively.

Table 2: Cost and return in production of Paddy hybrid seed (Rs. per ha.)

Particulars	**Hybrid seed production (Rs.)**
Variable cost	54522
Fixed cost	18500
Total cost	73022
Gross return	124100
Net return	51078
BC ratio	1.70

Cost and return analysis of grain and seed production of wheat has been presented in Table 3 (case study in Uttar Pradesh). 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.

Table 3: Cost and return in production ofWheat (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

Cost and return analysis of grain and seed production of groundnut has been presented in Table 4 (case study in Karnataka). The total cost of cultivation per hectare of groundnut grain and seed production estimated to be Rs. 28252.00 and Rs. 33245.00 respectively. The gross return per hectare in production of groundnut grain and seed estimated Rs. 49600.00 and Rs. 63200.00 respectively. The net profit per hectare in production of groundnut grain and seed was Rs. 21348.00 and Rs. 29955.00 respectively. The BC ratio for grain and seed production of groundnut worked out to 1.76 and 1.90 respectively.

Table 4: Cost and return in production of groundnut (Rs. per ha.)

Particulars	**Grain production (Rs.)**	**Seed production (Rs.)**
Total cost	28252	33245
Gross return	49600	63200
Net profit on total cost	21348	29955
BC ratio	1.76	1.90

Cost and return analysis of grain and seed production of pigeonpea has been presented in Table 5 (case study in Karnataka). The total cost of cultivation per hectare of pigeonpea grain and seed production estimated to be Rs. 32198.00 and Rs. 39436.00 respectively. The

gross return per hectare in production of pigeonpea grain and seed estimated Rs. 55700.00 and Rs. 73300.00 respectively. The net profit per hectare in production of pigeonpea grain and seed was Rs. 23502.00 and Rs. 33864.00 respectively. The BC ratio for grain and seed production of pigeonpea worked out to 1.73 and 1.86 respectively.

Table 5: Cost and return in production of pigeonpea(Rs. per ha.)

Particulars	**Grain production (Rs.)**	**Seed production (Rs.)**
Total cost	32198	39436
Gross return	55700	73300
Net profit on total cost	23502	33864
BC ratio	1.73	1.86

Studies were conducted by MK Saxena et al. (2011) on the cost of production and profitability of hybrid pigeonpea seed production at Indore in Madhya Pradesh. They estimated that the cost of producing of one hectare of pigeonpea hybrid ICPH 2671 seed was Rs. 26395, excluding the fixed cost. The plot produced hybrid seed of 1440 kg/ha and yielded the net profit of Rs70,000/ ha. Using these estimates the hybrid cost at farm gate was Rs.18.85 / kg.

Cost and return analysis of maize hybrid seed production has been presented in Table 6. The total cost of cultivation per hectare of maize hybrid seed production estimated to be Rs. 55046.00. The gross return and net profit per hectare estimated was Rs. 109109.00 and Rs. 54063.00 respectively.

Table 6: Cost and return in production of maize hybrid seed (Rs. per ha.)

Particulars	**Hybrid seed production (Rs.)**
Variable cost	40046
Fixed cost	15000
Total cost	55046
Gross return	109109
Net return	54063
BC ratio	1.98

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. Benefit cost ratio of quality seed production showed that 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.