सत्यमेव जयते

National Training
on
"Quality Seed Production Technology of Oil Seed Crops"
February 19-23, 2024
Training Manual

GOVERNMENT OF INDIA
Ministry of Agriculture & Farmers Welfare
Department of Agriculture & Farmers Welfare
NATIONAL SEED RESEARCH & TRAINING CENTRE
GT Road, Collectry Farm`, Varanasi- 221106
Phone: 0542-2370222, Fax: 0542-2370298
E-mail: dir-nsrtc-up@nic.in, Website: www.nsrtc.nic.in

NATIONAL TRAINING
ON
QUALITY SEED PRODUCTION TECHNOLOGY OF OILSEED CROPS
(FEBRUARY 19-23, 2024)

Course Director

Sh. Manoj Kumar, IAS
Director

Training Coordinators

Sh. Javesh Kumar
Junior Seed Analyst

Smt. Ekta Kumari
Senior Seed Analyst

Organized by:

Government of India
Ministry of Agriculture& Farmers Welfare
Department of Agriculture & Farmers Welfare
NATIONAL SEED RESEARCH AND TRAINING CENTRE
VARANASI-221106 (UTTAR PRADESH)
Tel: 0542-2370222, Fax: 0542-2370298
E-mail: dir-nsrtc-up@nic.in
Website: www.nsrtc.nic.in

Publication No. NSRTC/2023/0011

NATIONAL TRAINING
ON

QUALITY SEED PRODUCTION TECHNOLOGY OF OILSEED CROPS

(FEBRUARY 19-23, 2024)

Compiled & Edited by:

Sh. Javesh Kumar, Junior Seed Analyst

Mrs. Ekta Kumari, Senior Seed Analyst

Er. M. K. Vishwakarma, Seed Processing Engineer

Dr. M. P. Yadav, Seed Technologist

Dr. A. K. Verma, Senior Seed Analyst

Sh. Anil Varma Nalla, Junior Seed Analyst

NATIONAL SEED RESEARCH AND TRAINING CENTRE

VARANASI-221 106 (UTTAR PRADESH)

भारत सरकार
राष्ट्रीय बीज अनुसंधान एवं प्रशिक्षण केन्द्र
कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
जी.टी. रोड, कलेक्ट्री फार्म,
पोस्ट आफिस इन्डस्ट्रीयल इस्टेट,
वाराणसी 221 106 (उ.प्र.)

GOVERNMENT OF INDIA
NATIONAL SEED RESEARCH & TRAINING CENTRE
Ministry of Agriculture & Farmers Welfare
Deptt. of Agriculture & Farmers Welfare
G.T. Road, Collectry Farm,
P.O. Industrial Estate, Varanasi-221106
(U. P.)

FOREWORD

Oilseeds are considered as one of the core agricultural commodities. Oilseeds and their products have become an essential part of daily diet for millions of people in developing countries, and are these days developing more important role as cash crops. They add important nutritional value to the diet by high quality protein and vitamins. The oilseeds have been cultivated since the farmers adopted agriculture as a profession."

In India, the major oilseeds crops are Soyabean, Groundnut, Mustard, Linseed, Sunflower, Safflower, Sesame, Castor etc. In view of growing population, the demand for edible oils is growing and thus there is a need to increase the productivity of Oilseeds to cater the demand of the increasing population of the country. The most important factor for increasing yields of oilseeds is to make available high quality seeds to the farming community.

The Government of India, Ministry of Agriculture & Farmers Welfare, DA &FW is giving more emphasis to ensure the supply and distribution of high-quality seeds to the farming community. In this context National Seed Research and Training Centre, Varanasi has organized a National Training course on **"Quality Seed Production Technology of Oilseeds** "during **February 19-23, 2024.** The objective of this National training is to enhance the knowledge of the human resources engaged in various aspects of seed production, processing, distribution and quality regulation of oilseeds.

This training module consists of valuable information on various aspects of quality seed production in Oilseeds. I hope this compilation will serve as a useful resource book and guide to all concerned.

Date: 23 .02.2024

Place: Varanasi

(Manoj Kumar)
Director

National Training

On

Quality Seed Production Technology in Oilseed Crops

(February 19 – 23, 2024)

CONTENTS

*****

NSRTC at a glance...

National Seed Research and Training Centre (NSRTC), Varanasi established under Govt. of India, Ministry of Agriculture& Farmers Welfare, Department of Agriculture and Farmers Welfare, during October 2005.

The prime objective of establishment NSRTC is to have a separate National Seed Quality Control Laboratory, which is serving as **Central Seed Testing Laboratory (CSTL)** as well as to act as **Referral laboratory** for hon'ble court of the entire country.

Further, this **CSTL** has to coordinate and monitor the functioning of all the **notified State Seed Testing Laboratories** presently available in our country in order to obtain Uniformity in Seed quality Regulation at National level.

More importantly for facilitating International seed Movement, our CSTL the member laboratory of International Seed Testing Association (ISTA), ZURICH, Switzerland and expected to become accreditated Laboratory very soon and thereafter will be eligible for issuing International seed movement certificates on behalf of Government of India.

NSRTC is the National Centre for Training Human resources for the officials who are all involved in the **Seed Quality Control, Seed Law Enforcement and stake holders of Seed Industry.**

In order to fulfill the mandate, NSRTC organize National trainings, workshops, National seed congress for the benefit of personnel involved in seed development and quality control programme and stakeholders of seed industry for updating their knowledge and skills.

The NSRTC is situated under greater periphery of the Holy city Varanasi, which is located 7 KM away from heart of city towards south – west on Varanasi - Allahabad GT road, Collectry farm, surrounded by Banaras Hindu University (6 km), Indian Institute of Vegetable Research (20kms) and well linked by Air, Train and Road.

PRIME OBJECTIVES:

- To have a separate National Seed Quality Control Laboratory, which is serving as **Central Seed Testing Laboratory (CSTL).**
- To act as **Referral laboratory** for hon'ble court for the entire country w.e.f 1.4.2007 onwards.
- Member laboratory of **International Seed Testing Association (ISTA)**, Switzerland,
- Centre for testing all transgenic crop seeds etc., in future
- **To organize National and International seed related conferences, symposium and trainings** for the benefit of personnel who are involved in seed development and quality control programme and stakeholders of seed industry.
- Centre for training human resource on all seed related aspects.

VISION:

Our vision is to

- Contribute integrated approach towards quality seed availability.

- Have separate National Seed Quality Control Laboratory as CSTL.
- Maintain uniformity in seed testing and seed quality control at National level.
- Make Seed Industry in India globally competitive.

MISSION:

Our mission is to lead and engage in downstream programmes on Seed Science and Quality Control to disseminate the values of seed production and availability of quality seed to the need of National and International seed community.

STRATEGY:

NSRTC pursues its Mission and Goals through

- Integrated approach and system –based programs on seed quality control and act as Referral Lab for the hon'ble Court.
- Strengthening Seed Technological Research in seed production disciplines of major crops.
- Total seed quality management through systemic seed certification and law enforcement process.
- Interaction with stake holders of seed industry, officials of seed certification and law enforcement, seed producers and other seed organizations that share's NSRTC mission.
- Continued efforts in improving / updating knowledge and skill of human resources involved in seed certification and quality control as a training human resource on all seed related aspects
- In order to meet out these visions and mission's strategy the NSRTC is housed in a modern building with all latest infrastructural facilities, equipments and machineries, excellent conference/ seminar hall, workshop /class rooms, exclusive ISTA member laboratories, museum, well stocked library.

Staff strength:

The Ministry of Finance sanctioned of 23 posts for National Seed Research and Training Centre, Varanasi for making the centre functional so as to meet out the mandate.

NSRTC is especially designed for continuous dissemination of knowledge of seed and thereby improve skill, competency and scientific soundness of individuals engaged in seed development programme. NSRTC regularly organizes training on various aspects of seed for the officials working in Seed Certification Agencies (25 in number), Seed Testing Laboratory (147 in number), Seed Law Enforcement Agencies, Agricultural Universities and other institutes dealing with seeds. The NSRTC, Central Seed Testing Laboratory acts as a referral lab under clause 4(1) of the Seeds Act, 1966. CSTL, NSRTC is testing more than 20,000 samples per year and performs at par with ISTA (International Seed Testing Association) with regard to seed testing net work in the country.

National Seed Testing Laboratory as Central Seed Testing Laboratory

The testing of seed material will be flowing from different State Seed Corporations as well as Seed Producing Organizations for physical purity, seed health and at later stage genetic purity that is mostly required in referral cases. At present the mandate of Central Seed Testing Laboratory (CSTL) is to receive 5% samples from seed producing organizations all over the country. In addition, CSTL act as a Nodal centre for coordinating the activities of Seed Quality Control programmes on behalf of Government of India in accordance with the Act and Rules with the State Notified Seed Testing Laboratories.

Grow Out Test

NSRTC have been allotted 10 hectares of land out of which the office premises have been constructed in about 2.5 hectares of land and remaining land have been kept reserve for organizing Grow Out Test for which Green House/Poly House and other necessary facilities have been created.

NSRTC is geared to go Global

NSRTC is a globally competitive Institute in Seed Science and Quality control, marching ahead with:

- To promote the availability of quality seed to meet the challenges of Science based Agriculture.
- Making of promising Technologies reach the seed entrepreneurs and other stakeholders through innovative Trainings, Conferences, Workshops & Symposia.
- Establishing uniformity in Seed production & Quality Control programmes at National level.
- Innovative curriculum planning and implementation to make Seed Science & Research more vibrant and responsible to match the vision and needs of present and future.

Manoj Kumar, IAS
Director, NSRTC

Quality Seed Production in Sesame

A K Vishwakarma
Project Coordinating Unit Sesame & Niger, ICAR- JNKVV, Jabalpur

Sesame (Sesamum indicum L.) belonging to the order Tubiflorae, family Pedaliaceae, is an important and ancient oil-yielding crop cultivated for its flavorsome, edible seed and high-quality oil. Majority of the world area is found in developing world, with largest in India, Myanmar, China, Sudan, Nigeria, Ethiopia, Uganda and Turkey. Sesame is grown in different seasons in India and covers all agro ecological zones. India is a leading country in export of seed, white sesame has highest market and earns a sizeable foreign exchange (Rs. 3500 crores). The availability of the quality seed of Sesame is vital and crucial for sustainable production. The seed production chain and the ultimate availability of quality seed had been very poor and more than 80 % of the area is still sown with the seed saved by the farmers. There will be greater demand for the supply of the quality seed in the future to saturate larger areas. Therefore, it became imperative to produce genetically pure, quality seed for raising the productivity. Three paradoxes of very low seed rate (3-5 kg/ha), very high seed multiplication ratio (1:250) and very poor seed replacement rate (5-10%) coexist in sesame.

Important diagnostic characters: The main criteria used in the identification and seed certification of a variety is the distinct morphological traits specific to the crop and the variety. The distinct quantitative and resistance traits with high heritability and other characters of major importance in breeding as specified by the breeders are equally important in the production of genetically pure seed and for the identification of true to the type plants. The important diagnostic traits commonly used in the identification of a sesame variety and the existing pattern of variability in each character are Seedling vigour; Branching pattern; Branching habit; Stem hairiness; Flower colour; Days to flower; Corolla hairiness; Density of capsule hair; Capsule shape; Capsules per leaf axil; Seed coat colour; Capsule length; Days to maturity; 1000 seed weight (g); Oil content; Reaction to diseases and Reaction to pests.

Important agronomic/economic characters of sesame varieties for varietal improvement are: Days to flowering and maturity, Photoperiodicity response, Plant height, Branching and Branching pattern, Internode length, Leaf number, size and shape, Number of capsules per axil, Capsule length, Capsule breadth, Number of locules per capsule, Number of seeds per capsule, Seed yield, Oil content, Seed coat colour, Harvest index, Determinate habit, Resistance to pests and diseases, Wider adaptability, etc.

Pollination systems: Sesame is a self-pollinated crop with an average cross pollination of about 5%. However, the amount of out crossing ranges from 0 to 50% depending upon the pollinating insects and weather conditions. The insects are the only agents whereas wind plays no part for natural cross pollination.

Isolation: The seed crop should be essentially raised on an isolated plot to maintain seed purity. An isolation distance of 100 m is recommended for nucleus, breeder and foundation stages and 50 m for certified or other commercial stages.

Rouging: Strict rouging should be done at vegetative, flowering and maturity stages by the team of experts.

Certification standards

Seed standards	Foundation Seed	Certified Seed
Physical purity (%)	97	97
Inert matter (%)	3	3
Other crop seeds (No./kg)	10	20
Other variety seeds (No./kg)	10	20
Weed seeds (No./kg)	10	20
Minimum Germination (%)	80	80
Field standards	Foundation Seed	Certified Seed
Minimum inspections	3	3
Isolation distance (m)	100	50
Different plants (%)	0.1	0.2

Seed production technology: The non-availability of quality seed to the farmers at proper time is one of the important reason for low productivity. However, improved varieties and agro production techniques capable of boosting the productivity levels have been developed for different agro ecological situations.

Suitable areas: Seed production shall be under taken preferably in the areas where soil and climate are highly suitable for the growth and development with optimum expression of diagnostic characters. The varieties, which are popular with the farmers, shall be chosen for seed production.

Climate: Normally, the crop is grown in plains. For maximum seed yield, sesame requires fairly high temperatures and evenly distributed rainfall. It cannot withstand frost, prolonged drought, water logged conditions, specially at flowering and capsule development stages. It does best on sandy loams with adequate moisture. The optimum pH range is 5.5 to 7.5. Acidic or alkaline soils are unsuitable for seed production.

Production Technology: Select well leveled fertile land with facilities for irrigation and good drainage to overcome the problem of moisture stress, particularly the water stagnation to which sesame is sensitive. There should not be preceding crop of sesame in the field selected for seed production. One or two ploughings followed by 2-3 harrowings are to be done for pulverization and fine tilth required for good germination and plant stand. Keep the field weed free and perfectly leveled to avoid water logging. For easy inter culture and to realize higher seed yield, adopt line sowing. A seed rate of 4-5 kg/ha is adequate to achieve the required plant stand. Wherever seed drills are used, the seed rate may be reduced to 2.5 to 3 kg/ha.

Sesame responds well to inorganic fertilizers. The level of nutrients would however, vary depending on the variety, season, soil fertility status and soil moisture. Apply half the recommended dose of nitrogen and full dose of phosphorus and potash at the time of seeding. The remaining half nitrogen may be top dressed at flower initiation. Addition of Azotobactor and phosphorus solubilizing bacteria resulted in higher seed yield. Integration of two foliar applications of urea (2%) at flowering and capsule formation resulted in maximum seed yield. Application of Sulphur 30 kg /ha in the form of gypsum+60:40:20 (N.P.K.) kg/ha recorded higher seed yield. Integration of micronutrients, zinc 20 kg/ha + FYM 2.5 t/ha to RDF resulted in

maximum seed yield. The Kharif crop may need protective irrigation if there is moisture stress. Winter crop should be irrigated 2-3 times. The summer crop has to be irrigated 4-5 times depending on the type of soil. Water stress at critical stages like flowering or capsule formation lead to yield loss. Seed priming (soaking seed in water before sowing) during summer season or in places with moisture stress resulted in good crop establishment.

Crop Protection:

Major Insect pests

Insect	**Nature of damage**	**Stage when crop is damaged**	**Integrated management**
Leaf roller and capsule borer (Antigastra catalaunalis Dup.)	In early stage of crop, caterpillars feed on tender leaves and remain inside the leaf web. At flowering, larvae feed inside the flowers and on capsule formation, larvae bore into capsules and feed on developing seeds	The first attack of the pest starts when the crop is 2-3 weeks old.	Early sown kharif crop is less infested than late sown crop Removal of larvae from the leaf webs during the initial stages of plant growth and destroy them Intercropping with black gram, green gram, moth bean, pearl millet, pigeon pea and cowpea proved to be more effective than sole crop Birds readily eat the caterpillars and help to check when they are numerous, 40- 50 bird perches are required for one hectare Release of Larval parasite Bracon hebetor, Bracon geichi Ashm Spray NSKE 5 %
Gall fly (Asphondylia sesami Folt.)	Maggots feed inside the floral bud leading to formation of gall like structure which do not develop into flower/ capsule. The affected buds wither and drop.	At the time of bud initiation	Clipping of the galls, picking and burning the shed buds may help as prophylactic measure Spray NSKE 5 % Spray crop at bud initiation stage with any one of the following insecticides Dimethoate 30 EC @1.5 ml/l or Quinalphos 25 EC @ 1.5 ml/l or Imidacloprid 17.8% SL @ 0.3 ml/l

Sesame leaf hoppers (Orosius albicinctus Dist.)	Nymph and adults suck the sap of tender parts of the plants. The jassid or leaf hopper is a serious pest of sesame and is known to transmit phyllody disease.	From vegetative to capsule stage	Seed treatment with imidachloprid 70 WS 7.5 g/kg seed or thiamethoxam 25 WG 5 g/kg seed protects the crop from all sucking pests for about a month Remove and destroy infected plants Use Predator : Brumus suturalis (Early instar nymphs) Spray NSKE 5 %
Bihar Hairy caterpillar (Spilosoma obliqua)	In the early stages, larvae are gregarious feeders and are concentrated on few plants. Mature caterpillars migrate to other plants and feed voraciously leaving only the stem.	Starting from vegetative stage till maturity.	After harvesting of kharif crop, field should ploughed to expose larvae and pupae for bird predation Avoid pre monsoon sowing Use optimum seed rate and adequate plant spacing should be followed Destroy egg masses and young larvae during gregarious phase Install one light trap/ha to catch the adults Use bird perches 40-50/ha Use egg parasitiods Trichogramma evanescens or T. minutam or larval parasitoid Apanteles obliqua Use Bacillus thuringiensis var. Kurstaki @ 1g/l Spray NSKE 5%

Diseases

Disease	Symptoms	Integrated management
Phytophthora blight (Phytophthora Parasitica var. Sesami)	Initially water soaked spots appear on leaves and stem. The spots are brown in beginning, later turn to black. In humid weather, severity of disease increases and give blighted appearance. Black coloured lesions appear on the tem near the soil level. The disease spreads further	Deep ploughing in summer Seed treatment before sowing with Thiram + carbendazim (2:1) 3g/kg seed or or metalaxyl 4g/kg or Trichoderma harzianum or T. viride @ 10g/kg seed. Spray three times with Ridomil Mz @ 2.5ml/l or Copper oxychloride @ 3g/l alternately at an interval of 10 days from the initiation of disease

	and affects branches, and may girdle the stem, resulting in the death of the plant	
Stem and root Rot (Macrophomina phaseolina)	Disease appears on root and stem. The symptom starts as yellowing of lower leaves followed by drooping and defoliation. At ground level stem becomes black which extends upward rupturing the stem. Black dots appear on the infected stem, which are the pycnidia of the fungus. If wilted plant is uprooted, black coloured roots are observed having sclerotia of the fungus and looks as charcoal is sprinkled on the root. The roots become brittle.	Two years crop rotation Summer deep ploughing Use disease free seed Treat the seed with T. viride or T. harzianum @ 10 g/kg seed or Thiram 75 SD + Carbendazim (2:1) 3g/kg seed or Thiram 75 SD (0.3%) Uproot and destroy the infected plants On appearance of the disease, drench soil with carbendazim 1g/lt at 7 days interval. Irrigate field to avoid stress condition
Cercospora leaf spot (Cercospora sesami)	Disease appears as small, angular brown leaf spots of 3mm diameter with gray center and dark margin delimited by veins. In severity of the disease, defoliation occurs. In favorable conditions the disease spreads to leaf petiole, stem and capsules producing linear dark coloured deep seated lesions.	Early planting i.e. immediately after onset of monsoon Follow intercropping of sesame + pearl millet (3:1) Treat the seed with Thiram + Carbendazim (2:1) @ 3g/kg seed
Alternaria leaf spot (Alternaria sesami)	Spots on leaves are brown circular to irregular in shape and often have concentric rings.	Treat the seed with Thiram + Carbendazim (2:1) @ 3 g/kg seed Spraying of combination fungicide Mancozeb + Carbendazim @ 3 g/lt at 15 days interval when disease appears
Powdery mildew (Oidium sp, Sphaerotheca sp., Leveillula sp.)	Small cottony spot appears on the infected leaves, which gradually spread on the lamina. Defoliation of severely infected plant occurs before maturity.	Early planting i.e. immediately after onset of monsoon 2 to 3 Foliar spray of Wettable sulphur @ 2g/lt or Tilt @1 ml/lt or Karathane 1 g/lt alternately at 10 days interval
Phyllody (Phytoplasma)	All floral parts are transformed into green leafy structures. Infected plant is conspicuous by its stout internodes, abundant abnormal branching which cause top portion to	Rogue out diseased plants Delay in planting of sesame about 3 weeks after onset of monsoon Three sprays of neem oil @ 5 ml/lt at 30, 40 and 60 days after sowing

	bend down, such plants generally do not bear capsules but if capsules are formed on lower portion of plant they do not yield quality seed.	

Maintenance of genetic and physical purity in seed: Sesame is highly prone to mechanical mixture due to its very light, small seed and shattering habit which is the most important factor to affect genetic purity. Therefore, great care has to be taken to avoid mixture at all the stages of seed. Following precautions are to be taken to maintain the genetic purity.

Select the field with no preceding crop of Sesame.

Use source seed from authenticated source after ascertaining genetic purity through grow out test.

Renewal of seed should be done at least once in three years.

Follow strict rouging at vegetative, flowering and maturity stages by the team of experts.

Harvesting should be done at proper stage.

Threshing should be done on a clean floor.

Problems in seed production

Asynchronous maturity: In most of the varieties, the maturity of the capsules is not synchronous as a result the earlier capsules start shattering while others are still green. Shattering is the main problem to adversely effect the seed yield in sesame and source of mechanical mixture.

High conversion high speed multiplication ratio with very low conversion: The production of seed ranges from 0 to 15 q/ha. As a result, in spite of very low seed rate and very high multiplication ratio, the conversion from one to the other stage of seed multiplication is very low.

Frequent crop failures: Sesame is mainly grown in kharif crop. Prolonged exposure to variations in temperature and relative humidity may lead to shrinkage and attack of pathogens. It is sensitive to excessive moisture and highly susceptible to Phytophthora and Macrophomina at early stage. Crop failure due to these reasons is quite frequent.

Mechanical mixture: Very small, light seeds and shattering of capsules make the crop prone to mechanical mixture at harvesting, threshing and processing stages.

Lack of protective measures: To protect the seed from seed borne pathogens and storage fungi, a protective spray of systemic fungicide like Bavistin is recommended but not actually practiced.

Non-lifting: As also in other crops, non-lifting and delayed lifting of seed is a common problem of breeder seed production process.

Grow-out test: The grow-out test is conducted in the area where crop can express the maximum characters without any variation due to environment. Take a sample of 100 g from the seed lot to

estimate the genetic purity of the seed on the basis of morphological characters of the plants. Grow 800 plants of the submitted sample vis-a-vis the same population of authentic sample under recommended practices. The submitted sample for grow out test is drawn simultaneously with the samples for other tests. The permissible limit of off types in sesame is 0.5%. Make a comparison at all the stages from seedling to maturity according to the expression of the characters. Examine each and every plant throughout the growing season with emphasis on the marker characters and time of their expression. Tag the off types and count the total population along with off types. Reject or accept the samples as per the prescribed standards.

Seed production systems: Presently two seed production systems are operating in the country.

Formal system: This system is being operated through public sector agencies like NSC, SFCI, SSC's, SAU and oil federations etc. The seed multiplication ratio in this system is extremely poor. The main advantage of this system is that the identity, genetic purity, quality and source of the seed is known to the farmers.

Informal system: This system includes multiplication of varieties by private growers or individual farmers and sharing the seed by the farmers. The seed of most of sesame varieties under cultivation is being produced and supplied through this system. However, the seed produced through this system is less expensive and easily available to the farmers.

Alternative systems: The existing formal system of seed production had been hardly sufficient to cope up with the seed requirement. The possibility of improving the supply of quality seed in minor crops like sesame through the formal system in near future appears not to be so bright. Therefore, in these crops, alternative systems of seed supply may prove worthy for fulfillment of the requirement of this rewarding input capable of improving the productivity up to 50%.

Direct supply: Both, the formal and informal systems of seed supply, have their own limitations. To overcome the limitations of the prevalent informal system and the existing formal seed supply system, the seed production can be undertaken by the research institutes through farmer fairs/field days/sale counters. The direct supply is quite feasible and will be rather more effective in view of the specific advantages.

Seed village: Another option to augment the seed supply in sesame is the concept of seed village. The institutes can choose a single variety to grow in one ha plot which will easily produce 8-10 q seed sufficient to cover the area of about 250 to 300 ha in one village with the single variety only. Clubbing together the programme of front-line demonstrations and seed village will prove synergistic for the improvement of seed replacement rate.

****

Biotic & Abiotic factors affecting seed quality during storage

M.P. Yadav, Seed Technologist
National Seed Research & Training Centre, Varanasi (U.P.)

Seed plays a vital role in agriculture and acts as a carrier of genetic potentialities of improved varieties. Conjunctive use of quality seeds along with other inputs will tap the superior genetic potentiality of high yielding varieties and bring benefits to the farmers. Hence, production of high-quality seeds in a planned manner is very essential for increased agricultural production, thereby enhancing the economic status of the farmers. As the quality seed is very much essential and crucial input in agriculture, utmost care should be given in the process of seed production. Maintenance of seed quality at various stages of seed crop is highly essential because many abiotic and biotic factors act upon the crop growth and thus have their influence on seed quality factors
Biotic and Abiotic Factors.

Ecological factors which affect dynamic change in a population or species in a given ecology or environment are usually divided into two groups: abiotic and biotic. "All the living organisms that inhabit an environment are called biotic factors" Biotic Factors are, in entirety, anything that affects living organism that is itself alive. Such things include animals which consume the organism in question, or the food that the organism consumes. As opposed to abiotic factors (non-living components of an organism's environment, such as temperature, light, moisture, air currents, etc.), biotic factors are the living components of an organisms environment, such as predators and prey. Biotic means something that is living. Biotic is the opposite of abiotic which means non-living. Biotic means relating to, produced by, or caused by living organisms. The term biotic may also refer to:

- Life, the condition of living organisms'
- Biology, the study of life
- Biotic Factors in ecology,
- Biotic material, which is derived from living organisms,
- Biotic potential, an organism's reproductive capacity, or
- Biotic Banking Brigade, an unofficial group of pie-throwing activists.
- In the world of Mass Effect Biotics are people capable of using their minds to manipulate mass effect fields.

Abiotic factors are geological, geographical, hydrological and climatological parameters. A **biotope** is an environmentally uniform region characterized by a particular set of abiotic ecological factors. Specific abiotic factors include:

- Water, which is at the same time an essential elements to life and a milieu
- Air, which provides oxygen, nitrogen, and carbon dioxide to living species and allows the dissemination of pollen and spores
- Soil, at the same time source of nutriment and physical support soil pH, salinity, nitrogen and phosphorus content, ability to retain water, and density are all influential

- Temperature, which should not exceed certain extremes, even if tolerance to heat is significant for some species
- Light which provides energy to the ecosystem through photosynthesis
- Natural disasters can also be considered abiotic

Abiotic components can be split into 3 main categories: climatic, eudaphic and social. Climatic factors include sunlight, humidity, temperature, atmosphere etc. Eudaphic factors are things to do with the nature of the soil and ground, such as the geology of the land and the soil type. Social factors include land use, water resources etc.

I. Abiotic Factors on Seed Quality

1. Ecological Factors: Even though seed quality is influenced by numerous factors namely ecological factors, production factors and post harvest technology factors during seed production, the ecological factors (weather) are of paramount importance as mankind has no control over them. The weather parameters include temperature, light, rainfall, wind velocity and relative humidity, which play a vital role on the production of quality seeds.

i) Temperature: Of all the factors effecting seed production, temperature is considered as the most important one. In rice crop, prevalence of either high or low temperature during crop growth, affect the production of reproductive parts namely seed weight, size and seed yield. Seed dry weight in rice was stable over the temperature range from 21/16º to 30/25^{0}C. *Jia et. al.* (1991) have stated that high temperature after heading of rice crop resulted in increased chaffiness by shortening the effective tillering stage. In wheat crop, Kernel weight decreased as temperature rose above 18^{0}C. In maize, increased kernel abortion was reported up to 36% in high temperature condition (Cantarero et. al. 1999). In vegetable crops, the growth of warm season crops stops at 15^0 C and growth normally increased up to 40^{0}C.

Temperature may be considered as a measure of intensity of heat energy. The range of maximum growth for most agricultural plants is between 15 and 40^{0}C (59 to 140^{0}F). The temperature of a place is largely determined by its distance from the equator (latitude) and the altitude. Based on the above the vegetations are classified as tropical, temperate, taiga, tundra and polar. Every plant community has its own minimum and maximum temperature known as their cardinal points. The table indicates the cardinal points of some of the common crops.

Cardinal temperature of certain crops for germination

Crop	Minimum ^{0}C	Optimum ^{0}C	Maximum ^{0}C
Wheat	4.5	20	30-32
Barley	4.5	20	29-30
Oats	4.5	20	29-30
Maize	8-10	20	40-43
Sorghum	12-13	25	40
Rice	10-12	32	36-38
Tobacco	12-14	29	35

Chilling injury - Plants growing in hot climate are exposed to low temperature (which is above the freezing point) for some time, and are found to be killed or injured severely. Chlorotic condition or bands on leaves of sugarcane, sorghum and maize when exposed for 60 hours at 2 to 4^{0}C.

Freezing injury – This is generally caused in plants growing in temperature region. When the plants are exposed to very low temperature, water is frozen into ice crystals in the intercellular spaces. The protoplasm of the cell is dehydrated and mechanical distortion takes place resulting in killing of the cells. Frost damage to potatoes, tea etc in winter in the hilly areas like Nilgiris.

Suffocation – During winter the ice or the snow form a thick cover over the ground and the crop suffers for want of oxygen. Ice in contact with roots inhibits diffusion of carbon dioxide and the respiratory products may become harmful to plants.

Heaving – Injury to plants is caused by a lifting upward of the plant along with the soil from its normal position in temperate regions where snowfall is a common phenomenon.

Heat injury – Very high temperature often stops growth. The plant faces incipient starvation due to high respiration rates. The plant is stunted and if such a condition persists for a long period the plant is killed. Direct temperature effects are noticeable in young seedlings and transplanted crops. High temperature cases sterility in flowers. The general effects of excessive heat are defoliation, premature dropping or fruit and in extreme cases death of plant.

ii) Light: The light requirement at each kind of crop should be known otherwise, when they are grown in other conditions, their seed quality will be affected. For instance, wheat varieties in general are photosensitive while improved rice varieties are photo insensitive. In maize, the shading period from 3 to 17 days after silking has significant effect on the number of abortive seeds.

Light intensity – In photosynthesis about one per cent of the light energy is converted into potential chemical energy. Very low light intensity reduces the rate of photosynthesis and may even light intensity reduces the rate of photosynthesis and may even result in the closing of the stomata very high light intensities are detrimental to plants in many ways. It causes rapid loss of water resulting in the closure of stomata. The most harmful effect of high light intensity is the phenomenon of solarization in which all the cell contents are oxidized by atmospheric oxygen. This oxidation is different from respiration and is termed photo oxidation. Heliophytes (sun loving) and sciophytes (shade loving), the dry matter production is affected. Many species produce maximum dry matter under high light intensity if water is available in plenty.

Quality of Light - When white light is passed through a prism it is dispersed into wavelengths or different colours; violet 400-435 mμ; blue 435-490; green 490-514; yellow 574-595; orange 595-626 and red 626-750. The principal wavelengths absorbed in photosynthesis are in the violet-blue and the orange-red regions. Among these short rays beyond violet such as infrared are detrimental to growth. Red regions. Among these short rays beyond violet such as infrared are detrimental to growth. Red light seems to be the most favourable light for growth followed by violet-blue.

Duration of Light – The length of the day has greater influence than the intensity. The response of plant to the relative length of day and night is known as photoperiodism. Plants which develop and produce normally when the photoperiod is greater than a critical minimum (more

than 12 hours of illumination) are called 'long day plants' and those develop normally when the photoperiod is less than a critical maximum (less than 12 hours of illumination) are called 'short day plants.' Some plants are found to be unaffected by photoperiod and are called as ' day-neutral' plants. Plant characters like floral development, floral initiation, bulb formation, rhizome production etc., are all influenced by photoperiodism. Among the crop plants soybean, maize and millets are examples of short day flowering plants while sugar beet, wheat, and barley are long day plants and others are intermediate (day neutral) in that they flower at any day lengths.

Direction or Light - Shoots roots and leaves show different orientation to the direction of light. In temperate regions the southem slopes show better growth of crops than the northern slopes due to the direction of light contributing more sunlight towards the southern side.

iii) Rainfall: In the regions of moderate rainfall and humidity as compared to regions of high rainfall, good quality seeds can be obtained. Excessive rainfall interferes with the pollination, results in delayed maturity and precocious germination or vegetable seeds.

iv) Wind Velocity: Excessive wind during pollen production will result in poor seed set and ill filled seeds. Brown seed discoloration is caused by wind at flowering and occurrence milky white seed is increased by wind 14-21 days after heading in rice. (Ebata and lshikawa, 1989). Wind affects the growth mechanically and physiologically. The sand and dust particles carried by the wind may damage plant tissues. Emerging seedlings may be completely covered or alternatively the roots of young plants may be exposed by strong winds. Winds may also cause considerable losses by inducing lodging, breaking or stalks and shedding of grains. The physiological effects of wind consist mainly in increasing transpiration as well as evaporation from the soil. Hot dry winds, may however adversely affect photosynthesis and hence productivity, by causing closure of the stomata even when soil moisture is adequate. Moderate winds have a beneficial effect on photosynthesis by continuously replacing the carbon dioxide absorbed by the leaf surface.

v) Relative Humidity: Flowering, pollination and seed setting in temperate crops needed low humidity – dry weather at seed maturity and moderate to low humidity for sub temperate and topical crop. High humidity and temperature encourage production of diseased seeds. Warm dry climate is suitable for production of disease-free seed.

2. Season: More extreme cases of unseasonal climate usually reduce the flowers and subsequently the seed set. Late spring frosts in temperate regions kill flowers and young fruits. An abnormal drought also has similar effects. Even if death or premature shed of whole fruits does not occur, a proportion of seeds may abort later.

3. Irrigation: Irrigation at critical growth phases is very much essential for the normal seed development and maintenance of seed quality. Water stress during critical phases like seed germination, seedling establishment, flowering, fruiting and seed development stages is detrimental to seed set, yield and seed quality.

4. Soil nutrient and management factors: The fertility of the soil in which a plant grows influences the chemical composition of the developing seed and consequently its metabolism and vigour during germination. Nitrogen and phosphorus availability can influence seed development and seedling vigour, but their effect varies among species. It is probable that inorganic nutrients stored in seed provide valuable reserves during early germination of seeds. Minor elements are also known to affect the seed development. Deficiency in soil boron causes 'Hollow heart' defect in pea seed. In rice seeds, copper deficiency heads to loss of viability. Calcium deficiency causes darkened plumule in groundnut. Mn/Mo deficiency leading to 'Marshy spots' in peas grown in calcareous soil and it leads to promotion of hard coated seeds and hard seededness.

5. Post harvest handling of seeds: Seeds of few species cannot tolerate excessive desiccation and can still retain their viability. It is very important to harvest the seed in proper time to get best quality of seeds. Harvesting at an early stage will cause damage to seeds during threshing and cleaning. If the harvesting of the seeds are not done in the right time and optimum moisture content and allowed to remain in the field until dead ripe stage, the seeds are likely to be exposed to weather elements like rain and temperature, besides insect and fungal pathogens and suffer mechanical damage.

I) Seed Drying

Excessive drying rates may cause stress cracks in the seed, because of unequal drying throughout the seed. Even if the seeds are not dries too fast, they may be injured by over drying and usually this will lead to increased susceptibility to mechanical damage of the seeds there by reduction in the quality of seed.

ii) Moisture Content

Susceptibility to mechanical damage increases, as the moisture content decreases. However, safe moisture content varies among species. Large seed legumes are particularly sensitive and excessive injury begins to occur at moisture content below 15%.

iii) Mechanical Damage

Mechanization of harvest, handling and conditioning operation subject seed to physical forces that can-do mechanical resistance of the seed covering and the seed as a whole will be exposed to crusting impacts, abrasion, and various types of cutting and shearing action. The failure of the seed coverings to protect the embryonic axis and nutritive tissue affects the germination capacity of the seed.

iv) Seed Storage

The storage sanitation is very much essential that will tell upon the quality of the seed. Based on the storability of the seeds, the storage condition should be provided. Matrinez et. al., (1994) revealed that most beans varieties stored for 180 days at 75% RH maintained high germination rates (74-98%) on seed quality.

II. Biotic factors

1) Diseases

Seed borne diseases of different crops cause damage to the crop and reduce the seed yield and quality. They cause loss to the agricultural economy in different forms. Losses may be

immediate with the first crop produced from the infected seed lot and it may be a long-term effect if the pathogens are able to survive in the soil debris and weed hosts. It will serve as a storehouse to spread the infection to the succeeding susceptible crops. Hence, production of disease-free seeds is of prime importance.

2) Pests

Considerable reduction in the seed quality can be occurred due to insect outbreak in considerable quantity. Especially in the stored products, the main sources of infestations are field infestation, infestation by migration, infestation through conveyance and storage buildings or structures, birds, bird nests, ants, rodents etc. They cause hollowing of the seeds. Kernels are reduced to mere powder. *Sitophilus oryzea* and *S. zeamais* are known to attack seeds in fields too. Adults cut circular holes. Heating takes place during heavy infestation, which will lower the seed quality.

3) Weed seeds

Weeds are exceptionally tough plants and are able to reproduce e aggressively and quickly outnumber other desired plants. Especially in the seed production plots, the chances for contamination and admixture of weed seeds are more resulting in the reduction of seed quality. Right from the sources of production, processing, storage up to sowing of the seed by the cultivators, the scope of pollution remains. The weed plants affect the normal plant growth of a seed crop by becoming a competitor for space, light, water and nutrients and reduce the seed yield and vigour. During harvest, the weed seeds mix with seeds and thereby the recommended seed standards cannot be met.

Conclusion

Now-a-days seed has taken a new dimension and to improve the economy of our county, productions of high-quality seeds are highly warranted. Hence, application of favorable biotic and abiotic factors in the process of seed production will not only yield us high quality seeds but also make our seed production a profitable venture.

References:

Cantarero, M.G., Cirilo. A.G. and Andrade, F.H. 1999. Night temperature at silking affects kernel set in maize.
Crop Science, 39 (3): 703-710.

Jia, Z.K., Gao, R.S., Zhang, S.W. and Zhu, B.Y. 1991. Affecting ways of temperature on chalkiness of rice seeds afla full leeding. Acta Universitatis AgriculturalisBoreali-Occidentalls. 19(3): 27-31.

Matrinez, E.M., Badillo, M.E.V., Maya, R.N. and Gonzalez, J.R. 1994. Seed viability of different varieties of bean stored under low and high relative humidity. Seed Sci. & Tech. 22: 195-202.

Ebata, M. and lshikawa, M. 1989. Effects of wind and rain on the fertilization, kernel development and kernel characters of rice plant, Japanese Journal of Crop Science, 58 (4): 555-561.

*****

Important Insect Pest of Oil Seed Crops

Radhe Shyam Meena
Assistant Professor,
Institute of Agriculture Sciences, Banaras Hindu University, Varanasi

Oilseeds occupy a prominent place among the principal commercial crops grown in India. The important oilseeds cultivated in India are *Brassica sp*, groundnut, sunflower, safflower, castor, sesame and linseed. These crops are damaged by number of pests, of which mustard aphid, mustard sawfly and the painted bug are the most serious. The aphid is the most serious pest on brassica oilseeds throughout India. On groundnut crop, the white grub has recently assumed serious proportions in Rajasthan, Gujarat, Maharashtra, Karnataka and Uttar Pradesh. The leaf miner and the red hairy caterpillar are the serious in central and southern India. The groundnut aphid is a menace throughout the groundnut growing areas. Its incidence during different years varies with rainfall.

1.Aphids - *Aphis craccivora* (Aphididae: Hemiptera)

Distribution and status: India, Africa, Argentina, Chile, U.S.A. Europe and Australia.

Host Plants: Groundnut, beans, safflower, lablab, niger, peas, pulses and some weeds.

Damage symptoms

Both nymphs and adults suck the sap from the leaflets and tender shoots mostly upto two months after germination. It results in wilting of tender shoots during hot weather. Leaves mottled with chlorotic or dark green spots and plant growth becomes stunted. Sometimes honey dew deposited on the leaves and shoots could be seen which attract the ants.

Management

Spray the infested crop with methyl demeton 25 EC 500 ml or Imidacloprid 17.8 SL 100 -125 ml in 700 L of water per ha. As the strong point of this pest lies in its very quick multiplication the insecticidal treatment has to be repeated as soon as aphid population is found to have built again.

Release *Chrysoperla carnea* grubs @ 5000 / ha.

2.Leaf hopper: *Empoasca kerri* (Cicadellidae: Hemiptera)

Damage symptoms

Both adults and nymphs suck sap from young leaves, mostly from the lower surface. The first symptom of attack is a whitening of the veins. Chlorotic (yellow) patches then appear, especially at the tips of leaflets, probably caused by a reaction between the jassids salivary secretion and plant sap. Under severeinfestation, the leaf tips become necrotic in a typical V shape , giving the crop a scorchedappearance known as 'hopper burn'

Management

Spraying the infested crop with imidacloprid 17.8 SL 100 - 125 ml in 700- 1000 L of water per ha.

3.Thrips: *Scirtothrips dorsalis* (Thripidae: Thysanoptera)

Damage symptoms

Nymphs and adults suck sap from the surface of the leaflets. This results in white patches on the upper and necrotic patches on the lower surface of the leaves. It consists of

distortions of the young leaf lets and patchy areas of necrotic tissue that puncture and split as the leaflets grow. Injury is normally seen in seedlings.

Bionomics
Nymphs and adults dark coloured with fringed wings. Female thrips lay 40-50 eggs inside the tissues of leaves and shoot. Egg period 5 days, nymphal period 7-10 days and adult period is 25-30 days. There are several overlapping generations.
Management
Intercrop lab lab with groundnut 1:4 ratio
Spray methyl demeton 25 EC 500 ml or dimethoate 30 EC 500 ml/ ha

4.Red hairy caterpillar: *Amsacta albistriga* (Arctiidae: Lepidoptera)

Distribution and status

Oriental in distribution including India. It is a serious pest under rainfed conditions on pulses in Rajasthan and groundnut in southern part of India. *Amsacata albistriga* is predominant in South India while *A. moorie* dominates northern parts of the country. Seasonal outbreak largely depends on the climatic conditions and local agricultural practices of the region concerned. It takes place twice a year May-June and August-October. It's outbreak occurs only once in Rajasthan during August- October
Host range
Maize, sorghum, green gram, sesame, pearl millet, finger millet, groundnut, sunhemp, castor, cotton.
Damage symptoms
The larvae feed on the leaves gregariously by scraping the under surface of tender leaflets leaving the upper epidermal layer intact in early stages. Later they feed voraciously on the leaves and main stem of plants. They march from field to field gregariously. Severely affected field looks as though they are grazed by cattle. Sometimes itresults in the total loss of pods. They also feed on sorghum, cotton, finger millet, castor, pulses and cowpea, etc.
Bionomics
Adults are medium sized moths. In *A. albistriga* forewings are white with brownish streaks all over and yellowish streaks along the anterior margin and hind wings white with black markings. A yellow band is found on the head. In *A. moorei* all markings are red in white wings. On receipt of heavy rains, about a month after sowing in *kharif* season, white moths with black markings on the hind wings emerge out from the soil in the evening hours. It lays about 600-700 eggs eggs on the under surface of the leaves. Egg period is 2-3 days. Tiny greenish caterpillar feeds on the leaves gregariously. A full grown larva measures 5 cm in length, reddish brown hairs all over the body arising on warts. The larval period is 40-50 days. With the receipt of showers, the grown up larva pupates in earthern cells at a depth of 10-20 cm. They pupate mostly along the field bunds and in moist shady areas under the
trees in the field and undergo pupal diapause till the next year.
Management
Organize campaign to collect and destroy the pupae after summer ploughing on receipt of showers.
Grow cowpea or red gram as an intercrop to attract adult moths to lay more eggs.

Set up 3-4 light traps and bonfires immediately at the onset of rains at 4 weeks after sowing in the rainfed season to attract and kill the moths and to know brood emergence.
Collect and destroy egg masses in the groundnut, cowpea and redgram.
Collect and destroy gregarious early instar larvae on lace like leaves of inter crops *viz*., red gram and cowpea.
Organize campaign by involving school children (or) general public to collect and destroy the migrating grown up caterpillars from the field.
Dig out a trench around the field to avoid the migration of caterpillars, trap larvae and kill them.
Use nuclear polyhedrosis virus @ 250 LE/ha.
For young caterpillars - apply endosulfan 4D 25 kg/ha (or) carbaryl 10 D 25 kg/ha.
Organize mass ground spraying in endemic areas if necessary in the case of outbreak of the pest.
For grown up caterpillars - spray endosulfan 750 ml/ha (or) dichlorvos 625 ml/ha (or) chlorpyriphos 1250 ml/ha in 375 litres of water.

5.Leaf miner: *Aproaeroma modicella* (Gelechiidae: Lepidoptera)

Distribution and status
India, Pakistan, Sri Lanka, Burma and South Africa.
Host range
Groundnut, soybean and redgram.
Damage symptoms
It prefers rainfed crop and bunch varieties. Young newly hatched green caterpillar mines into the leaflets and feed on green tissues resulting in brownish dried up patches. Later instars caterpillars fold the leaves together and feed on the green tissues by remaining inside. Severely infested crop presents a burnt up appearance. Caterpillars (or) pupae can be seen inside the mines and folded leaflets. It also attacks red gram and soybean.
Bionomics
Adult is dark brown with a white spot on the coastal margin of each forewing. The small hind wings are covered by fringe of minute hair. Adults are found briskly whirling around the plants in field and lay shiny transparent eggs singly on the under surface of leaflets. A female moth lays 150-200 eggs that hatch in 2-3 days. The larvae are pale brown. Fully grown larva measures 6-8 mm. The larval
period is 4-17 days. They pupate in white silken cocoons within webbed leaflets and the pupae are reddish brown. The pupal period is 5-7 days. Adult longevity is 5-6 days. Life cycle is completed in 20-25 days. They cause severe damage from September to November to the rainfed crop and during March & April to irrigated crop.
ETL: 1 larva per meter row or five or more active larvae per plant are found up to 30 days after seedling emergence (DAE), 10 larvae per plant at 50 DAE and 15 larvae per plant at 75 DAE or later.
Management
Grow resistant cultivars like ICGV 86031, ICGS 156 (M 13), FDRS 10, ICG 57, 156, 541, 7016, 7404, 9883
Sow groundnut early and synchronously in rainy and rabi season.
Intercrop groundnut with pearl millet @ 4:1 ratio.

Set up light traps between 8 and 11 PM at ground level.
Mulch the soil with straw within 10 days after germination wherever possible.
Avoid water stress in irrigated crop to avoid the pest infestation.
Maintain the fields and bunds free from weeds.
Apply either endosulfan 4D or carbaryl 10 D at 25 kg/ha when the pest crosses ETL.
Spray any one of the following insecticides - dichlorovos 76 SC 625 ml/ha, quinolphos 25 EC 750 ml/ha, lambda cyhalothrin 5 EC200-300 ml in 375 L of water,

6.Tobacco caterpillar: *Spodoptera litura* (Noctuidae: Lepidoptera)

Distribution and status

India, Sri Lanka, Indonesia, Bangladesh, Pacific Islands, China, Pakistan, Korea and Japan.

Host range

Groundnut, citrus, soybean, cotton, tobacco, castor, pulses, millets, safflower, banana, cabbage, tomato, sweet potato, bhendi, chillies, etc.

Damage symptoms

Neonate, green caterpillars feed on the leaves voraciously and present an appearance to the field as if grazed by cattle. Since this pest is nocturnal in habit larvae hide under the plants, cracks and crevices of soil and debris during the day time. Faecal pellets are seen on the leaves and on the ground which is the indicator of the pest incidence

Bionomics

Adult moth is stout with wavy white markings on the brown forewings and white hind wings with a brown patch along its margin. Eggs are laid in groups and covered with hairs on the leaves. The egg period is 4-5 days. Larva is stout, cylindrical, pale brownish with darkmarkings. The body may have row of dark spots or transverse and longitudinal grey and yellow bands. When fully grown, measures about 35-40 mm in length. The larval period is 14-21 days. It pupates in earthen cells in soil for 15 days. Life cycle is completed 30-40 days.

ETL: 1-2 egg masses per meter crop row of 7-12 plants or pheromone trap catches exceed 100 moths per night, averaged over a week.

Management

Grow castor as a border (or) intercrop in groundnut fields to serve as indicator (or) trap crop.
Grow resistant cultivars like ICGV 86031, FDRS 10
Monitor the emergence of adult moths by setting up of light traps.
Set up pheromone trap (Pherodin SL) to monitor, attract and kill the male moths @ 12 nos./ha and change the septa once in 3 weeks.
Collect egg masses and destroy.
Collect the gregarious larvae and destroy them as soon as the early symptoms of lace-like leaves appear on castor, cowpea and groundnut.
Avoid migration of larvae by digging a trench 30 cm deep and 25 cm wide with perpendicular sides around the infested fields.
Prepare a bait with following for 1 ha. Rice bran 12.5 kg, molasses or brown sugar 2.5 kg, carbaryl 50 WP 1.25 kg (mix the ingredients to obtain a homogenous mixture sprinkle water gradually and bring the bait to a dough consistency. Distribute the above

bait on the soil, in and around the field in the evening hours immediately after preparation).

Apply NPV @ 250 LE/ha with crude sugar 2.5 kg/ha which is as effective as that of chlorpyriphos at 200 g a.i./ha at 7 days interval.

Apply any one of the following insecticides per ha to control early instar larvae (1st to 3rd instar). Carbaryl 10 D 25 kg, carbaryl 50 WP 2 kg, quinalphos 25 EC 750 ml, phenthoate 50 EC 1250 ml and dichlorvos 76 SC 750 ml.

Spray any one of the following per ha to control 4th to 6th instar larvae. Chlorpyriphos 2 L, dichlorovos 1 L, phenthoate 2 L or Diflubenzuron 25 WP 400 g or Methomyl 40 SP 750-850 g in 375-500 L of water/ha.

7.Gram pod borer: *Helicoverpa armigera* (Noctuidae: Lepidoptera)

Distribution and status: World wide

Host range

Cotton, sorghum, lablab, soybean, pea, safflower, chillies, groundnut, tobacco, okra, maize, tomato.

Damage symptoms

Small or large irregular feeding holes on the leaves. Presence of pale green or rose or brown or chocolate colored caterpillars with dorsal and lateral stripes and hairs on the body. Caterpillars also damage the fruiting bodies by entering into them.

Bionomics

Adult is brown coloured moth with 'V' shaped speck on forewings and dull black border on the hind wing. Eggs are laid singly on host plant. The egg period is 5-7 days. Larva is greenish with dark brown to grey lines. Color varies with kind of host plant. The larval period

is 14-20 days. It pupates in soil and pupal stage lasts for 10 days. Cannibalism is common among larvae.

Management

Set up light trap to attract and kill the moths.

Set up pheromone traps @ 12 nos./ha to attract male moths.

Release of egg parasite *Trichogramma* spp. and egg larval parasite *Chelonusblackburnii*.

Apply Nuclear Polyhedrosis Virus (NPV) @ 250 LE/ha.

Combined use of NPV of *S. litura* and *H. armigera* on groundnut indicated that single application of NPV of each pest at 250 LE/ha with crude sugar 2.5 kg/ha is highly effective.

Spray emamectin benzoate 5 SG 220 g or spinosad 45 SC 180-220 ml per ha in 375-500 L of water per ha

8.White grub : *Holotrichia consanguinea* (Melalonthidae: Coleoptera)

Damage symptoms

Growth of plant is retarded. Plants wilt or die. Roots partially or fully eaten off by white and fleshy grubs.

Bionomics

The dark brown adult beetles reenter the soil to hide and lay eggs. Female lays 20 - 80 white, roundish eggs in clusters. Egg period 9 - 11 days. Grubs are white and translucent.

Pupates in soil and remain as pupae until the following year. The adult beetles emerge with the first monsoon showers.

Management

Plough deep at the time of land preparation to expose grub and kill.

Adopt crop rotation with rice in irrigated endemic areas to bring down grub damage.

Ensure adequate irrigation to irrigated groundnut in endemic areas since the grub attacks roots under inadequate soil moisture condition.

Set up light traps or bonfires to attract and kill the adults on receipt of summer showers.

Apply carbaryl dust @ 25 kg per ha in the soil prior tosowing during last ploughing.

Repeat the same on 40 DAS and incorporate in the soil during earthing

9.Cutworms: *Agrotis* spp. (Noctuidae: Lepidoptera)

The cutworms may be serious during March - April in fields where sunflower follows potato. Caterpillars cut the seedlings at the ground level.

Management

Sow the crop in ridges to avoid cutworm damage in the germinating seedlings.

Where flat sowing is practiced, apply 5 L of chlorpyriphos 20EC per ha before sowing.

The insecticide should be mixed in 25 kg fine soil and broadcasted uniformly in the field after last ploughing but before planking.

10.Castor semilooper, *Achaea janata* (Noctuidae; Lepidoptera)

This is a serious pest of castor in all parts of India, Sri Lanka and Thailand. The adult of *A. janata* is a pale reddish brown moth with a wing expanse of 6-7 cm. The wings are decorated with broad zig-zag markings, a large pale area and dark brown patches. The full grown larva is dark and is marked with prominentblue-black stripes.

Life cycle: Female lays up to 450 eggs during its life span. The egg, being about 1 mm in length, is fairly large and also has on its surface a few ridges and furrows which radiate from the circular depression at the apex. The larva emerges by cutting a hole in the egg-shell in 3-5 days and devours it immediately. The larva feeds and moults 4-5 times and becomes full-grown in 15-20 days. The grown-up larva prepares a loose cocoon of coarse silk and some soil particles, and pupates under the fallen leaves on the soil, usually at the edge of the field. In some cases, pupation also takes place within the folded leaves on the plant itself. The pupal stage lasts 10-15 days and the moths, on emergence, feed on the soft fruits of citrus, mango, etc. There are 5-6 generations in a year.

Nature of damage: The caterpillars feed voraciously on castor leaves, starting from the edges inwards and leaving behind only the midribs and the stalks. With the excessive loss of foliage, the seed yield is reduced considerably

Management Strategies

Hand collection and destruction of the egg masses and first instar larvae.

Spray of 0.05 % quinalphos 25 EC in 250 litres of water per acre and repeat at 15-day intervals.

Castor hairy caterpillar, *Euproctis lunata* (Lymantriidae; Lepidoptera)

The castor hairy caterpillar is widely distributed in India particularly in Uttar Pradesh, Orissa, Haryana, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. It is observed feeding on linseed, groundnut and grapevine. Full-grown larvae are dark grey, with a wide white dorsal stripe, and have long hairall over body. The moths are pale yellow color.

Life cycle: The eggs are covered with the female anal tuft of brown hair. They hatch in 5-7 days and the young larvae feed gregariously for the first few days. Later on, they disperse and feed

individually. They pass through six stages and are full-fed in 2-3 weeks. The full-grown caterpillars make loose, silken cocoons in the plant debris lying on the ground and pupate inside. The pupal stage lasts about one week in the summer. The pest passes through several generations in a year.

Nature of damage: Caterpillars feed on the leaves of various host plants and in case of severe infestation, they may cause complete defoliation. The attacked plants remain stunted and produce very little seed.

Management Strategies

Deep summer ploughings to destroying the weeds and hibernating stages Use of light traps help in reducing the population of this pest.

Hand collection and destruction of the egg masses and first instar larvae

Miner Insect

Leaf hopper: *Empoasca punjablensis* (Cicadellidae: Biology: most abundant from december to march, during summer it is believed to migrate to the hills.

The pest breeds parthenogenetically and the females give birth to 26-133 nymphs.

About 45 generations are completed in a year.

Cloudy and cold weather is very favourable for the multiplication of the pest

Green peach aphid: *Myzus perricae* (Aphididae: Hemiptera);

Lace wing: *Monanthia glubulifera* (Tingidae: Hemiptera);

Dolycoris indicus (Pentatomidae: Hemiptera);

Safflower caterpillar: *Spodoptera exigua, Helicoverpa armigera and Eublemma rivula* (Noctuidae: Lepidoptera);

Leafminer: *Chromatomyia horticola* (Agromyzidae: Diptera)

Surface weevil: *Tanymecus indicus* (Curculionidae: Coleoptera

******

Seed production technology for Niger

A K Vishwakarma
Project Coordinating Unit Sesame & Niger, ICAR- JNKVV, Jabalpur

Niger, is the lifeline of the tribal economy, has been under cultivation in India for millennia. Niger seed contains 35 to 40% oil and 25 to 35% protein. Niger plant has great potential for soil conservation, land rehabilitation and good degree of tolerance to insect pests, diseases, drought, attack of wild animals and birds. These attributes favour cultivation in hilly, sloppy areas on marginal and sub marginal lands in and around forestlands where other crops can hardly be raised. Niger has an added advantage of yielding oil and seed completely free from any toxin and thereby good export potential. Niger is an erect, annual dicotyledonous plant that develops yellow flowers that produce shiny black seeds. In Ethiopia, India, and Myanmar, it is primarily grown as an oilseed crop, but also produced to sell to various countries as wild bird seed.

Niger is primarily grown on the denuded soils in the states of Madhya Pradesh, Chhattisgarh, Orissa, Maharashtra, Bihar, Karnataka and Andhra Pradesh. The productivity of niger as compared to other oilseeds, is low mainly due to the non-availability of required inputs. Seed is the basic and cost-effective component of improved technology. However, the production and supply of quality seed of improved varieties to the farmers is very poor in this crop. In spite of very low seed rate and very high seed multiplication ratio, the seed replacement rate in niger is very low, due to weak seed chain at foundation and certified seed stages. Assured supply of quality seed needed to popularize the improved technology without which the other components of technology are not going to make a significant impact. The development of proper technology for seed production is important for the growth of the seed chain, particularly the disadvantaged crops like niger. The information on different aspects of niger seed production have been compiled an aid to augment the supply of the quality seed.

Quality seed production which follows efficient certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures for almost all the crops through the Seeds Act, 1966.

Mode of Pollination: Niger is completely out crossing species due to sporophytic self-incompatibility mechanism. Insects, particularly bees are the major agents of pollination. Self-incompatible nature and exclusively entomophyllous mode of pollination make selfing a difficult process. Very high inbreeding depression associated with very poor seed setting is observed with the advancement of generation. With the initiation of flowering, selfing or sib mating is done by covering two or more representative adjacent plants of a line by a bag made of fine muslin cloth or mosquito net, shaking of bags/plants is done on alternate days to ensure pollination.

Diagnostic Characters: The classification of varieties based on morphological characters is essential for identification and seed certification. The use of distinct traits with high heritability as specified by the breeders are important in the production of pure seed. The important diagnostic characters on which the identification of varieties are as follows: Leaf colour, Leaf width, Leaf margin, Stem colour, Days to flower, Branching habit, Flower colour, Capitulum

size, Maturity of heads, Seed colour, Seed shape, Days to maturity, 1000-seed weight, Seeds per captitulum, Oil content.

Production Technology: The All India Coordinated Research Project on Niger has developed and refined the technology for enhancing seed production. The production areas may not necessarily be suitable for seed production due to parallel built up of diseases and pests. The seed production shall be undertaken in the areas where the environment allows full expression of the diagnostic characters; facilities for protective irrigation exist and the productivity and seed quality is high. Cuscuta weed is the major menace for seed production. The areas for seed production have to be essentially free from this problem.

Varietal Development: Nineteen varieties have been developed for different agro ecological situations. Seed yield of these varieties range from 600-800 kg/ha, days to maturity 90-110 and oil content 35-40%.

State wise recommended varieties

Madhya Pradesh and Chhattisgarh	JNC-6, JNS-9, JNS 28. JNS 30, JNS -2016-1115, JNS -521, JNS -2015-9, JNS 2016-1413
Maharashtra	IGP-76 (Sahyadri), N-5, IGPN-2004-1, IGPN 8004
Orissa	GA-10, Utkal Niger-150
Bihar and Jharkhand	Birsa Niger-1, Pooja-1, BNS-8, BNS 10
Karnataka	No.71, KBN-1, RCR-18, DNS 4
Gujarat	Gujarat Niger-1, NRS-96-1, GNNIG-3, GNIG-4
Tamil Nadu	Paiyur-1
Rajasthan	JNS-9, JNS 28, JNS -2016-1115
West Bengal	JNS-9, JNS 28, JNS -2016-1115
North Eastern states	IGP-76, JNS-9, IGPN-2004-1, JNS 28, JNS -2016-1115

Soil:

Niger is adapted to a wide range of soil types from clay loam to sandy loam, sandy and gravely soils but it thrives best on well drained loamy soils of good depth and texture with pH range of 5.5 to 6.5. Niger seed is successfully produced as a sole crop under rainfed situations in kharif and rabi seasons. Niger is generally grown on sloppy, denuded soils where other crops cannot be taken. However, for the seed crop a well leveled, uniform field with no preceding crop of niger should be selected to avoid difficulty in seed certification.

Land Preparation:
Two deep ploughings followed by one harrowing and planking are usually recommended to obtain optimum soil tilth required to ensure even depth of seed placement and subsequent emergence.

Seed & sowing:
The seed rate depends on the method of sowing. Generally, 5 kg/ha seed are required for the sole crop. To protect the crop from seed and soil borne pathogens, seed should be treated with Thiram or Captan 3.0 g/kg seed before sowing. Seed treatment with Phosphorus solublising bacteria 10 g/kg seed gives higher yield. The crop is generally sown by broadcasting by farmers, however, line sowing at a spacing of 30-45 cmx 10 cm is recommended for seed crop. Seeds are mixed with sand/ powdered FYM/ ash, 20 times to ensure even distribution of seed. Planking is done to cover the seed. On slopes, line sowing along the contour, across the slope is recommended. Seeds should be sown 2-3 cm deep depending upon soil type and moisture. Seed bed temperature of 15-22oC is optimum. Temperatures below 100 C and above 350 C impair germination. The normal seed rate recommended for niger gives higher plant stand. To maintain optimum plant population (3.5 lakhs/ha), thinning is recommended after two weeks of sowing or when the seedlings attain 8-10 cm height.

Isolation Distance: An isolation distance of 1000m is recommended for nucleus, breeder and the foundation stages of seed production, whereas 500m for certified stage production and should be rigorously followed to produce genetically pure quality seed. Time isolation should be avoided.

Rouging: Rouging should be done strictly to remove all the off-type plants, which exhibit variation from the parental variety. The plants infested by diseases and pests especially by Cuscuta weed, should be removed. The field should be inspected thoroughly at seedling, vegetative, flowering and maturity stages by monitoring team consisting of experts.

Nutrient Management:
The crop is mostly grown on unfertile, marginal and submarginal land without manure or fertilizer application. However, this crop has shown good response to fertilizer application. Application of recommended N through urea + seed treatment with PSB 10 g/kg seed enhances yield significantly. Application of sulphur (20-25 kg/ha) increases yield and oil content. Weeding is recommended at the time of thinning, which is done 15-20 days after sowing. Second weeding should be done after a month of sowing before top dressing with nitrogenous fertilizer. In Orissa, Cuscuta infestation has become a major problem. Seed should be obtained from Cuscuta free areas. Sowing should be done after separation by sieving with a 1 mm sieve. Niger is invariably grown in monsoon season without any irrigation. Prolonged moisture stress adversely affects stand and growth of the plant. In such situation, protective irrigation, helps in plant stand establishment and gives good yield. For semi rabi crop one or two irrigations, one at flowering and other at seed filling stage gives higher yield.

Plant Protection: Major insect pests and diseases

Important insect pests of niger with their efficient management

Common name	Nature of damage	Management / control
Niger caterpillar (Condica conducta)	The caterpillar green with purple markings, feed on leaves and defoliates the plants.	Proper weeding reduces hiding places Crop rotation is effective in reducing pest population Birds readily eat the caterpillars and help to check when they are numerous, 40-50 bird perches are sufficient for one hectare Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water)
Cutworm (Agrotis ipsilon)	The moth hides under dried twigs during day time and lays eggs on leaves. Larvae attack the crop and plants at ground level.	Keep grass bundles or crop refuges in cluster in field for the caterpillars to hide during evening and collect the caterpillars early in the morning Proper weeding reduces hiding places Crop rotation effective in reducing pest population Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water)
Bihar hairy caterpillar (Spilosoma obliqua)	The caterpillars remain gregarious under neath leaves in early stages and cause serious loss in yield at third and fourth instar.	Collection and destruction of egg masses of early instars of caterpillars Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l water)
Aphids (Uroleucon carthami)	This is one of the sucking pest of niger during later period of crop growth.	Spray NSKE 5% or Neem based insecticide (Nimbecidin 5 ml/l) Spray crop at bud initiation stage with any one of the following insecticides dimethoate 30 EC 1.5ml/l or Quinalphos 25 EC 1.5 ml/l or Dichlorvos 76 EC 1 ml/l or Triazophos 40 EC 1 ml/l or Imidacloprid 17.8% SL 0.25ml/l
Semilooper (Plusia orichalcea)	The semilooper feeds on the leaves and defoliates the plant.	As recommended in case of hairy caterpillar
Niger capsule fly (Dioxyma sarorcula)	Maggot feed on seed and pulp inside the capitula.	Install the light trap one per ha. Spray Quinalphos 25 EC 1.5 ml/l or Acephate 75% SP 1.5 g/l of water

Important diseases of niger and their efficient management

Disease (Causal organism)	Symptoms	Management
Cercospora leaf spot (Cercospora guizoticola)	Disease appears as small straw to brown coloured spots with gray centre on the leaves, spots	Seed treatment with Thiram (0.2%) + Carbendazim (0.1%), 3g/kg seed or Trichoderma

	may coalesce causing defoliation.	viride @5g/kg seed Two foliar spray with saaf 75wp (Carbendazim 12% + Mancozeb 63%) @2.5 g/lit water at 45 and 60 DAS.
Alternaria leaf spot (Alternaria spp.)	Spots are brown to black with concentric rings.	
Powdery mildew (Sphaerotheca sp.)	Small powdery spots appear on leaves, which gradually spread on the lamina and stem resulting in defoliation.	Foliar spray of 0.2% Wettable sulphur or Carbendazim (0.1%) when disease appears
Stem/root rot (Macrophomina phaseolina)	Infected roots are light blackish to black in colour, which are covered with black sclerotia and are brittle. The blackening extends from ground level upward on the stem giving black colour to stem.	Seed treatment with Thiram (0.2%) + Carbendazim (0.1%) 3g/kg seed or Trichoderma viride @5g/kg seed Deep ploughing in the summer Crop rotation, Grow resistant variety Apply 2.5 kg/ha Trichoderma viride mixing with 50 kg FYM in the field before sowing
Cuscuta weed (Cuscuta chinensis/ C. hyalina)	Infested plants are stunted, pale yellow with small flowers.	Removal of Cuscuta seed by seiving before sowing Steeping of Cuscuta seed in brine solution before sowing Removal of Cuscuta infested niger seedlings at the early crop growth Pre sowing soil application of Fluchloralin (1 kg a.i./ha) Pre emergence application of Pendimethalin (1 kg a.i./ha).

Post harvest handling: Usually the crop matures in 105-120 days after sowing and harvest by sickles when the leaves dry up and the head turns blackish in colour. The threshing floor should be neat and clean without any seed to avoid contamination. After drying in the sun for about a week by stacking on the threshing floor, the crop is threshed by beating with sticks. The threshed material is cleaned by winnowing. The produce is dried in the sun so as to bring down the seed moisture level up to 7-8% and then stored properly. The seed should be treated with Thiram or Captan 3g/kg seed before packaging and storing. Proper and accurate labeling is essential to ensure the purchaser about the quality of seed. The label should state clearly (i) period of the seed (crop), (ii) variety, (iii) germination %, (iv) purity (v) weed seed %, (vi) inert materials, (vii) name and address of producer and (viii) other information pertinent to seed or its identification as per the guidelines.

Maintenance breeding and nucleus seed production

Commercial crop–growing areas may not necessarily be suitable for seed production due to a parallel buildup of diseases and pests. Seed production needs to be undertaken in areas where the environment allows full expression of diagnostic characters, facilities for protective irrigation, productivity and seed quality to be higher.

Estimated Area Required for Production of Quality Seed in India

Category	Seed (kg)	Area (ha)
Nucleus seed	15	0.03
Breeder seed	1050	2.0
Foundation seed	37500	80 .0
Certified seed	2000000	4000.0

Seed production systems: Presently two seed production systems are operating in the country.

Formal system: This system is being operated through public sector agencies like NSC, SFCI, SSC's, SAU and oil federations etc. The seed multiplication ratio in this system is extremely poor. The main advantage of this system is that the identity, genetic purity, quality and source of the seed is known to the farmers.

Informal system: This system includes multiplication of varieties by private growers or individual farmers and sharing the seed by the farmers. The seed of most of niger varieties under cultivation is being produced and supplied through this system. The main disadvantage of this system is that the identity, genetic purity, quality and source of the seed is not authenticated. However, the seed produced through this system is less expensive and easily available to the farmers.

Alternative systems: The existing formal system of seed production had been hardly sufficient to cope up with the seed requirement. The minor crops like niger receive least priority of seed producing agencies and therefore the production of quality seed to the farmers in niger is pathetic. The possibility of improving the supply of quality seed in crops like niger through the formal system in near future appears not to be so bright. Therefore, in this crop, alternative systems of seed supply may prove worthy for fulfillment of the requirement.

Direct supply: Both the formal and informal systems of seed supply, have their own limitations. To overcome the limitations of the prevalent informal system and the existing formal seed supply system, the seed production can be undertaken by the research institutes and distributed through farmer fairs/field days/sale counters. The direct supply is also feasible and will be more effective in view of some advantages. This system has been successful to a certain extent to cover the maximum possible area under quality seed of improved varieties.

Seed village: Another option to augment the seed supply in niger is seed village. The institutes can choose a single variety and produce seed sufficient to cover entire village with the single variety. The seed village should grow only one variety. The local or other varieties should not be grown in seed the village. Combining together the programme of demonstrations and seed village will prove synergistic for the improvement of seed replacement rate.

The production practices for the breeder, foundation and certified seed are the same as outlined. Grow at least five border rows of genetically pure seed of the same variety. Maintain a minimum isolation distance of 1000 m for breeder and foundation stages and 500m for certified seed and strictly avoid time isolation. Do not spray any insecticide during flowering stage as it will kill the pollinators and thereby reduce the seed yield. In case it is warranted, spray any selective insecticide in the evening. Harvest and stack the bundles for sun drying on a clean threshing floor. A considerable care is required in harvesting and threshing to prevent mechanical mixtures and weed seeds. Report the periodical information of breeder seed production in various proforma.

Seed certification standards

Seed standards	Foundation Seed	Certified Seed
Physical purity (%)	98	98
Inert matter (%)	2	2
Other Distinguishing Varieties, ODV, (Max. No./kg)	10	20
Other crop seeds (Max. No./kg)	10	20
Total Weed seeds (Max. No. /kg)	10	20
Minimum Germination (%)	80	80
Moisture (%)		
Ordinary Container	9	9
Waterproof Container	5	5
Field standards		
Minimum inspection	3	3
Different plants (%)	0.10	0.20
Off-types (%)	0.10	0.20
Seed borne diseases	0.05	0.10

Maintenance of Genetic Purity in Seed: Niger is completely out crossing with pollination exclusively by insects which itself is a big problem in the maintenance of genetic purity. Niger is highly prone to mechanical mixture due to its very light, small seed and shattering habit which is another major factor to affect genetic purity. Therefore, great care is to be taken to avoid mechanical mixture at all the stages from seedling to final processing of seed. Following precautionary measures shall be taken to maintain the genetic purity. Use source seed with 100% genetic purity and restrict selection of only true to the type plants. Any selection will change the gene frequencies in the original population and consequently the identity of the variety. Follow strict rouging at vegetative and flower initiation stages by the team. Take utmost care to clean threshing sheets/bags/containers/equipment's used in sowing, harvesting, threshing and processing operations.

Problems in Seed Production

Self-incompatibility system: The self-incompatibility makes the evaluation/ maintenance of the single plant progenies at nucleus seed production stage very difficult so as to ascertain the purity of source seed.

Lodging: Under optimum conditions of fertilization, niger tends to lodge because of its soft hollow stem which adversely affect the seed production.

Inadequate isolation: Niger is completely cross pollinated on account of sporophytic self-incompatibility. The pollination is exclusively entomophilous which increases the chances of out crossing.

Cuscuta weed: Cuscuta weed is a menace in niger seed production. Initially the weed spread through seed contamination and soon becomes soil borne if not controlled effectively. Once the weed becomes soil borne it is very difficult to control it and the whole area becomes unsuitable.

Non-lifting: Timely lifting and/or non-lifting of seed has been a problem discouraging the seed production.

Grow Out Test: The grow out test is conducted in the area where crop can express the maximum characters without any variation. Take a sample of 100g from the seed lot to estimate the genetic purity of the seed on the basis of morphological characters. Grow 800 plants of the submitted sample vis-a-vis the same population of authentic sample under recommended practices. The submitted sample for grow out test is drawn simultaneously with the samples for other tests. The permissible limit of off types in niger is 0.5%. Make a comparison at all the stages according to the expression of the characters. Examine each and every plant throughout the growing season with emphasis on the marker characters and time of their expression. Tag the off types and count the total population along with off types. Reject or accept the samples as per the following prescribed standards.

****

Seed Production in Rapeseed and Indian Mustard

S. K. Chakrabarty
Division of Seed Science and Technology
ICAR-Indian Agricultural Research Institute, New Delhi-110012

Oilseed Brassica species, commonly called as rapeseed-mustard, are the third most important oilseed crops of the world after soybean and palm. During the 2018–19 growing season, the world's rapeseed–mustard area, production and productivity was predicted to be 36.59 mha, 72.37 mt, and 1,980 kg/ha, respectively (USDA, 2019). India is accounted for 11.7% and 21.7% of all production and acreage, respectively (USDA, 2021). In India the area, production and yield of rapeseed-mustard are 9.3 mha, 12.79 mt and 1,279 kg/ha, respectively (Ministry of Agriculture, Govt. of India, 2021-22). During 2021-22 the contribution of rapeseed-mustard to the total oilseed acreage and production was 27.9 % and 25.0 %, respectively. The national average yield of rapeseed-mustard was 1142 kg / ha as compared to 969 kg / ha of all oilseeds (Anonymous, 2022).

Among the oilseed Brassicas {Indian mustard (B. juncea); Gobhi sarson (B. napus); Ethiopian mustard (B. carinata); yellow sarson, toria, brown sarson (B. rapa); both self- and cross-pollinated forms are available (Table 1). In India, a good number of improved varieties in these crops have been developed and their improved production and protection technologies were refined to obtain higher yields. Due to different maturity durations (Table 1), these species are suitable for different cropping systems. Further, being diverse these are adapted to different agro-climatic conditions. Among these, B. juncea (2n=36, AABB genome) contributes more than 80% to the total rapeseed-mustard production in the country and is an important component in the oilseed sector.

Table1: Mode of reproduction, ploidy level and maturity of oilseed Brassicas

Name of the crop	Common name	Ploidy level	Compatibility type	Days to maturity*
B. juncea	IndianMustard	Amphidiploid	Self-compatible	100-152
B. napus	Gobhi sarson (rapeseed)	Amphidiploid	Self-compatible	145-180
B. carinata	Ethiopian mustard	Amphidiploid	Self-compatible	160-180
B. rapa var. toria	Toria(rapeseed)	Diploid	Self- incompatible	70-100
B. rapa var. Yellow sarson	Yellow sarson (rapeseed)	Diploid	Self-compatible	90-135
B. rapa var. Brownsarson	Brownsarson (rapeseed)	Diploid	Self- incompatible	110-150

*Based on days of maturity among the released varieties

Quality seed is the most important input in realizing higher yields. Once a variety is released it takes about 3-4 seed multiplication cycles to reach the farmers. In addition to the genetic potential, fate of the variety also depends on the quality of the seeds used for commercial cultivation. Therefore, utmost care needs to be taken for maintenance of purity in this process. The process of seed production starts with the production of nucleus seed. The purity of any genotype can be breached at different stages and during different agronomical operations. The factors identified by Agrawal (1980) for variations in the seed crop/harvest are:
Developmental variations
Seed admixture during harvesting or threshing or handling
Mutations
Natural crossing with undesirable types
Minor genetic variations
Selective influence of diseases and insect pests
Technique of plant breeder

The affect of the above factors can be minimized by strict compliance of seed production procedures and practices defined under section 8 of the Seed Act 1966 ensuring the minimum seed certification standards of any crop variety during seed production. The required level of genetic purity need to be maintained for each class of seeds i.e. nucleus, breeder, foundation and certified seeds. Various field and laboratory standards are to be followed for genetic purity of the variety under seed production chain.

Field standards
Selection of field
Good agronomic practices
Isolation distance
Roguing at appropriate stage

Seed Standards
Pure seed (Min)
Inert matter (Max)
Other crop seeds (Max)
Total weed seeds (Max)
Objectionable weed seeds
Germination (Min)
Moisture (Max)

The procedure of nucleus/breeder/foundation/certified seed production varies from crop to crop according to the mode of pollination. Field and seed standards as per the Indian Minimum Seed Certification Standards (Trivedi and Gunasekaran, 2013) are briefly discussed as under:

Selection of land for seed production
Seed crop is taken in a field in which same crop was not taken in the previous season. Failing which volunteer plants are often observed in seed crop

Shattering of seed at harvest in previous crop and seed dormancy increase the incidence of volunteer plants which are the major source of contamination in seed crop
Frequency of such plants higher than permissible limit 0.10 and 0.50 for foundation and certified seed respectively makes the seed crop unfit for seed certification
If however, higher or same class of seed of given variety was taken in the previous year, the seed crop of the same variety can be grown in the field
Field Inspections/Rogueing Pre-flowering stage
Off-type plants: weeds, plants of different variety/species
Plant height
Leaf characters
Flowering stage
Differences in petal colours, plant height, early and late maturing plants
Pre-harvesting/Maturity stage
Late maturing plants
Size, shape and surface of siliqua
Angle of siliqua placement
Pod locules
Seed colour
Mexican prickly poppy (Argemone mexicana) is an objectionable weed. All plants of this weed should be removed.

Identification of off-type plants in a seed production plot is very crucial which require lot of skills. The off-types may be a weed or a plant of different variety/ species, need to be removed at adequate stage. In rapeseed-mustard different diagnostic traits are documented (Yadava and Singh 2003), which are helpful in identification of off-types (Table 2).

Field Standards
General requirements
Isolation distance: For the purpose of seed production, the self-pollinated types (compatible types) should be considered as often cross-pollinated crops since the natural out crossing from 5 to 15 per cent is reported. The natural out crossing is largely facilitated by honey bees in both self-compatible and incompatible types. The isolation distance for both types is as follows:

Mode of pollination	Foundation	Certified
Self-compatible types	100	50
Self-incompatible types	200	50

Seed field to be isolated from:
Field of other varieties of same species
Field of same variety not conforming to varietal purity requirements
Field of Eruca sativa and other Brassica species: B.rapa,B.chinensis,B.napus,B. juncea, B. nigra, B. pekinensis, B. tournifortii, B. alba
No isolation is required from B.oleracea types (cabbage,cauliflower,knolkholetc.)

Table2:Stage specific diagnostic traits considered for varietal identification in oilseed Brassicas

Characteristics	States	Stage of observation
Leaf shape	Serrated / non serrated	Vegetative
Leaf type	Sessile / petiolate	Vegetative
Leaf colour	Light green / medium green / dark green / purple green / purple	Vegetative
Leaf hairiness	Present /absent	Vegetative
Calyx colour	Green / light green	Flowering
Corolla colour	Dark yellow / yellow / cream yellow / white	Flowering
Petal shape	Narrow / broad	Flowering
Plant type	Erect / semi-erect / spreading	Vegetative/reproductive
Plant height	Dwarf / medium / tall	Vegetative/reproductive-
Main shoot length	Short / medium / long	Vegetative/reproductive
Siliqua arrangement	Appressed / semi-appressed /spread	Maturity
Siliqua surface	Smooth / intermediate / constricted	Maturity
Siliqua beak	Short stout / long slender	Maturity
Seeds / siliqua	Less / average / more	Maturity
Pod locule	Unilocular / bilocular / trilocular / tetra locular	Maturity
Seed colour	Yellow / dull grey / reddish brown / brown / black	Maturity/post harvest
Seed size	Small / medium / bold	Post harvest
Oil content	Low / medium / high / very high	Post harvest

Specific requirements

Factor	Maximum permitted (%)*	
	Foundation	Certified
Off types	0.10	0.50
Objectionable weed plants	0.05	0.10 (Argemone mexicana)

*Maximum permitted at the final inspection

Seed standards:

There are no fixed seed standards for nucleus and breeder"s seed as these are produced by the breeder himself along with the representatives from ICAR, NSC, therefore, their genetic purity should be of highest level. However, for certification of foundation and certified seed standards has been laid out, which are mandatory for qualification of seed. The seed standards forrapeseed-mustard are as follows:

Factor	Maximum permitted (%)*	
	Foundation	Certified
Pure seed(minimum)	97.0%	97.0%
Inert matter(maximum)	3.0%	3.0%
Other crop seeds(maximum)	10/kg	20/kg

Other distinguishable 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(minimum)	85%	85%
Moisture(maximum)	8.0%	8.0%
For vapour-proof containers(maximum)		
Mustard and taramira	5.0%	5.0%
Rapeseed	7.0%	7.0%

Rapeseed-mustard Hybrid seed production:

Hybrids released for commercial cultivation in rapeseed-mustard are based on cytoplasmic genetic male sterility-fertility restoration (CGMS-FR) system commonly called as 3-line system. The seed of male sterile line (A line) is produced by raising A and B lines in a specific ratio. In general, 4:1 ratio of A line and its maintainer (B line) is followed. To avoid admixture, B line need to be harvested first and later the A line is harvested and threshed. The seeds of both these lines need to be threshed separately and bulked as separate lots of A and B lines for further use. The hybrid seed through raising A and R (fertility restorer) need to be raised in a ratio of 4:1 to 5:1 depending on the flower bearing capacity of R line. To avoid admixture, R line need to be harvested first and later on A line is harvested and threshed. The seeds from both these lines need to be threshed separately and bulked as separate lots of hybrid (F1) and R line seed. The seeds of B and R lines can be multiplied by growing them separately in isolation just like any other pure line variety.

Selection of land for seed production: Same as in varieties

Isolation distance for hybrid seed production and multiplication ofA/B/Rlines

Contaminants	Minimum isolation distance(m)	
	Breeder/ Foundation	Certified
Fields of the varieties/hybrids/parental lines other hybrids of same parental lines of the same spp.	200	100
Fields of the same variety/hybrid/parental line not conforming to varietal purity requirements for certification	200	100
Fields of Rocket salad (Eruca sativa) and any of the other species of the genus Brassica	50	25

B.juncea(L.)and its subspps.,Indian mustard or rai Bangla sarson or vegetable mustard or Pahadi rai B.rapa cvs.Yellow sarson,toria and brown sarson B.napus:Gobhi sarson;B.carinata:Karanrai B.nigra:Black mustard orBanarasi mustard B.alba: White mustard; B. tournefortii: Jungli rai		

Grow out test: All seed lots shall be subjected to grow out test and shall confirm to the following genetic purity requirements:

Class	Genetic purity (%)(Minimum)
Foundation	95.0
Certified	85.0

Important agronomic interventions for better seed quality and quantity:

The seed production of a variety should be taken up in the area for which it is released

Sowing should be done on time as per the recommendations for agro-climatic or geographical zone

Standard row to row and plant to plant spacing should be maintained

Recommended dose of fertilizers should be applied for raising healthy crop

Thinning should be done three weeks post-sowing

Two-three irrigations depending on days to maturity of the variety should be ensured to raise good crop

Rogueing should be done at three stages viz., before flowering, flowering and maturity

Required plant protection measures should be adopted to raise healthy crop

Borderrowplantsof1mareafromallsideofplotshouldfirstbeharvestedseparatelyand harvesting should be done at the stage when 70-80% plants turn yellow. The harvested crop should be dried before threshing.

Oil content and other quality traits need to be analysed before grading by taking random samples from dried seed lot

The moisture of the seed lot, after threshing, should be dried to 8% moisture level

Germination test of the individual seed lot need to be done. The seed should be graded before packing

The graded seed should be treated with Apron 35SD@6g/kg seed or with Thiram@2g/kg to impart protection against diseases during seedling emergence

The seed should be packed in bags sufficient for minimum standard unit of cultivated land eg. acre, hectare etc.

Seed at 8% moisture level should be stored at 30% relative humidity and seed store should be properly fumigated to avoid storage pests

****

Major Diseases of oilseed crops and its Management

Dr Chanda Kushwaha
Department of Plant Pathology,
Bihar Agricultural University, Sabour

India is the fourth largest oilseed economy in the world after USA, China and Brazil. The performance of oilseeds on the domestic front during the last two decades has been improving. y is world's fourth largest. Oilseed cultivation is undertaken across the country in about 260 lakh ha, mainly on marginal lands and dependent on monsoon rains (un-irrigated) and with low levels of input usage. Almost 72% of the total oilseeds area is confined to rainfed farming cultivated mostly by marginal and small farmers. Lack of appropriate technologies, cultivation under input-starved conditions, combating the biotic and abiotic stresses are some of the major causes for poor productivity of oilseeds. Biotic stress in form of disease is one of the major reason to reduce the quality and yield of crops. Eight major edible oilseed crops listed are Groundnut, Rapeseed (Toria, Mustard and Sarson), Soybean, Sunflower, Sesame, Safflower, Linseed and Niger.

Major diseases of Mustard:

Alternaria Leaf blight

It is caused by Alternaria brassicae and A. brassicicola. A. brassicae and A. brassicicola can affect host species at all stages of growth, including seeds. On seedlings symptoms include dark stem lesions immediately after germination, which can result in damping-off, or stunted seedlings. Alternaria symptoms often occur on the older leaves, since they are closer to the soil and are more readily infected as a consequence of rain splash or wind-blown inoculums present in the soil. The spots produced by this disease are brownish or grayish that coalesce to cover large patches showing blighted appearance. Under severe infections defoliation occurs. Circular to linear, dark brown lesions also develop on stems and pods, which are elongated as they mature. Infected pods produce small, discoloured and shriveled seeds affecting the quality (Mallick et al, 2015).

Management:

Removal of plant debris from the field and destroying it reduces the levels of initial inoculum. Crop rotation with non-cruciferous crops reduces the initial inoculums and also destroys those present in the soil. Use of partial resistant resistance and use of fungicides like

White rust

White rust is caused by an obligate parasite Albugo candid. The typical symptoms of white rust infection in host are white creamy yellow raised pustules appear on the leaves which later coalesce to form patches. Swelling and distortion of the stem and floral parts results into hypertrophy and hyperplasia, commonly known as stag head condition. In humid weather, mixed infection of white rust and downy mildew develop on stag head structure.

Management:

Destroy previous year crop debris. Spray Ridomil MZ 72 @ 0.1% on first appearance of the disease. Repeat after 10-15 days interval. Crop rotation and intercropping with non-cruciferous plant.

Powdery Mildew

Powdery mildew in mustard is caused by obligate parasite Erisiphe cruciferarum. Initial symptoms appear as powdery white spots first on the leaves, and eventually grow to cover entire leaves. Symptoms usually develop on the bottom surface of older leaves first, but all leaves become diseased at an advanced stage of disease development. Infected leaves wither and die, leading to premature defoliation. Powdery mildew reduces yield by reducing the effective photosynthetic area, but powdery mildew is not generally considered a serious disease problem on mustard.

Management

A fungal hyperparasite (Ampelomyces quisqualis) of the powdery mildew fungus available in form of AQ10 biofungicide may be used for management of powdery mildew in mustard as. Prophylactic measure. Alternatively, conventional fungicides like strobilurins or wettable sulphur may be used for management of Powdery mildew.

White rot/ Sclerotinia rot

Initially the symptoms appear as elongated water-soaked lesions on stem near the ground. Later these lesions are covered with white cottony mycelial growth. Plant appears whitish from distance at internodes or base. Occasionally the plant may break at these points of infection. Premature ripening and shredding of stem, wilting and drying may be associated with the disease.

Management:

Rotating with non-host crops like wheat, barley, rice and maize. Timely sowing of crops can escape some levels of infection. Soil application of T. viride / T. harzianum @ 2.5 kg/ha, improves parasitisation of sclerotia of the pathogen present in the soil. Spraying of Carbendazim @ 0.1% twice during the flowering period at 20 days interval or as soon as the symptoms appears may mange the disease in fields.

Black leg disease of crucifer

Symptoms are visible on 2 months old plant in form of dark coloured streaks on stem from the ground level. Gradually these streaks enlarge and girdle the stem. Stem become hollow due to internal rotting. Lower leaves midrib, cracking, browning of veins and withering are observed. In severe cases, the vascular bundles of the stem also turn brown and the plant collapses.

Management:

Since the pathogen can survive in soil in plant debris; it should be removed from the field to reduce the infective propagules from the soil. Rotating the mustard crop with non-cruciferous plants also results in reducing the effective propagules in the soil. Follow complete crop and field sanitation to reduce the initial inoculum. Spray Streptocycline 250 ppm (2.5 g/10 litre water) or Copper oxychloride @ 0.2% at the initiation of disease. If needed repeat the spray after 15-20 days interval.

Diseases of Groundnut:

Early leaf spot/ tikka disease:

This disease is caused by Cercospora arachidicola. Initial symptom of infection starts about a month after sowing that appears as small chlorotic spots on the leaves that later enlarge and turns brown to black in colour with oval to circular shape on upper leaf surface. On lower surface of leaves light brown discolouration is observed. Lesions may also appear on petioles, stems, stipules. In severe cases several lesions coalesce to form larger spots accompanied by premature senescence.

Management

Spray of fungicides like Chlorothalonil 1000 g/ha, Carbendazim 50 WP @ 500gm/ha or Difenaconazole 25 % EC @ 0.1%. If necessary, give the second spray at an interval of 15 days

Late leaf spot:

This disease is caused by Phaeoisariopsis personatum. Infection starts around 55-57 days after sowing in Kharif and 42-46 days after sowing in Rabi.Black & nearly circular spots appear on the lower surface of the leaflets. Lesions are rough in appearance. In extreme cases many lesions coalesce resulting in premature senescence along with shedding of the leaflets.

Management

Intercropping pearl millet or sorghum with groundnut (1: 3) is useful in reducing the intensity of late leafspot. Crop rotation with non-host crops preferably cereals. Deep burying of crop residues in the soil, removal of volunteer groundnut plants are important measures in reducing the primary source of infection. Spraying of Carbendazim 0.1% or Chlorothalonil 0.2% or Hexaconazole 5% EC @ 0.5ml/l can be used for management of the disease

Rust:

This disease is caused by Puccinia arachidis. Yellow orange colored rust pustules appear first on the lower surface in highly susceptible cultivars that later appears on the upper surface of the leaflet also. They may be formed on all aerial plant parts apart from flower and pegs. Severely infected leaves turn necrotic and dries but are attached to the plant.

Management

Spray of fungicides Chlorothalonil 1000g /ha or Wettable sulphur 2500g /ha or Flubendamide 3.5% + Hexaconazole 5% WG @ 500g/ha

Stem rot:

This disease is caused by Sclerotium rolfsii. The first symptom appears as the sudden drying of a branch that is completely or partially in contact with the soil. The leaves turn brown and dries but remain attached to the plant. White growth of fungal mycelium may be observed on the plant surface near the soil line under humid conditions.

Management

Deep ploughing to bury infected plant debris, cultivation of groundnut in flat or lightly raised beds to facilitate proper drainage. Seed treatment with biocontrol agent Trichoderma viride @ 4 g/kg seed and soil application of Trichoderma viride @2.5 kg/ha mixed with 50 kg FYM or in addition to organic amendments such as castor cake or neem cake or mustard cake @ 500 kg/

ha. Seed treatment with Carbendazim 12%+ Mancozeb 63%WP @ 2 g per Kg seed is recommended.

Bud necrosis:

It is caused by Peanut bud necrosis virus (PBNV). Initial symptoms include chlorotic spots that appears on young leaflets that eventually lead to development of necrotic rings and streaks. Terminal bud necrosis occurs when temperature is relatively high. As the plant matures it becomes stunted with shorter internodes along with proliferation of auxiliary shoots. There is severe stunting with deformation under acute infection. The infected plants produce small discolored and shriveled kernels. The virus is mainly transmitted by thrips.

Management

Use of tolerant varieties recommended for the region. Remove and destroy infected plants up to 6 weeks after sowing. Application of insecticides to control vector population. Intercropping of cereals and pearl millet. Spraying of anti-viral product (AVP). AVP are extracted as follows: Sorghum or coconut leaves collected, dried, cut into small bits and powdered to one kg of leaf powder two litres of water is added and heated to 60°C for one hour. It is then filtered through muslin cloth and diluted to 10 litres and sprayed. To cover one ha 500 litre of fluid will be required. Two sprays at 10 and 20 days after sowing will be required.

Diseases of Sunflower

Downy mildew in sunflower:

This disease is caused by Plasmopara halstedii. The initial symptoms of the disease appears on basal parts and may affect root, basal, stem, leaf & seed. The symptoms are damping-off, systemic infection, local lesion, basal rot or stem gall. Infected leaves are abnormally thick, and shows downward curling. Whitish downy growth develops on lower surface of the leaves the flower heads remain sterile and erect. Local foliar lesion appears as small angular greenish yellow spots on leaves whereas systemic infection showing chlorotic leaf veins. Rain during seedling growth favours disease.

Management:

Cultural control involves deep summer ploughing, clean cultivation and field sanitation, Avoid excessive irrigation and removal of infected plants during early infections. Seed treatment with Metalaxyl 35% WS – 2g/kg seed may be recommended. Spraying with Ridomil MZ 72 WP @ 3g/lit at - 20, 40 and 60 days after sowing can reduce the disease severity.

Powdery mildew in sunflower: Erysiphe cichoracearum

Symptoms of powdery mildew is characterised by presence of white powdery growth on the leaves. White to grey mildew appears on the upper surface of older leaves initially. Symptoms are also seen on stem and petiole under acute infection. Conditions that favour the host, also favour the pathogen. Spores germinate optimally at 20-25°C under conditions of high humidity, as quickly as two to four hours after landing on the leaf.

Management: Prophylactic sprays of wettable sulphur @1 g/l can help manage the disease.

Alternaria leaf spot:

This disease is caused by Alternaria helianthi. Initial symptoms of the diseases appear on leaves, petioles, stem, sepals and petals. Symptoms appears as dark brown irregular leaf spots with dark brown border and grey center. Spots first appear on lower leaves and later spreads to middle and upper leaves. At later stages spots may be formed on petioles, stem and ray florets. In later stages the leaf lesions may coalesce resulting in leaves to wither away.

Management:

Deep summer ploughing, clean cultivation and field sanitation and use of resistant variety. Use of resistant variety Spraying with Hexaconazole 5 EC – 1 ml/lit 2-3 sprays at an interval of 15 days starting from first appearance of the disease. Seed treatment with Thiram or Carbendazim at 2 g/kg seed.

Sunflower Rust:

It is caused by Puccinia helianthi. That produces small, reddish-brown pustules covered with rusty powder initially on the lower surface of the lower leaves. Infection later spreads to upper leaves and even to the green parts of the head. Under acute infection, when numerous pustules appear on leaves, they become yellow and dry. Later as the disease progresses the black coloured telia are also seen among uredia on the lower surface. The disease is autoecious rust. The pycnial and aecial stages occur on volunteer crops grown during off-season.

Management:

Use of fungicides like Azoxystrobin or Tebuconazole a

Diseases of Safflower

Alternaria Blight:

This disease is caused by Alternaria carthemi. Other species of Alternaria is also associated with it. The characteristic symptoms of the diseases are presence of dark necrotic lesions of 2-5 mm in diameter formed on hypocotyls and cotyledons initially in the seedling emergence stage. In mature plants, small brown to dark brown concentric spots of 1-2 mm appears on leaves. Under severe infection symptoms also appear on stem and infected plant gets blighted. Brown discolouration can also appear on the stem, dark brown spots with concentric rings up to 1 cm in diameter also appears on the leaves. The lesions enlarge as the disease progresses.

Infection may extend to seeds under severe infection. Dark sunken lesions are produced on the testa. Infected seeds may rot and produce damping off of seedlings after germination.

Management: Clean cultivation, use of resistant varieties of the region, Spraying of Carbendazim + Mancozeb @2g/l

Cercospora Leaf spot:

Safflower plants few weeks after planting or at flowering stage are commonly attacked by this disease. Initial symptoms are presented as circular to irregular brown sunken spots of 3-10 mm diameter are on the leaves. Lesions are surrounded by yellow halos. Symptoms first appear on lower leaves and then spread to upper leaves, Stems and nodes. In severe infections bracts are also affected with reddish brown spots. Affected flower buds turn brown and dies

Management: Clean cultivation, use of resistant varieties of the region, Spraying of Carbendazim + Mancozeb @2g/l

Fusarium wilt of safflower

Fusarium wilt of safflower is caused by the soil-borne fungus Fusarium oxysporum f. sp. carthami. Initial symptoms of Fusarial will appear on lower leaves that exhibits yellowing and wilting, it becomes more prominent as the disease progress upward. Often chlorosis is occurs during severe infection leading to stunting. The margins of the infected leaves turn tan to brown and diseased plants shows progressive yellowing. Severely infected plants exhibit permanent wilting and premature defoliation.

Management: Use of Resistant variety NARI-H-15, PBNS-12, NARI-6, Seed treatment with Trichoderma harzianum @ 10g/kg seed

Diseases of Linseed:

Rust –

It is caused by obligate parasite Melampsora lini . Initial symptoms appear as bright orange colored powdery pustules on leaves, stems and bolls but initially on the underside of the leaves. As the disease progresses, the orange pustules turn black and produce overwintering teliospores. Early infections may lead to completely defoliate of the plants and reduce the seed yield

Management

Destruction of plant debris from the diseased field. Seed treatment with Oxycarboxin. Spray of fungicides like tebuconazole. Growing of partially resistant variety like Sabour tisi-1 and Sabour tisi-2

Wilt –

The causal organism of this disease is Fusarium oxysporum f.sp. lini. The characteristic symptoms of this disease is Yellowing and wilting of leaves, followed by browning and death of the plant. The roots of dead plants appear ash-grey. The tops of wilted plants often turn downward, forming a "shepherd's crook". Warm weather favours the disease

Management:

Crop rotation of at least 3 years. Seed treatment with Thiram or carbendazim@ 2.5g/kg seed. Soil drenching with Carbendaazim @ 0.1 % or COC@ 0.25% can manage this disease.

Powdery mildew –

The causal organism of this disease is obligate fungus Oidium lini. The characteristic symptoms of this disease is presence of white powdery mass of mycelia that starts as small spots and rapidly spreads to cover the entire leaf surface. Heavily infected leaves dries up, wither and die. Early infections may lead to defoliation and reduce the yield and quality of seed.

Management: use of wettable sulphur 2 g/l

Brown stem blight-

The causal organism is Alternaria linicola and affects the plant right from the seedling stage causing Damping-off, root rot, and seedling blight. Initially brown circular lesion is formed on

the leaves. Later as the disease progresses the leaves shows progressive browning and eventually the whole leaf dries up. Under acute infection defoliation may result in complete loss of yield.

Management:

Remove and burn previous year's crop debris. Use of recommended variety of the region, avoid delay in sowing and use strobilurins for the management of this disease

Diseases of Sesame:

Phyllody.

It is a Phytoplasmal disease. The symptoms of this diseases are present in floral parts that are transformed into green leafy structures followed by abundant vein clearing in different flower parts. In severe infection, the entire inflorescences are replaced by short twisted leaves closely arranged on a stem with short internodes, abundant abnormal branches bend down. Finally, plants look like witches broom. If capsules are formed on lower portion of plant they do not yield quality seeds. The disease is transmitted through jassids and the phytoplasma survives in leaf hopper throughout its life

Management:

Removal of infected plants as soon as the disease appears. and use of Insecticidal Spray to manage the jassids.

Dry root rot.

It is caused by Macrophomina phaseolicola the fungus attacks young seedling, their stems become water soaked soft and incapable of supporting the seedling which falls over and dies. On older seedlings elongated brownish black lesions appear at the collar region which increase in length and width girdling the stem and plant dies. Acute infection leads to rotting of the roots. That leads to yellowing, drooping and defoliation in the plants. The pathogen survives in seed and soil.

Management: Crop rotation, Destruction of previous season crop residues. Seed treatment with Trichoderma viride @4 g/ Kg. Soil Application of Trichoderma viride @ 2.5 Kg/ Ha amended with 500g FYM at 30 days after sowing.

Alternaria blight.

It is caused by Alternaria sesame. The pathogen attacks all parts of the plant at all stages and is particularly severe in high humid conditions. It causes seed rot, pre emergence and post emergence seddling blight Small, dark brown water soaked, round to irregular lesions, with concentric rings, 1-8 mm in diameter appear on the leaves and under excessive humidity the spot increases in size and number. The lesions may also appear on the midrib and veins of the leaves. Milder attacks cause only defoliation, in severe cases the plant may die.

Management: remove previous season crop debris. Spray Mancozeb @2g/l

Diseases of Soybean:

Anthracnose/pod blight: It is caused by Colletotrichum truncatum. Its charchteristic symptoms on Infected seeds appears as shrivelled, mouldy and brown appearance of seeds. Symptoms on cotyledons appear as dark brown sunken cankers. In early stage, irregular brown lesions appear on leaves, stems and pods. In advanced stages, the infected tissues are covered with black

fruiting bodies of fungus. Under high humidity, symptoms on leaves are veinal necrosis, leaf rolling, cankers on petioles and premature defoliation.

Management

Use healthy or certified seeds. Rotate soybean with cereals. Completely remove plant residue by clean ploughing the field soon after harvest. Destroy last years infected stubble. Maintain well drained field. Seed treatment with Thiram or or Carbendazim 2 g/kg and Use carbendazim (12 %) + Mancozeb (63%) @ 2 g/l as spray.

Dry root rot –

It is caused by Macrophomina phaseolina. The disease symptom starts initially with yellowing and drooping of the leaves. The leaves later fall off and the plant dies with in week. Dark brown lesions are seen on the stem at ground level and bark shows shredding symptom. The affected plants can be easily pulled out leaving dried, rotten root portions in the ground. The rotten tissues of stem and root contain a large number of black minute sclerotia.

Management: practice clean cultivation. Treat the seeds with Carbendazim at 2 g/kg or pellet the seeds with Trichoderma viride at 4 g/kg or Pseudonomas fluorescens @ 10g/kg of seed. Apply farm yard manure at 10 t/ha or neem cake at 150 kg/ha.

Wilt –

It is caused by Fusarium oxysporum f. sp. Tracheiphilum. Symptoms do not appear until the plants are about six weeks old. Initially few plants are noticed with pale green flaccid leaves which soon turn yellow. Growth is stunted, chlorosis, drooping, premature shedding or withering of leaves with veinal necrosis often occurs and finally plant dies. Brownish, purple discoloration of the cortical area is seen, often extends throughout the plant.

Management:

Treat the seeds with Carbendazim @ 2 g/kg or treat the seeds with Trichoderma viride at 4 g/kg. Spot drenching with Carbendazim at 1 g/litre.

Soybean Mosaic Disease

This is a viral disease caused by Soybean mosaic virus (SMV). The characteristic symptoms is expressed as stunting with distorted (puckered, crinkled, ruffled, narrow) leaves. Pods become fewer and bears smaller seeds. Infected seeds get mottled and deformed. Infected seeds fail to germinate or they produce diseased seedlings. It is vectored by aphids.

Management:

Deep summer ploughing. Use resistant or tolerant varieties. Use healthy/certified seeds. Keep the field free from weeds. Rogue out infected plants and burn them. Pre-sowing soil application of Phorate @ 10 kg/ha. Two foliar sprays of Thiamethoxam 25 WG @ 100 g/ha or Methyl demeton 800 ml/ha at 30 and 45 days after sowing.

Diseases of Niger

Alternaria Blight

It is caused by Alternaria sp. The characteristic symptoms include appearance of brown to black spots with concentric rings on the foliar parts

Management:

Seed treatment with carbendazim 50 WP @ 2g/l and foliar spray with carbendazim (12 %) + Mancozeb (63%) @ 2 g/l.

Cercospora leaf spot

This disease is caused by Cercospora guizoticola, the characteristic symptoms of the disease appears as small straw to brown coloured spots with gray centre on the leaves, As the disease progresses these spots grows and may coalesce together to form larger lesions. Under severe conditions the disease leads to defoliation.

Management: Seed treatment with carbendazim 50 WP @ 2g/l and foliar spray with carbendazim (12 %) + Mancozeb (63%) @ 2 g/l as spray.

****

Seed Production of Castor

S. K. Chakrabarty
Principal Scientist
Division of Seed Science and Technology,
ICAR-Indian Agricultural Research Institute, New Delhi

Castor is an important non-edible oilseed crop possessing unique fatty acid used in various industries, mainly as lubricants and innumerable derivatives for pharmaceutical purposes. India is a major castor producing country in the world with a phenomenal increase in area and productivity. The development of hybrid and its wide spread cultivation has made it possible along with a sound production and protection technologies developed. Gujarat, Andhra Pradesh and Rajasthan are the major castor growing states in India. I t is grown two different ecosystems i.e., rainfed subsistence farming (A.P., Karnataka, Tamil Nadu etc.) and irrigated with high input management (Gujarat and Rajasthan). High yielding short duration varieties and hybrid have been developed for different agro-ecological conditions of the country. The improved varieties and hybrids of castor recommended for cultivation are presented below.

Improved varieties and hybrids of castor recommended for different states

State		Recommended varieties/hybrids
	Varieties	Jyothi,Jwala, Kranti, Kiran, Haritha,48-1
Andhra Pradesh	Hybrids	GCH-4,DCH-32,DCH-177,PCH-1,DCH-519
	Varieties	VI-9,SKI-73(GC2),48-1,GC-3
Gujarat	Hybrids	GAUCH-1,GCH-2,GCH-4,GCH-5,DCH-32,GCH- 6, GCH-7, DCH-519
	Varieties	Aruna,RC-8,Jyothi, 48-1
Karnataka	Hybrids	GHC-4,DCH-32,DCH-177,DCH-519
	Varieties	Jyothi,AKC-1, 48-1
Maharashtra	Hybrids	GCH-4,DCH-177,DCH-32,DCH-519
	Varieties	Jyothi, 48-1
Rajasthan	Hybrids	GCH-4, GCH-5, DCH-32, RHC-1, DCH-177, DCH-519
	Varieties	S-2,TMV-5TMV-6,Jyothi,Co-1,48-1
TamilNadu	Hybrids	GCH-4,DCH-32,TMVCH-1,DCH-177,DCH-591

Uttar Pradesh	Varieties	T3,T4, 48-1, Kalpi
	Varieties	CH-1,Jyothi,48-1
Haryana and Punjab	Hybrids	GAUCH-1,GCH-2,GCH-4,GCH-5,DCH-32, DCH-177,DCH-519
	Varieties	Jyothi, 48-1
Others	Hybrids	GCH-4,GCH-5,GCH-6,DCH-177,DCH-519

Seed Production

The production and supply of high-quality seeds of hybrids and varieties are important to realize its maximum potential. A systematic production planning and management of nucleus, breeder, foundation seed of parental lines and varieties are the critical in maintaining the required quality of certified seeds.

Isolation: Castor seed production is entirely a cross-pollinating process with wind as a primary source of pollen dispersal and transfer. Therefore, it is absolutely essential to avoid undesirable pollen in seed production. The extent of cross-pollination mainly depends on the direction and velocity of wind. The proportion of female and male flowers on the raceme also determines the extent of cross-pollination. In monoecious varieties which produce abundant pollen, cross pollination is very much limited even when contamination source is nearer because of the failure of foreign pollen to compete with native pollen. Genotypes which produce mostly female or 100% female racemes easily get pollinated by foreign pollen from sources located as far as 1000 m distance. Besides wind, insects like honey bees, butterflies, moths etc. also play a role in pollen dispersal and result in variable levels of cross pollination leading to contamination of varieties and parental lines. Based on systematic research in this direction the following isolation distances for different seed categories are recommended.

Recommended isolation distance for different seed categories

S.No.	Seed Production stage	Isolation distance(M)
Varieties and male parents of hybrids		
1.	Nucleus and Breeder	1500
2.	Foundation	1000
3.	Certified	600
Female parent of commercial hybrids		
1.	Nucleus and Breeder	2000
2.	Foundation	1500

3.	Certified	1000

Hence, maintaining proper isolation distance is very important in nucleus and breeder seed production in order to produce genetically pure seed. It is ideal to take up seed production of castor in non-traditional areas and seasons to avoid contamination.

Season and Planting Time: Time of planting and specific season has profound influence on sex expression. While summer and kharif seasons provide ideal male promoting environment for undertaking seed production of varieties, male and female parents of hybrids, rabi(winter) is the most ideal season for taking up hybrid/certified seed production as it is most conducive for production of female flowers. In case of varieties and male parents, such an exposure to male promoting environment i.e. kharif-summer encourages good expression of less productive plants bearing mostly male spikes which could be easily eliminated through timely rouging. Similarly, the female parents when raised in male promoting environments produce environmentally sensitive staminate flowers which are very essential for self-multiplication of the female parents. Based on the different genotypic response to environment, the following seeding dates are suggested for various categories of seed.

	Areas/regions	
Stage of seed production	Western and Northern	Southern
Varieties and male parents		
Nucleus and breeder	February1stFN	January2ndFN
Foundation and certified	July1stFN	June2ndFN
Female parent and hybrid		
Nucleus and breeder	February1stFN	January2ndFN
Foundation	July1stFN	
Certified (Hybrid)	August2ndFN	September2ndFN

Breeder/Foundation seed production of male parents/varieties
the seed used to produce breeder seed of varieties and parental lines of a hybrid is the selfed and bulked seeds of selected progenies i.e., known as nucleus seed. The suitable time of sowing is summer or kharif. While adopting all recommended agronomic practices in the seed production plots, the breeder has to visit regularly the crop for identification and removal of plants which do not conform to the diagnostic morphological characteristics of the line/ variety. The following points are to be noted and carefully followed:
Exert selection pressure for environmentally sensitive sex expression (proportion of female and male flowers in the raceme) with the male flowers only at the bottom 2 to 3 whorls.

While performing second round of rouging, ensure that at least half of the population has similar average node number (at primary spike flowering) and the remaining have one less or more than the average.

Before first picking, identify four representative samples of at least100 random plants each and label them. Record all the morphological characters, yield contributing characters and oil content. Estimate the population means, standard deviation and phenotypic co-efficient of variation for yield and yield components.

Harvest, thresh and process the seed in the pickings at 25 to 30 days interval starting from100 to 120 days. Keep the picking-wise produce separately and store under well-ventilated ambient conditions.

Draw 1 kg of representative samples from each lot for conducting purity tests. Based on the results of purity tests, pack seeds in bags and label with all details required as per the standard.

Roguing: Roguing of off-types involves removal of genetically impure plants differing in their morphological as well as sex expression related traits in castor. A thorough practical knowledge on the important morphological characters of parental lines of hybrids is essential. Roguing has to be undertaken in different stages of crop growth to ensure maximum genetic purity by avoiding contaminants.

Stage I: (Before flowering initiation i.e.30 days after sowing (DAS))
During preliminary rouging operations look for deviants, if any, for various diagnostic morphological characteristics like stem colour, internode type, shape of leaves and remove them.
Immediately after primary spike initiation, examine the seed production plots for number of nodes up to primary raceme, type of internode, expression of sex, proportion of male to female flowers in the primary spike, branching and other spike characteristics in relation to the parameters specified for the variety and parental line and pull-out all plants not conforming to the stipulated standards.

Any laxity in rouging operations or delay in the timing of rouging would have adverse effect on the ultimate quality of the seed and hence follow the schedule strictly.

Stage II (During flowering stage i.e.45-65 DAS)

Remove the morphological deviants keeping the number of nodes to primary within the stipulated range.

Since the flower initiation extends over a period of 10 to 15 days, carry out second round of roguing for 3 to 5 rounds at intervals of 2 to 3 days to avoid any possible left over.

To get good quality seed with high productivity, the spikes with highly pistillate nature of spikes with male flowers restricted to the basal two whorls should be selected.

All the plants with male flowers beyond the basal two whorls should be removed.

Stage III (During first picking stage i.e. 90-120 DAS)

Off-types based on capsule characteristics should be removed.

Breeder/Foundation Seed Production of Female Parents

The seed to be used to produce the breeder seed of female parents is nucleus seed as described earlier. The ideal season to undertake the production in case of pistillate lines is summer (planting during January second fortnight). The following two methods have been adopted for producing breeder seed of female parents based on the pistillate nature of the line. Conventional method

As per the prevailing standards, 20 to 25% monoecious plants are allowed in seed production plot to ensure adequate pollen supply to pistillate plants.

Prior to flower opening in primary raceme (at least 2-3 days), remove all deviants from diagnostic characters especially node number upto primary spike, nature of internodes, bloom, leaf shape etc.

At flower opening in primary raceme, identify pistillate plants conforming to diagnostic morphological characteristics of the female line and tag them at the base of primary raceme with a red colour thread.

Examine all monoecists and remove those which have exclusively male flowers beyond three whorls at the base of the spike.

Plants with interspersed staminate flowers, if any, should be retained subject to the condition that the retained plants fulfill all other prescribed standards.

Count the ultimate number of female and male plants in each row and remove the monoecious plants over and above the stipulated percentage.

Examine the labeled or tagged female plants regularly for possible reversion to monoecism in secondary, tertiary and quaternary order racemes. Remove the tags as and when the female plant reverts to monoecism upto 4th sequential order of the branches.

On maturity, harvest the female plants bearing the tags and keep a picking-wise seed in separate lots after proper drying, packing and labeling.

Modified method
Unlike in the conventional method, rogue-out all monoecious at least 2 to 3 days earlier to flowering in the primary raceme.
Verify individual female plants for various morphological characters particularly the number of nodes upto primary raceme.

Most of the female flowers on primary raceme fail to set fruits due to non-availability of pollen.

A host of interspersed late male flowers however, appear on primary as well as subsequent order racemes in about 35 to 50% female populations which provides sufficient pollen for the later developed female flowers on the same raceme as well as later sequential order racemes.

Observe all plants regularly for any reversion to monoecism upto 4th order raceme and rogue-out the off-types. However, the pistillate plants reverting to monoecism in 5th sequential order onwards can be allowed in the population as supplement pollen source.

Collect the seed from all female plats and keep the picking-wise seed lots separately after proper drying and labeling.

Rouging in Female Line

Morphological characters to be observed to identify the rouges are stem colour, bloom, plant type, leaf shape, spike type, capsule type etc. the main principle in female line is to have completely only female flowers in all the orders. The different stages of rouging involve:

Before flowering (35-45 DAS): Initially, in the first 30 days prior to primaryspike initiation the off types based on morphological characters are to be removed.

At the time of primary spike flowering (50-65 DAS): Monoecious or male plants should be removed at the bud stage itself. The plants with male flowers in the first basal whorl to 100% male flowers should be considered as male and removed.

At the time of secondary spike flowering

At the time of third spike flowering

Other Precautions
Number of ISF may vary from 1 – 2 to > 10 - 15 male flowers per spike. These plants should be retained as pollen source.
However, the primary spikes with highly ISF nature i.e. 5-6 male flowers per each and every whorl have the tendency to revert to monoecious in the later orders which are to be closely observed.

Majority of the primary spikes may not set seed due to non-availability of pollen. However, the later orders or on the matured primary spikes itself interspersed male flowers appear and fertilize the female flowers.

Observe the female plants carefully for any revertants in any stage (secondary to pentenary). Remove such revertants in the bud stage itself.

However, in case the number of revertants appears high in number (>30%) in 3rd or 4th order, only such spikes can be removed and harvest the seed from the earlier orders only.

In case the proportion of late revertant female plants with interspersed male and occasional bisexual flowers increase in the population those can be allowed to continue in the population.

However, seed should be collected from all female plants only and picking-wise seed lots should be kept separately.

Seed from late order revertants should not be mixed with the female plants.

Hybrid Seed Production

To obtain high productivity levels in the commercial scale, the supply of quality hybrid seed assumes importance. It is done in a female promoting environment where the pistillate line does not produce staminate flowers. The practices that followed for hybrid seed production at different situations are detailed below:

Certified hybrid seed requires 85% genetic purity. To attain this high percentage of genetic purity, good quality female and male line seed should be used. Thus, seed should be

collected from authentic sources or the institutes themselves. Secondly, contaminations should be avoided by following stipulated isolation distance (1000 m) and timely rouging should be done. Sowing should be done by August end to October-depending on the onset of winter season in different locations so that primary and secondary spikes coincide with cool season. If delayed beyond October, flowering period experiences higher temperatures resulting in ISF in female lines.

Method of Planting

3 Female: 1 Male with males in two rows all around the seed production plot are suggested for laying out hybrid seed production plot.

Rouging

The main principle of rouging in certified hybrid seed production is to keep the female lines as completely pistillate and get it fertilized by the desirable male or pollen line. The possible rouges in female line are monoecious, pistillate with ISF, revertant, hermaphrodite or bisexual.

First Stage: within 30 days prior to primary spike initiation, off-types based on morphological characters both in female and male lines should be removed.

Second Stage: At the time of primary spike initiation, monoecious and pistillate plants with ISF or hermaphrodite in the female parent should be removed. Within male plants all morphological deviants should be removed. The male plants with male flowers in more than 2-3 whorls in the primary spike should be removed.

Third Stage: At the time of secondary spike initiation, in addition to the above, revertants in the second order should also be removed. Deviants based on spiny or non-spiny nature of capsules should be removed. Plants with ISF may increase with increasing temperatures. The removal of plants or spikes depends on the population size and the extent of ISF plants.

Fourth Stage: At the time of tertiary spike initiation, early revertants, plants with ISF, hermaphrodite should be removed. This depends on the population size and extent of revertants. If revertants are high and the population size itself is low, only reverted spikes should be cut off and removed after harvesting the primary spike.

Seed-set

The poor seed-set and low-test weight is mainly due to water or nutrient stress during critical stages. In case of moisture stress, it has to be avoided by providing irrigation at all the critical stages for better seed-filling. The adoption of all recommended agro-production and protection technologies will result in better seed-set and high-test weight with low processing losses in castor seed production.

Seed Yield

Generally, seed yield of variety/male and pistillate lines vary with genotypes. It is possible to realize the seed yield of 10-12 and 8-10q/ha in these lines, respectively, depending upon the soil and other growing conditions. In the hybrid seed production plots, seed harvested from female is the hybrid seed while the male parent can be sold in the commercial market. Picking-wise seed should be harvested and stored separately. The seed under joint custody of seed certification agency and farmers will be tested for physical and genetic purity. Similarly, an average yield of 12-15 q/ha of hybrid seed is expected in the hybrid seed production plot with better management. Adoption of recommended packages with better management will double or triple the present-day low average yields in the hybrid seed production plots.

Monitoring

Breeder seed production plots should be subjected to visits by a duly constituted monitoring team, the first one coinciding with full flowering in primary raceme and the second one 10 to 15 days after first picking. During first visit, the team inspects the plot for confirmation of all well-defined morphological characters including the proportion of female and male plants in conventional method and 100 percent female plants in the refined method. The plots are checked during second round of rouging for elimination of early revertants by removing the tag in conventional method and removing the entire plant before the reverted racemes shed pollen in case of revised/improved method.

In the foundation and certified seed plots, monitoring is be done by seed certification agency in all these stages regarding–isolation distance, morphological characters, extent of monoecious population, revertants etc., the seed lots under the joint custody of seed certification agency are tested for their genetic and physical purity.

Agronomic Crop Management

The cross–pollinated nature of the crop with differential sex expression due to its high sensitivity to environmental factors (climate, nutrition etc.) further make seed production in castor complicated. In castor, pistillateness, a polygenically controlled character is highly variable but can be managed to a greater extent by various agronomic manipulations like sowing time, nutrition and irrigation. Hence, knowledge on crop adaptation and following

location-specific agronomic recommendation is a pre-requisite for obtaining higher seed yield.

Climate and Crop Adaptation

Castor requires temperatures ranging from 200 to 260 C with low humidity and long, clear, summer days throughout the growing period to produce maximum yields. Cloudy or humid days irrespective of temperature reduce yields and castor is highly susceptible to frost. Humid and cloudy weather during flowering period promote fungal diseases (Botrytis) of the spike resulting its total loss. A hard frost normally kills castor plant at any stage of growth, young plants being most susceptible, and a frost-free growing period of 140-190 days in necessary for successful castor seed production. The air temperature also influences the nature of flowering on the spikes. The warmer temperatures at the time of flower initiation promote more male flowers and cooler temperature produce more female flowers in a given

variety/hybrid. Similar response of flowering is seen for nutrition and soil moisture, where stress for these result to high degree of maleness in the spikes reducing seed yield drastically.

Castor is basically a long-day plant, but is adaptable with some loss of yield to a fairly wide day-length range. The day length has the most significant effect on the sex expression of castor. A short day (9 hrs) resulted in a sharp increase in the number of male flowers and their ratio to female flowers became unfavourable at 3.3:1 from 2.3:1 at 15 hrs period and 16:1 a 24 hrs periods under controlled conditions.

Castor is a drought tolerant plant well-adapted to low moisture conditions by way of deep root system. Higher yields of castor can be realized with a moderate rainfall of 600-700 mm and fairly good yields can be obtained with a well-distributed rainfall of 375-500 mm.

Selection of Site

Avoid seed production of castor year after year in the same field that may aggravate the problem of soil-borne pathogens and other fungi and also lead to nutritional imbalances. Added to adverse effect of continuous cropping on yields, there is also the danger of volunteer plants from mature capsules/seed fallen to ground during harvesting operations of previous crop if the field is not rotated.

Land Preparation and Sowing

Castor is a deep-rooted plant with its tap root extending beyond 2-3 m under unrestricted conditions. In deep soils, it survives mostly on the residual soil moisture extracted by deeper layers and maintains its perennial nature. Due to this, practices of deep tillage by breaking hard pans and good soil conservation measures are important as the castor with a loose and open canopy on the above ground and little soil binding ability though roots below ground offer little resistance to soil erosion.

In fields selected for castor seed production, give deep summer ploughing in order to break the hard-sub-soil that facilitates easy root penetration and achieves effective weed control. For good growth, castor requires fine seed-bed with loose sub-soil upto 45 cm depth. For

ensuing proper tilth and good seed-bed preparation, summer tillage or off-season tillage with pre-monsoon rains is recommended. Perform 2-3 harrowings with blade harrows for the purpose. As castor is widely spaced and has slow initial growth, weed competition is severe and thus it is much more important that the land preparation should be directed to support deep root system of crop and reducing weediness.

Sowing depth: Optimum seed depth plays an important role in timely and uniform germination and emergence. Under light soils, deeper placement at 8-10 cm is safer and under sufficient moisture conditions, placing seed at 6-8 cm ensures better germination and mergence. In heavier soils, seeding depth should not be more than 5-6 cm.

Seed rate and spacing: Castor is a branching and indeterminate plant with perennial growth habit. Castor has sensitivity to spacing and plant population. It has a compensatory mechanism for loss of plant stand by putting forth profuse branches. A seed rate of 5 kg/haforhybridsand8-10kg/ha for varieties is recommended. Maintaining as pacing of 90x60

cm under rainfed conditions and 120 x 60 cm under irrigated conditions is recommended for realizing higher seed yield.

Pre-sowing Seed Treatment: Seed should be treated with thiram or captan @ 3 g/kg seed or carbendazim@2g/kg to protect from seed-borne diseases like Alternaria leaf blight, seedling blight and wilt.

Planting method: Castor cultivation along the ridges and furrows is the ideal method of planting. It is desirable to dibble the seeds at regular spacings and depths along the side of ridge.

Manures and Fertilizers

Castor is highly responsive to use of fertilizers. Nutritional requirement of seed production plots depends on soil, specific variety and parental materials chosen for seed production. The response of castor to fertilizer application differs from rainfed to irrigated situations, genotypes and soil moisture availability, soil type and moisture holding capacity. There are genotypic differences for the degree of response as per the yield potential for fertilizer application. In general, hybrids respond better compared to varieties. The response to fertilization is modified by the associated moisture conditions and insect-pests and diseases. It is always desirable to apply the fertilizer based on the soil test values for increasing the nutrient use efficiency.

Application of 8-10t FYM/ha helps in moisture retention and provides nutrition to the crop. Castor crop responds profitably to N and P fertilizers and response to K fertilizers is generally not noticed and soil reserve of K is sufficient for castor. A fertilizer dose of 60-40 kg N, P2O5/ha is generally recommended. For irrigated castor 120-25-0/200-5-0 N, P2O5 K2O/ha is recommended. It is recommended to apply 20 kg S/ha to castor under irrigated conditions.

In case of basal application, drill the fertilizer just by the side of seed row and below the seed. Wherever top dressing is given, additional dose of nitrogen may be applied in the form of split application at least 6 cm away from the plant.

Weeding and Interculture

Castor is highly susceptible to weed competition in the initial stages due to its slow growth and wider spacing. The large soil volume untapped by the castor crop is exploited by weeds and thus weed control in castor is of paramount importance. The critical period for weed-free competition for castor is 45-50 days. Inter-cultivation with blade harrow 2-3 times commencing from 25 days after sowing followed by 2 or 3 hand weedings at interval of 15- 20 days is ideal. Planting at wider spacing (120 x 60 cm) may also permit use of tractor drawn implements for inter-culture. Pre-sowing application of herbicides such as Fluchloralin @1 kga.i./ha or pre-emergenceapplicationofPendimethalinorAlachlor@1.25 kg a.i./ha is equally effective under irrigated conditions and in areas of labour shortage.

Irrigation: Castor is a drought tolerant crop but responds favourably to irrigation. The magnitude of response to irrigation is higher with hybrids than varieties. The number and interval of irrigations depend on soil type, their water holding capacity and temperature. As compared to heavy soils, light-textured soils require more frequent irrigations. For Kharif crop which benefits from monsoon, 4-6 irrigations may be more than sufficient. During rabi, the number of irrigations may go upto 6-8 while in summer as many as 15 irrigations may be required at intervals of 7-10 days depending on soil type and prevailing temperature. Proper

timing of irrigation is very important to avoid moisture stress at sensitive crop growth stages viz. primordial initiation on various sequential order branches and primary and secondary spike development. Hence, following timely schedule of irrigations is important as moisture stress during these critical stages may lead to production of more male flowers in varieties.

Harvesting

Harvesting is one of the important operations in seed production as there is chance of mechanical mixtures if not performed carefully. Castor being long duration crop with a phenology of different order of branches each terminating with a spike, each maturing at different times needs to be harvested at right time with multiple harvests. On an average, castor produces 4 to 5 sequential order spikes which can conveniently be harvested manually in 3-4 pickings starting from 90 to 120 days and at an interval 25-30 days. Physiological maturity in castor is attained when some of the capsules in as pike turn brown in colour. With the currently used female parent, the time of harvesting plays a very important role. While premature harvesting results in poor germinability of seed, on the other hand, shattering becomes a problem if the harvesting is delayed until complete drying of capsules. The primary spike in female rows is ready for harvest within 100 to 105 days after seeding. The change of capsule colour from green to yellowish brown and drying of few capsules in the spike is an indication of maturity of the whole spike. Depending on the maturity, harvest different sequential order spikes. Adequate facilities

and better care during harvesting considerably enhance physical quality and longevity of the seed.
Conduct a final comprehensive inspection of the seed crop to clear for harvesting. Ensure that crop plants and rows NOT REQUIRED for harvesting are removed (e.g., Male lines, off-types, other crop plants, diseased and late maturing plants etc.) before start of harvesting. Ensure that seed is physiologically mature before harvest commences.

New bags only may be used for seed harvest into bags. Bags must be clearly labeled externally and tagged internally. Each bag must be clearly labeled and securely covered immediately on completion of filling.

The seed lots usually are at high moisture content at the time of harvesting. Therefore, ensure that harvested capsule is carefully and rapidly transported to the drying facilities.

In order to preserve viability and vigour of seed, it is necessary to dry seeds to safe moisture content levels.

Certification Standards
Field Standards: Field standards have been established for all those factors which affect the purity (genetic and physical) and seed health of standing crop. The various field standards can be grouped into four categories.
Land Requirements: A seed crop of castor shall not be eligible for certification if planted on land where the same kind of crop was grown in the previous year, unless the crop grown in the previous year was of the same variety and of an equivalent or higher class of seed and was certified.

Minimum Isolation Requirement:

Seed production stage	Isolation distance recommended (m)	Statutory isolation limits(m)
Varieties and male parents of commercial Hybrids		
Nucleus and Breeder Seed	1500	-
Foundation seed	1000	300
Certified seed	600	150
Female parent of commercial Hybrids		
Nucleus and Breeder seed	2000	-
Foundation seed	1500	300
Certified seed of common hybrids	100	150

Field Inspection: Considering the multiplicity of characters involved and the extended growth duration of the crop, castor seed production plots require relatively more number of inspection and roguing than other crops. For ensuring high standards of genetic purity of various varieties, hybrids and their parental material, a minimum of 3-4 field inspections are necessary. Important parameters/diagnostic characteristics, which form the basis for field inspection at different stages of crop growth, are described below:

Field inspection no.	Stage of crop at field inspection	Category of seed production plots	Verification parameters
I	Week to ten days prior to flower initiation in primary spike	Varieties, parents and hybrids	Isolation, volunteer plants, planting method including row proportion of female and male parents in hybrid seed production plots and varieties in respect of stem colour, internode type, leaf shape and bloom
II	Full flowering in primary spike	Varieties, parents and hybrid	Confirm isolation, variants for nodes upto primary spike, branching type, sex expression as per the guidelines given in section 6, incidence of insect pests and diseases
III	A week before first picking	Varieties, parents and hybrids	Variants for spike and capsule characters and secondary order reverts in female parent (both foundation and certified) and confirm all the above specifications of the genotypes.
IV	Flowering in Tertiary order spikes	Foundation seed production plots of female parent and certified hybrid seed Production plot	Reversion to monoecism in tertiary and higher order racemes

As per the existing standards, the maximum permissible limits of off-types in different categories of seed production plots during various field inspections are as follows:

Description of variant/off-type	Maximum permitted (%)

	Foundation	Certified
First inspection		
Stem colour, leaf shape and bloom	0.50	1.00
Second inspection		
Nodes upto primary spike, One node less or more than the Defined range besides them and specified no.*	0.50	1.00
Internode type , branching, disease and insect pest incidence	1.00	2.00
Male and mostly male variants in varieties and male parents	1.00	2.00
Monoecists bearing male flowers not beyond lower three whorls Conventional method Renovated method Interspersed late male flowers in female parent	 25.00* 0.50+ 1.00**	 1.00 1.00 2.00
Third inspection		
Variants for spike and capsule characters including shattering	0.25	1.00
Disease and insect pest incidence	1.00	2.00
Secondary order reverts in female parent	0.25	1.00
Fourth inspection		
Tertiary order reverts in female parent	0.50	1.00
Disease and insect pest incidence	1.00	2.00

*Monoecists to be retained for pollen source in conventional method of foundation seed production.

**In modified method, pollen source from monoecists is eliminated. About 25 to 55% female plants produce interspersed late male flowers in summer and kharif seasons which serve as pollen source.

+Since it is a newly developed method not yet included in the currently followed certification standards. The method is advocated in view of its distinct merit over the conventional meth.

*****

Quality Seed Production Technology in Linseed

Prof (Dr.) Vijay Kumar Yadav
Director, Seed and Farm
Chandra Shekhar Azad University of Ag. & Tech . Kanpur U.P.-208002
Email.- vkyadu@gmail.com

INTRODUCTION

Linseed /Flax (Linum usitatissimum L.) is one of the oldest crop plants cultivated for the purpose of oil and fibre. In India, it is mainly cultivated as an annual rabi oilseeds crop under input starved and moisture stress situation. Depending upon use, linseed is classified into three types. Varieties grown only for seed/oil are known as seed type linseed, whereas, varieties yielding only fibre are known as flax. Varieties grown for getting both seed and fibre are called dual purpose linseed. The plant architect of all three types of linseed is different from each other. The seed type linseed is shorter with average height of 30 to 50 cm, multibranched from the base with more number of capsules. The flax plant is taller with average height of 100 to 120 cm with very few branches at the top of the plant. But with advent in research under AICRP on Linseed, such varieties have been developed which can yield good quality fibre as well as seed. Such varieties have average height of 75 to 100 cm and technical height (height between ground to the point where first branch starts) of more than 50 cm with more branches on the upper part of plant. In our country, linseed occupies 3.84 lakh ha area with a production of 1.54 lakh tonne and contributes about 10.81% and 5.31%, respectively to the global area and production. Recent advances in medical research have found linseed as best herbal source of Omega-3 and Omega-6 fatty acids with immense nutritional/medicinal effect on human body system. Essential Omega-3 fatty acid (ALA) plays an important role in lowering cholesterol, reducing inflammatory disorder like rheumatoid arthritis and providing immunity and cardiovascular benefits. Linseed is one of the richest sources of lignin (800 times more than any other plant seed except sesame seeds 47 times more) which provides protection against certain form of cancer due to estrogenic and anti-estrogenic activity in the body. The use of different grades/form of fibre and seed (raw or oil) in different products.

Quality Seed Production Technology

The improved quality seed production techniques of linseed will certainly be helpful in changing the production status of linseed, which will ultimately improve the economic status of the farmers of the region.

Field Standard

Isolation Seed fields shall be isolated from the contaminants distance (meters). Foundation & Certified Field isolation distance 50 M & 25 M. Fields of the same variety not conforming to varietal purity requirements for certification.

Seed Standard:-

Factor	Foundation	Certified
Pure seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	10/kg	20/kg

Other distinguishable varieties (maximum)	10/kg	20/kg
Weed seeds (maximum)	5/kg	10/kg
Germination (minimum)	80%	80%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers (maximum)	7.0%	7.0%

Land preparation

The land should be ploughed 2 to 3 times followed by 2 to 3 harrowing for fine tilth. To conserve moisture, it is advisable to create soil mulch with the help of hoe after each good shower. The well drained, sandy loam or silty clay loam soils having pH of 5.5 to 7.0 are suitable for its cultivation.

Climate

Dual purpose linseed for better fibre yield requires a cool humid climate with mild temperature ranging from 10^{o} C to 27^{o} C, rainfall ranging from 155 to 200 mm and high midday humidity (60-65%) during growing season. Drought and high temperature of about 320C during flowering reduce yield. The lower temperature along with relative humidity of about 76% protest the stalk height.

Varieties

Selection of right variety and getting quality seed are essential to obtain high yield. The best suited dual-purpose varieties for this region are Jeewan, Nagarkot, Him Alsi-2 and for seed purpose most popular varieties are as Meera, Ruchi, Indu Shekhar, Rajan and Uma

Linseed varieties with their salient features released by CSAUAT, Kanpur

Sl. No.	Variety	Days to maturity	Av. Yield (kg/ha)	Area of cultivation	Salient features
1.	T-397	122	1100(I)	Bundelkhand of UP, Bihar, Assam, MP, Rajasthan	Brown, small seeded, spreading type, tolerant to rust, wilt and drought, oil content 44%
2.	Neelam	143	1500(I)	Central and Western UP	Medium tall, erect, brown bold seeded, tolerant to rust and wilt, oil content 43%
3.	Garima	127	1490(I)	UP, Bihar, WB, Assam	Brown medium seeded, resistant to rust, tolerant to PM, oil content 42%
4.	Sweta	133	880(R)	UP, Bihar, WB, Assam	Uneven light brown medium seeded, resistant to blight, oil content 44%
5.	Shubhra	133	1390(I) 870(R)	UP, Bihar, WB, Assam	Brown medium bold seeded, resistant to rust, tolerant to Alternaria blight, oil content 45%
6.	Laxmi-27	115	1260(I) 1020(R)	UP(Bundelkhand)	Dark brown bold seeded, resistant to rust, oil content

					45%
7.	Padimini	123	943(R)	MP, Maharashtra, Rajasthan, Orissa and Bundelkhand ,UP	Blue flower, brown seeded, resistant to rust, wilt, and PM, oil content 43%
8.	Sheela	155	1379(R)	HP, Punjab, Haryana and J&K	Erect deep blue flower, shining brown seeded, resistant to rust, wilt and Alternaria blight and bud fly, oil content 41%
9.	Shekhar	137	1555(I) 920(R)	UP, Bihar, WB, Assam	Violet blue flower, shining brown seeded, resistant to rust, wilt, PM and moderately resistant to Alternaria blight and bud fly, oil content 43%
10.	Sharda	103	762(R)	Chhattisgarh, Orissa, Maharashtra, Karnataka	Dwarf, early duration, white flower, brown seeded, moderately resistant to wilt, PM and bud fly, oil content 41%

Fertilizer application

Linseed responds well to fertilizers. Fertilizer recommendation dose vary between agro-eco-regions. Fertilizers should be applied at the time of sowing. Under rainfed conditions, the fertilizer dose of 30 kg of N and 15 kg of P per ha is given. The deep placement of fertilizer at sowing in the case of the rainfed crop gives better results. Nitrogen is applied in two splits, half the dose as basal and the other half at 40 to 50 days after sowing. The relay crop is fertilized at the rate of 10 kg of N per ha applied at the time of sowing. An application of 5t FYM/ha can save 25% of inorganic fertilizer. NPK fertilizers are applied 5 to 10 cm away and below the seed in moist soil layers, especially under dryland cultivation.

Seed treatment

Treatment with Bavistin/Thiram @ 2.5 g/kg of seed before sowing for protection against seed borne and soil-borne diseases.

Sowing

First fortnight of October is ideal for sowing, before the ambient temperature becomes too low and to affect germination of seeds. Delay in sowing affect the seed and fibre yield adversely. Seeds @ 40 kg/ha are sown in rows with row-to-row spacing of about 23 cm at 2-3 cm depth.

Irrigation

A minimum of two irrigations are required i.e. the first at about 35 days after sowing and second at about 65 days after sowing for raising the good crop of dual-purpose linseed.

However, third irrigation after completion of flowering can be given, if required and water is available.

Weed control

Because of slow growth of linseed during initial stages of crop and less leaf canopy, it competes poorly with mixed weed flora. It is necessary to keep the crop free from weeds for first 35 to 60 days after sowing. Manually two-hand weeding's after 4 and 7 weeks of sowing are sufficient to keep the weed population below threshold level. Chemically weeds can be controlled effectively with given herbicides the spray should be done with knapsack sprayer fitted with flat fan nozzle. The volume of water to be used for spraying must be 750 to 800 liters/ha.

Plant-protection

Usually the incidence of insects and pest on this crop is almost negligible. Sometimes minor incidence has been reported on moderately resistant or susceptible variety for disease in this region.

Rust Symptoms

Rust is readily recognized by the presence of bright orange and powdery pustules. Rust pustules develop mostly on leaves, but also on stems and bolls. Spread and infections are favored by high humidity during cool nights, warmer day temperatures and on plants growing vigorously. As the season progresses, the orange pustules turn black. The black pustules are most common on stems.

Control: (i) Use resistant varieties as discussed; and (ii) Spray 0.25% dithane Z-78/Indofil M-45.

Wilt Symptoms_

Early infections may kill linseed seedlings shortly after emergence, while delayed infections cause yellowing and wilting of leaves, followed by browning and death of plants. Roots of dead plants turn ashy grey. The tops of wilted plants often turn downward and form a 'shepherd's crook'. Affected plants occur more commonly in patches but may also be scattered throughout the field.

Control:(i) Use resistant varieties; and (ii) Treat the seed with Bavistin or Thiram @ 2.5-3.0g/kg of seed before sowing.

Powdery mildew Symptoms

The symptoms are characterized by a white powdery mass that start as small spots and rapidly spread to cover the entire leaf surface. Heavily infected leaves dry up, wither and die. Early infections may cause complete defoliation of linseed plants.

Control: (i) Use of resistant varieties; and (ii) Spray Sulfex 0.25% in infected areas.

Harvesting

It is important to harvest linseed crop at optimum stage. It would be advantageous to harvest the crop at yellow ripe stage of stem, when lower two-thirds portion of the stem is defoliated i.e. capsule maturity stage without loss of fibre as well as seed quality. Delayed harvesting promotes lignification which in turn impairs the fibre quality. Harvest the crop from ground level.

*****

PPV&FR ACT, 2001 in context to quality seed production of oilseed

U. K. Dubey,
Deputy Registrar,
Protection of Plant varieties and Farmers' Rights Authority,
Ministry of Agriculture &Farmers' Welfare,
Government of India, New Delhi -110012.

Introduction:

The "Protection of Plant Varieties and Farmers' Rights Act" (53 of 2001) is a unique Act which fulfills the spirit of International Treaty on Plant Genetic Resources for Food & Agriculture (ITPGRFA). It also strikes a balance between the rights to breeders and the farmers as per the national requirement. The Authority, since its establishment in the year 2005, has been consistently improvising the system of registering the plant varieties, connecting the stakeholders, encourage innovation in seed sector, acknowledge the contribution by the farmers/communities towards conservation of plant genetic resources and making them available to plant breeders, established a National Gene Fund, build and maintain gene banks etc. The Government of India has notified 192 crop species on the recommendations of PPV&FR Authority for plant variety registration.

1.2. Objectives of the PPV&FR Act, 2001:

To establish an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants.

To recognize and protect the rights of the farmers in respect of their contribution made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.

To accelerate agricultural development in the country, protect plant breeders' rights; stimulate investment for research and development both in the public and private sector for development of new plant varieties.

To facilitate the growth of seed industry in the country that will ensure the availability of high-quality seeds and planting material to the farmers.

Salient features of the Act:

The PPV&FR Act is based on the option under TRIPS Agreement for a member country to protect the rights of plant breeders sui generis system by enactment by legislation if they would not opt for UPOV (International Union for Protection of New Varieties of Plants, Geneva) Convention, and is also unique in the sense that it concurrently recognizes the rights of plant breeders, farmers (including their right as plant breeders), farming communities and researchers who breed new varieties as well as those already bred and existing prior to protection (extant). It confers exclusive rights upon the breeder or his successor, his agent or licensee, to produce, sell, market, distribute, import or export of the registered variety. As far as farmers' rights are concerned, the Act recognizes a farmer as cultivator, conserver and breeder and provides that the farmers' variety can also be registered. Further, the Act provides for compulsory license of a registered variety, if the seeds/propagating material is not available to the public at a reasonable price or quantity. Any person or group of persons or any organization

can also claim for benefit sharing, if the plant genetic material belonging to them is used in the development of a registered variety. The researchers are conferred the right to use any registered variety for conducting experiment or research and the use of a variety by any person as an initial source of variety for the purpose of creating the other varieties. India is a pioneer country where a national legislation has been enacted to establish and secure Farmers' Rights. The Act also recognizes the past, present and future contributions of the farming communities and provides an opportunity for the award to farming communities/farmers for their contributions in agro-biodiversity conservation.

PPV&FR Authority

The PPV&FR Authority is a Statutory Body established by the Parliament of India through the PPV&FR Act of 2001. The Authority is a body corporate, having perpetual succession and a common seal with the power to acquire, hold and dispose of movable and immovable properties and to contract and shall by the said name sue and be sued. The head office of the Authority is at New Delhi and it is functioning from a leased space in the premise of the National Agricultural Science Centre Complex, Dev Prakash Shastri Marg, Pusa Campus, New Delhi.

Plant variety registration

The PPV&FR Authority has finalized the distinctiveness, uniformity and stability (DUS) test guidelines for registration of 192 crop species covering cereals, pulses, millets, oilseeds, spices, vegetables, flowers, medicinal and aromatic plants and fiber crops. The Authority has issued 6598 certificates of registration for plant varieties (under new, extant and farmers' variety category) till 14.2.2024. To facilitate more applications seeking plant varieties protection from different stakeholders, the Authority regularly organizes/supports awareness and capacity building programmes. The PPV&FR Authority has also established network of DUS test centres across the country under the Central Sector Scheme for the implementation of PPV&FR Act, 2001, to verify the claims of candidate varieties by applicants, maintenance breeding, multiplication of reference/example varieties/ the varieties notified under section 5 of the Seeds Act, 1966, and generation of database for varietal characteristics as per crop specific DUS (Distinctiveness, Uniformity and Stability) guidelines. In addition, DUS tests for the candidate varieties are being conducted at crop specific centres. The data recorded as per the DUS test guidelines is submitted by these centres to Authority for further analysis. The Authority, in consultation with the ICAR institutes and SAUs has identified potential crop species of economic importance and supports projects for the development of the DUS guidelines. The Authority has established its National Gene Bank, field gene banks across the country. It regularly publishes Plant Variety Journal of India and maintains the National Register of Plant Varieties at Headquarters and also its branch offices.

Categories of protection of plant varieties

The plant variety protection as enshrined in the Act follows a broad principle of internationally recognized system of DUS and novelty for a new variety. Any person can apply for registration in any of the following:

New variety of such genera and species as specified under section 29(2) of the Act.

Extant variety (To a limited period after the species is notified (in the case of new and VCK varieties) as announced time to time by the Authority)

- Notified under section 5 of Seeds Act, 1966,
- Variety of common knowledge (VCK),
-Farmers' variety
- Traditionally cultivated and evolved by the farmers in their fields,
- Wild relative or landrace of a variety about which the farmers possess common knowledge.

Essentially derived variety (EDV)

A variety predominantly derived from an 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.

Registration of Plant Varieties

An application for registration of a plant variety and its denomination can be made under the following categories:

New Variety: On the date of filing of application for registration if the variety has been commercialized for period of less than one year then it is a new variety

Extant Variety: Consist of the following categories namely:

Extant variety notified under section 5 of Seeds Act, 1966: Varieties notified under Section 5 of Seeds Act, 1966 are eligible for registration under this category

Variety of Common Knowledge: which are not notified under Section 5 of Seeds Act, 1966 and are in commercial chain for more than a year

Essentially Derived Variety: A variety pre-dominantly derived from an initial variety and should fall either under new or extant category

Farmers' variety: Traditionally cultivated and evolved by the farmers in their fields and includes wild relative or land race or a variety about which the farmers possess common knowledge.

1.8. Extent and Nature of Field-Testing (DUS Testing) of Varieties

The application is processed and depending on the category of the variety claimed for registration, the applicant is required to deposit DUS test, registration and any other fees, as may be required. After receipt of necessary fees and seeds and to a satisfactory examination of the application at the Plant Varieties Registry, the Registrar shall send the variety to crop specific centres for conducting DUS test. The period of DUS testing is as follows:

New Varieties: Two similar crop seasons at two locations.

Farmers' Variety and VCK: One crop season at two locations.

Extant variety notified under section 5 of Seeds Act, 1966: No DUS testing is conducted but variety is processed by an Extant Variety Recommendation Committee (EVRC) as per regulation 6 of PPVFR Regulations 2006.

EDV: DUS testing is not mandatory but field test is conducted to ascertain DUS criteria.

After the receipt of DUS test result, the application is processed and distinctiveness is ascertained through DUS test and comparison across the database. Subsequently, the passport data of the variety is published in the Plant Varieties Journal of India. The application is advertised in Plant Variety Journal of India inviting opposition within a period of three months from the date of publications. If no opposition is filed or if opposition filed is rejected, the variety proceeds for registration.

1.8.1. Protection Period in Different Types of Crops:

A total of 192 crop species are presently eligible for protection. The total period of protection for field crops is of 15 years with 6 years of protection at the time of registration renewable to next 9 years, whereas that of trees and vines is for 18 years with 9 years of protection at the time of registration renewable to next 9 years. The extant varieties notified are given a protection for 15 or 18 years for field crops or trees and vines respectively, from date of notification under Seeds Act, 1966.

1.9. Award/Rewards to Farmers'/Farming Communities:

Section 45(2) of the Act reads with Rules 70 (2) (a) of PPV&FR Rules, 2003 provides for support and reward, to farmers, communities of farmers, particularly the tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas identified as agro-biodiversity hotspots from National Gene Fund. To operationalize these provisions, Plant Genome Savior Community Award was instituted in 2009–10. A maximum of five such awards can be conferred annually. Along with this, ten farmers are conferred the Plant Genome Saviour Farmer Reward and twenty farmers are conferred Plant Genome Saviour Farmer Recognition certificates. The details of the awards conferred are mentioned in Table below. The selection of awardees is made by a committee of experts/ scientists headed by an eminent scientist/ subject matter specialist.

Award	Details	Application
Plant Genome Saviour Community Awards	Five farming communities are awarded each year. Each award includes a citation, a memento and Rs. 10 lakhs.	Advertisement for these awards is published in the National dailies and on the Authority website: (http://www.plantauthority.gov.in/forms .htm)
Plant Genome Saviour Farmers' Rewards	Ten farmers are rewarded every year. Each reward includes a citation, a memento and cash of Rs. 1.5 lakh.	The applications should be forwarded by Chairperson/Secretary of the concerned Panchayat Biodiversity Management Committee or Concerned District Agricultural Officer or Director of Research of Concerned State Agriculture University or Concerned District Tribal Development Officer
Plant Genome Saviour Farmers' Recognitions	Twenty farmers are rewarded every year. Each reward includes a citation, a memento and cash of Rs. 1 lakh.	

1.10. Status of Oilseed crops

A total of 18282 applications were received for registration till date of which 6598 certificates of registration (RC) was issued as on 14.2.2024. In case of Oilseed crops a total of 1066 applications were received out of which 382 registration certificates were issued.

1.10.1 The status of Oilseed crops as under;

S. No.	Oilseed Crops	Applications of Oilseed	Registration Certificate

		crops received	of Oilseed crops issued as on 14.2.2024
1	Castor	45	13
2	Groundnut	109	47
3	Indian Mustard (Karan Rai)	15	7
4	Indian Mustard (Sarso)	240	107
5	Linseed	119	16
6	Rapeseed (Gobi Sarso)	12	7
7	Rapeseed (Toria)	113	36
8	Safflower	20	8
9	Sesame	147	14
10	Soybean	102	58
11	Sunflower	144	69
Total		1066	382

1.10.2 Application received by different category of applicants;

S. No.	Applicants category	Applications of Oilseed crops received as on 14.2.2024	Registration Certificate of Oilseed crops issued as on 14.2.2024
1	Farmers'	627	111
2	Private	216	92
3	Public	223	179
	Total	1066	382

1.11 References:

1. Annual report, Published from PPV&FR Authority, 2021-2022.
2. The Bare Act with short notes, Published from PPV&FR Authority, 2019.
3. WWW.plantauthority.gov.in

******

Quality Seed Production in Groundnut

Prof (Dr.) Vijay Kumar Yadav
Director, Seed and Farm
Chandra Shekhar Azad University of Ag. & Tech . Kanpur U.P.-208002
Email.- vkyadu@gmail.com

Groundnut is the sixth most important oilseed crop in the world. It contains 48-50% oil and 26-28% protein, and is a rich source of dietary fiber, minerals, and vitamins. Groundnut is grown on 26.4 million ha worldwide with a total production of 37.1 million metric tons. Developing countries constitute 97% of the global area and 94% of the global production of this crop. The production of groundnut is concentrated in Asia and Africa (56% and 40% of the global area and 68% and 25% of the global production, respectively).

Groundnut belongs to family Leguminoceae (Fabaceae) sub-family Papilionoideae. The genus Arachis is morphologically well defined and clearly delineated from its closest relatives by the presence of geocarpic peg. The genus Arachis is placed with its relatives Stylosanthes, Chapmannia, Arthrocarpum and Pachecoa in the sub-tribe Stylosanthinae of the tribe Aeschynumeneae on the basis of the shared morphological characters of a staminal tube with alternately attached basal and dorsal anthers, flowers in terminal or axillary spikes or small heads (which are sometimes raceme-like), pinnate leaves, and leaflets without stipules. The flowers are borne on axils of leaves on primary or secondary branches. The pollen matures 6 - 8 hours before anthesis. The self-pollination occurs because the stigma and anthers are enclosed by the keel. However, cross pollination (ranging from 0 to 6%) also occurs through bees. After fertilization, the elongated gynophores develop into a peg like structure and becomes sub-terranean, which are converted into pods. Groundnut pods are elongated with varying degrees of reticulation on the surface. They contain two to five seeds. Seed weight of kernel ranges from 0.15 to >1.3 g/seed/kernel.

Groundnut has been classified on the basis of growth habit, branching pattern, inflorescence, pod and seed characters, seed dormancy etc. The details of most widely adopted classification of groundnut, is shown in Table 1.

Table 1: Classification of Groundnut

Botanical type	Subspecies	Cultivar	Branching pattern	Growth habit	Seed/pod
Virginia Bunch	hypogaea	hypogaea	Alternate	Prostrate to semi erect	2-3
Virginia Runner		hirsuta	Alternate	Prostrate	2-4
Valencia	fastigiata	fastigiata	Sequential	Erect	2-3
Spanish Bunch		vulgaris	Sequential	Erect	2

Seed is the basic and very essential input in agriculture. The quality of seed used by farmers determines the status of agriculture they practice. However, application of both improved varieties and improved integrated crop management practices are required for maximum gain in productivity.

Seed of improved varieties is a costly input; more so in the case of groundnut, where the non-availability of improved variety seed is a major constraint. The private sector has little interest in the groundnut seed enterprise because of there is the low seed multiplication ratio, bulky nature of the produce, quick loss of seed viability, high cost of transportation, low profit margin and the self-pollinated nature of the crop; therefore, the task of making the seed of improved groundnut varieties available to farmers in required quantities and at the right price is the responsibility of public sector seed services. Unfortunately, services have not been able to meet the demand of good quality seed of improved varieties of groundnut in many states. There remains a large gap between the seed demand and seed supply resulting in low area coverage by improved varieties.

One of the most efficient means for the farmer to improve the productivity is to use high quality groundnut seeds. Organizing high quality seed production and distribution is critical to the implementation of any seed program. Pod and grain size of a specific variety are important parameters for determining seed value. The crop should be grown under appropriate climatic and soil conditions to ensure good pod formation, filling, and seed maturity. Cultural techniques must be perfectly mastered in order for the plant to attain its full potential and ensure quality production. These standards are fundamental for producers who want to sign up for a national multiplication program. The farmer must also accept controls and conform to certification standards.

Seed certification standards

Criteria	Seed classes		
	Breeder	Foundation	Certified
Minimum isolation in meters	3	3	3
Off-type plants (maximum at final inspection stage)	0.10%	0.1%	0.5%
Number of diseased plants/500 m2	0/500 m2	3/500 m2	3/500 m2
Pure seed (minimum %)	99.9	99.5	98/95
Specific purity (minimum %)	96	96	96
Inert matter (maximum %)	4	4	4
Other crop seed (maximum kg)	Nil	Nil	Nil
Weed seeds (maximum)	Nil	Nil	Nil
Germination (minimum %)	70	70	70
Moisture content (maximum %)	9	9	9
Bruchid infestation (maximum %)	2	2	2
Aspergillus contamination (maximum %)	5	5	5
Fusarium contamination (minimum %)	5	5	5

Source: INSAH (2002)

Monitoring and inspection

The nucleus and breeder seed do not come under the purview of a seed certification scheme. As such, there is no prescribed monitoring/inspection procedure for them. However, the breeder responsible should ensure full conformity to diagnostic characteristics of the variety under nucleus seed production and the highest purity standards of the seed. The breeder should carry out a thorough inspection of the crop before and after flowering and at harvest to eliminate any unhealthy, abnormal and off-type plants. This will ensure genetic purity, which in the next generation would conform to the standards of foundation seed. Monitoring/inspection are mandatory for certification of other classes of seed (foundation, certified). A duly authorized seed certification agency organizes the field and post-harvest inspections by a team of technically qualified personnel. A seed analysis report and results of a grow-out test, wherever prescribed, are taken into account before issuance of a certificate.

Field isolation

Groundnuts are self-pollinating and therefore do not require isolation. A distance of 5-10 m between varieties is recommended to avoid mixing during harvesting and stripping.

Seed dormancy

Dormancy is a natural phenomenon in the plant kingdom. It is defined as the inability of newly harvested seeds to continue their development under favorable environmental conditions (temperature and humidity). Dormancy allows plants to survive unfavorable environmental conditions.

Environmental factors can break the dormancy. It is absent in Spanish and Valencia groundnut or is naturally broken several weeks after seed maturity. Non-dormancy results in field sprouting especially if harvesting is delayed. This reduces seed yield and quality considerably. Virginia type groundnuts have a longer dormancy of 4 or more months.

Chemical products such as ethylene (3.5ppm) induce excellent germination. Ethephon® can also be used to break dormancy in groundnuts. Ethephon® or ethrel, originally a growth regulator, progressively decomposes into mainly ethylene as well as several other substances. It is available in liquid or powder form. The powder is added to the fungicide-insecticide mixture and the liquid is sprayed onto untreated seeds. Exposure to high temperatures (40- 45°C for 15 days) can also break the dormancy.

Agro -techniques for groundnut seed production

Quality seed production techniques for Uttar Pradesh

S.No.	Particulars		Details
1.	Selection of field/land preparation practices		Sandy and Sandy loam soil, well drained field.
2.	Seed treatment-rate of timing/chemical		3g thyrum or 2g thyrum + 1g carbondazim per kg kernels.
3.	Seed Rate/sowing method-line sowing with row to row and plant to plant distance/direct sowing		Seed Rate : 65-70 Kg kernels/ha Spacing L to L : 40 cm P to P : 15 cm
4.	Fertiliser doses per hectare with timing	20 Kg Nitrogen	at the time of sowing all the quantity of P2O5 and K2O, borax and ½ quantity of gypsum and nitrogen are applied and rest ½ quantity of gypsum and nitrogen are applied after 3-4 week of planting.
		30 Kg Phosphorus	
		45 Kg Potash	
		4 Kg Borax	
		200 Kg Gypsum	
5.	Weed Control-chemicals with doses & timing		Spray pendimethylene 30 EC @ 3.3 litre/ha within 3 days after sowing. Two hand weeding are also required at the interval of 3 week and 5-6 week of sowing.
6.	Disease and pest control-chemicals with doses & timing		For insect pest White Grub : 20-25kg phorate10g/ha at the time of sowing. For Termite & Thrips, 4-5 litre Chlorpyriphos/ha are used in standing crop.
7.	Irrigation schedule		Two irrigations are required for critical stages: First at time of flowering & penetration of pegs in the soil and second at development stage.

Soil and Climate

Warm and moist conditions are highly congenial for groundnut cultivation. Temperature, light intensity, rainfall and humidity significantly influence the productivity of groundnut. Optimum temperature of 25-35 °C is required for good germination, flowering and pod formation.

Groundnuts require well-drained sandy loamy soils that facilitate penetration of the pegs after pollination, and easy digging without pod loss. Groundnut plants are sensitive to salinity, and high soil acidity (pH<5) could induce magnesium or aluminum toxicity. In this type of soil, calcium should be added to maintain the pH above 6.

Land preparation

Removal of crop residues that spread diseases and harbor pests is important. For light soils, this type of cleaning should be followed by a shallow raking after the first light rains. This eliminates early weeds and breaks up the soil surface. In wetter areas or with heavier soils, fields must be ploughed at the beginning of the season to suppress weeds and break up the soil, which must then be refined by harrowing. With this soil type, raised-beds are often made to limit run-off or water logging. If groundnut is to be grown on ridges, the ridges should be made at or just before sowing, and should be flat-topped. If the soil is dry when the ridges are being made, a light rolling after ridging will help make the seedbed firm.

Selection of Varieties:

For Quality seed production, variety is selected on the basis of national, state, public and private sector demand and indent and as per location specific suitability. After inception of AICRP >160 varieties of groundnut have been released for different agro ecological situations, out of which old varieties like TMV-2, TMV-7, GG-11, Chitra Kaushal, SV-xi, JL-24 Polachi-1, GAUG-10, and new varieties like K-6,K-9, TG37-A, GBPD-4, GBPD-5, Narayani, ICGV-91114, TPG-41, TG-38, VRI-6 have become popular among the farmers for large scale cultivation. Variety GPBD-4 in Karnataka, Rajasthan & TN; TG 37A in AP, Chhattisgarh, Gujarat & Karnataka, MP, Odisha; TPG 41 in AP, Chhattisgarh, Karnataka, TN; Kadri-6 & Narayani in AP; new varieties K-9, Harithandra, Dharani, GJG-31, TPG-41, GPBD-4, GPBD-5, Phule-6021, Phule Unnati, GJG-17, TG-51 ,Avtar have adopted by the farmers.

Sowing time

- Kharif-groundnut- June to July subject to onset of monsoon.
- Rabi groundnut-November.
- Summer groundnut-February-March.

Methods of sowing

- Line sowing on flat –bed system.
- Criss-cross sowing on flat –bed system.
- Broad Bed and Furrow System.
- Ridge and Furrow System.

Seed rate, spacing and plant population

- Bunch type groundnut varieties- 100-110 kg seed /ha.
- Spreading and semi-spreading varieties- 95-100 kg seed /ha.
- Spacing for bunch type varieties- 30 x 10 cm with plant population of 3.33 lakh/ha.
- Runner type varieties- 45 x 10 cm or 15 cm with plant population of 2.22 lakh/ha.

Nutrient management

A reasonable level of organic matter must be maintained in the light, weakly structured, tropical soils where groundnuts are grown. The groundnut plant has an extensive root system that allows it to explore a large volume of soil and therefore benefit from organic manure residues from the preceding crop (cereal). Groundnuts can be cultivated with a balanced fertilizer N-P-K. Calcium must be added to slightly acidic soils to correct the pH and improve the quality of the seeds. Calcium deficiency leads to a high percentage of aborted seeds (empty pods or "pops") and improperly filled pods. Calcium is barely translocated across the leaves, and should therefore be applied near to the fruiting zone (as a side dressing) at the onset of pod formation. For every one tone of pod yield and two tone of haulm yield, groundnut crop removes 60 kg nitrogen, 11 kg Phosphorous, 46 kg Potassium, 27 kg Calcium and 14 kg Magnesium from the soil. To obtain higher yield well decomposed farm yard manure @ 10 t/ha should be applied at least 21 days before sowing of crop.

State wise recommended doses of NPK fertilizers under rainfed and irrigated situation and correction of micronutrient deficiencies are given in Table.3 and Table.4.

Table-03: Recommended doses of NPK for different states

State	Situation	N-	P-	K (kg/ha)
Andhra Pradesh	Rainfed	20	40	20
	Irrigated	30	60	45
Gujrat	Rainfed	12.5	40	0
	Irrigated	25	50	0
Karnataka	Rainfed	15	30	25
	Irrigated	25	75	25

Madhya Pradesh	Rainfed	20	40	20
Punjab	Irrigated	15	40	25
Rajasthan	Rainfed	20	60	0
	Irrigated	20	60	0
Maharashtra	Irrigated	20	40	0
Uttar Pradesh	Rainfed	15	30	45
West Bengal	Irrigated	15	30	45
Tamil Nadu	Rainfed	11	22	33
	Irrigated	22	44	66

Table-4: Correction of Micronutrient deficiencies

Micronutrient	Form and rate of application to soil	Spray schedule
Boron	Borox 5-20 kg/ha	0.2% Borox
Copper	Copper Sulphate 5-10 kg/ha	0.1% Copper Sulphate + 0.05% lime
Manganese	Manganese Sulphate 10-50 kg/ha	0.6% Manganese Sulphate + 0.3% lime
Zinc	Zinc Sulphate 10-50 kg/ha	0.5% Zinc Sulphate + 0.2% lime
Molybdenum	Sodium or Ammonium Molybdenum 0.5-1.0 kg/ha	0.07-0.1% Ammonium Molybdenum
Iron	Ferrous Sulphate 10 kg/ha	0.5% Ferrous Sulphate + 0.2% Citric Acid

Weed management

Groundnut cannot compete effectively with weeds, particularly at the early stages of development (3-6 weeks after sowing). Early removal of weeds reduces this competition. Crop rotation may reduce certain species of weeds. Pre- emergence herbicides viz., Pendimethalin @1.0-2.0 kg a.i./ha , Oxyfluorfen @0.25-0.50 kg a.i./ha and post-emergence herbicides like Quizalofop & Imazethapyr @0.050 kg a.i./ha may be used to eradicate weeds but they are too expensive for most small-scale farmers. The crop should be thoroughly weeded following two hand weeding, first around 20 days after sowing and 2nd at about 35 days after sowing. Inter-cultivation usually starts around 10 days after emergence and continues up to 35 DAS at 7– 10 days interval till pegging begins.

Rouging out off-type plants

This consists of manual removal of plants of other varieties present in the field. Depending on the degree of contamination a field can be retained or rejected for seed production. Fields of mother seeds should have less than one off-type in 1000 and those of certified seeds, one in 200. Regular field checks allow elimination of off-types based on phenotypic characteristics

of the cultivated variety. Field rouging maintains the genetic purity and can only be effective if checks are rigorously continued throughout all operations.

Water Management

Groundnut crop is mostly cultivated during kharif under rainfed conditions (80%).
Crop could with stand up to 25 days of emergence without irrigation/rainfall.

Rainfall/protective irrigation is necessary at flowering (20-40 DAS), pod formation (40-70 DAS) and pod filling (70-100 DAS).

Eight irrigations are adequate for optimal yield i.e. pre –sowing irrigation followed by an irrigation at 25 DAS, 4 irrigations at 10 days interval and final two irrigations at 15 days interval.

Sprinkler irrigation is ideal for the crop grown under sandy soils.

Drip irrigation is becoming popular among groundnut growers as it increases crop yield by 25-40% besides improving seed quality and saves up to 40-50% irrigation water compared to flood irrigation.

Plant protection

Groundnut is susceptible to a number of pests and diseases that can cause considerable yield losses. Recommended protection measures against diseases and insect pests should be regularly followed during the cropping season.

The Insect-pest management practices in groundnut

Deep ploughing during April-May to expose pupae to sunlight and predatory birds.
Clean cultivation by rouging out weed hosts and self-sown plants.
Growing of resistant varieties like, BR 2, ICGV 87160, ICGV 86031, ICGV 86699 (Leaf Miner), ICGV 86590 (Spodoptera), BG 2, Girnar 1 (aphids), Girnar 1, Co-1, Dh-3-30, ICGS 11, MH 1, POL 2, S 206 (Leafhoppers) and Girnar 1 (Thrips).
Early sowing escapes the damage caused by Leaf Miner and White Grubs.
Set up the petromax light traps @ 1-2/ha to attract and kill the moths during June-August.
Install pheromone traps @ 10 traps/ha for Spodoptera and Helicoverpa and 25 traps/ha for leaf miner.
Spray neem oil @5ml/lt water along with suitable surfactant like soap powder @ 1g/lt or NSKE 5% as it acts as oviposition deterrent.

Disease management practices in groundnut

Deep burial of surface organic matter and crop debris.
Use good quality seeds of resistant/tolerant varieties.
Seed treatment with commercial formulation of Trichoderma harzianum or T. viride or Pseudomonas fluorescens @ 10g/kg seed or Thiram or Carbendazim or Captan or Mancozeb @ 3-4g/kg seed or Tebuconazole (Raxil 2 % DS) @ 1.25g/kg.
Avoidance of deep sowing and injury to the seedling.

Soil application of neem cake or castor cake @ 500kg/ha or neem seed kernel powder @ 3-5%. 13 Status paper on Groundnut.
Foliar application of Carbendazim (0.025%) + Mancozeb (0.2%) at 2-3 weeks interval, 2 or 3 alternate spray of Mancozeb (0.2 %), Carbendazim (0.02 %) and Mancozeb (0.2 %) or three sprays of Chlorothalonil (0.2 %) or Hexaconazole (0.005 %) or Difenoconazole 25% EC @ 2ml/L at 30, 50 and 70 DAS effectively reduces the early leaf spot and late leaf spot severity.
Spray Mancozeb (0.2 %) or Copper Oxychloride (0.2 %) and destroy the collateral weeds and self-sown plants.

Harvesting
It is important to harvest groundnut at the right time, ie, when the crop is mature. Flowering is indeterminate in the groundnut; therefore, there is a variable proportion of mature and immature pods at the end of the crop cycle. Groundnuts are mature when 70-80% of the inside of the pods shells have dark markings and the kernels are plump, with color characteristic of that variety. If harvested prematurely, the kernels shrink upon drying, resulting in decreased shelling percentage, poor seed quality and lower oil content. If harvested late, non-dormant varieties will sprout in the field, resulting in yield losses.

Post harvest handling
Seed quality mainly depends on appropriate handling and storage techniques for the harvested crop. Handling facilitates the selection of the best seeds while storage conditions ensure the conservation of high seed quality. Groundnut seeds are protected by a shell, which acts as an excellent natural barrier against pests and diseases. However, this shell should be intact. Removal of damaged pods is therefore necessary. Crop residues mixed with the pods are often sources of contamination.

Drying
The primary objective of curing or drying, is to achieve a rapid but steady drying of pods in order to avoid aflatoxin contamination. Harvested plants should be staked in the field for a few days to allow them to dry in the sun and air, before stripping the pods. Then drying should be continued until the moisture content is reduced to 6-8%. This can normally be achieved by drying the pods in the sun for 6-7 days, taking care to cover them if it rains. If pods are exposed to the sun too long, both kernel quality and seed germination will be affected. Under mechanized farming systems, combine harvesters collect windrows, strip and clean pods in one single operation. The pods are then artificially cured in drying trailers. Airflow temperature should be 5-6°C above ambient temperature but should not exceed 35°C. Optimal depth varies from 0.6 to 3 meters according to pod water content and the type of curing equipment used.

Stripping–winnowing
Pods are stripped at about 2 to 6 weeks after harvesting, when the pod water content stabilizes at around 10%. This operation consists of separating the pods from the vegetative parts of the plants (vines). In traditional farming systems, manual stripping is the rule. Pods are individually detached from the vines and therefore dry very quickly stabilizing at 6-8% moisture content. The process results in a perfect quality product. This technique is used for

the production of edible or confectionery groundnuts in order to minimize pod damage and contamination by Aspergillus flavus. However, stripping is most often done using sticks. These reduce the heap of groundnut plants into a mixture of chopped vines and partially broken pods that are then separated by winnowing.

Several types of mechanical combines can be used to strip groundnut windrows with less than 10% moisture content. This consists of manually feeding pods into the combine. Stripping is achieved by friction between the stripper bars against the base of the plant and the pegs. The stripped product is evacuated across a counter stripper made up of a cylindrical grid. Large pods retained by the grid are carried along by the rotation of the combine. Pods are then stripped a second time. A built-in blower separates the trash from the finished product. The intake speed, selection of the grid, combine rotation speed and airflow speed must be regulated (by adjusting the opening of the air intake shutters).

Packaging: pods can easily be stored in bulk. Storage in clean jute or woven polyethylene fibre bags ensures the best protection of groundnuts and facilitates manipulation of stocks (manual or palletized). Groundnut seeds should only be stored in bags or drums. Each bag or drum must be properly labeled. Labels must show batch origin, year, level of multiplication, seed weight and eventual chemical treatments.

******

Oilseed production, constraints and options: Indian perspective

Gyan P. Mishra
ICAR-Indian Agricultural Research Institute, Pusa, New Delhi
*Correspondence: gyan.gene@gmail.com

Abstract
By 2050, the global population is projected to reach approximately 8.8 billion, with urbanization expected to rise from 50% to 70%, presenting the challenge of producing 70% more food without expanding arable land. Seeds are identified as a critical input in addressing this challenge, serving as the foundation of agricultural productivity to meet the escalating demands of a growing population. In the edible oil sector, efforts to promote healthier consumption habits and reduce reliance on imports are underway through an aggressive campaign. However, the production of oilseeds in India faces challenges such as rainfed farming, poor productivity, biotic and abiotic stresses, and preference for cereals over oilseeds. To address these challenges, a multifaceted approach encompassing cropping system integration, variety replacement, weed and nutrition management, pest and disease control, farm mechanization, and post-harvest strategies is imperative. These strategies aim to enhance oilseed productivity, ensure sustainability, and contribute to overall food security and rural livelihoods.

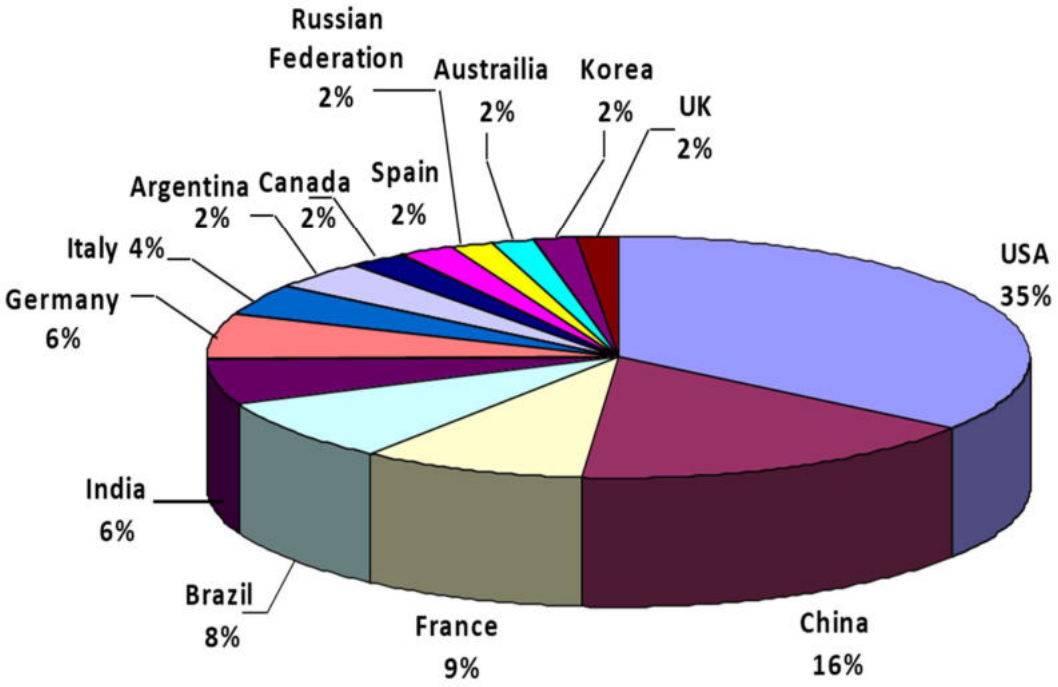
Introduction

By 2050, the global population is projected to soar to approximately 8.8 billion, with urbanization escalating from 50% to 70%. This dramatic demographic shift poses a pressing challenge: the need to produce 70% more food without an increase in arable acreage. In response, solutions must be sought at the input level, with seeds emerging as a crucial component. As the fundamental unit of agricultural productivity, seeds hold the key to enhancing yields and meeting the escalating demands of a burgeoning population. Ensuring seed security is paramount in safeguarding food security for the future. This entails several critical components. Firstly, there must be an adequate supply of breeder seed, the foundation upon which high-yielding oilseed varieties are developed. Deployment of these varieties is essential to maximizing agricultural productivity. Additionally, a robust seed chain infrastructure comprising institutions such as the National Seed Corporation (NSC), State Seed Corporations (SSCs), Seed Development Agencies (SDAs), Indian Council of Agricultural Research (ICAR), and State Agricultural Universities (SAUs) is indispensable. Such institutions play pivotal roles in research, development, production, and distribution of quality seeds. Supportive government policies are imperative to create an enabling environment for seed security initiatives to thrive. Equally important is raising farmers' awareness and providing them with necessary support, including access to information, training, and resources, to optimize seed utilization and contribute effectively to overall food security efforts.

Major global players: Seed production

In the realm of seed production, major global players wield significant influence, driving the dynamics of the agricultural sector. The global commercial domestic seed market boasts a substantial value, estimated at around US$ 59.5 billion, reflecting the immense scale and importance of the industry. Within this landscape, India emerges as a notable contender, ranking as the fifth-largest global seed economy. With its vast agricultural landscape and

burgeoning demand for seeds to support its agricultural output, India's position underscores its pivotal role in the global seed market. As a major player, India's contributions to seed production not only cater to domestic needs but also have ripple effects on global agricultural trends and food security initiatives.



Source: https://www.marketsandmarkets.com/Market-Reports/seed-market-126130457.html

Table 1. Breeder seed production (q): Oilseed crops

Oilseed Crops	2019-20 (q)		2020-21 (q)		2021-22 (q)		2022-23 (q)	
	Indent	Prod.	Indent	Prod.	Indent	Prod.	Indent	Prod.
Soybean	17897.9	13837.9	13787.60	12179.88	15188.2	15179.1	14,770.0	14,805.6
Groundnut	11030.4	12146.6	9709.60	11359.35	10229.8	18092.4	10,555.4	15,448.8
Linseed	190.6	330.9	190.55	330.88	151.2	162.6	168.8	338.0
Mustard	109.0	238.4	113.03	258.19	66.5	121.3	79.5	189.3
Rai	78.1	188.4	78.07	188.36	28.4	29.5	2.1	110.3
Castor	55.9	82.2	14.77	29.56	59.9	78.1	25.4	52.6
Sesame	36.3	57.9	48.58	95.06	29.2	36.2	59.5	58.9
Toria	23.2	59.8	20.52	42.97	14.3	35.3	18.3	62.0
Safflower	22.4	75.3	23.44	76.46	22.6	98.0	31.8	592.5
Ghobi Sarson	19.7	29.2	19.65	29.20	6.4	8.0	10.0	15.6
Niger	17.0	15.7	3.26	4.48	12.4	13.5	12.5	8.5
Raya	6.3	8.6	6.30	8.55	0.2	0.2	2.2	3.2
Yellow Sarson	4.7	14.0	4.74	13.98	5.7	18.8	0.0	0.0
Sunflower	3.5	45.2	2.72	16.40	0.5	54.5	21.9	28.4

Brown Sarson	3.1	4.5	3.10	4.52	0.8	0.8	2.3	3.2
Taramira	1.0	0.0	1.04	0.00	1.0	7.3	0.0	0.0
Karan Rai	0.5	0.6	0.50	0.55	0.0	0.0	0.5	0.6
African Sarson	0.0	0.0	0.00	0.00	0.0	0.1	0.2	0.3
Total	29,499.6	27135.0	24,027.5	24,638.4	25,816.9	33,935.7	25,760.4	31,717.7

Table 2. Quality seed production of various oilseed crops under AICRP on seed (in Quintals)

Oilseed Crops	2020-21			2021-22		
	FS	CS	TFL	FS	CS	TFL
Groundnut	2139.3	912.7	2101.5	1841.3	1336.1	2446.1
Castor	0.0	274.8	738.5	0.2	707.4	617.6
Safflower	113.0	644.0	303.2	113.7	616.9	537.7
Sunflower	26.0	219.2	47.5	3.2	444.1	73.9
Soybean	2851.7	4158.5	1357.6	7787.9	413.1	870.5
Toria	71.9	168.5	444.7	42.8	121.0	1398.0
G. Sarson	4.1	75.0	2606.6	8.3	113.0	461.2
Indian Mustard	108.9	93.7	1460.1	68.0	73.4	1166.6
Linseed	77.0	45.5	86.3	95.0	69.1	33.5
Rai/Sarson	81.7	0.0	243.2	365.0	67.0	261.2
Y. Sarson	29.7	89.8	24.6	2.3	63.8	0.2
Sesame	36.2	6.6	501.1	14.0	33.9	410.5
Niger	7.4	0.1	7.3	1.2	6.0	58.0
B. Sarson	64.6	0.0	233.2	0.0	0.0	10.0
Karan Rai	0.0	0.0	70.0	0.4	0.0	0.0
Raya	1.0	170.0	72.0	0.0	0.0	195.4
Taramira	0.0	0.0	10.0	0.0	0.0	4.1
A. Sarson	0.0	0.0	11.0	0.0	0.0	5.5
Total	5,612.3	6,858.3	10,318.3	10,343.1	4,064.8	8,549.8

National scenario- Oilseeds

In the national scenario of oilseeds production in India, the trajectory has been marked by both achievements and challenges. The "Yellow Revolution" of the 1990s initially propelled the country towards self-sufficiency in edible oils, yet this accomplishment proved difficult to sustain over time. Despite efforts to boost production, factors such as the rapid increase in population and per capita consumption of oil have posed persistent hurdles. Notably, per capita consumption has surged from 6.2 kg per annum in 1986-87 to 18.01 kg per annum in 2021-22, driving up the demand for edible oils. However, domestic availability has lagged behind, with demand reaching approximately 27 million metric tons while domestic production hovers around 13 million metric tons as of 2021-22. Consequently, India finds itself heavily reliant on imports, which account for about 55% of its edible oil consumption, incurring substantial costs totaling approximately Rs. 1.38 lakh crores in 2022-23 alone. Compounding this issue is the stagnation in the total area under oilseeds cultivation, which remains nearly static at around 25 million hectares, despite efforts to increase production. In light of these challenges, addressing

the gap between demand and domestic production remains a critical imperative for India's oilseed sector to ensure food security and mitigate the economic burden of oil imports.

Edible Oil Sector

In case of edible oil sector, addressing consumption patterns has emerged as a pressing concern, prompting concerted efforts to promote healthier habits and reduce reliance on imports. With the Indian Council of Medical Research (ICMR) recommending a daily intake of 30 grams per person or 12 kilograms per person annually, there is a recognized need to curb excessive consumption. To this end, an aggressive campaign is set to be launched across various media platforms, leveraging print, electronic, and social media channels. This campaign will feature prominent personalities and citizens advocating for reduced edible oil consumption, aiming to foster widespread awareness and behavioral change. Currently, per capita consumption stands at 18.01 kilograms annually, significantly exceeding the WHO's recommended limit. Notably, India's reliance on imports underscores the urgency of this initiative, with total imports of edible oils reaching 14.02 million tons, dominated by palm oil (56%), followed by soybean oil (27%), sunflower oil (16%), and other varieties (1%). By promoting healthier consumption habits and reducing dependence on imports, these efforts strive to enhance both public health outcomes and the nation's food security landscape.

Table 3. details od Edible Oil Sector in India.

Year	Edible oil for available for consumption (MT)	Domestic Production (MT)	Imports (MT)	Value of import (Rs. in crore)	Dependency on imports (%)	Per capita Consumption (kg/yr)
1986-87	5.34	3.87	1.47	700	28.0	6.2
1994-95	7.54	7.19	0.35	300	5.0	7.3
2014-15	21.36	8.63	12.73	64,894	59.6	18.3
2019-20	25.06	10.60	14.46	68,576	57.7	18.7
2020-21	25.82	12.47	13.35	79,190	54.9	18.2
2021-22	27.19	13.17	14.02	1,04,423	51.5	18.01
Source: Department of Sugar & Vegetable Oils; DG, CI&S, Dept. of Commerce, Kolkata						

Table 4. Share of Public & Private Sectors: Oilseed Production (lakh q)

Oilseeds	2020-21						2021-22					
	Req.	Availability			% Share in total prod.		Req.	Availability			% Share in total prod.	
		Public	Private	Total	Public	Private		Public	Private	Total	Public	Private
Castor	0.52	0.09	0.49	0.58	15.52	84.48	0.50	0.08	0.84	0.92	8.70	91.30
Rapeseed & mustard	2.88	1.64	1.44	3.08	53.25	46.75	2.46	1.42	1.24	2.67	53.18	46.44
Groundnut	26.35	14.27	12.43	26.70	53.45	46.55	26.40	15.91	12.37	28.28	56.26	43.74
Niger	0.03	0.01	0.03	0.04	25.00	75.00	0.04	0.03	0.00	0.04	75.00	0.00
Til	0.50	0.17	0.36	0.53	32.08	67.92	0.42	0.14	0.38	0.52	26.92	73.08
Linseed	0.13	0.13	0.03	0.16	81.25	18.75	0.13	0.15	0.04	0.18	83.33	22.22

Soybean	27.23	11.38	12.65	24.03	47.36	52.64	29.00	9.75	18.37	28.12	34.67	65.33
Sunflower	0.33	0.02	0.37	0.39	5.13	94.87	0.20	0.15	0.08	0.22	68.18	36.36
Safflower	0.05	0.02	0.03	0.05	40.00	60.00	0.03	0.02	0.02	0.04	50.00	50.00
Total Oilseeds	58.02	27.73	27.83	55.56	49.91	50.09	59.18	27.65	33.34	60.99	45.34	54.66

India: Scenario of oilseed crops

In the diverse landscape of oilseed crops in India, sources span across various categories, reflecting the country's rich agricultural diversity. Primary sources encompass both edible and non-edible groups, with prominent members including groundnut, rapeseed (including toria, mustard, and sarson varieties), soybean, sunflower, sesame, safflower, niger, castor, and linseed. Additionally, secondary sources contribute significantly to the oilseed supply chain. Within the edible group, seasonal crops such as cotton seed, rice bran, maize germ, and watermelon, along with plantation crops like coconut and red-oil palm, play substantial roles. Tree-borne oilseeds like sal seed, mahua, mango kernel, kokum, among others, further diversify the available sources. Similarly, the non-edible group features seasonal crops such as mesta seed and tobacco seed, plantation crops like rubber-seed, and various other tree-borne oilseeds including neem, karanj, palash, wild-apricot, rattan-jyot, jojoba, and more. This wide array of sources underscores the richness and versatility of India's oilseed cultivation, contributing significantly to both domestic and global supply chains while catering to diverse industrial and nutritional needs.

Sources of Oilseeds

Oilseed crops in India are sourced from a variety of sources, with nine major crops leading the sector. These include soybean, groundnut, rapeseed-mustard, sesame, sunflower, castor, safflower, linseed, and niger. Among these, soybean, rapeseed-mustard, and groundnut stand out with the highest average production rates, collectively contributing 92% (38%, 27%, and 27%, respectively) from 2016-17 to 2020-21. In terms of cultivated area, soybean again takes the lead, accounting for 44%, followed by rapeseed-mustard at 24% and groundnut at 20%. The distribution of oilseed production across seasons is also notable, with kharif oilseed crops contributing to 67% of the total production and rabi/summer oilseed crops making up the remaining 33%. This diversity in both production levels and seasonal distribution underscores the resilience and importance of India's oilseed sector in meeting domestic and global demand while navigating seasonal variations and agricultural dynamics.

Table 5. Increase in Oilseed Exports (000' Tons)

Oil seed	2019-20	% Share	2020-21	% Share
	Qty.	(2019-20)	Qty.	(2020-21)
Groundnut (Kernel)	664.44	61.34	638.58	59.43
Sesame seed	282.26	26.05	273.13	25.42
Soybean	74.67	6.89	68.59	6.38
Mustard / Rapeseed	31.78	2.93	56.56	5.26
Niger seed	13.83	1.27	19.59	1.82
Linseed	12	1.10	11.94	1.11
Safflower seed	2.61	0.24	3.98	0.37

Sunflower seed	1.2	0.11	1.33	0.12
Cottonseed	0.38	0.35	0.74	0.07
Total	1083.17	100	1074.44	100
Source: DGCIS/MOC (April-March)				

Problems in oilseed production in India

The production of oilseeds in India faces a myriad of challenges, hindering the sector's growth and potential. A significant portion, approximately 72% of the total oilseed area, is cultivated through rainfed farming by marginal and small-scale farmers, exacerbating the vulnerability of production to weather fluctuations and water scarcity. Poor productivity further compounds the issue, stemming from a lack of appropriate technologies and cultivation practices under input-starved conditions. Moreover, oilseed cultivation grapples with the daunting task of combatting biotic and abiotic stresses, further impeding yield potential. The absence of hybrids and shorter crop durations add to the complexities, limiting the efficiency and scalability of production methods. Additionally, farmers often prioritize cereals under irrigated conditions due to assured buyback schemes, diverting attention and resources away from oilseed cultivation. This preference, coupled with growing imports that depress the domestic market and production, underscores the urgent need for comprehensive strategies and interventions to revitalize India's oilseed sector, ensuring sustainability, resilience, and food security for the nation.

Reasons for Low Productivity

1. Genetic ceiling

Low productivity in the oilseed sector can be attributed to various factors, with one primary reason being the genetic ceiling of existing crops. Despite efforts in agricultural research and development, the genetic potential of oilseed crops has not been substantially elevated. Many varieties share similar plant types and common ancestry, leading to limited variation in traits and yield potential. Furthermore, the development of hybrids, which could offer a breakthrough in productivity, has been sluggish and remains a low priority area in both public and private sector programs. This stagnation in genetic enhancement significantly constrains the ability of oilseed crops to achieve higher yields and meet growing demand, highlighting the urgent need for concerted efforts to accelerate research and innovation in this critical aspect of agricultural development.

2. Stability of Performance: Susceptibility to diseases and insect pests

The stability of performance in oilseed crops is significantly hindered by their susceptibility to diseases, particularly evident in the rapeseed-mustard group of crops in India. Over 22 diseases have been reported to affect this group, posing a significant challenge to productivity and yield consistency. One major obstacle in combating these diseases is the lack of cultivars possessing absolute resistance. Even resistant sources often succumb to regional isolates of prevalent pathogens, as these pathogens have not been delineated into pathotypes or races. Additionally, the absence of host differential sets hampers the identification and designation of genes conferring resistance. Efforts to develop genomic resources enabling precise transfer of resistance have been limited, further exacerbating the problem. Moreover, the reliability of identified molecular markers is often challenged by variations in different isolates of pathogens. In addition to diseases, insect pests also contribute to yield instability, with no absolute resistance sources available. Infestation levels vary due to factors such as insect preference and

crop stage, making it challenging for breeders to select resistant sources under natural infestation conditions. Furthermore, the lack of widely applicable artificial screening methodologies for many insect pests complicates efforts to develop resistant varieties. Addressing these issues requires concerted research efforts and innovative strategies to enhance disease and pest resistance in oilseed crops, thereby promoting stability and sustainability in their performance.

Agro-ecology and Agronomic Practices

The cultivation of oilseed crops is highly influenced by agro-ecological conditions and agronomic practices, presenting both challenges and opportunities for farmers. These crops are cultivated across diverse environments, ranging from arid sand dunes to steep hilly slopes, showcasing their adaptability to adverse conditions. However, their productivity is often hampered by insufficient tolerance to various abiotic stresses such as drought, heat, frost, salinity, and soil acidity. Furthermore, the non-availability of adequate irrigation water, both in terms of quantity and quality, poses a significant constraint to crop growth and yield. Compounding these challenges is the fact that a substantial portion of oilseed cultivation occurs in rainfed areas, where farmers face constraints such as untimely sowing and the practice of broadcasting seeds, leading to poor plant stand establishment. Addressing these issues requires tailored agronomic practices and innovative solutions to enhance the resilience of oilseed crops to adverse agro-ecological conditions, thereby promoting sustainable production and food security.

Choice of Varieties

The choice of varieties plays a crucial role in determining the success of oilseed cultivation, yet it often presents challenges due to certain prevailing practices. Many farmers opt to cultivate old varieties, local non-recommended varieties, or landraces, often out of habit or lack of access to improved varieties. Additionally, there is a tendency to sow varieties that are not recommended for a particular zone or region, leading to suboptimal yields and susceptibility to various environmental stresses. Untimely sowing of varieties further exacerbates these challenges, as it disrupts the crop's growth cycle and reduces its ability to withstand adverse conditions. Addressing these issues requires increased awareness and access to high-quality, region-specific varieties, along with support mechanisms to encourage farmers to adopt improved cultivation practices aligned with agro-climatic conditions and crop requirements.

3. Policies and infrastructure

The oilseed sector in India faces significant challenges stemming from inadequacies in policies and infrastructure. Access to quality seeds of the latest released varieties remains a persistent issue, hindering farmers' ability to adopt improved cultivars and enhance productivity. Moreover, the sale of crop produce below the Minimum Support Price (MSP) undermines the economic viability of oilseed cultivation, discouraging farmers and impeding sector growth. Inadequate availability of weedicides and limited choices of insecticides further exacerbate pest management challenges, compounded by the prohibition of genetically modified (GM) technologies for weed and insect control. Furthermore, oilseeds receive low priority and insufficient funding for research and development initiatives, particularly evident in the weak regional research infrastructure in Eastern and Northeastern zones of India. This disparity is reflected in the scarcity of oil mills, particularly for mustard, in these regions, impeding value

addition and downstream processing capabilities. Addressing these policy and infrastructure deficiencies is crucial to unlocking the full potential of India's oilseed sector, fostering innovation, enhancing productivity, and promoting sustainable growth across diverse agro-climatic regions.

Major components of Oilseed crops

Several key components constitute the framework of oilseed crop cultivation, each playing a vital role in ensuring successful production and maximizing yields. Beginning with the purchase of breeder seed, which forms the foundation of varietal development, the process progresses to the production of certified or foundation seed to maintain quality standards. Distribution networks then disseminate certified seeds to farmers, facilitating access to high-quality planting materials. Block demonstrations and seed minikits serve as valuable extension tools, showcasing best practices and enabling hands-on learning for farmers. Micro-irrigation systems, including water-carrying pipes, contribute to efficient water management, crucial for oilseed crop growth. Plant protection equipment and chemicals are essential for pest and disease management, safeguarding crop health and productivity. Soil ameliorants and bio-fertilizers enhance soil fertility and nutrient uptake, supporting robust crop growth. Farm implements aid in various cultivation tasks, ensuring efficiency and precision in farming operations. Training programs for extension officers, dealers, and farmers impart knowledge and skills essential for effective crop management practices. Additionally, cluster frontline demonstrations conducted through Krishi Vigyan Kendras (KVKs) serve as platforms for showcasing innovative technologies and practices at the grassroots level, fostering adoption and dissemination within farming communities. Collectively, these components form a comprehensive framework for promoting sustainable oilseed cultivation and enhancing agricultural productivity across diverse landscapes.

Way Forward

For enhancing productivity and bolstering production in oilseeds, a multifaceted approach encompassing various strategies is imperative. Embracing a cropping system approach, wherein oilseed cultivation is integrated into diverse cropping systems, can optimize resource utilization and enhance overall productivity. This should be complemented by the strategic replacement of older varieties with high-yielding and resilient cultivars, tailored to local agro-climatic conditions. Effective weed management practices, including the adoption of innovative techniques and herbicides, are crucial for minimizing yield losses and maximizing crop performance. Similarly, optimizing nutrition management through balanced fertilization and soil health enhancement measures can bolster crop vigor and resilience to stress. Rigorous pest and disease management strategies, incorporating both preventive and curative measures, are essential to safeguarding crop health and minimizing losses. The adoption of farm mechanization technologies tailored to oilseed cultivation can enhance efficiency and precision in farming operations, thereby optimizing input utilization and reducing labor intensity. Furthermore, attention to post-harvest handling and storage practices is essential to preserving crop quality and minimizing losses. By prioritizing these key pillars—cropping system approach, variety replacement, weed and nutrition management, pest and disease control, farm mechanization, and post-harvest strategies—the oilseed sector can realize its full potential, achieving sustained productivity gains and contributing to food security and rural livelihoods.

Options to improve production

To enhance oilseed production, several options can be pursued, each aimed at maximizing cultivation areas and improving productivity. One strategy involves expanding the area under oilseed crops, achieved through various means such as increasing protective irrigation to enable cultivation in previously unsuitable areas and diversifying low-yielding cereal crops through intercropping. Another approach involves targeting rice fallow areas (TRFA), with plans to cover an additional 4.5 million hectares under pulses and oilseeds across six eastern states, thereby optimizing land utilization and bolstering production. Additionally, efforts to increase productivity and improve performance stability include replacing older varieties with higher-yielding ones and promoting the adoption of new varieties through seed minikits and frontline demonstrations (FLDs). Collaboration with agricultural research institutions such as ICAR-KVKs and State Agricultural Universities (SAUs) facilitates technology transfer and adoption at the grassroots level. Targeting specific challenges, such as wheat blast in areas like West Bengal, involves redirecting wheat cultivation areas to oilseed crops across five districts, ensuring efficient land use and mitigating disease risks. By implementing these diverse strategies, the oilseed sector can harness its full potential, optimizing production levels and contributing significantly to agricultural sustainability and food security.

Extending to non-traditional areas & non-traditional seasons

Expanding oilseed cultivation into non-traditional areas and seasons presents a promising avenue to enhance production and optimize resource utilization. Initiatives such as spring sunflower cultivation in the Indo-Gangetic Plain (IGP) region and Rabi sunflower cultivation in states like West Bengal and Odisha demonstrate the potential for diversifying cropping patterns. Similarly, spring groundnut cultivation in Uttar Pradesh and safflower cultivation in Chhattisgarh, Gujarat, and Madhya Pradesh during the Rabi season showcase efforts to tap into unexplored regions and seasons for oilseed production. Additionally, mustard cultivation in Andhra Pradesh, Telangana, and Karnataka, along with soybean cultivation in Telangana, reflects the expanding geographical footprint of oilseed crops. Rabi castor cultivation in Telangana, Karnataka, and Tamil Nadu, as well as castor cultivation in Haryana, further illustrate the opportunities for extending oilseed cultivation beyond traditional boundaries. By leveraging these non-traditional areas and seasons, the oilseed sector can diversify production, mitigate risks associated with climate variability, and contribute to sustainable agricultural development across different regions of the country. Expanding oilseed cultivation through intercropping offers the potential to cultivate an additional 2 million hectares, while also promoting oilseed cultivation in Southern, Eastern, and Northeastern states where it is traditionally less common.

Way forward interventions

The way forward for interventions in the oilseed sector encompasses multifaceted strategies aimed at enhancing productivity, promoting awareness, and ensuring sustainable development. As part of the National Food Security Mission (NFSM) for Oilseeds and Oil Palm, the establishment of 36 seed hubs by State Agricultural Universities (SAUs), Indian Council of Agricultural Research (ICAR), and Krishi Vigyan Kendras (KVKs) marks a significant step towards creating a robust seed supply chain for oilseed crops. Furthermore, the implementation of small oil extraction units at the Panchayat level through Farmer Producer Organizations (FPOs), cooperatives, and self-help groups (SHGs) under the National Mission on Oilseeds and

Oil Palm (NMOOP) aims to enhance value addition and income generation opportunities at the grassroots level.

In tandem with these efforts, a mass awareness campaign on vegetable oil consumption is imperative to address the disparity between recommended and actual consumption levels in India. With the average consumption exceeding 18.01 kg per annum per person, initiatives focusing on educating consumers through various media platforms, mobile applications, and nutritional camps can promote healthier dietary habits and reduce oil wastage.

Improving productivity remains a central goal, necessitating the development of high-yielding varieties with enhanced stress tolerance and hybrid vigor. This entails the creation of heterotic gene pools, infusion of variability in active germplasm, and exploration of novel heterotic Quantitative Trait Loci (QTLs) from alien or related species. Additionally, efforts to optimize plant ideotypes for improved Harvest Index (HI) and Biomass, alongside the utilization of wide relatives for novel variability, hold promise for advancing breeding programs. Furthermore, enhancing stability of performance under abiotic stresses such as drought, heat, salinity, and frost requires a multifaceted approach focusing on input use efficiency, development of stress-tolerant varieties, and exploration of genetic diversity within related species. By integrating these interventions, the oilseed sector can foster resilience, sustainability, and productivity gains, contributing to food security and economic prosperity across diverse agro-ecological zones.

Incorporation of Disease Resistance

The incorporation of disease resistance into oilseed crops represents a critical strategy for mitigating yield losses and ensuring sustainable production. This involves a multifaceted approach encompassing various aspects of genetic improvement and breeding techniques. Firstly, identifying sources of resistance, understanding the inheritance patterns of resistance traits, and elucidating the underlying genes are essential steps in developing disease-resistant cultivars. Delineating pathotypes or races of pathogens is crucial for identifying specific resistance genes (R genes) effective against particular strains. Incorporating R genes or Quantitative Trait Loci (QTLs) from diverse sources, including different species, facilitates the transfer of resistance traits between genotypes. The sequencing of genomes in key oilseed species such as B. juncea, B. napus, B. rapa, and B. oleracea has enabled the discovery of novel R genes, further enhancing breeding efforts. Hybridizing cultivars possessing race-specific and nonspecific resistance genes allows for the development of cultivars with broad-spectrum resistance. Additionally, pyramiding multiple R genes or QTLs into a single genetic background enhances the durability and efficacy of disease resistance in cultivars. Through these approaches, breeders can develop multiple disease-resistant genotypes of Indian mustard, contributing to the sustainability and resilience of oilseed crop production.

Adoption of Novel Technologies

The adoption of novel technologies is instrumental in addressing key challenges in oilseed crop management, particularly in combating threats such as Orobanche infestation and insect pests. For managing Orobanche, the deployment of non-GM Clearfield herbicide tolerance technology developed by BASF offers a promising avenue for controlling this parasitic weed effectively. Screening the entire germplasm set available with the National Bureau of Plant Genetic

Resources (NBPGR) is essential to identify potential sources of resistance and develop resistant cultivars. In managing insect pests, innovative tools such as CRISPR/Cas9 technology hold immense potential for targeted resistance breeding and quality improvement in oilseed crops. Additionally, exploring genetically modified (GM) options for insect-pest management presents another avenue for enhancing pest resistance and minimizing crop losses. By leveraging these advanced technologies, oilseed producers can improve crop resilience, optimize resource utilization, and ensure sustainable production practices in the face of evolving agricultural challenges.

Agronomic Interventions

Agronomic interventions are vital for optimizing oilseed crop production and ensuring sustainable farming practices. Timely sowing of recommended or notified varieties, coupled with appropriate input utilization, forms the foundation of successful cultivation. Mechanical interventions for tillage, especially in Eastern regions with rice fallow areas and Northeastern states, are essential to prepare the soil adequately for planting. Sowing with seed drills facilitates uniform seed placement, ensuring an adequate plant stand while also enabling seed-saving practices. Effective weed, disease, and insect pest management are crucial for safeguarding crop health and maximizing yields. Identifying and recommending suitable weedicides, fungicides, and pesticides play a pivotal role in combatting these challenges. Moreover, strengthening irrigation facilities in rainfed areas with low precipitation levels is imperative to mitigate moisture stress and ensure consistent crop growth. By implementing these agronomic interventions, farmers can enhance productivity, optimize resource utilization, and foster sustainable oilseed crop production in diverse agro-climatic conditions.

Table 6. Major Constraints vis-a-vis Interventions in Oilseed crops

Constraint/Critical Gap	Intervention taken up
Lack of availability of quality seed	Strengthening of seed chain and supply of certified seed of recommended varieties under subsidy Breeder seed → Foundation seed → Certified seed Foundation seed → Certified seed
Non-adoption of seed treatment	Seed treatment with Trichoderma viride against seed and Soil borne diseases
Imbalance in fertilizer application	Soil test based fertilizer application
Non-application of Gypsum	Distribution of Gypsum on 100% subsidy under INM scheme (SDP) to improve quality & productivity
Micro-nutrient deficiency	Supply of Zinc Sulphate, Ferrous Sulphate & Boron on subsidy under INM Scheme
Non Adoption of IPM Practices	Capacity building; Deep summer ploughing; Growing of resistant var.; Early sowing escapes the damage caused by leaf miner & white grub
Dry spells in critical stages of the crops	Zeba: An organic super absorbent (for climate resilience)
Vagaries of monsoons (sporadic, erratic & untimely	Advance contingency plan; Drought proofing measures

rains)	

Breakthrough

The year 1986 marked a pivotal moment in India's quest for self-reliance in oilseed production, as the establishment of the Technology Mission on Oilseeds (TMO) ushered in a transformative era. What ensued was a remarkable trajectory of progress, as oilseed production surged from 108.3 lakh tonnes in 1985-86 to a staggering 361.0 lakh tonnes by 2020-21. This phenomenal growth was underpinned by concerted efforts to increase both the area under cultivation and productivity levels. From a modest 570 kg/ha in 1985-86, productivity soared to record highs of 1284 kg/ha in 2017-18 and 1254 kg/ha in 2020-21. Central to this success story were ground breaking initiatives encompassing the introduction of cutting-edge technologies, enhanced inputs, extensive marketing networks, and post-harvest innovations, all facilitated by seamless coordination among various governmental bodies. Moreover, favorable weather conditions coupled with unwavering support from the Government of India further fortified the nation's oilseed programs and policies. Key programs such as the National Food Security Mission (NFSM) for Oilseeds, Technology Refinement and Focused Adoption (TRFA), establishment of seed hubs, and cluster demonstrations of improved technologies played instrumental roles in propelling this breakthrough. Today, as India celebrates its highest-ever production of 361.01 lakh tonnes in 2020-21, it stands as a testament to the power of innovation, collaboration, and steadfast determination in achieving agricultural excellence. Use of New Breeding Techniques (Fast track breeding, genomic selections, genome editing, cis-transgenesis, gene silencing, gene introgression) and exploitation of heterosis; Pre-breeding for trait discovery

Table 7. Advancing the productivity

Crop	India*	World	Country with highest productivity**	Genetic potential of newly bred Indian varieties
Groundnut	1720	1699	4426 (USA)	3500-4000
Rapeseed-Mustard	1719	2039	3303 (Germany)	3000-3500
Soybean	1040	2784	3378 (USA)	2200-2800
Sunflower	927	1802	4378 (China)	2000-2500
Safflower	694	799	1721 (Mexico)	1000-1200
Linseed	706	951	1432 (Canada)	1200-1600
Sesame	454	487	1618 (China)	1000-1500
Oilpalm fruit	12380	14561	18534 (Malaysia)	-

*DA&FW TE 2021-22; **FAOSTAT , 2021 from the countries with >80% global contribution

Varietal Improvement in Oilseeds (2014-2022)

During the period of 2014-2022, significant strides were made in varietal improvement in oilseeds, marking a notable chapter in India's agricultural innovation. A total of 319 climate-resilient oilseed varieties were developed, showcasing the nation's commitment to enhancing agricultural sustainability in the face of changing environmental conditions. Among these advancements, ground breaking achievements such as the introduction of high oleic groundnut varieties Girnar 4 and Girnar 5, boasting an impressive oleic content of approximately 78%, emerged as game-changers in the industry. Additionally, the release of ISF 1, the first high oleic safflower variety, represented a pioneering breakthrough. Noteworthy contributions also

included the development of Indian mustard varieties PDZ1 and RLC 2, characterized by their double-zero quality attributes—containing less than 2% erucic acid and less than 30 ppm glucosinolates—ensuring superior nutritional value and market competitiveness. Furthermore, the advent of NRC127, the first Kunitz Trypsin Inhibitor (KTI) free soybean variety derived through Marker-Assisted Selection (MAS), marked a significant milestone in addressing allergenic concerns while maintaining crop productivity. Other notable achievements encompassed the release of Shubhra, the first sesame variety exhibiting tolerance to delayed shattering, and the introduction of NRCHB-506, India's maiden mustard hybrid, heralding a new era of hybridization in oilseed cultivation. These advancements not only underscore India's prowess in agricultural research and development but also hold immense promise in bolstering food security and rural livelihoods across the nation.

Closing the Yield Gaps

Closing the yield gaps in edible oilseed production presents a pivotal opportunity for enhancing agricultural productivity and addressing food security challenges. Through the widespread adoption of high-yielding varieties (HYVs) and tailored agronomic practices, coupled with location-specific plant protection technologies, substantial strides can be made in bridging these gaps. Currently, the average yield gap in edible oilseeds stands at approximately 60%, a disparity that holds significant implications for both yield potential and overall production capacity. However, with concerted efforts and focused interventions, it is projected that this gap can be reduced to 20% within the next five years. Such a reduction has the potential to unlock a remarkable surge in production, estimated at 13-14 million tons of additional edible oilseeds or an extra 3-4 million tons of edible oil, all without the need for expanding cultivation areas. This transformative shift not only promises to bolster domestic supply chains but also holds the key to mitigating dependency on imports while fortifying the resilience of India's agricultural landscape. By closing the yield gaps, India can pave the way towards a more sustainable and self-reliant future in edible oil production, ensuring greater economic prosperity and food sovereignty for generations to come.

Table 8. Exploring newer niches for production.

Crop	Area (mha)			States/Regions
	2024-25	2029-30	2034-35	
Groundnut	0.28	0.30	0.10	Rice- and potato- fallows in West Bengal; Potato-fallows in Deesa-Gujarat and Western UP; rice fallows in Odisha and Jharkhand; NEH region; intercrops with sugarcane in UP, Odisha and Karnataka, etc.
Rapeseed-Mustard	0.11	0.08	0.10	NEH region, part of Telangana, Andhra Pradesh, and Karnataka under conserved moisture and assured irrigated conditions
Soybean	0.64	0.56	0.53	Andhra Pradesh, Arunachal Pradesh, HP, Jharkhand, UP, Uttarakhand, West Bengal, Punjab, Haryana and Odisha
Sesame	0.065	0.02	0.01	Parts of Bihar, Haryana, Punjab, Assam, and

				NEH region
Sunflower	0.10	0.10	0.20	Parts of Punjab, Haryana, Bihar, West Bengal, NEH region, Telangana, UP, and Madhya Pradesh
Safflower	0.012	0.012	0.02	Parts of Bihar, Haryana, Punjab, Assam, and NEH region
Total	1.207	1.072	0.96	

Adopting higher import duty regime

Adopting a higher import duty regime on edible oils is a critical policy measure aimed at bolstering domestic production and safeguarding the interests of oilseed farmers in India. With import duties set at 27.5% on crude palm oil, 35% on other crude edible oils, and 45% on refined edible oils, recent measures have seen refined palm oil being categorized under the 'Restricted Category.' Observations reveal that a low import duty regime for vegetable oil has adversely affected the domestic production of oilseeds, leading to a noticeable shift towards non-oil crops due to the allure of higher price realization. The government of India's fluctuating stance on import duties, oscillating between low and high regimes over the years, has had a significant impact on the area and production of edible oilseeds during corresponding periods. Notably, high import duty regimes from 2000 to 2008 were associated with increased domestic production, emphasizing the pivotal role of import duties in shaping the dynamics of the oilseed sector. Embracing a higher import duty regime underscores the government's commitment to supporting domestic oilseed cultivation, promoting self-sufficiency, and safeguarding the interests of farmers amidst global market fluctuations.

Inviting cooperatives and corporates

Encouraging the involvement of cooperatives and corporates is instrumental in revitalizing the oilseed sector and fostering sustainable growth. Establishing production and processing hubs can streamline operations and optimize resource utilization. Delineating oilseed crops' ecological zones in major oilseed-growing states, such as Gujarat, Rajasthan, Karnataka, Telangana, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Tamil Nadu, can unlock the full potential of these regions for enhanced production. Collaborative efforts between public and private sectors, particularly through Public-Private Partnership (PPP) mode, can facilitate the establishment of oil mills, solvent extraction units, and other processing facilities in non-traditional areas. Offering soft loans to entrepreneurs for setting up factories manufacturing farm implements encourages mechanization and efficiency in oilseed cultivation. Providing tax holidays and minimizing freight costs for transportation incentivizes investment in processing units and infrastructure. Additionally, fostering the formation of Self-Help Groups (SHGs) and Farmer Producer Organizations (FPOs) promotes value addition and marketing of oilseed-derived products. Embracing innovative institutional models of processing and marketing, akin to successful examples like Amul, Parag, Dhara, and Saffola, can further drive innovation and competitiveness in the oilseed industry, ultimately contributing to economic growth and rural development.

Self Sufficiency

The National Mission on Edible Oils, with a particular focus on Oil Palm (NMEO-OP), has set ambitious targets for enhancing self-sufficiency in edible oil production by 2026. These targets

include expanding the area under oil palm cultivation from 3.5 to 10.00 lakh hectares, increasing the fruiting area from 1.9 to 5.31 lakh hectares, and boosting crude palm oil production from 2.79 to 11.20 lakh tonnes. Looking further ahead, by 2030, the broader National Mission on Edible Oils (NMEO) aims to elevate overall oilseed production from 36.10 to 54.10 million tonnes, with a corresponding increase in productivity from 1254 to 1676 kilograms per hectare. This concerted effort is projected to raise edible oil production from 12.14 to 18.00 million tonnes, while simultaneously reducing import dependence to 40%. These milestones underscore the government's commitment to achieving self-sufficiency in edible oil production, thereby enhancing food security, promoting agricultural sustainability, and reducing reliance on imports.

Prospects of oilseed Production

The prospects of oilseed production hold significant promise for enhancing agricultural sustainability and ensuring food security. To capitalize on these prospects, it is essential to prioritize several key measures. Ensuring sufficient availability of breeder seed is paramount to boost seed production and Seed Replacement Rates (SRR), thus facilitating expanded cultivation. Maintaining genetic purity is crucial for enhancing productivity and reducing seed production costs, underscoring the importance of genetic integrity throughout the production chain. Moreover, sustaining the seed production chain is vital for covering extensive areas under quality seed, necessitating incentives for breeder seed purchase and the production of foundation and certified seed. Rigorous adherence to seed rolling plans, facilitated through Memorandums of Understanding (MOUs) with states, Seed Supply Corporations (SSCs), National Seed Corporation (NSC), and other seed-producing agencies, ensures timely and adequate seed availability as per the planned schedule. Addressing skewed SRR and low Varietal Replacement Rates (VRR) emerges as pivotal factors in elevating oilseed productivity levels. Notably, SRR exhibits a robust positive correlation with crop productivity, highlighting the significance of concerted efforts to enhance seed replacement rates and drive productivity gains in the oilseed sector. By implementing these strategic interventions, stakeholders can harness the full potential of oilseed production, contributing to agricultural resilience and fostering sustainable development.

Strategy for increasing availability of quality seed

Enhancing the availability of quality seed of improved varieties and hybrids at the right time and affordable prices requires strategic deployment of suitable models. Participatory seed production, which involves farmers in the seed production process, can play a crucial role in ensuring access to quality seed. Additionally, initiatives such as the Seed Village Scheme and Community Seed Banks empower communities to manage and distribute seeds locally, enhancing accessibility and affordability. Collaborations with the private sector, Self-Help Groups (SHGs), Non-Governmental Organizations (NGOs), and community-based organizations further expand distribution networks and facilitate outreach to remote areas. By leveraging these diverse models and partnerships, stakeholders can effectively address the challenge of seed availability, ensuring farmers have access to high-quality seeds of improved varieties and hybrids, thereby contributing to increased productivity and agricultural sustainability.

Path Ahead Towards Self-Sufficiency of Oilseeds

Moving towards self-sufficiency in oilseeds demands a multifaceted approach encompassing several strategic interventions. Firstly, there is a critical need for the expansion of the area under hybrids, which offer significantly higher yields compared to Open-Pollinated Varieties (OPVs). This can be achieved through the promotion of CMS-based hybrids in crops like sunflower, castor, Indian mustard, and safflower, among others. Secondly, expanding the total area under oilseeds is imperative, with opportunities for utilizing rice fallow lands in eastern India for cultivating linseed, safflower, and rapeseed. Additionally, intercropping and sequential cropping practices such as soybean-wheat rotations in North India and soybean-pigeonpea intercropping in South India need to be encouraged. Furthermore, innovative approaches like rapeseed and mustard intercropping with autumn-planted sugarcane in North India can optimize land utilization. Ensuring crop insurance and guaranteed returns on investment for oilseed production are essential to mitigate risks and incentivize farmers. The formulation of a clear-cut policy on the use of genetically modified (GM) crops is imperative, given the significant reliance on imported edible oils. Lastly, popularizing new improved cultivars through the distribution of mini-kits can accelerate the adoption of high-yielding varieties among farmers, paving the way for enhanced oilseed production and reduced import dependency. By embracing these strategies, the path towards self-sufficiency in oilseeds can be effectively navigated, ensuring food security and economic prosperity for the nation.

Conclusions

The current scenario regarding oilseeds in India reveals a stark deficit in the balance between demand and supply, exceeding 50 million tonnes, excluding the imported palm oil. To address this deficit and achieve self-sufficiency, India must embark on a path akin to a Second Yellow Revolution. This can be realized through either a technological breakthrough similar to BT Cotton or a significant expansion in the area under oilseeds, coupled with high-yield varieties. Furthermore, the expansion of oil palm cultivation, particularly in South India, offers promising prospects due to its superior yield potential compared to traditional oilseed field crops. Key interventions, including breakthroughs in the production and distribution of quality seeds, alongside the implementation of Minimum Support Prices (MSP) for oilseeds and ensuring timely access to quality inputs, are crucial for propelling the oilseed sector towards self-sufficiency. By addressing these challenges and implementing strategic interventions, India can chart a course towards a more resilient and prosperous oilseed industry, contributing to national food security and economic growth.

Suggested readings

DK Yadava, HK Dikshit, GP Mishra, S Tripathi (2023). Fundamentals of Field Crop Breeding. DOI https://doi.org/10.1007/978-981-16-9257-4, ISBN978-981-16-9258-1

Radhakrishnan, T., Kona, P., Ajay, B.C., Kumar, N. (2022). Groundnut Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore. https://doi.org/10.1007/978-981-16-9257-4_16

Yadava, D.K., Yashpal, Saini, N., Nanjundan, J., Vasudev, S. (2022). Brassica Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore. https://doi.org/10.1007/978-981-16-9257-4_15

Rani, A., Kumar, V. (2022). Soybean Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore. https://doi.org/10.1007/978-981-16-9257-4_17

Meena, H.P., Sujatha, M. (2022). Sunflower Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore. https://doi.org/10.1007/978-981-16-9257-4_19

Senthilvel, S., Manjunatha, T., Lavanya, C. (2022). Castor Breeding. In: Yadava, D.K., Dikshit, H.K., Mishra, G.P., Tripathi, S. (eds) Fundamentals of Field Crop Breeding. Springer, Singapore. https://doi.org/10.1007/978-981-16-9257-4_18

*****

Seed Sampling: Principles and Procedures

M. P. Yadav
Seed Technologist, National Seed Research & Training Centre, Varanasi

Seed sampling is the process of obtaining the representative portions of small quantities of the seed from the seed lot. The process itself is a highly technical and it is the pre-requisite of seed testing. The analysis results obtained on the sample tested in the seed testing laboratory may cause the rejection of the seed lot for distribution or further multiplication, certification or may serve as evidence in the Court of Law against the seller of faulty seeds. It is neither physically possible nor practicable to test the entire quantity of the seed lot. Accordingly it is essential that the sample drawn from the seed lot must be representative to avoid problems in seed certification and seed law enforcement. It is customary that the analysis results on the sample tested in the seed testing laboratory should reflect the quality of the whole lot from where the sample was drawn.

Principles of Sampling:

Samples are derived from different portions of a seed lot and mixed to obtain a sample of required quantity representing the seed lot in true sense. From this composite sample, small portion of required quantity is obtained in such a way that even after reduction, it represents the seed lot. In each and every stage thorough mixing and dividing is necessary.

Seed Lot:

A seed lot is a specified quantity of the seed of one cultivar, of known origin and history and controlled under one reference number (lot number). It is an uniformly blended quantity of seed either in bag or in bulk.

Equipment and Materials: Trier, plastic tubs, bags, balance, seed divider, sticker and labels.
Trier: It is required to draw the primary sample from the seed lot stored in bags or containers. Two types of triers are required for sampling *Stick and Nobbe trier.*

Seed divider:

It is equipment used for getting desired quantity of true to the type sample for submission in laboratory for individual test. Three types of divider are used in seed testing Boerner *type divider* (conical divider), *Soil type divider* and *Gamet type divider* (centrifugal divider).

Sampling in processing plant

1) **Primary sample:**

It is a small quantity of seed taken from one point of the processed lot. The seed lot is arranged to approach conveniently up to individual container. Primary samples are drawn from different portions and depth by inserting the stick Trier with the closed slot diagonally in the seed bag or container up to desirable depth with minimum damage to seed. The flow of seed is facilitated in the tube by opening and closing of the slot. Finally, the trier is withdrawn with closed slot and collected sample is transferred to a container.

Stick Trier is inserted into a bag up to a desirable depth at an angle of 30 degree with the hole present at the pointed end facing downwards. The spear is withdrawn gently, so that, equal quantity of seeds enter into the hole from centre to the side of the bag. The point of insertion is closed with the help of a sticker or by running across the trier on the hole a couple of times in opposite direction. Minimum number of primary samples should be taken

as per Table 1. and 2. The quantity of seed drawn in one primary sample depends on the sampling intensity, size of submitted sample and seed lot size of crop.

2) **Composite sample:** Primary samples drawn from different places of a lot are mixed and the mixture is known as composite sample. The size of composite sample should be 10 times more than the required submitted sample.

3) **Submitted sample**: The required quantity of seed, which is sent to seed testing laboratory, is known as submitted sample. The weight of the submitted sample varies accordingly to the kind of seed or the kind of test required. (Table 1 and 2). To prepare a submitted sample, the composite sample is mixed thoroughly and reduced up to required quantity with the help of seed divider or by repeated halving method.

Category of seed sample:

Mainly three categories of samples are received in the seed testing laboratory based on their usages. Viz.

a) Service samples
b) Certification samples
c) Enforcement/legal/official samples

Service samples:

These are the samples drawn from the farmer stored stock / dealers by extension workers or by the dealer/farmers themselves to know the quality of the seed for further immediate use. The result obtained on these samples is generally utilized for sowing or labeling purpose. The sample should contain the necessary information for documentation (sample slip). Non notified laboratories can also test these categories of seed samples.

Certification sample:

The samples drawn submitted to the seed testing laboratory by the authorized official from seed certification agency for certification purpose. Such seeds are tested in the seed testing laboratory to know whether they confirmed to the seed certification standard prescribed. Only notified seed testing laboratories are authorized to test the certification samples.

Seed law enforcement sample:

For seed quality regulation at distribution and marketing level these sample are drawn from sale/stock point by the notified seed inspectors in their respective jurisdictions as per the provisions of the section 14 (1) a, b Seeds Act 1966. These samples are also know as quality control samples and are tested only in notified: Seed testing laboratories. These samples are tested by the authorized or notified seed analyst as per the procedure laid down in Seeds Act 1966 and Seed Rules 1968.

Separate sample for determination moisture:

The seeds are hygroscopic in nature and tend to absorb atmospheric moisture when exposed. Therefore when the seed sample is to be taken for moisture content a separate seed sample of 100 gram (for species that require grounding) and 50 gram (for other species) in a polythene bag (700 gauge)/ moisture proof bag is to be apportioned, tightly secured and be submitted along with the submitted sample bag.

Sampling situations:

Seed sample are required to be drawn before or during processing and after bagging or packing operations. Seed may be stored in the form of heaps, in the storage bins/gunny bags / cloth bags, paper packets/pouches or moisture impervious containers such as laminated aluminum foils, sealed tins etc.

General principles of sampling:

1. Sampling should be carried out only by persons trained and experienced in seed sampling.
2. The seed lots shall be so arranged that each individual container or part of the lot is conveniently accessible. Upon request by the sampler, the owner shall provide full information regarding the bulking and mixing of the lot. Sampling may be refused when there is definite evidence of heterogeneity.
3. The size of the seed lot should also not exceed to maximum seed lot size prescribed in the rules, subject to a tolerance of 5%
4. Seed sampler may request the producer to get some bags emptied or partially emptied to facilitate sampling. The bags may then be refilled. This may be necessary since it is impossible to obtain sample deeper than 400 mm, i.e. from the lower layer in bags and bins.
5. The sampler should determine that all seed bags sampled are identified as belonging to a single lot, either by a label or stencil mark on the bag
6. The sampler must sample the minimum requisite number of bags from the seed lot in accordance with the sampling intensity.
7. Care must be exercised in reducing composite samples. Careless splitting of the sample cannot be expected to produce two similar portions.
8. Any seed know to have been treated with a poisonous fungicide should be identified so that the person who subsequently may handle the sample will be informed of the potential hazard.
9. While taking samples from machine sewed cotton bags, a few stitches at one of the top corners can be broken and then this break can be closed with a hand stapling device, after the contents of the bag have been sampled.
10. The sample drawn should not be less than the weight of submitted sample prescribed in the rules.

Table 1: Sampling intensity for a seed lot stored in container

Number of container	Sampling intensity
up to 5	Each container, at least 5 Primary samples
6 - 30	Sample 5 Containers or at least one in every three containers, Whichever is the greater
31 - 400	Sample 10 Containers or at least one in every 5 containers, Whichever is the greater
401 or More containers	Sample 80 Containers or at least one in every 7 containers, Whichever is the greater

Table 2: Sampling intensity for seed stored as bulk

Lot size (Kg)	Sampling intensity
up to 500	At least 5 primary Samples.
501 - 3,000	One primary sample for each 300kg, but not less

	than 5 primary samples.
3,001-20,000	One primary sample for each 500 kg, but not less than 10 primary samples.
20,001 and Above	One primary sample for each 700 kg, but not less than 40 primary samples.

Dispatch of submitted sample:

Sample should be dispatched to the seed testing lab as early as possible providing all the details like date of sampling, number of processing plant, crop, variety, class of seed, lot number, lot size / Quantity of seed in lot (kg) Senders Name and Address etc. and Tests required: 1) Purity (2) Germination (3) Moisture, apart from this sample, two reference samples are also prepared by the same method. One reference sample is stored by the office and second by producer. Office sample of seed lot passed in seed testing is stored for two years.

Sampling in seed testing lab:

The submitted sample received in seed testing lab is registered and designated by a code number. Submitted sample is tested for determination of seeds of other crop, weed, objectionable weeds, objectionable diseases and other distinguishing varieties by number. Three working samples of the submitted sample, which passes the seed certification standard by number are prepared. Each working sample consists of at least 2500 seeds (Table 3).

Preparation of working sample:

Mechanical divider: As described for preparation of submitted sample.

Repeated halving method: As described for preparation of submitted sample or the seed is poured on a clean smooth surface and shaped as a mound after thorough mixing. Mound is divided into two halves, each half is again halved, each portion is again halved giving total 8 portions. Alternate portions are combined i.e. 1st and 3rd of first row and 2nd and 4th of second row. The remaining portion is kept in a pan and the process is repeated to obtain required size of the working sample.

Random cup method: Six to eight small cups of equal size and shape are arranged at random on a tray. The seed is poured uniformly over the tray. The seeds, which fall into the cups, are collected as working sample. This method is useful for the crops with small seed size but not for chaff and round seeds.

Spoon method:

The seeds are poured evenly in one direction over the tray. If required, seed can be poured second time in opposite direction. Shaking of the tray is avoided, small quantity of seeds are collected with the help of spatula from minimum 5 random places to make a working sample of required quantity. The working sample is stored in paper bag marked with code number, name of the crop and purpose.

Table 3: Size of submitted and working samples required for different crops

Crop	**Submitted sample (g)**	***Working sample (g)***
FIELD AND FODDER CROPS		
Wheat, oat, triticale	1000	0120
Sorghum	0900	0090

Pearl millet	0950	0015
Italian millet	0090	0009
Kodo millet	0080	0008
Linseed, jute, common millet	0150	0015
Fieldpea, maize	1000	0900
Lentil	0600	0060
Chickpea, groundnut	1000	1000
Pigeonpea	1000	0300
Horse gram, moong bean	1000	0400
Grass pea	1000	0450
Castor, soybean	1000	0500
Rice, rajmash, urid bean	1000	0700
Sunflower	1000	0200
Safflower	0950	0090
Cotton	1000	0350
Gueina grass, Setaria grass	0025	0002
Marvel grass	0030	0003
Brassica juncea, taramira	0040	0004
Lucerne, Indian clover	0050	0005
Egyptian clover, finger millet, buffel grass	0060	0006
VEGETABLE CROPS		
Celery	0025	0001
Chinese cabbage, parsley	0040	0004
Carrot, lettuce	0030	0003
Tomato	0015	0007
Turnip	0070	0007
Onion	0080	0008
Brassica olerecea all varieties	0100	0010
Chilli, egg plantl	0150	0015
Cucumber, musk melon	0150	0070
Spinach	0250	0025
Radish	0300	0030
Pumpkin	0350	0180
Coriander	0400	0040
Fenugreek	0450	0045
Sugar beet	0500	0050
Cluster bean, asparagus	1000	0100
Okra	1000	0140
Water melon, sponge gourd	1000	0250
Ridge gourd	1000	0400
Bitter gourd	1000	0450
Bottle gourd	1000	0500
Indian bean	1000	0600
French bean and all squashes	1000	0700

*****

Determination of Moisture Content of Seed Lots

A. K. Verma
Senior Seed Analyst, NSRTC, Varanasi

Testing moisture content in Seed Sample is very important aspect of Seed Testing. The moisture content of a sample is the loss in weight when it is dried in accordance with the Seed Testing Rules. It is expressed as a percentage of the weight of the original sample. The submitted sample shall be accepted for moisture determination only if it is in intact, moisture - proof container from which as much air as possible has been excluded. The moisture determination of the seed sample must be started at earliest possible after receipt of sample.

Procedures:

Weighing shall be in grams to three decimal places. Seeds of larger size (Table 1.) are ground before drying unless its high oil content makes it difficult. After grinding, the sample is passed through different sizes of sieves (Table 2.). Pre-drying before grinding is required for samples having moisture content more than 17%. After pre-drying, the sub-samples are reweighed in their containers to determine the loss in weight.

I. Low constant temperature oven method:

The working sample must be evenly distributed over the surface of the container. Weigh the container and its cover before and after filling. Place the container rapidly, on top of its cover, in an oven maintained at a temperature of 103 ± 2°C and dry for 17 ± 1 hour. The drying period begins at the time the oven returns to the required temperature. At the end of the prescribed period, cover the container and place it in a desiccators to cool for 30-40 minutes. After cooling, weigh the container with its cover and contents. The relative humidity of the ambient air in the laboratory must be less than 70% at the time of final weighing. ISTA prescribes the low constant temperature oven method, for all tree species. Normally oilseeds are subjected to low constant temperature oven method while cereals and pulses are subjected to high constant temperature oven method.

II. High constant temperature oven method:

The procedure is the same as low constant temperature oven method, except that the oven is maintained at a temperature of 130-133°C, the sample is dried for a period of four hours for tree species and no special requirement pertain to the relative humidity of the ambient air in the laboratory during determination.

The moisture content expressed as a percentage by weight shall be calculated to one decimal place by means of the following formula:

$$(M_2-M_3) \times \frac{100}{M_2 - M_1}$$

Where,

M_1 - is the weight of the container and its cover (in grams),

M_2 - is the weight of the container & its cover (in grams) and its contents before drying and

M_3 - is the weight of the container, cover (in grams) and contents after drying.

If the material is pre-dried, the moisture content is calculated form the results obtained in the first (pre-dried), the second stages of the procedure. If S_1 is the moisture lost in the first stage, and S_2 is the moisture lost in the second stage, each calculated as above and expressed as a percentage, then the original moisture content of the sample calculated as a percentage is

$$S_1 \times S_2$$

$$S_1 + S_2 - \frac{\text{----------}}{100}$$

Table 1. Grinding requirements for Different Crop Seeds:

Crop	Grinding	Mesh size	
Paddy, wheat, maize, sorghum, cotton	Fine	50% ground material is passed through 0.5 mm mesh	10% ground material remain on 1.00 mm mesh
Pea, chickpea, soybean, lathyrus	Coarse	50% ground material is passed through 4 mm mesh	

Table 2 . Pre-drying requirements:

Crop	Moisture content	Temperature required for Drying (in °C)	Duration
Maize	>25%	>0	2 - 5 hrs
Rice	>13%	130	5 - 10 min
Soybean	>10%	130	5 - 10 min

III. Universal moisture meter:

Universal moisture meter is a popular and most dependable instrument for moisture estimation. The following are its essential parts:

1. Compression unit
2. Moisture meter dial
3. Thermometer
4. Compression knob
5. Cups of different volumes

Moisture estimation is made quick by the advent of digital moisture meters. The principle involved is that electrical conductivity of moist material is directly proportionate to the amount of moisture content in it. A representative sample of prescribed weight or volume (Table 3.) is taken and placed in the sample cup. It is fixed in the lower house of compression unit.

Meter is calibrated by pressing the button "CAL" and "BELL" with the help of calibration knob. Sample is compressed as per requirement with the help of compression knob and scale. At required compression the meter dial (M) is read by pressing the knob "Read" and bell. Temperature (T) is observed by the thermometer fixed in between meter dial and compression chamber. The reading M and T are intercepted on the corelator dial (moisture meter dial) by turning the temperature dial. On adjustment of both the reading mark of arrow on the outer reading of temperature dial indicates the moisture percentage. For some crops factor is also considered for estimation of moisture content.

Table 3. Determination of moisture content by universal moisture meter:

Crop	Sample size		Compression	Factor
	Weight (g)	Volume*		
	FIELD AND FODDER CROPS			
Barley	50	B	0.600	
Maize	60	B	0.560	
Oat	30	B	0.400	
Pearl millet	60	B	0.500	

Rice	50	B	0.550	
Sorghum	50	B	0.675	
Wheat	30	A	0.275	Add 1%
Moong and urid		A	0.275	Add 1.5%
Chickpea		C	0.500	Subtract 1%
Horse gram		A	0.275	
Lentil		A	0.250	x 0.7 + 3.5%
Pigeon pea, field pea		C	0.450	
Castor		C	0.500	Multiplied by 0.5
Groundnut	25		0.300	Multiplied by 0.6
Groundnut (kernel)	26		0.450	Multiplied by 0.56
Safflower	15		0.450	Multiplied by 0.66
Sesame			0.550	Subtract 0.5%
Soybean	60	C	0.575	Subtract 2.5%
Sunflower	30	B	0.500	Multiplied by 0.6
Rape seed and mustard			0.450	Multiplied by 0.6
Cotton (linted)	30	C	0.360	Subtract 5%
	VEGETABLES			
Kidney bean	50	B	0.400	
Okra		C	0.425	
Cabbage		A	0.260	Multiplied by 0.6
Cowpea		A	0.325	Multiplied by 0.8
Cucumber		B	0.525	Multiplied by 0.8
Lettuce		B	0.500	Multiplied by 0.9
Onion		A	0.250	Subtract 2.5%
Tomato	25	B	0.250	Multiplied by 0.8
Turnip	25		0.200	Multiplied 0.8
Watermelon		B	0.425	Subtract 3.5%
Coriander		C	0.325	Multiplied by 0.6

* A, B and C - Container size

The moisture content must be reported to the nearest 0.1% in the space provided on the Analysis Certificate. Seed lot with moisture content more than the minimum seed certification standards (Table 4.) are recommended for drying.

Table 4. Minimum seed certification standard for moisture percentage:

Crop	Sample in vapour proof container	Sample not in vapour proof bag
FIELD AND FODDER CROPS		
Castor, mustard, taramira	5	8
Groundnut, niger, sesame	5	9
Cotton	6	10
Rape seed	7	8
Linseed, horse gram, rajmash, safflower, sunflower, jute	7	9
Berseem, lucerne, Indian clover	7	10
Soybean	7	12
Moong, urid, chickpea, field pea, pigeon pea, lentil, lathyrus, kidney bean, rice bean	8	9
Buffel, Dharaf, Dinanath, guinea, marvel, setaria and stylo grass	8	10
Wheat, maize, sorghum, pearl millet, barley, triticale, oat, minor millets, teosinte, forage sorghum	8	12
Rice	8	13
VEGETABLES		
Rat tail radish, radish, turnip	5	6
Cole crops	5	7
All cucurbits	6	7
TPS, brinjal, tomato, chilli, capsicum, onion, fenugreek, lettuce, amaranth, asparagus	6	8
Carrot, celery, parsley	7	8
French bean	7	9
Cowpea, Indian bean, cluster bean, spinach, sugar beat	8	9
Okra	8	10

*****

Quality seed production and overview of soybean crop

Gyan P Mishra
Indian Agricultural Research Institute, New Delhi
gyan.gene@gmail.com

Abstract
Soybean, celebrated for its nutritional richness and diverse industrial applications, is a vital crop globally. Despite its ancient origins in China, soybean cultivation has expanded worldwide, with significant research focused on enhancing productivity and quality. From meticulous land selection to post-harvest processing, every step in soybean production is crucial for ensuring seed quality and crop performance. Challenges such as anti-nutritional factors and poor productivity hinder soybean's full potential. Researchable issues like developing resistant varieties and reducing beany flavors offer promising solutions. Collaborative efforts in innovation and agricultural practices are essential to harness soybean's potential for sustainable production and economic growth. Furthermore, addressing constraints in production and research is imperative to unlock soybean's full nutritional and economic benefits.

Introduction

Soybean, a remarkable crop celebrated for its multifaceted nutritional and industrial significance, stands out as a powerhouse among oilseeds, despite its classification outside the realm of pulse crops. With its seeds boasting approximately 18-22% oil content and a remarkable 40-45% protein composition, soybean emerges as a vital source of sustenance and economic value. Characterized by a modest plant height of around 1 meter (3.3 feet), soybean plants exhibit an exceptional ability to convert atmospheric nitrogen, ranging from 60-100 kg, into a substantial 30-40 kg of nitrogen in the soil, enriching agricultural landscapes. This versatile crop garners widespread acclaim not only for its nutritional prowess but also for its nutraceutical compounds such as isoflavones, tocopherol, and lecithin, making it indispensable in various industries, including food, feed, fuel, cosmetics, pharmaceuticals, and beyond. Soybean oil, renowned for its low saturated fatty acid content, emerges as a prime source of high-quality vegetable protein, catering to diverse dietary needs. Moreover, with its carbohydrate content ranging from 25-35% and virtually devoid of starch, soybean holds promise as a diabetic-friendly food source, further enriched with essential minerals like ascorbic acid, Vitamin E (tocopherol), beta-carotene, and more. Notably, its 0.3% isoflavone composition renders it beneficial for women, aiding in mitigating post-menopausal issues, breast cancer, prostate cancer, among others, while also serving as a lactose-free alternative for the lactose intolerant. Given its myriad benefits and applications, it comes as no surprise that soybean is affectionately hailed by various monikers such as the 'Wonder Crop,' 'Golden Bean,' and 'Miracle Bean,' affirming its status as an agricultural marvel.

Origin and History

The domestication of soybean can be traced back to the eastern half of North China in the 11th century B.C. Over time, it has been known by various names such as beer beans, green beans, sweet beans, and edamame (in Japanese) or mao dou (in Chinese). Initially, soybean

production remained localized in China until the aftermath of the Chinese-Japanese war of 1894-95, after which it began to spread to other regions. Its introduction to India likely occurred from central China, either through the Silk Route or via Assam and Myanmar to Manipur and the Naga Hills. The 1960s saw significant research efforts on soybean, notably by institutions like GBPUAT in Pantnagar and JNKVV in Jabalpur. In 1967, the establishment of the All India Coordinated Research Project (AICRP) on Soybean marked a pivotal moment, with headquarters initially based in New Delhi and later relocated to Pantnagar. By 1987, the project evolved into the National Research Centre (NRC) for Soybean, subsequently upgraded to a Project Directorate. In 2016, another significant milestone was achieved with the Directorate of Soybean Research (DSR) being elevated to the status of the ICAR-Indian Institute of Soybean Research (IISR), signifying the growing importance and recognition of soybean research and development in India.

Fig. 1. Various uses and applications of soybean.

Biology of soybean

Soybean, characterized as a self-pollinated plant, exhibits diverse growth habits including determinate, semi-determinate, and indeterminate forms. Its flowers, typically purple (dominant) or white, emerge in clusters of 3-15 blossoms. Each flower comprises a tubular calyx consisting of 5 sepals, a corolla with 5 petals (including 1 banner, 2 wings, and 2 keels), 1 pistil, 9 fused stamens, and a single separate posterior stamen. Notably, the stigma becomes receptive to pollen approximately 24 hours before anthesis and maintains receptivity for 48 hours after anthesis, facilitating successful pollination. Beneath the soil surface, soybean develops a taproot from which lateral roots emerge, contributing to its robust root system. Moreover, soybean seeds vary in size, ranging from 5 to 55 g per 100 seeds, reflecting the diversity within this agriculturally significant crop.

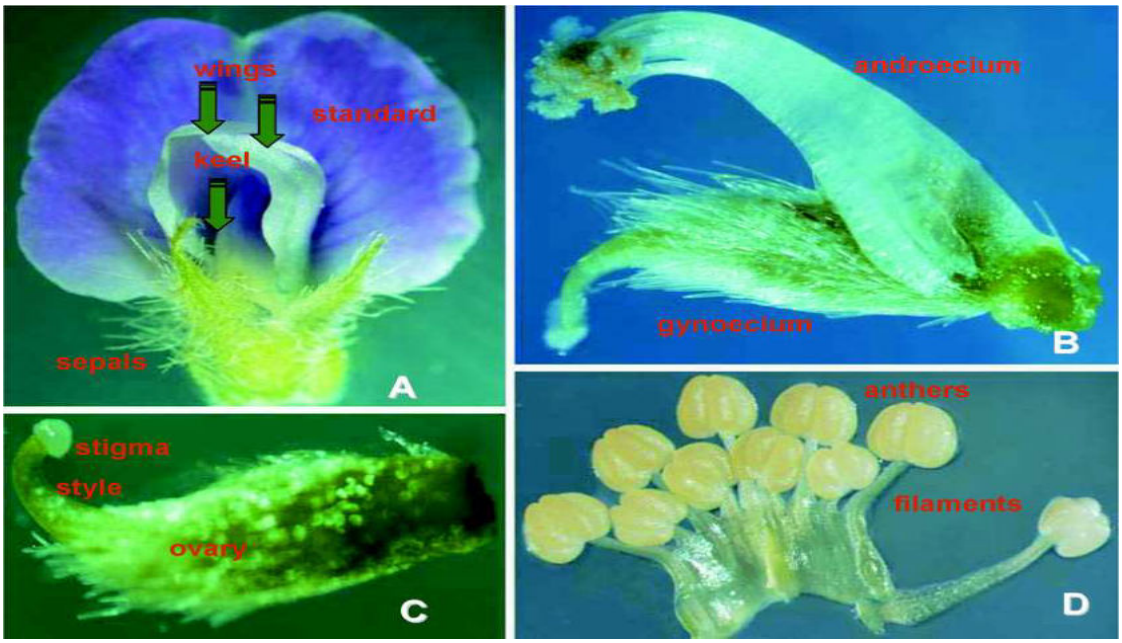


Fig 1. Floral details of soybean (Ref: Singh et al. 2007)

Season and climate for soybean cultivation

Soybean cultivation follows distinct seasonal patterns, with Kharif sowing typically occurring at the onset of the monsoon, spanning from the last week of June to the first week of July. Alternatively, spring sowing takes place between February 15th and March 15th. This crop exhibits remarkable adaptability to a wide range of climates and soils, particularly thriving in Vertisols enriched with organic content. Annual rainfall ranging from approximately 60-65 cm and a soil pH between 5.8-7.0 (with an optimum of 6.0) are conducive to optimal growth. Soybean is both photo- and thermo-sensitive, with germination occurring within a temperature range of 13-18°C, while crop growth thrives within the temperature range of 21-32°C (with an optimum of 28/18°C). Ideal conditions for superior yield include over 95 hours of sunshine, accompanied by 90 mm of rainfall during the pod filling stage, and a diurnal temperature of 26°C at pod maturity. However, adverse weather conditions such as drought during or just before flowering can lead to flower and pod drop, while rainfall during maturity may compromise grain quality. Despite these challenges, soybean remains a major oil crop within the rainfed agro-ecosystems of central and peninsular India, demonstrating its resilience and importance in agricultural landscapes.

Genetic Resources of soybean

The Indian Institute of Soybean Research in Indore plays a pivotal role in the conservation and study of soybean diversity. With an impressive collection comprising 4,248 accessions of cultivated soybean, the institute serves as a repository of invaluable genetic resources for research and breeding programs. Additionally, it houses 36 accessions of wild relatives and the annual wild progenitor Glycine soja, as highlighted in a study by Agarwal et al. in 2013. Complementing these efforts, the National Bureau of Plant Genetic Resources (NBPGR) in New Delhi also contributes significantly to the preservation of soybean germplasm. Their repository boasts 4,005 soybean genotypes, providing researchers and breeders with a diverse array of genetic material to explore and utilize in enhancing soybean cultivation and resilience. These collections serve as crucial reservoirs for genetic diversity, fostering

advancements in soybean research and contributing to the sustainability and productivity of soybean agriculture in India and beyond.

Table 1. Soybean accessions available in various countries.

Country	Accessions
China	32,021
USA	21,075
Korea	17,644
AVRDC	15,314
Brazil	11,800
Japan	11,473
Russia	6,439
India	4,022
Total world	119,788

Table 2. Area, Production and yield of soybean in the world.

Year	2022/23	2021/22	2020/21	2019/20	2022/23	2021/22	2020/21	2019/20	2022/23	2021/22	2020/21	2019/20
APY	Area Harvested (m ha)				Production (mt)				Yield (t/ha)			
World	137.6	131.9	129.69	124.03	370.71	357.11	368.09	337.66	2.69	2.71	2.84	2.72
USA	35.41	34.97	33.43	30.31	116.38	121.53	114.75	96.67	3.29	3.48	3.43	3.19
Brazil	43.53	41.49	39.2	36.95	151.42	127.71	138.15	124.84	3.48	3.08	3.52	3.38
Argentina	16.3	16.00	16.60	16.90	28.00	44.00	46.20	48.80	1.72	2.75	2.78	2.89
China	9.93	8.41	9.88	9.33	20.29	16.4	19.6	18.09	2.04	1.95	1.98	1.94
India	12.4	12.16	12.81	12.19	13.97	12.99	12.61	11.23	1.13	1.07	0.98	0.92

Source: AMIS/USDA

Area and Production (India)

The area dedicated to soybean cultivation has witnessed a remarkable expansion over the years, soaring from approximately 0.03 million ha in 1970 to around 13 million ha presently. Despite this substantial increase in cultivated land, soybean productivity in India remains relatively low, hovering around 1.0 t/ha, significantly trailing behind the global average of 2.6 t/ha. Among the major soybean-producing nations, including the United States, Brazil, Argentina, China, and India, the latter contributes approximately 10% of the total area under cultivation but only 4% of the world's production. It's noteworthy that soybean cultivation is not limited to grain production alone; significant acreage is also devoted to vegetable soybean production. The primary players in this segment include China, Japan, Taiwan, Thailand, and Indonesia, each contributing to the global supply chain of vegetable soybeans. Despite India's burgeoning cultivation area, efforts to enhance productivity are crucial to

align with global standards and capitalize on the immense potential of soybean as a key agricultural commodity.

National Soybean Scenario

Madhya Pradesh emerges as the foremost soybean-growing state in India, boasting an expansive cultivation area of approximately 5.07 million hectares. Following closely behind is Maharashtra, with 4.34 million hectares dedicated to soybean cultivation. Rajasthan, Gujarat, and Karnataka also make notable contributions to the soybean landscape, with cultivation areas of 1.03 million hectares, 0.22 million hectares, and 0.44 million hectares, respectively. These states collectively form the backbone of India's soybean production, ensuring a steady supply of this versatile crop. Presently, soybean holds significant sway in the Indian agricultural sector, contributing approximately 42% and 26% to the total oilseeds and edible oil production of the country, respectively. This underscores the pivotal role of soybean in meeting the nation's oilseed and edible oil requirements, cementing its position as a cornerstone of India's agricultural economy.

Table 3. Varieties notified recently 2022-2023.

Name of variety	Notification	Adaptation	Duration	Yield Average
RSC 10-52	2022	Eastern Zone	101	2054
RSC 10-71	2022	Eastern Zone	107	1899
Chhattisgarh Soya 11-15	2022	Chhattisgarh	101	2507
VLS 89	2023	Uttarakhand and HP	116	2324
JS 21-72	2023	Central Zone	97	2132
Himso-1689	2023	Central Zone	99.9	2077
NRC 150	2023	Central Zone	90.6	1757
NRC 152	2023	Central Zone	89	1823
(RCS 1-9)	2023	Meghalaya	98-105	2470
Shalimar Soybean 2	2023	Jammu and Kashmir		
MAUS 725	2023	Maharashtra	92-96	2398
NRC 131	2023	Madhya Pradesh	93	1451
NRC 157	2023	Madhya Pradesh	91.5	1467.5

Growth and development

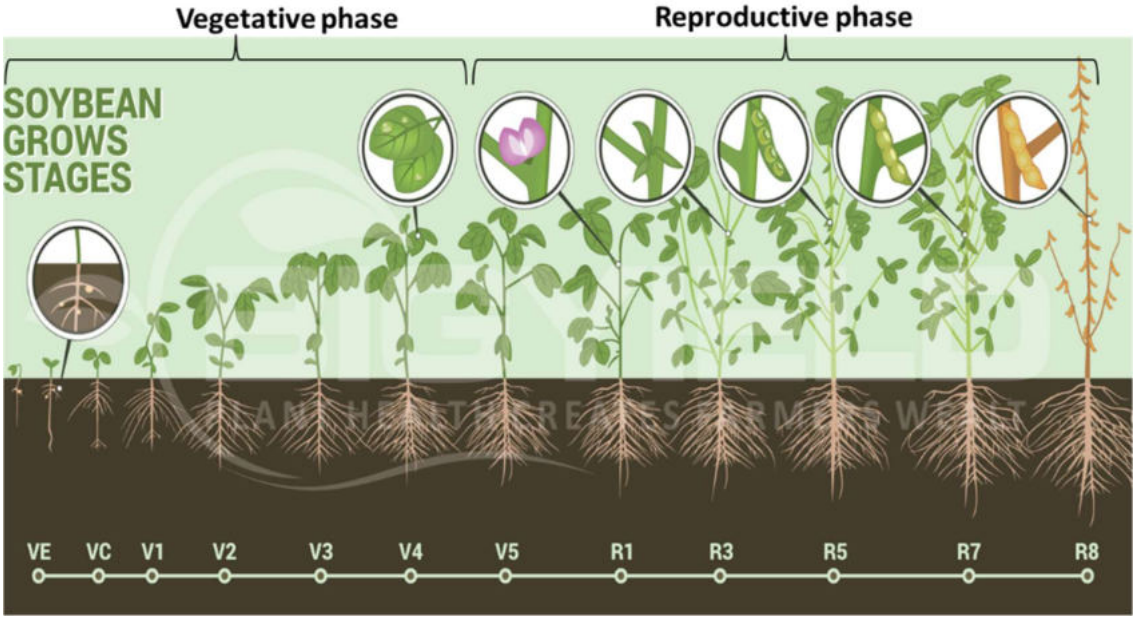


Fig. 2. Growth and developmental stages of soybean crop.

Package and Practices: Seed production

Soybean cultivation thrives in moist alluvial or vertisols, making these soil types optimal for its growth. Effective management practices play a crucial role in maximizing yield potential, with deep ploughing during summer serving to expose insect and pest populations to sunlight, reducing their impact on crops. The recommended seed rates vary depending on the variety, with small-seeded types requiring 75-80 kg/ha and bold-seeded varieties necessitating 100-120 kg/ha. Adequate spacing between rows (60-90 cm) and individual plants (10-15 cm) is essential for optimal growth and resource utilization. Soil fertility management involves the application of well-decomposed farmyard manure (5-10 t/ha) and a balanced fertilizer regimen comprising nitrogen, phosphorus, potassium, and sulfur in appropriate proportions. Sowing typically occurs in mid-June, timed to coincide with the availability of moisture or rainfall. Risk mitigation strategies include adopting a varietal cafeteria approach rather than monoculture, enhancing resilience against environmental fluctuations. Furthermore, seed treatment with beneficial microorganisms such as Rhizobium or PSB, along with fungicides like Carbendazim, Thiram, or Thiamethoxam, helps safeguard against pathogens. Weed control is crucial and involves the application of pre-emergence herbicides followed by inter-culture operations. Effective water management is achieved through the adoption of systems such as Broad-Bed-Furrow or Ridge-Furrow, optimizing water use efficiency. Additionally, intercropping soybean with arhar offers further risk management benefits, diversifying agricultural output and enhancing overall sustainability. These comprehensive practices underscore the multifaceted approach required for successful soybean cultivation, ensuring optimal yields while minimizing risks.

Insect Pests and diseases

Utilizing resistant soybean varieties presents an effective strategy in combating various insect pests and diseases. For instance, against stem fly infestations, cultivars like JS 335, PK 262, NRC 12, and MACS 124 demonstrate resilience. Similarly, to mitigate defoliator damage, options such as NRC 7, NRC 37, JS 80-21, Pusa 16, Pusa 20, Pusa 24, PS 564, and PK 472 prove effective. Girdle beetle attacks can be countered with JS 71-05 variety. Concerns of

soybean rust can be addressed using resistant strains like JS 80-21, PK 1029, PK 1024, and Indira Soya 9. In combating collar rot, resistant varieties such as PK 262, PK 416, PK 472, PK 1042, and NRC 37 offer protection. Myrothecium leaf spot, another common issue, can be managed with cultivars like Bragg and JS 71-05. Additionally, against bacterial pustule and yellow mosaic, varieties such as PK 416, PK 472, PS 564, Bragg, PK 1024, PK 1029, PS 1042, PS 1092, and SL 295 demonstrate resistance, providing comprehensive protection against a range of threats to soybean cultivation.

To combat the Yellow Mosaic Virus (YMV) disease, spraying methyl dematon 25EC at a rate of 0.8 L/ha or Thiomethoxam 25WG at 100 g/ha is recommended to control vectors. For defoliator control, a two-step approach involving microbial pesticides such as Dipel, Biobit, or Dispel followed by a chemical insecticide spray after 15 days proves effective. In rust-prone regions, prophylactic sprays of Hexaconazol, Propiconazol, or Triadimefon at 0.8 kg/ha are advised to minimize the impact of the disease. Managing foliar diseases requires timely intervention, with two sprays of Carbendazim or Thiophenate methyl at 0.5 kg/ha applied at 35 and 50 days after sowing (DAS) recommended to mitigate disease progression and ensure healthy crop development. These integrated pest and disease management practices contribute to maintaining soybean health and maximizing yield potential, essential for sustainable agricultural production.

Breeding Objectives of soybean

The breeding objectives for soybean cultivars are multifaceted, aiming to enhance various aspects of the crop's performance and quality. Firstly, there's a focus on developing cultivars free from trypsin-inhibitor, a compound that can hinder protein digestion in livestock. Additionally, breeders aim to produce photo- and thermo-insensitive cultivars that allow for early picking, optimizing yield potential and adapting to changing climatic conditions. Longer harvest durations are sought after to extend the period of optimal yield and streamline harvesting operations. Resistance to major insect pests is a critical objective, reducing the need for chemical pesticides and promoting sustainable agricultural practices. Moreover, resistance to seed shattering ensures minimal yield loss during harvesting, contributing to overall productivity and profitability. Finally, there's a push for cultivars with high seed shellability, facilitating efficient processing and utilization in various industries. These breeding objectives collectively aim to enhance soybean cultivars' resilience, yield potential, and market value, ensuring the continued success of soybean agriculture.

Leading Institutes Working for soybean Genetic Improvement

Several prominent institutes are dedicated to advancing soybean genetic improvement, playing pivotal roles in research and development efforts. The AVRDC-Regional Center for South Asia, situated on the ICRISAT Campus in Hyderabad, spearheads initiatives to enhance soybean varieties suited for South Asian climates. Meanwhile, the ICAR-Indian Institute of Soybean Research in Indore serves as a premier hub for soybean research, fostering innovations to address challenges in cultivation and production. HARP, hosted by the ICAR-Research Complex for Eastern Region Research Centre in Ranchi, focuses on developing soybean varieties tailored to the unique agricultural landscape of eastern India. Additionally, the University of Agricultural Science at GKVK, Bangalore, contributes to

soybean genetic improvement through its research endeavors and collaborations, further enriching the genetic diversity and resilience of soybean cultivars. Together, these leading institutes form a robust network dedicated to advancing soybean genetic improvement, driving innovation, and supporting the sustainable growth of the soybean industry.

QUALITY SEED PRODUCTION IN SOYABEAN

Land requirement and Isolation

Quality seed production in soybean necessitates meticulous attention to land selection and isolation practices. The land used for cultivation must be meticulously cleared of volunteer plants to prevent unwanted cross-pollination and maintain genetic purity. Additionally, the previous crop should not have been the same variety or other varieties of soybean, unless certified by the appropriate certification agency. However, if the same variety is used, it must be certified as per the procedures outlined by the certification agency. Adequate isolation measures are critical to further safeguard against cross-pollination and ensure the integrity of the seed crop. Specifically, for certified or quality seed production, maintaining a distance of 3.0 meters all around the field from the same and other varieties of the crop is recommended. These meticulous land selection and isolation practices lay the groundwork for producing high-quality soybean seeds, essential for successful cultivation and optimal crop performance.

Pre-sowing seed treatment and harvesting

In addition, pre-sowing seed treatment and precise harvesting practices play integral roles. To optimize field establishment, seeds undergo meticulous pre-sowing treatment, involving pelleting with $ZnSO_4$ at a specific ratio, along with the use of adhesive and filler materials. Typically, $ZnSO_4$ is applied at a rate of 0.25 to 0.3 grams per kilogram of seed, with 2% carboxymethyl cellulose (CMC) or 10% maida serving as adhesive, and vermicompost utilized as a filler at a rate of 300 grams per kilogram of seed. This tailored treatment regimen enhances seed germination and vigor, ensuring robust plant establishment in the field. As the soybean plants progress through their growth stages, seeds attain physiological maturity approximately 27-30 days after flowering. Harvesting is timed meticulously, with pods harvested at the onset of yellowing, signifying optimal seed maturity. These careful pre-sowing treatments and precise harvesting practices are fundamental to the production of high-quality soybean seeds, laying the groundwork for successful cultivation and subsequent crop performance.

Threshing, Seed grading and Drying

Following the harvesting stage, proper post-harvest processing is crucial to maintain seed quality in soybean production. Threshing, the process of separating seeds from pods, can be carried out manually or mechanically using pliable bamboo sticks, ensuring efficient seed extraction while minimizing damage. Once separated, the seeds undergo grading to ensure uniformity in size and quality. This is achieved by passing the seeds through round perforated metal sieves, typically ranging from 14/64" (5.6mm) to 12/64" (4.8mm), depending on the variety. This step helps eliminate undersized or damaged seeds, ensuring only high-quality seeds proceed to the next stage. Subsequently, proper drying is imperative to reduce moisture content and prevent fungal growth. Seeds are dried to a moisture content of 7-8%, utilizing appropriate drying methods and facilities to maintain seed viability and

quality during storage. These meticulous post-harvest processes are essential to preserve seed quality and viability, contributing to successful soybean cultivation and optimal crop performance.

Seed treatment and Storage

Ensuring the quality and viability of soybean seeds extends beyond harvesting and grading; it also involves meticulous seed treatment and storage practices. Seed treatment is a critical step in safeguarding seeds against pathogens and pests. Two common methods include slurry treatment with carbendazim and carbaryl, or utilizing an eco-friendly halogen mixture comprising calcium hypochlorite ($CaOCl_2$), calcium carbonate ($CaCO_3$), and Albizzia amara leaf powder. These treatments effectively protect seeds while minimizing environmental impact. Once treated, proper storage is imperative to maintain seed quality over time. Short-term storage, lasting 8-9 months, is best achieved in gunny or cloth bags with a seed moisture content of 10-12%. For medium-term storage, lasting 12-15 months, polylined gunny bags with a lower seed moisture content of 8-10% are recommended. For prolonged storage exceeding 15 months, 700-gauge polythene bags are ideal, ensuring a seed moisture content of less than 7%. These tailored storage methods help preserve seed viability, allowing for successful planting and optimal crop performance in subsequent seasons.

Vegetable Soybean (EDAMAME)

Vegetable soybeans, also known as Edamame, offer a unique and flavorful twist to traditional soybean varieties. Coined by William Morse in the 1930s, these soybeans have gained popularity worldwide for their distinct characteristics and culinary versatility. China stands as the largest producer of vegetable soybeans, boasting an annual production of 1.6 million tons. Additionally, Japan, Taiwan, and Thailand emerge as significant contributors to the global vegetable soybean market. Unlike their grain-type counterparts, vegetable soybeans are harvested at an immature stage, known as R6, rather than waiting until they reach full seed maturity (R8). This early picking results in larger seeds with a sweeter, more tender, nutty, and mild flavor profile, making them a sought-after ingredient in various cuisines. Furthermore, vegetable soybeans typically exhibit a slightly higher protein content and slightly lower oil content compared to typical field-type soybeans, further enhancing their nutritional value and culinary appeal.

Vegetable Soybean varieties (India)

Several notable vegetable soybean varieties have been developed to cater to diverse agricultural landscapes and nutritional requirements. Himso-1563 stands out as the first vegetable soybean variety released in 2001 by the ICAR-IARI. With a maturity period of 100-120 days, this variety is specifically tailored for cultivation in the northern hills region, offering a promising yield potential of 5 tons per hectare. Another noteworthy variety is Swarna Vasundhara, developed by HARP, Ranchi. Renowned for its nutritional richness, Swarna Vasundhara boasts a protein content of 11.4% along with essential minerals and nutrients such as calcium, potassium, phosphorus, vitamins A, C, E, and dietary fibers. Lastly, Karune (GC 00209-4-1-1), released by UAS Bangalore, further contributes to the diversity of vegetable soybean cultivars available to farmers. These varieties collectively underscore the continuous efforts of agricultural research institutions to develop high-

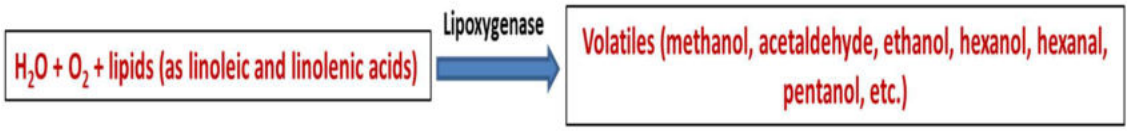
yielding, nutritionally rich vegetable soybean varieties tailored to specific regions and dietary needs, thereby enhancing agricultural productivity and food security.

Basmati flavor in vegetable soybean

The unique and aromatic flavor of Basmati rice finds an unexpected counterpart in certain varieties of vegetable soybeans. Varieties such as 'Dadachamame' (patented in Japan) and 'Chakaori' boast an aroma reminiscent of Basmati rice, adding an intriguing dimension to their culinary appeal. This distinct flavor is attributed to the presence of a recessive allele of the GmBADH2 gene, responsible for encoding a volatile compound known as 2-acetyl-1-pyroline (2AP), which contributes to the characteristic aroma. Traditionally, Basmati flavor lines have been associated with brown and black seed coats. However, advancements in breeding efforts, particularly by AVRDC, have resulted in the development of vegetable soybean varieties with various seed coat colors, such as AGS-447, AGS-456, and AGS-457, while still retaining the desirable Basmati-like aroma. These developments not only showcase the potential for flavor diversity in vegetable soybeans but also highlight the intricate genetic mechanisms underlying flavor profiles in crops, paving the way for further exploration and innovation in agricultural research and culinary applications.

Beany Flavor

The distinctive "beany flavor" often associated with soybeans is primarily attributed to the presence of lipoxygenase, an enzyme that is both heat-sensitive and contains iron. This enzyme serves as a defense mechanism in soybeans but can also contribute to the characteristic taste. Lipoxygenase exists in three forms: Lx 1, Lx 2, and Lx 3. Interestingly, many Edamame cultivars lack or have reduced activity of the Lx 1 lipoxygenase, which is primarily responsible for the beany flavor. Varieties like AGS 408 (GC-96025-43) exhibit a triple null genotype for Lx genes, while others like AGS 415 (GC-96026-10) possess null genes for Lx 1 and 2. To further mitigate the beany flavor, the Asian Vegetable Research and Development Center (AVRDC) has developed lipoxygenase null vegetable soybean lines, leveraging AGS 292 as the recurrent parent. These advancements in breeding techniques offer the potential to produce vegetable soybean varieties with reduced or negligible beany flavor, enhancing their culinary appeal and consumer acceptance.



Constrains in soybean production and research

Challenges in soybean production and research stem from various anti-nutritional factors inherent in the crop. These factors, including trypsin inhibitor, phytate, saponins, isoflavones, and oligosaccharides such as raffinose and stachyose, pose significant hurdles to both agricultural practices and scientific investigations. Trypsin inhibitor, for instance, can interfere with protein digestion, while phytate can hinder mineral absorption. Saponins, isoflavones, and oligosaccharides also present concerns related to human and animal nutrition. Addressing these anti-nutritional factors is paramount to unlock the full potential of soybeans as a valuable source of protein and other essential nutrients, thereby contributing to enhanced food security and improved agricultural sustainability.

Reasons of poor productivity

Several factors contribute to the poor productivity observed in soybean cultivation. Primarily, soybeans are predominantly rainfed crops, often receiving minimal attention compared to other cultivated crops. This neglect leads to inadequate management practices, including suboptimal soil preparation, irrigation, and pest control measures. Moreover, soybeans are vulnerable to a wide range of biotic and abiotic stresses, such as pests, diseases, drought, and soil nutrient deficiencies, further exacerbating yield limitations. Additionally, the insufficient availability of quality seeds poses a significant challenge, hindering optimal crop establishment and growth. Furthermore, the lack of appropriate soybean varieties adapted to specific agro-climatic conditions further impedes productivity. Addressing these multifaceted challenges requires concerted efforts in research, extension services, and policy interventions to enhance soybean productivity and contribute to food security and agricultural sustainability.

Researchable Issues/ Actionable Points

Several researchable issues and actionable points emerge to address key challenges and enhance soybean cultivation and utilization. Development of resistant varieties against Yellow Mosaic Virus is critical to mitigate yield losses caused by this prevalent disease. Similarly, the creation of short-duration varieties suited for dryland areas can improve productivity and resilience in water-limited environments. Varieties with low linolenic acid content hold promise for extending the shelf life of soybean oil, enhancing its marketability and economic value. Moreover, reducing beany flavors and lipoxygenase content in soybean varieties, exemplified by the Kyushu-III-Japan variety, can boost domestic consumption of protein-rich soy foods by improving palatability. Additionally, the development of varieties with bold pods and seeds offers potential for expanding the use of soybeans as a vegetable crop. Finally, the advancement of technology for safe storage and transport of soybean seeds without compromising viability is crucial to ensure seed quality and availability for future planting seasons. Addressing these researchable issues and implementing actionable points can contribute to sustainable soybean production, food security, and economic prosperity.

Conclusions

In conclusion, soybean emerges as an indispensable crop celebrated for its remarkable nutritional profile and multifaceted industrial applications, positioning it as a cornerstone of global agriculture and food systems. Despite its ancient origins in China, soybean cultivation has evolved into a global phenomenon, with ongoing research and development efforts focused on enhancing productivity, resilience, and nutritional quality. The journey of soybean from seed to harvest is marked by various challenges and opportunities, with meticulous practices such as land selection, isolation, and post-harvest processing playing crucial roles in ensuring seed quality and crop performance. Addressing anti-nutritional factors and overcoming production constraints are vital steps in realizing the full potential of soybean as a sustainable source of nutrition and economic prosperity. Looking ahead, researchable issues and actionable points offer promising avenues for advancing soybean cultivation and utilization, including the development of resistant varieties and improving the shelf life of soybean oil and enhancing the palatability of soy foods. By embracing innovation, collaboration, and sound agricultural practices, we can harness the full potential

of soybean to meet the nutritional needs of current and future generations while promoting agricultural sustainability and prosperity.

Suggested readings

Nair, R.M.; Boddepalli, V.N.; Yan, M.-R.; Kumar, V.; Gill, B.; Pan, R.S.; Wang, C.; Hartman, G.L.; Silva e Souza, R.; Somta, P. Global Status of Vegetable Soybean. Plants 2023, 12, 609. https://doi.org/10.3390/plants12030609

Lal SK (2022) An Indian perspective to soybean improvement. Kamala Print and Publish, New Delhi. ISBN: 9789356350049

Soybean Production technology Prepared by DR. P. M. NIMJE AGRCULTURAL CONSULTANT, AISECT

*****

Determination of Seed Viability

A. K. Verma
Sr. Seed Analyst, NSRTC, Varanasi

Seed Viability

"Seed viability can be defined as the ability of the embryo to live, grow and develop into a seedling under favorable environmental conditions".

or

Seed viability refers to state of aliveness

Objectives of seed viability

- To obtain quick estimation of viability of seed samples or of individual seeds remain ungerminated at the end of germination test.
- To determine the rapidly viability of the seeds of certain species which germinate very slowly or show high degree of dormancy.

Factors affecting seed viability

1. Internal factors

- ✓ Immature and small seeds within a seeds ,within a seed lot do not store as well as mature and large seeds within a seed lot (Wien *et al*)
- ✓ Several kinds of environmental stresses during seed development, and prior to physiological maturity, can reduce the longevity of seeds.
- ✓ The physical condition and physiological state of seeds greatly influence their life span.
- ✓ Seeds that have been broken,cracked,or even bruised deteriorate more rapidly than undamaged seeds(McDonald 1985;Priestley 1986)

2. Genetic factor

Seeds of some species are genetically and chemically equipped for longer storability than others under similar conditions.

Most long-lived seeds belong to species possessing hard, impermeable seed coats.Seeds of canna (Sivoriet *et al*., 1968), Lotus (Wester 1973), and Lupinus (Porsild and Harrington 1967) have been reported to be viable even after 500 years.

Seeds of other species are characteristically short lived, these include vegetables such as lettuce, onion, and parsnip and also agronomic crops such as Rye. Generally seed species possessing high oil content do not store as well as those with low oil content. For ex, whole wheat seeds contain only about 3% oil, but their embryo portion has about 27% oil. Seeds of different species may also be chemically similar but have different storability due to differences in genetic potential. For example, Chewings Fescue and annual rye grass seeds are similar in appearance and chemical composition; however rye grass seeds have much better storability under comparable conditions. Genetic differences in storage potential are not limited to seeds of different species, It also occur among cultivars. The bean cultivar black Valentine stores better than Brittle wax (Toole and Toole 1953).However the environment strongly alters the genetic potential for seed longevity.

Relative humidity and temperature

Temperature

At a temperature of 0^0 c, formation of intracellular ice crystals can disrupt membrane integrity & contribute to seed deterioration. However Seeds with moisture levels below 14% do not form ice crystals. It should be noted, however, that at 14% initial moisture, seeds

stored in cold rooms below 0^0c will likely gain moisture. Most cold rooms have a high relative humidity & seeds achieve equilibrium with relative humidity after a brief period of storage. Thus seeds stored at low temperature must be in conditions in which the relative humidity is controlled or placed in moisture –proof containers to avoid increase in moisture content & increased deterioration.

Seed Moisture

Seeds contain moisture above 14% begin to exhibit increased respiration, heating, and fungal invasion that destroy seed viability more rapidly. Below 5% seed moisture, a breakdown of membrane structure hastens seed deterioration. This probably a consequence of reorientation of hydrophilic cell membranes due to loss of the water molecules necessary to retain their configuration. Thus, studies standardized that storage of seeds Cereal (10-12 %), Pulses (7-8 %), Vegetables (4-5 %), Oilseeds (7-8 %) appears to be ideal; for maximum longevity.

VIABILITY TESTS

- Standard Germination test
- Tetrazolium test
- Excised embryo test
- Fast green test
- Conductivity test

1. STANDARD GERMINATION TEST

The emergence and development of seedling to a stage where the aspects of its essential structures indicate whether or not it is able to develop further in to a satisfactory plant under favorable conditions in soils (ISTA,1985).

STEPS OF GERMINATION TEST

- Putting of seeds
- Keeping in germinators at optimum condition
- Period of test -Days to count -Ist and II nd count
- Seedling evaluation
- Calculation of results
- Reporting of results

SEEDLING EVALUATION:

- CONCEPT: Evaluation should be done only after all essential structures are fully expressed & evaluate as NS, AS, HS, FUG & dead seeds
- Normal seedlings (NS) : Seedlings showing continued capacity for development into normal plant when grown in good quality soil under favorable conditions
- NS Categories (ISTA)
- Intact seedlings :Seedlings with essential structures well developed in all proportions, healthy, showing balanced growth
- Slight defective Seedlings : Seedlings with slight defects in their essentials structures provided they show normal vigorous, balanced growth in comparison with intact seedlings
- Seedlings with secondary infection : Seedlings with clear evidence of secondary infection are classified as NS provided all essential structure are otherwise normal.
- Seedlings with secondary infections even if seriously decayed or diseased are considered as normal

2. Tetrazoloium test

Tz is a biochemical test and one of the quick methods to predict seed viability developed by Lakon (1942) in Germany.

Viability: Seed viability indicates that a seed contains structures and substances enzyme system which give it the capacity to germinate under favorable condition in the absence of dormancy.

Objectives:
1. To obtain quick estimation of viability of seed samples or of individual seeds remained ungerminated at the end of germination test.
2. To determine the rapidly viability of the seeds of certain species which germinate very slowly or show high degree of dormancy.

Equipments and chemicals required:

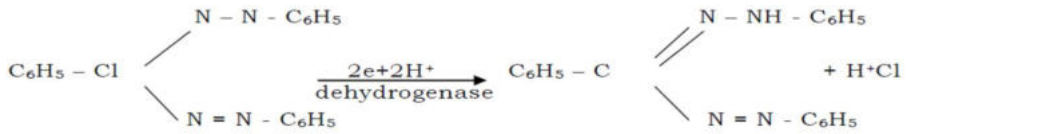
a. One percent solution (W/V) of 2, 3, 5 Triphenyl tetrazolium chloride (TZ) or bromide.
b. Potassium dihydrogen phosphate.
c. Disodium hydrogen phosphate.
Conditioning Media: Blotter, paper towel or beaker.
Cutting or piercing devices: Razor blade, dissecting knives and needles.
Staining dishes: Watch glasses/petridishes.

Magnifying devices: Hand lens and stereoscopic microscope.

Preparation of buffer solution
Solution 1 – dissolve 9.078 g KH_2PO_4 in 1000 ml water
Solution 2 – dissolve 11.876 g Na_2HPO_4 in 1000 ml water
Mix 400 ml of solution 1 with 600 ml of solution 2 to get a liter buffer solution of neutral pH.
To get 1% of TZ solution, dissolve 1 g of TZ salt in 100 ml of buffer solution. (The one percent solution is used for seeds that are not bisected through the embryo, while the 0.1 percent solution is used for seeds in which the embryo is bisected. Other low concentration such as 0.2 percent and 0.5 percent are some time used instead of 0.1 percent solution).
Straining: The prepared seed should be placed in suitable container (small beaker, Petri-dishes, watch glass, etc.) and place these container in a dark ward place. The staining time varies for different kinds of seed, different methods of preparation and different temperature (less than one hour to approximately eight hours).

A sample is satisfactorily stained when tissue develops interpretable staining characteristics and the analyst can sense'embryo conditions. When observations indicate that a sample has stained sufficiently, the TZ solution should be discarded and observation can be made.

Principle: when the seeds are soaked in colorless solution of 2, 3, 5 triphenyl tetrazolium chloride (TZ) or bromide. it interferes with the reduction process of living cells within the seed tissue and accepts hydrogen ions from the dehydrogenase enzymes. Due to hydrogenation, (H+ ions transfer) triphenyl tetrazolium chloride get reduced into a red coloured compound, non diffusible substance called formazan. In the living cells. Since, the reactions takes place within the respiring (living) cells and the formazan is no diffusible a clear topography of living and nonliving areas within the seed can be developed by using proper procedure. For this reason, the test is designated as the topographical tetrazolium test.
The reaction as follows:



2,3,5 – triphenyl tetrazolium chloride (forms a clear solution in water)

2,3,5 – triphenyl formazan (a red stable, no diffusible substance)

Evaluation of sample: The sample is ready for evaluation when it is stained. Observe the staining pattern and calculate the percentage of viable seed.

1. On the basis of staining of embryo

a. Embryo completely stained- viable.
b. Embryo unstained-non viable.
c. Plumule or radical unstained-non viable.

2. Assessment on the basis of cotyledon

a. Complete staining-viable.
b. Unstained-non viable.
c. Necrosis –evolution on the basis of category.

3. Assessment on the basis of necrosis

a. Unstained tissue at the attachment of the embryo-non viable.
b. Unstained tissues are away and are not connected with embryo-viable.

4. Assessment on the basis of colour intensity

a. Dark red –vigours seed.
b. Pink colour -weak seed.
c. Dark red fractured- non viable.

5. Specific evaluation

A. Germinable seeds of cereals

a. Well developed embryo with an fractured normal cherry red stain.
b. Necrosis with the upper or lower ends of the scutellum.
c. Radical unstained but embryonic axis stained.

B. Non germinable seeds f cereals

a. Whole embryo unstained.
b. Scutellum node unstained.
c. Major area of coleoptiles unstained.

C. Germinable seeds of legumes/oil seeds

a. Non fractured red coloured embryo and cotyledon.
b. Normal red coloured embryo with only one normal cotyledon.
c. Normal red coloured embryo with half or more than half of both the cotyledons attached to embryo are of red colour.

D. Non germinable seeds of legumes

a. Embryo completely unstained.
b. Fracture at radical or plumule with dark red line.
c. Plumule or radical tip unstained.
d. More than ½ part of both the cotyledons attached to embryo are colourless.
e. Attachment of embryo to cotyledon is unstained.

Calculation: the results are reported as percentage of viable seeds in relation to total seed tested.

Advantages of TZ:

1. Quick estimate of viability can be obtained (within 12-20 hrs.)
2. When the seed is dormant or very slow in germination, a viability test is extremely useful.
3. Seeds are not damaged (in dicot only) in analysis, therefore they could be germinated.

Disadvantages of TZ:

1. It is difficult to distinguish between normal and abnormal seedlings.
2. It does not differentiate between dormant and non dormant seeds.

3. Excised embryo test

- The excised embryo test is similar to germination tests in that it measures the quality of the seed by their actual germination.
- In addition it allows some measure of the embryo dormancy to be made, by counting those seeds which, although not growing normally, have grown slightly, remained firm and have kept their color for the test period.
- The test is not valid for previously germinated seeds and must not be applied to samples which contain any dry germinated seeds.
- The success of the test requires considerable skill and experience in the operator and the ISTA rules restrict it to only a few species

4. Fast green test

- The fast green test reveals physical fractures in the seeds such as corn.
- seeds are soaked in a 0.1% fast green solution for only 15-30 seconds.
- During this period, the fast green penetrates any area of the seed coat which has been fractured and stains the endosperm green .
- After the soak period, the seeds are washed and the fractures then become apparent (visible) in the seed coat.

5. Conductivity test

- The conductivity test is a biochemical test, which measures the amount of electrolytes, which leach through the seed coat or fruit coat of the intact seed.
- A higher conductivity may indicate a low viable seed lot.
- The expected readings for a conductivity test will vary greatly from crop to crop.
- It is most useful for peas, soybean samples, and a lesser degree for corn.

*****

Seed Germination Testing

Smt. Ekta kumari
Sr. Seed Analysts, National Seed Research and Training Centre, Varanasi

A germination test determines the maximum germination potential or viability of the seed. Germination is an important parameter while determining the seed quality. Moreover, this is a **s**tatutory requirement for seed certification and marketing for labeling and seed law enforcement. Thus the ultimate aim of testing the germination in seed testing laboratory is to obtain information about the field planting value of the seed sample and by inference the quality of seed lot. The results also assist in comparing performance potential or superiority of the different seed lots.

In order for germination to occur, three conditions must be fulfilled. First, the seed must be viable; that is, the embryo must be alive and capable of germination. Second, internal conditions within the seed must be favourable for germination i.e. any physical or chemical barriers to germination must have disappeared. Third, the seed must be subjected to favourable environmental conditions, the essential factors being available water, proper temperature, a supply of oxygen and sometimes light. Although in any one seed each of these conditions may have an effect distinct from the others, the beginning of germination may be more often determined by the interactions among them.

Definition and principle of evaluating germination test:

Germination represents a dynamic period in the life cycle of plants as a seed makes the transition from a metabolically quiescent to an active and growing entity. In general, germination is transformation of the embryo into seedling. It is defined as the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, indicate its ability to produce a normal plant under favourable conditions. The essential structures include root system, shoot axis (hypocotyl, epicotyl, mesocotyl), coleoptile and cotyledons (ISTA, 1985). Seedlings with essential structures are considered as normal seedling while, seedlings devoid of an essential structure viz., showing weak or unbalanced development; decay or damage affecting the normal development of seedling are not considered in calculating the germination percentage.

Essential equipments and supplies for germination test

The following equipments and supplies are essential to carry forward the germination tests in the seed testing laboratories.

1. **Seed germinator:** The seed germinators are the essential requirement for germination testing for maintaining the specific conditions of temperature, relative humidity and light. The seed germinators are generally of two types, namely: Cabinet germinator and walk in germinator. The cabinet seed germinators are essential under the situations, where various kinds of seeds that require different sets of conditions, are being handled in the laboratory. The number of the pieces of the germinators required by the laboratory will depend on the number of seed samples and the species being analysed by the laboratory. The seed testing laboratories that handle large number of seed samples and require maintaining only fewer (2-3) sets of temperature conditions, the walk-in-germinators are preferred. Such germinators are more useful for conducting the germination tests in sand media, which require large germination space.

2. **Counting devices:** The counting devices include the counting boards, automatic seed counter and vacuum seed counter. These devices are required to aid germination testing by minimizing the time spent on planning the seeds as well as to provide

proper spacing of the seed on germination substrata. Counting boards are suitable for medium and bold sized seeds, while vacuum counter can be, used for small sized seeds. In the absence of counting devices, the work may be accomplished manually.

3. **Other equipments:** The other equipments required for germination testing include the refrigerators, scarifier, hot water bath, incubator, forceps, spatula, germination, boxes, plastic plates, roll- towel stands and plastic or surgical trays, etc. A large oven with temp. Range 100 -200 C is also required for sterilizing the sand.

4. **Miscellaneous supplies, glassware and chemicals:** Germination paper (Creppe Kraft paper or towel paper, sunlit filter paper and blotters) and sand are the basic supplies required for germination tests. In addition, the laboratory may also require some glassware, such as Petri dishes, beakers, funnel, measuring cylinders, muslin cloth, rubber bands and tubes etc. and certain chemicals like Potassium nitrate, Thiourea, Gibrellic acid, and Tetrazolium chloride for specific purposes. Voltage stabilizers are required for the supply of the constant electric current. The voltage stabilizers are essential for costly germinators, air-conditioners and refrigerators. Under the situations of erratic power supplies and breakdowns, electricity generators are also required.

Care of equipments: The seed analyst must ensure that:
1. All the equipments are in proper working condition
2. The germinators are maintaining correct temperature
3. The relative humidity inside the germinator is maintained 90--98%
4. The phytosanitary conditions of the germinators and germination trolleys are adequate
5. The germinators are disinfected periodically by flushing with hot water; solution of Potassium permanganate or chlorine water
6. The temperature and the R.H. of the walk-in-germinators are recorded daily and displayed on a chart
7. The floor, ceiling and walls of the walk-in-germinator are devoid of cracks, crevices;
8. Evenly plastered and duly painted to avoid contamination by fungus, bacteria or insects.

Substratum (Media) for germination

Seeds require certain conditions for germination. The most important requirements are substrata (media), moisture, temperature and light. Suitable substrata for seed germination include paper towels, blotter paper, filter paper, cotton, vermiculite, sand or soil. The accuracy and reproducibility of the test is very much dependent on the quality of substrata being used. The substrata must meet the following qualities:

- It must be easy to handle and use.
- It must provide adequate aeration and moisture to the germinating seedlings.
- It must be non-toxic to germinating seedlings.
- It must be free from moulds and other microorganisms.
- It should make good colour contrast of the substrate for judging seedlings.
- It must be less expensive

A. Germination Paper : The most widely used substrate are filter paper, blotter and Kraft paper towel (creped). Paper media are easy to handle, cheap and occupy less space. The paper should be made up of cotton or other purified cellulose. The fiber content of the paper should be 100 per cent chemically bleached wood cellulose. The strength of paper should be uniform throughout the area and should resist tearing when handled during test. The germination paper should have good capillarity rise and should have the following quality characters. In case of filter paper, Whatman 60 No. filter paper discs are generally used. It is not re-usable.

Specifications for paper substrate

- **Composition:** The fiber content of the paper should be 100 % chemically bleached wood, cotton or other purified vegetable cellulose with an ash content of 1.5 % by mass.
- **Texture:** It should be open and porous in nature. The roots of the seedlings should grow on the paper and not into it.
- **Strength**: It should have sufficient strength to enable it to resist tearing when handled during the test. It should have mass of 95-100 m/m^2 and a bursting strength of 2kg/ cm^2.
- **Moisture capacity:** The paper should have the capacity to hold sufficient water for the whole of the test period.
- **pH :** The pH should be between 6.0 – 7.5
- **Storage:** It should posses the ability to be stored for long period without losing its texture or the qualities mentioned above.
- **Sterilization**: Upon purchase it must be sterile and also be amenable for sterilization in oven or pressure cooker without losing its qualities mentioned above. It should also be free from pathogens.
- **Free from toxic chemicals**: The paper media is tested using sensitive species like *Phleum, Agrostis, Festuca, Brassica or Allium* sps. The seeds may be placed on two layers of germination paper in box and watered. After 3 days for mustard and 6 days for onion seedlings are observed. If the paper is non-toxic the seedling growth is normal if toxic, abnormalities like stunted root with discoloured root tip will be noticed. The root hairs will be bunched and plumules will be shortened.
- **Determination of capillary rise**: Ten strips of germination paper each 10 mm wide are cut with 5 strips along one direction and 5 in the opposite direction and immersed upto 20 mm of distilled water at 27 $\pm 2^0$C. After 5 min the water level is measured. A minimum raise of 15 cm must be observed (i.e. 3 cm / min).
- **Colour** : White or coloured with dyes that are non toxic. Generally white, blue or khaki coloured paper is preferred.

B. Sand Media: Sand should be reasonably of uniform size and free from very small and large particles. A particle size which passes through a sieve having holes of 0.8 mm diameter and be retained on a sieve having holes of 0.05 mm diameter is ideal. The sand should be free from foreign materials and pathogens. The sand should be capable of holding adequate moisture to provide continuous supply of moisture to the germinating seeds with pH range of 6.0 to 7.5. Its phyto-toxicity has to be checked before its use. Both river sand and quartz sand are used for evaluation of germination. It is a reusable media. It may need washing and sterilization before it is used. Never store the sand in the stores where fertilizers and chemicals are stored. If the sand is found to be heavily contaminated or changed in colour, after repeated use, it should be replaced with fresh stocks.

C. Vermiculite: For highly sensitive species vermiculite is used as substrata.

TEST CONDITIONS

1. Moisture: The moisture requirements of the seed will vary according to its kind. Large seeded species require more water than the small seeded species. It is essential that the substratum must be kept moist throughout the germination period. Care need to be taken that the sub-stratum should not be, too moist. The excessive moisture will restrict the aeration and may cause the rottening of the seedlings or development of watery seedlings. Except under the situations where a high moisture level is recommended (e.g. paddy and jute), the substratum should not be so wet that a film of water forms around the seeds. In situations, where low level of moisture is recommended (e.g. cucurbit seeds), the moist

substratum should be pressed against the dry blotters or towel paper to remove excess moisture.

The water used for moistening the substratum must be free from organic and inorganic impurities. Normally the tap water is used. However, it is essential to measure the pH of water before its use. The pH of the water should be in the range of 6.5-7.5 (neutral). Under the situations where pH of the water is not satisfactory, distilled water or deionized water may be used. Under such situation care need to be exercised to aerate the tests frequently to provide oxygen supply to the germinating seedlings because oxygen level in distilled water is very low. The initial quantity of water to be added to the substratum will also depend on its nature and dimensions and also on the size and species of the seed to be tested. Subsequent watering, if any may be left to the discretion of the analyst but it should be avoided as far as possible because it may cause the variation in germination results. In order to reduce the need for additional watering during the germination period, the relative humidity of the air surrounding the seeds should be kept at 90-95% to prevent loss of water by evaporation.

2. Temperature: Temperature requirement varies with the species and with the age of seeds. At very low or high temperatures, the germination is prevented. The temperature should be as uniform as possible throughout the germinator and the germination process. Care should be taken that the temperature of tests does not exceed the prescribed level and variation not more than $\pm$ 1^0C. Most of the agricultural crop species germinate between the temperature of 5°C and 35°C. Hence, required temperature should be provided with appropriate temperature control mechanism as per ISTA recommendation (Table 1).
According to the Rules for seed testing, either constant temperature or alternating temperatures are used. In constant temperature, a specific temperature is maintained during the entire test period and wherever, an alternating temperatures are prescribed, the lower temperature should be maintained for 16 hrs and the higher for 8 hours. A gradual change change-over lasting three hours is usually satisfactory for non-dormant seeds. However, a sharp change-over lasting 1 hour or less, or transfer of test to another germinator at lower temperature, may be necessary for seeds which are likely to be dormant. If temperatures cannot be conveniently altered over week-ends or holidays, the tests must be kept at the lower temperature. The daily alterations of temperature either brought out manually by transferring the test from one germinator to another or by changing the temperature of the chamber (Automatic seed germinator).

3. Light: Seeds of most of the species will germinate either in light or in darkness. However, illumination of the substrate from artificial source or by daylight is generally recommended during germination, for better seedling development to avoid etiolating and also to detect seedlings having chlorophyll deficiency. Seeds of tobacco and lettuce need light for germination. Cool tube lights or CFT are preferred to incandescent bulbs. Tube light emit more radiation in the normal sunlight range, while bulb emit more in IR range and hence is not preferred. Light intensity normally required for different crop seeds is 750 -1250 lux for atleast 8 hours in every 24 hours cycle. Under the situation where testing of the seed is required to be undertaken at alternating temperatures together with light, the test should be illuminated during high temperature period.

4. Air: Most seeds required aeration for higher germination. Some of the leguminous tree seeds exhale toxic fumes upon germination. Such seeds must be aerated to reduce auto-toxicity. Special measures for aeration are not usually necessary in case of top of paper (TP) tests. However, in case of 'Roll towel' tests (BP) care should be taken that the rolls should be loose enough to allow the presence of sufficient air around the seeds. In case of sand media, the sand should not be compressed while covering the seeds.

PROTOCOL FOR GERMINATION TEST

1. Drawl of Working Sample

The working sample for germination test consists of 400 seeds randomly selected either manually or with the help of counting devices from the pure seed fraction obtained from the purity test. A minimum of four replications of hundred seeds each or eight replications of fifty seeds or 16 replication of 25 seeds may be kept. The seeds for germination test must be drawn as follows in accordance with the following two situations:

Situation I: Both purity and germination tests are required,

- Seeds for germination test will be selected randomly from pure seed fraction received after conducting purity test.
- The counting of seeds must be made without discrimination as to the size and appearance.

Situation II: Only germination tests is required

1. If the percentage of pure seed is estimated to be 98 %, then pure seeds for germination test shall be taken indiscriminately from a representative portion of the submitted sample.
2. If pure seed is found to be less than 98 %, the seeds for germination test must be obtained by separating the sample into two components, namely (a) the pure seed and seeds of other species and inert matter. For this purpose, atleast one-fourth of the quantity required for regular purity analysis must be used after proper mixing and dividing the submitted sample. The seeds should not be pre-treated except those approved for improving the germination. If any pre-treatment is done then a mention must be made in the germination test result.

2. Conducting germination test

Germination test is always carried out with seeds counted randomly from the pure seed fraction. Testing of 400 seeds is recommended for all seed control and seed certification samples. However, at least 200 seeds may be tested for service samples. The seeds are counted and evenly spaced on the substratum by hand or by a vacuum counter or by a counting board. Some seeds that are fresh from harvest possess dormancy. When test seeds have dormancy, mere storage will reduce the dormancy. However some seeds possess dormancy even a month after harvest due to physical, physiological reasons and combination of both. Under such circumstances several methods have been prescribed by ISTA as provided below.

3. Pre-treatments for germination (Special treatments for breaking dormancy)

After the completion of germination period, if fresh ungerminated or hard seeds are observed in large proportions, a retest may be carried out either after a period of dry storage or by applying one of the special treatment for breaking dormancy as under.

A)Temperature treatment

a)Pre-heating : Warming seeds at 30-35^{0}C for 3 hrs or soaking in warm water (50^{0}C) for few hrs.

b) Pre-chilling : Seeds are kept in moist substratum at 5-10^{0}C for seven days before they are removed and shifted to the temperature prescribed for that crop species (Table 1.). In some cases even prolonged pre-chilling or re-chilling is recommended. The pre-chilling period is not included in the germination test period but the duration and temperature should be reported in the analysis certificate.

c) Pre-drying: Seed samples are heated at a temperature not exceeding 40^{0}C with free air circulation for period of upto seven days before placing for germination. Some time the pre-drying period can be extended.

d) Low temperature: Either low temperature or low temperature alternating with high temperature is provided. The germination may be slower and the test period can, therefore,

be extended by an additional period equivalent to that given in Table 1. Both temperature and duration should be mentioned.

B. Chemical treatment:

a) Potassium nitrate (KNO_3): Germination substratum is moistened with 0.2 % Potassium nitrate solution by dissolving 2 g in 1 liter of water. If necessary, subsequent moistening should be done with water.

b) GA_3 : The substratum is moistened with 500 ppm, GA_3, which can be prepared by dissolving 500 mg of GA_3 in one liter of water. If dormancy is weak then 200ppm solution is sufficient. If stronger, even 1000 ppm solution may be necessary. The time taken for breaking dormancy is not counted into germination period.

c) Pre-washing: When germination is affected by a naturally occurring water soluble substance in the seeds, which acts as an inhibitor, it may be removed by soaking and washing seeds in running water. After the preparation of seeds they have to be sown on the selected substrata according to the method prescribed below.

5. **Sowing of Seeds in Media**

A. Paper method

a) Top of the paper (TP): Seeds which are small and photoblastic are tested in top-of-paper method. In this method, place 2-3 layers of filter paper in petridish and moisten with enough paper. Remove excess water. Seeds are placed on a moist blotter paper or germination paper on petri dish. Seeds which germinate under dark (skotoblastic) are placed in between the two layers of blotter paper in petri dish.

b) Between paper (BP): The seeds are germinated in between layers of filter paper. This is done in two ways namely 1) Seeds are placed in between layers of filter paper in a plastic box and placed in germinator and seeds are placed in roll towel method.

c) Roll towel method: In this method, soak the germination paper in water and remove the extra moisture by pressing. Spread the sheet on a flat table and then seeds are placed on a germination paper in equal distance and covered with another strip of germination paper. To avoid evaporation of moist from the paper, a polythene sheet or butter paper is used to cover the germination paper. Keep a label with test number at one corner. Then the germination paper is rolled carefully and the entire assembly is kept in a germinator or partly immersed in water upright position (if germinator facility is not present). The disadvantage in this method is that daily observation without disturbance is not possible. Sometime the seeds germinate on the paper and the root penetrates the paper which causes difficulty during evaluation This method is done in case of seeds that are large and where seedling characters are to be observed and for those seeds which do not need light.

d) Pleated paper (PP) : Seeds are placed in pleated strips. The paper may have 5-10 pleats which can be made in the laboratory. Each pleat may have ten seeds. The pleated strips are kept in moistened bread boxes to ensure uniform moisture conditions. This method may be used in TP and BP methods. This method is highly useful in calculation of speed of germination, where daily emergence of seedlings is counted

e) Inclined plate method: Seeds are placed over a strip of germination paper which is placed on a plastic or glass or acrylic plate. Then the seeds are covered with another paper and a polythene sheet is covered over it to prevent evaporation of moisture. The entire assembly is placed in 45 degree angle in a water tub/germinator.

B. Sand method

The seeds can be placed in two methods.

a) On sand (OS): The seeds are pressed into the surface of sand. This method is used for small and tiny seed (eg. *casuarina*), which may fail to germinate if sown even at little depths.

b) In sand (IS): The depth of sand bed should be approximately two inches. The seeds are placed on a leveled layer of moist sand in uniform spacing (not less than twice the length of the seed) and covered with 10-20 mm (approx. ¼ " to 1/2") 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. Put the cover on the germination boxes and place them under prescribed controlled temperature conditions.

5. Duration of the test

Each kind of seed based on their genetic potential are kept under the germination room condition for certain period as per ISTA which is noted as the germination/test period. Special dormancy breaking period (like chilling duration) is not included in the test duration.

The seeds placed for germination test are evaluated for germination after the germination period. First and second counts are usually taken with paper tests; however, only a single final count is made with sand test. At first and second counts, the seedlings which fulfill normal seedling conditions are removed, counted and discarded. All hard seed, diseased and abnormal seedlings, non germinated seeds are left until the final count when their number is recorded. Diseased seeds and seedlings which may affect healthy seeds may be removed before the final count. Hence, seedlings may have to be removed and counted at frequent intervals during prescribed period of the test when a sample contains seeds infected with fungi or bacteria.

If at the end of the prescribed test period some seeds have just started to germinate, the test period may be extended for an additional period up to 7 days. A test may be terminated prior to the prescribed time when the analyst is satisfied that the maximum germination of the sample has been obtained. The time for the final count is approximate and a deviation of 1-3 days is permitted. The first count may be delayed to permit the development of root hairs in order to be certain that the root development is normal, or may be omitted. Intermediate counts may be made at the discretion of the analyst to remove seedlings, which have reached a sufficient stage of development for evaluation, to prevent them becoming entangled. But the number of intermediate counts should be kept to minimum to reduce the risk of damaging any seedlings which are not sufficiently developed.

Table 1. Duration and specifications for conducting germination test as per ISTA

Crop	Botanical Name	Prescription for				Additional directions including recommendation for breaking dormancy
		Substrata	Temp (^{0}C)	First count (days)	Final count (days)	
FIELD CROPS						
CEREALS						
Barley	*Hordeum vulgare*	BP; S	20	4	7	Preheat (30-35^{0}C), prechill, GA_3
Paddy	*Oryza sativa*	BP; TP; S	20-30; 25	5	14	Preheat (50^{0}C) soak in water or KNO_3 24 hrs
Triticale	*Triticosecale*	BP	15-20	-	7	GA_3, Prechill
Wheat	*Triticum spp*	TP; BP; S	20	4	8	Preheat

MILLETS						
Barnyard Millet	*Echinocloa frumentacea*	TP	20-30	4	10	Prechill, KNO_3, GA_3
Finger Millet	*Elusine coracane*	TP; BP	20-30	4	8	0.2% KNO_3 (2-3 hrs)
Kodo Millet	*Paspalum scorbiculatum*	TP	20-30	7	20	KNO_3
Pearl Millet (Bajra)	*Pennisetum typhoides*	TP; BP	20-30	3	7	0.2% KNO_3 (2-3 hrs)
Sorghum	*Sorghum bicolor*	TP; BP	20-30;25	4	10	Prechill
PULSES						
Common vetch	*Vicia satva*	BP; S	20	5	14	Prechill
Lentil	*Lens culinaris*	BP; S	20	5	10	Prechill
OILSEEDS						
Groundnut	*Arachis hypogea*	BP; S	20-30;25	5	10	Remove shells, Preheat -40^{0}C
Linseed	*Lininum usitatssimum*	TP; BP	20-30;20	3	7	Prechill
Mustard	*Brassica juncea*	TP	20-30;20	5	7	Prechill, KNO_3
Mustard (Black)	*Brassica nigra*	TP	20-30;20	5	10	Prechill, KNO_3
Niger (Ramtil)	*Guizota abyssinica*	TP	20-30	-	14	Prechill
Sunflower	*Helianthus anuus*	BP:S	20-30-25;25	4	10	Ethrel (25 ppm) 48 hrs
FIBRE CROPS						
Cotton	*Gossypum spp.*	BP;S	20, 30:25	4	12	Hot water (85^{0}C-1 minute)
FORAGE CROPS						
Bird wood grass (Dhama)	*Cenchrus setigerus*	TP	20-35	3	14	Preheat (40^{0}C)
Buffel grass	*Cenchrus cilliaris*	TP;S	20-35	7	28	Preheat ; Prechill, KNO_3
Burmuda grass (Doob)	*Cynodon dactylon*	TP	20-35	7	21	Prechill, KNO_3; Light
Dharaf grass	*Andropogan montanus*	TP	20-35	7	28	Prechill at 5^{0}C for two weeks
Dinanath grass	*Pannisetum pedicellatum*	TP	35;20-35	7	28	H_2SO_4 fro 5 min
Guinea grass	*Panicum maximum*	TP	15-35;20-30	10	28	Prechill, KNO_3
Indian clover (Senji)	*Melilotus indica*	TP;BP	20	4	7	Prechill
Lucerne	*Medicago sativa*	TP;BP	20	4	10	Prechill
Marvel grass	*Dichanthium anulatum*	TP	20-30	7	21	KNO_3
Oat	*Avena sativa*	BP;S	20	5	10	Preheat 30-35^{0}C, Prechill

Rye	*Secale cereale*	TP;BP;S	20	4	7	Prechill ;GA_3
Rye grass	*Lolium parenne*	TP	20-30	5	14	Prechill ; KNO_3
Sataria grass (Nandi grass)	*Setaria anceps*	TP	20-35	7	21	KNO_3
Stylo	*Stylosanthus spp*	TP	20-35	4	10	H_2SO_4
Sudan grass	*Sorghum sudanense*	TP;BP	20-30	4	10	Prechill
Teosinte	*Euchlaena mexicana*	BP;S	20-30;25	-	7	GA_3 1000 ppm – 24 hrs
GREEN MANURE AND MISCELLANEOUS CROPS						
Dhainch	*Sesbania sp*	TP;BP	20-30	5	7	Rub seed coat on sand paper
Indigo	*Indigofera hirsuta*	BP	20-30	-	14	Continue test for a further 5 days if hard seeds have begun to imbibe
Chicory	*Cichorium intybus*	TP	20-30;20	5	14	KNO_3
Garden cress	*Lepidium sativum*	TP	20-30;20	4	10	Prechill
Lotus	*Lotus corniculatum*	TP;BP	20-30;20	4	12	Prechill
Poppy (Opium)	*Papaver somniferum*	TP;	20	5	10	Prechill
Purslane	*Portulaca oleracea*	TP;BP	20-30	5	14	Prechill
Sugarbeet	*Beta vulgaris*	TP;BP;S	20-30 ; 15-25	4	14	Prewash multigerm 2 hrs ; monogerm 4 hrs
Tobacco	*Nicotiana tabacum*	TP	20-30	7	16	KNO_3
CUCURBITS						
Ashgourd	*Benincase hispida*	S	30-35	5	14	Light
Pointed gourd	*Trichosanthus dioica*	S	30-35	-	14	Dark, GA_3 500 ppm 24 hrs, Remove seed coat
Snakegourd	*Trichosanthus anguina*	S	30-35	-	14	Dark, GA_3 500 ppm 24 hrs, Remove seed coat
FRUIT VEGETABLES						
Chilli	*Capccum spp*	TP ; BP	20-30	7	14	KNO_3
Tomato	*Lycopercicum esculentum*	TP ; BP	20-30	5	14	KNO_3
BULB AND TUBER CROPS						
Leek	*Allium porrum*	TP ; BP	20-15	6	14	Prechill
Lesser yam	*Dioscora spp*	S	30	-	21	Prechill – 5^0C 3 day light
Onion	*Allium cepa*	TP ; BP	20-15	6	21	Prechill
True Potato Seed	*Solanum tuberosum*	TP	20-30	-	14	GA_3 500 ppm, 24 hrs; light
GREEN / LEAFY VEGETABLES						
Amaranth	*Amaranthus spp*	TP	20-30	-	8	Light
Lettuce	*Lactuca sativa*	TP;BP	20	4	7	Prechill
Parsnip	*Pastinaca sativa*	BP;TP;S	20-30	-	28	Prechill 5^0C
Spinach	*Spinaca oleracea*	TP; BP	15-10	7	21	Prechill

Spinach beet	*Beta vulgaris*	TP ; BP	20-30, 15-25	4	14	Prewash (multigerm 2 hrs ; genetic monogerm 4 hrs)
ROOT CROPS						
Celeriac	*Apium graveolens*	TP	20-30	10	21	Prechill, KNO_3
Garden beet	*Beta vulgaris*	TP; BP; S	20-30	4	14	Prewash multigerm 7 hrs monogerm 4 hrs
Radish	*Raphanus sativus*	TP ; BP	20-30;20	4	10	Prechill
Turnip	*Brassica rapa*	TP	22-30 ; 20	5	7	Prechill, KNO_3
LEGUME VEGETABLES						
Broad bean	*Vicia faba*	BP; S	20	4	14	Prechill
COLE CROPS						
Cabbage, Knol-kohl	*Brassica oleracea*	TP	20-30; 20	5	10	Prechill, KNO_3
Cauliflower, Broccoli	*B.oleracea var. botrytis and var. Italica*	TP	20-30;20	5	10	Prechill, KNO_3
Chinese cabbage	*B.pekinensis and chinenss*	TP	20-30;20	5	7	Prechill

TP-Top of the paper; BP - Between papers; 20-30 - Alternate temperature; 20; 25 - Constant temperature.

Note:-

1. Pre chilling: The replicates for germination are placed in contact with the moist substratum and kept at low temperature (between 5^0 and 10^0C) for upto seven days for all agricultural and vegetable seeds.
2. Potassium nitrate (KNO_3): Instead of water 0.2 % KNO_3 solution (prepared by dissolving 2 g 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.
3. Gibberellic acid (GA_3): Required concentration should be prepared. For preparing 1000 ppm solution dissolve 1 gm GA_3 in 1000 ml of H_2O; for 500 ppm dissolve 500 mg in 1000 ml of water; and for 100 ppm, 100 mg should be dissolved in 1000 ml of water. When concentration of GA_3 is not mentioned, any concentration ranging from 100 to 500 ppm should be used. Seeds should be soaked in required concentration of GA_3 for 17 hrs at room temperature, dried on the laboratory table and put for germination.

SEEDLING EVALUATION

The seeds placed for germination test are evaluated for germination after the germination period. Germination capacity of the seed lot is determined based on the evaluation of seedlings which is based on the presence of specific combination of the essential structures. The essential structures include root system (primary and seminal roots), shoot axis (hypocotyl, epicotyl and mesocotyl) and cotyledons.

Classification of seedlings

Based on the development of essential structures, seedlings are classified into:

- Normal seedlings (intact seedlings, seedlings with slight defects, with secondary infection);

- Abnormal seedlings (damaged, deformed, deranged, decayed and diseased seedlings)
- Fresh un germinated
- Hard seeds and
- Dead seeds

The fresh un-germinated or hard seeds and abnormal seedlings should be evaluated at the end of the test period. The stage of the development of the essential structures must be sufficient to permit detection of any abnormal seedlings. It may also be necessary to remove the seed coat and separate the cotyledons in order to examine the plumule in species where essential structures are still enclosed at the end of the test.

a) Normal seedlings: It is necessary to separate the normal seedlings, which are counted in the percentage germination, from any abnormal seedlings. To achieve uniformity in evaluating normal seedlings, they must conform to one of the following definitions:
a.Seedlings which show the capacity for continued development into normal plants when grown in good quality soil and under favourable conditions of water supply, temperature and light.
b.Seedlings which possess all the following essential structures when tested on artificial substrata.

The following categories of seedlings are regarded as normal seedlings:

b) Intact seedlings: A well developed root system consisting of a long primary root ending up with fine tip and presence of seminal roots (atleast two) instead of one primary root in Poaceae.

- In Poaceae family, a well-developed primary leaf within or emerging through coleoptiles or an intact epicotyl with a normal plumular bud.
- In dicots, a well-developed shoot axis consisting of straight, slender and elongated hypocotyls and intact epicotyl (without damage to the conducting tissue).
- One cotyledon for seedlings of monocotyledons and two cotyledons for seedlings of dicotylcdons.

c) Seedlings with slight defects: A primary root with slight defects provided the damage or the defect does not affect the conducting tissues.

- Seedlings of *Pisum, Vicia, Phaselolus, Lupinus, Vigna, Glycine. Arachis. Gossypium. Zea* and all species of Cucurbitaceae, with slight defect in the primary root and with well developed secondary roots and lateral roots to support the seedlings in the soil can be considered as normal seedling.
- Seedlings with superficial damage or decay to the hypocotyls, epicotyl or cotyledons which is limited in area and does not affect the conducting tissues.
- In dicots, seedlings with one cotyledon can be regarded as normal.
- Seedlings with primary leaves with limited damage are regarded as normal seedlings.
- Coleoptile with slight twist can be considered as normal seedlings.
- Decayed or damaged seedling, provided, the infection should not be from parent seed (only from the secondary infection) and the essential structures are well developed.
- Seedlings of tree species having epigeal germination when the radicle is four times the length of the seed. Provided all structures which have developed appear normal.

II. Abnormal seedlings

Abnormal seedlings are those which do not show the capacity for continued

development into normal plants when grown in good quality soil and under favorable conditions of water supply, temperature and light.

a) General

Seedlings with the following defects shall be classed as abnormal:

i. Damaged seedlings; seedlings with no cotyledons; seedlings with constrictions, splits, cracks or lesions which affect the conducting tissues of the epicotyls, hypocotyl or root; seedlings without a primary root of those species where a primary root is an essential structure, except for *Pisum, Vicia, phaseolus, Lupinus, Vigna, Glycine, Arachis, Gossypium, Zea* and all species of Cucurbitaceae, when several vigorous secondary roots have developed to support the seedling in soil.
ii. Deformed seedlings: Seedlings with weak or unbalanced development of the essential structures such as spirally-twisted or stunted plumules, hypocotyls or epicotyles; swollen shoots and stunted roots; split plumules or coleoptiles without a green leaf; watery and glassy seedlings, or without further development after emergence of the cotyledons.
iii. Decayed seedlings: Seedlings with any of the essential structures so diseased or decayed that normal development is prevented, except when there is clear evidence to show that the cause of infection is not the seed itself.
iv. Seedlings showing cotyledon development from the micropyle, or radicle development from a part of the seed other than the micropyle.

b) Special categories of abnormal seedlings

The three main categories of abnormality, damage, deformity and decay, outlined in the previous section, can be further classified into categories as follows:

i.Roots

- No roots, in *Avena, Hordeum, Secale* and *Triticum* or one seminal root only.
- Primary root (or seminal roots in Gramineae) short and stunted.
- Primary root thin and weak, too short or too long.
- Primary root short and stunted, or short and weak, or spindly; secondary roots weak.
- No primary root or no well-developed secondary roots.
- Seminal roots short and weak, or spindly, or watery.
- Primary root split longitudinally, or damaged with secondary roots weak.
- Radicle with no root hairs.
- Radicle or primary root brown in colour.

ii.Hypocotyl and Epicotyl

- Hypocotyl short and thick, or twisted, or curled over, or watery.
- Epicotyl or stem with constriction, grainy lesion, or open split likely to interfere with the conducting tissue.
- Hypocotyl with constriction, grainy lesion, or open split likely to interfere with the conducting tissues.
- Epicotyl or stem short and thick or twisted round the main axis, or curled over along the main axis.
- No terminal bud.
- Two shoots which are short and weak, or spindly.
- No primary leaves, with or without terminal or axillary buds, or with more than half the total area of the primary leaves missing or not capable of functioning normally, or with one primary leaf and evidence of damage to the shoot apex.
- **Goose neck seedlings:** Seedlings with bent hypocotyl which affects the functions of leaf and shoot.

iii.Coleoptile (Gramineae)

- No green leaves.
- Short leaves extending less than half the length of coleoptiles.
- Leaves shattered or split longitudinally and/or coleoptile with a split easily visible to the naked eye, or abnormal coleoptile development due to damage.
- Plumule spindly, or pale, or watery.
- Plumule short and thick, usually with short or stunted seminal roots.

iv.Cotyledons (Dicotyledonous species)

- None
- One, with evidence of damage to the shoot apex.
- Poorly developed leaf-like cotyledon in Allium, without a definite bend, or "knee".
- Enlarged, with short hypocotyl.
- Physiological necrosis - as in (iv)h.
- Grey in colour
- Swollen and blackened
- More than half the total area broken off, or covered with spots or darkened areas, or with open splits if development as a whole is out of proportion compared with that of a normal seedlings germinated at the same time.
- **Bald head:** Produced in cotton and groundnut seedlings where the seed coat is still attached to the cotyledons preventing the opening of cotyledons which affects the development of seedling.

v. Decay

- Decayed cotyledons.
- Decayed hypocotyls.
- Decayed epicotyls or stem
- Decayed plumule, or decay at point of attachment between seedlings and endosperm, or discolouration of the coleoptiles which has penetrated to the leaves.
- Decayed primary root (except secondary infection by *Phoma betae)* or seminal roots in the Gramineae.
- Decay or discolouration at point of attachment between cotyledons and seedling axis, or adjacent to the shoot apex.
- Completely decayed seedling.
- **Other abnormalities**
- Seedlings short and weak, or spindly, or watery.
- Frost damaged seedlings with grainy Coleoptile or a plumule which is weak and spirally twisted.
- Entirely white seedling in the Gramineae and Liliaceae
- Completely shattered seedling.

III. Hard Seeds

Seeds of Leguminosae, *Gossypium,* and *Hibiscus,* which remain hard at the end of the prescribed test period because they have not absorbed water due to an impermeable seedcoat, are classified as hard seeds. The percentage of hard seeds shall be reported separately from the percentage germination on the analysis Certificate.

IV. Fresh Ungerminated Seeds

Seeds, other than hard seeds, which imbibe water but do not germinate (due to defects or physiological disorders etc.) for want of some external treatments or conditions (i.e. dormant seeds) are classified as fresh ungerminated seeds and must be reported separately from the percentage germination. They become viable after the appropriate treatment for dormancy

This occurs mostly in freshly harvested seed lots. They must be reported separately from the percentage germination.
Seeds which have just started to germinate at the end of the test period should be referred to the Section Leader.

V. Dead seeds
Seeds which at the end of the test periods are neither hard, nor fresh and have not produced any part of the seedlings are considered dead. If pressed, inner content oozes out due to decaying.

VI. Others :
Unfertilized, embryo less seeds, empty seeds etc.

VII. Multiple Seed Structures
Multiple seed structures of ***Beta vulgaris*** **and** ***Tetragonia expansa,*** schizocarps of *umbelliferae*, and multiple florets of *Chloris gayana, Arrhanatherum elatius, Dactylis glomerata,* and species of *poa* shall be tested as single seeds. The result of the test indicates the percentage of structures which have produced at least one normal seedling. The average number of seedlings produced by 100 seed structures may also be reported at the discretion of the testing station.

A tree seed giving rise to multiple seedlings as a result of polyembryony shall be counted as a single seed in the germination test. When the percentage of tree seeds with multiple embryos exceeds 5, the actual percentage should be shown on the Analysis Certificate.

Calculation and expression of result
Results are expressed as percentage by number.

$$\text{Germination (\%)} = \frac{\text{Number seeds germinated } \mathbf{x}\ 100}{\text{Number seeds on tray}}$$

When four l00-seed replicates of a test are within the maximum tolerated range, the average represents the percentage germination to be reported on the Analysis Certificate. The average percentage is calculated to the nearest whole number. The total % of all the category of seeds (normal, abnormal. dead hard, fresh ungerminated) should be 100.

Reporting of result
The following items shall be entered in the appropriate space of the analysis certificate when reporting the result of a germination test:

1. Kind of variety
2. Date of testing
3. Duration of test
4. Percentage of normal seedlings, abnormal seedlings, hard seeds, fresh seeds and dead seeds. If the result for any of these categories is found to be nil, it shall be entered as 0

The following additional information shall also be reported:

(a) In all cases
1. Substrate and temperature used.
2. Any special treatment or method used for promoting germination.

3. The germination percentage obtained within the prescribed time, if the germination period has been extended beyond the period indicated.
4. The second result obtained when duplicate tests are indicated in Table 5A.

(b) Upon request

1. The result of any additional test,
2. The viability of ungerminated seeds and method used to determine it.
3. Categories of ungerminated seeds and methods used to determine them.
4. With multi-germ seed units: number of normal seedling produced by 100 units; proportion of units producing one, two or more than two normal seedlings.

Unsatisfactory results:

The result of a germination test is considered unsatisfactory, and is not to be reported under the following circumstances:

1. When the range in results for the 100 seed replicates exceeds the maximum tolerated range given in the tolerance table.
2. When there is an evidence that the results may not be reliable because of wrong test conditions, errors in seedlings evaluation or inaccuracies in counting or recording the results.
3. When there is evidence that the result may not be reliable because of dormancy, phytotoxicity, or the spread of fungi or bacteria.

Retesting

The result of a test shall be considered unsatisfactory and shall not be reported and a second test shall be made by the same or an alternative method, under the following circumstances:

1. When dormancy is suspected (fresh un-germinated seeds).
2. When the result may not be reliable because of phyto-toxicity or spread of fungi or bacteria
3. When there is difficulty in deciding the correct evaluation of a number of seedlings.
4. When there is evidence of errors in test conditions, seedling evaluation or counting.
5. When the range for the 100-seed replicates exceeds the maximum tolerated range

Reasons of variation in the germination test results

1. Poor sampling *i.e*. non uniform representative sample, random sampling error
2. Poor equipment, including variation in temperature, light and humidity in germinator
3. Substrata quality: Toxicity or impurities in Paper or sand
4. Use of stored or old germination papers
5. Incidence of fungi or bacteria or others in the seed
6. Improper phytosanitary conditions of laboratory, containers and germinators
7. Effect of seed treatment
8. Untrained or inexperienced analysts
9. Inaccurate counting of seed or seedling
10. Observation before or after prescribed time
11. Interpretation of seedling performance: Normal/abnormal and dead and fresh un-germinated.

*****

Quality seed production of safflower

J. Jawahar Lal, HD Pushpa, C. Manimurugan, B. Usha Kiran A. Anil, A. Divya, P. Padmavathi, P.S. Srinivas, RD Prasad, K. Anjani

ICAR-Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad-30

Safflower (*Carthamus tinctorius* L.) belongs to the family *Compositae* and it is a self-pollinated crop. Safflower is cultivated in 20 different countries of the world on a total cultivated area of 1,140,002 hectares that produces approximately 948,516 tons. It is grown as an important industrial crop for different purposes, which include extraction of edible oil, production of dyes, and several uses in the pharmaceutical industry. Safflower has better adaptation to stress conditions such as salinity and drought, although it produces oil in lower quantity than other oilseed crops. Safflower also gained importance because it has the capability of biofuel production. *Carthamus* species have been utilized since the pre-historic period as its archeological remains were found at sites in Syria since 7500 BC. Safflower was distributed from its center of domestication (i.e., Syria) to linked regions comprising Egypt, the Aegean region and southern Europe.

Safflower is considered an underutilized crop in comparison to other oilseed crops such as soybean, rapeseed and sunflower. Key factors contributing to its underutilized status include lower oil content and seed yield, insect pest susceptibility, and lower resistance to diseases, which decrease safflower productivity and quality.

Plant morphology

Safflower is a fast growing, erect, winter/spring-growing annual herb, that resembles a thistle. Originating from a leaf rosette emerges a branched central stem (also referred to as terminal stem), when day length and temperature increase. The main shoot reaches heights of 30–150 cm (12–59 in). The plant also develops a strong taproot, growing as deep as 2 m (6 ft 7 in). First lateral branches develop, once the main stem is about 20–40 cm (7.9–15.7 in) high. These lateral branches can then branch again to produce secondary and tertiary branches. The chosen variety as well as growing conditions influence the extent of branching.

The elongated and serrated leaves reach lengths of 10–15 cm (3.9–5.9 in) and widths of 2.5–5 cm (0.98–1.97 in) and run down the stem. The upper leaves that form the bracts are

usually short, stiff and ovate, terminating in a spine.[3] Buds are borne on the ends of branches, and each composite flower head (capitulum) contains 20–180 individual florets. Depending on variety, crop management and growing conditions, each plant can develop 3–50 or more flower heads of 1.25–4 cm (0.49–1.57 in) diameter. Flowering commences with terminal flower heads (central stem), followed sequentially by primary, secondary and sometimes tertiary branch flower heads. Individual florets usually flower for 3–4 days. Commercial varieties are largely self-pollinated. Flowers are commonly yellow, orange and red, but white and cream color forms exist. The dicarpelled, epigynous ovary forms the ovule. The safflower plant then produces achenes. Each flower head commonly contains 15–50 seeds; however, the number can exceed 100. The shell content of the seeds varies between 30 and 60%, the oil content of the seeds varies between 20 and 40%.

Though safflower is a predominantly self-pollinated species, cross-pollination up to 40-45% was reported in safflower. Therefore, there are chances of pollen contamination and occurrence off-types in certified seed producing plots of both varieties as well of parental lines of hybrids. Off-type plants have to be removed prior to flower initiation in the seed production plots. Field visits prior to and after flowering are required for maintaining genetic purity. Since honeybee is the major pollinator in hybrid/variety seed production blocks, space isolation distance of seed production plot from the neighbouring safflower plot is the most important factor for maintaining genetic purity in certified seed lots. Isolation distance should be maintained is 200 m in case of variety and 500 m in case of hybrid seed production. If weather conditions permit, time isolation of 45 days gap between neighbouring safflower seed production plots can be followed. But sowing beyond October would reduce seed yield. About 7 kg/ha seed is required for variety seed production with 45 x 20 cm spacing. Plant 2-3 seeds per hill and keep one seedling per hill after germination. For adequate and balanced fertilization, incorporate 5 t/ha of well decomposed FYM/compost 2-3 weeks prior to sowing. The recommended doses of N, P2O5, K2O (40 : 40 : 20 kg/ha) should be applied for both variety and hybrid seed production plots. However, it is desirable to apply fertilizer based on soil test values. Fifty percent of nitrogen and the entire dose of P2O5 and K2O should be applied basal and the remaining 50% of nitrogen should be applied at 40-45 days after planting. Sowing immediately after monsoon rain or pre-or post-sowing irrigation is must to ensure good plant stand, and one irrigation at 40-45 days after sowing and one at pre-flowering stage would certainly boost seed yield. Safflower crop is very sensitive to weeds at early growth stage that is up to 50-55 days after planting.

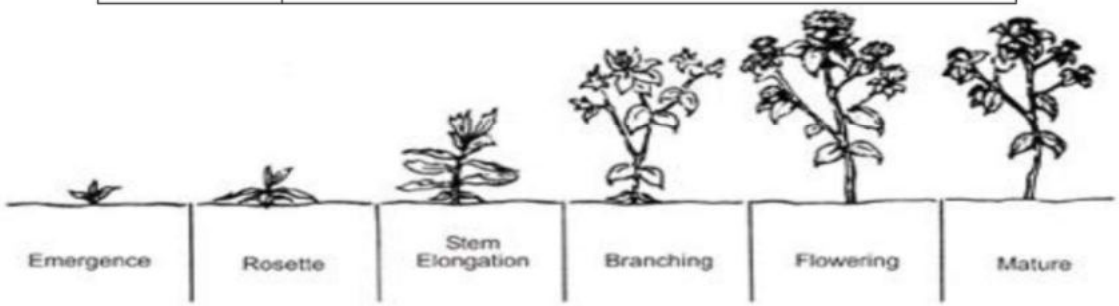
One or two hand weeding and hoeing/harrowing at 25 to 30 and 45 to 50 days after planting should be given to ensure good yields.

Time of field inspection to certified seed production plots

Minimum of three visits to seed production plot is required to remove off-types. The off-types differing from identified morphological traits of variety or parents have to be removed prior to flowering as well as during initiation of first flower opening from rows of both female and male parents. Delay in rogueing would cause pollen contamination from off-types; this would lead to rejection of variety/hybrid seed. The first visit is before flowering to rogue off-types with different leaf shape, stem colour, branch angle, spine index and objectionable weeds. Second visit is during flowering in order to remove off-types having different flower colour and capitula traits. The third should be during maturity, which allows removing of off-types with different flower color after bloom and objectionable weeds.

Time of field inspection to certified seed production plot

Filed visit	Time of inspection
1st visit	Prior to flowering (40-45 days after planting)
2nd visit	During flowering 80-85 days after planting)
3rd visit	During maturity (90-95 days after planting)



Hybrid seed production

To get pure hybrid seed, care should be taken right from pre-flowering to post-flowering stage in hybrid seed production block. Delayed sowing beyond the ideal date of sowing would reduce male sterility percent in female parent rows of GMS-based hybrid leading to reduction in hybrid seed production. Relatively cooler climate is required for CMS-based

hybrid seed production to reduce pollen shedders in A-line rows. Hence, cooler places in UP and MP are now identified as ideal places for CMS-based hybrid seed production.

The seed production site must ensure availability of optimum population of honeybee as it is the major pollinator. Otherwise, one or two beehives can be provided near the site during flowering period. The female (A-line in case of CMS hybrid) and male parents are to be taken up in either 4 : 1 row ratio or 4:2 depending on abundance of honeybee for seed production of both GMS and CMS-based hybrid. About 5 kg/ha seed of female parent/A-line and 3 kg/ha seed of male parent are required for sowing at 60 x 30 cm spacing between rows and plants. Staggered sowing of parents of hybrids is not required as both the parents of the hybrids flower more or less at the same time.

Identification of pollen shedders in A-line rows in CMS-based hybrid seed production block: DSH-185 is a CMS-based hybrid. Its female parent is called A-line, which is a cytoplasmic male sterile line. The pollen shedders in this line should be nil or negligible to avoid female-selfs in hybrid seed lot. Taking up CMS- hybrid seed production in cooler areas is ideal as the pollen shedders in A-line would be zero and the male sterility percent would be 100%. Occasionally, in these areas pollen shedders may appear; these should be identified by presence of pollen grains in flowers and be removed as soon as the first floret of the flower head opens. The flower heads of pollen shedders are relatively bigger and wide-open than those of male sterile plants.

Staggered sowing: Male parent/R-line (1705-p22) should be sown about 5-7 days earlier than female parent/A-line (A-133). Isolation distance: A minimum isolation of 700 m for foundation and 400 m for certified seed production is optimum

Management of important dieses and insect pests

Aphid is the major pest on safflower. Spray Dimethoate 30 EC @ 2 ml/l or Acephate 75 SP @ 1.5 g/l or Imidacloprid 17.8SL @ 0.4 ml/l at 15 days interval depending upon aphid infestation. Safflower caterpiller sometimes becomes sever. For its control spray Indoxacarb 15 EC @ 0.3 ml/l or Spinosad 45SC @ 0.15 ml/ l as soon as larvae are noticed. Gujhia weevil is a problem in some safflower growing areas. To control this pest, apply Phorate 10G to soil @ 10 kg/ha and foliar spray with chloryriphos @ 2 ml/l about two to three times depending up on level of infestation.

Wilt and Alternaria leaf spot are the major dieses in safflower. For management of wilt seed treatment with Thiram or Mancozeb @ 3 g/kg seed is recommended. Spray Mancozeb @ 2.5 g/l or Carbendazim @ 1g+ Mancozeb @ 2g/l for management of Alternaria leaf spot.

Plant protection measures determined for seed production need to be applied in time in order to realize high hybrid seed yield. It was suggested to avoid plant protection measures during the peak periods of honeybee visit to the field, which are the main pollinators in safflower. Safeguard the crop from bird damage after crop reaching the maturity till harvesting.

Ghujia weevil Aphids leaf spot wilt

Harvesting and threshing

It was recommended to harvest the crop in the early hours of the day to avoid sharp spines at the time of harvest. Seed shattering is not a problem in parents and hybrids; therefore, plants after cutting from base can be bundled in heaps by arranging them in opposite directions with the cut ends one side and spiny branches on the other way. Used gunny bags or old thick cloths can be wrapped around to avoid spines while harvesting and threshing. Beating sticks or bullock drawn stonerollers or tractor can be used for threshing the seed. The power-operated threshers can be used to thresh and clean the seed. Combine harvesters can be used to harvest variety seed but not to harvest hybrid seed to avoid contamination with seed from male parent after harvesting in the field.

Seed standards and maintenance of variety/hybrid seed purity

I. **Application and Amplification of General Seed Certification Standards** The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of safflower seed.

II. Land Requirements Land to be used for seed production of safflower shall be free of volunteer plants.

III. Field Inspection A minimum of three inspections shall be made, the first before flowering, the second from flowering and the third at maturity and prior to harvesting.

IV. Field Standards

A. General requirements

1. Isolation

Safflower seed fields shall be isolated from the contaminants shown in column 1 of the Table below by the distances specified in column 2 and 3 of the said Table:

Contaminants	*Minimum distance (meters)*	
	Foundation	*Certified*
1	2	3
Fields of other varieties	400	200
Fields of the same variety not conforming to varietal purity requirements for certification and wild safflower (*Carthamus oxyacantha* M. Bieb.)	400	200

B. *Specific requirements*

Factor	*Maximum permitted (%)**	
	Foundation	*Certified*
Off-types	0.05	0.10
**Objectionable weed plants	None	None
*Maximum permitted at any inspection at and after flowering **Objectionable weed shall be : Wild safflower (*Carthamus oxyacantha* M. Bieb.)		
V. Seed Standards		
Factor	*Standards for each class*	
	Foundation	*Certified*
Pure seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	None	None
Total weed seeds (maximum)	5/kg	10/kg
*Objectionable weed seeds (maximum)	None	None

Post Harvest Handling & Management of Oil Seed Crops

Er. M. K. Vishwakarma
Seed Processing Engineer, National Seed Research & Training Centre, Varanasi

Seed is one of the most important inputs for sustainable agriculture. Quality of seed affects both yield and credibility in the market. Unlike in grain, extreme care and vigilance is required in seed to avoid mechanical mixing of crop varieties during post harvest stages such as threshing, winnowing, drying, Pre-cleaning, grading, packaging, storage and marketing. Many a time carelessness as well as ignorance at any stage cause colossal loss in seed quality and market value. Hence in-depth knowledge of post harvest care and improvement in physical purity of seed is most important.

The objective of seed processing is to achieve clean, pure seeds of high physiological quality (germinability) which can be stored and easily handled during succeeding processes, such as pretreatment, transport and sowing. Processing includes a number of handling procedures, where applicability differs e.g. according to seed type, condition of the seeds after harvest and potential storage period. Seed cleaning typically consists of a series of processes during which impurities are gradually removed and the seed lot concurrently achieves a progressively higher purity (Fig-1). The type, order, and adjustment of the processes depend on seed type and type of impurities. During seed processing, contaminants are removed to a level that meets the industry wide minimum seed certification standards, failing which, they may be discarded or blended with a relatively better lot of the same variety. Contaminants are removed by procedures utilizing machines which exploit the differences in physical characteristics of the desirable seed and other components in the mixture. These physical properties include but are not limited to length, width, thickness, shape, density, terminal velocity, drag coefficient, reflectivity, surface texture, electrical conductivity and resilience. Seed separators are designed to utilize the difference in a single physical property or a combination of physical properties of the seed.

Concept of Separation Processes:

Separation and purification of materials forms an important process in post harvest handling of agricultural products. Naturally occurring processes are inherently mixing processes and have led to the reverse procedure of separation processes which are becoming the most challenging categories of engineering problems. Mechanical separations are applicable to heterogeneous mixtures. Broadly, a separation processes a mixture of substances in two or more products which differ from one another in composition. The separation is caused by the addition of a separating agent which may be in the form of energy. Need for separation accounts for the most of the production cost of a pure substance. Often separation itself can be the key function of the entire process e.g. grain cleaning. To a large extent man's ability to ease food shortage depends upon his technical knowledge and capacity to extract and separate essential food materials from the new or inexpensive sources. From the above considerations, it is apparent that much careful thought and effort must go into understanding and improvement of various separation processes.

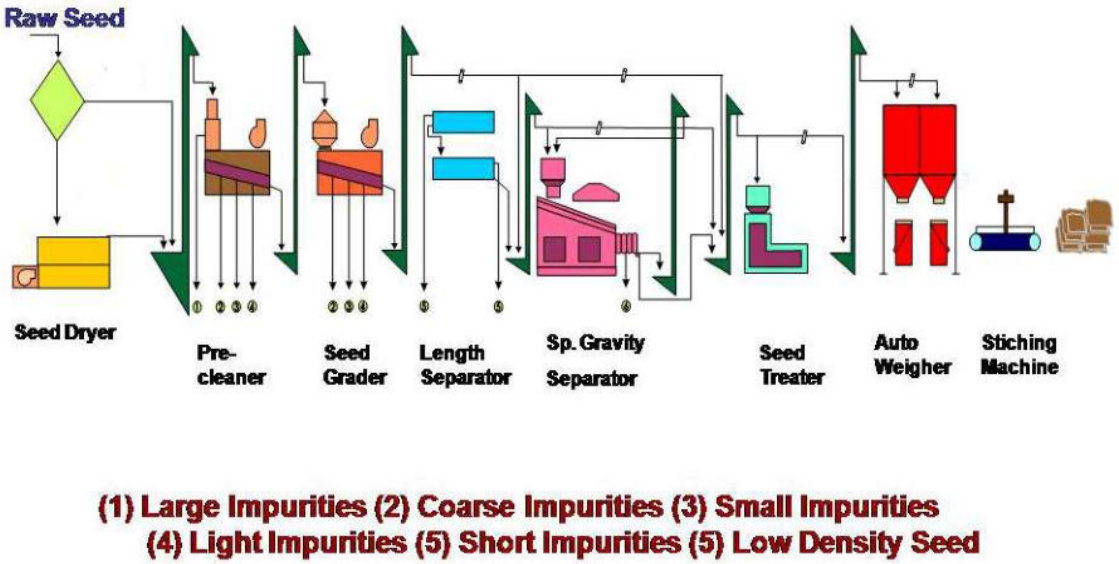


Fig-1: Flow diagram of modern seed processing

Methods of Seed Separation:

Improvement in seed separation technology from simple hand picking and domestic hand screen to present day methods runs parallel to the story of civilization. A modern seed processing involves moving the field produce through a series of machines which perform specific operations and pass on the product to the next machine after discharging the reject. A well designed seed processing plant is laid out to permit by passing any machine without interrupting the product flow. Many types of seed cleaning machines are used to remove contaminants from the harvested-threshed seed.

Air-Screen Cleaner:

The air-screen cleaner is the most widely used machine. It is an essential unit operation in seed processing plant. The simplest mechanical method of separating particulate solids, the class to which most agricultural seeds and food grains belong, is by passing than over screens which are stationary or reciprocating and are set at a slight downward slope, so that small particles will pass through and larger materials will tail over them. In combination with air-fans or blowers, the screen machine provides adequate conditioning for some seed crops. Such machines work by taking advantage of dimensional and aerodynamic differences. Agricultural screens are constructed of perforated metal or woven wire mesh. Hole shapes in perforated screens are usually round, triangular, oblong or rectangular, Openings in wire screens are square or rectangular, their size being represented by mesh numbers. Round hole screens are identified by a number denoting diameter of the perforation. In India, these numbers indicate the diameter in millimeters. Rectangular or oblong holes in perforated screens are identified by two numbers describing the width and length of the slot. Selection of the screen depends on the seeds being handled. Screen opening sizes used for different crops have been prepared and are available in literature. Screens with various sizes and shapes of holes drop some particles and retain others depending mainly on the width and thickness of particles and, to a lesser extent on their length. Pneumatic separators or air columns exploiting aerodynamic differences are used to remove dust, chaff or other light contaminants. The air system in air-screen machine operates in this manner. As a finishing machine it can remove light, immature, shriveled or

damaged seeds from already cleaned good seed lots. Air screen combinations are extensively used in grain combining and threshing.

The air screen machine in general employs three cleaning elements: aspiration, scalping and grading. The light seeds and chaffy materials are removed from the seed through aspiration. In scalping operation, the good seeds are dropped through top screen opening and the larger materials (trash, clods etc.) are carried over the screen into the rejection spout. In grading operation, the good seed ride over screen openings, while smaller particles (under size, cut shriveled, broken seeds) drop through.

Feed hoppers of air screen cleaner cum grader are of three types: Roll feed hopper consists of a container to receive the seed, hopper flights and auger to spread the seed across the width of the hopper and a revolving fluted roll in the bottom of the hopper that feeds and even steady flow of seed to the top screen and distributes the seed across the full screen width. In roll feed brush hopper a rotating shaft pulls trash of seeds down to the revolving fluted roll and a tough fibre brush to prevent clogging. In the metering hopper a shaft width specially bent rod is used to spread the seed. Other special purpose variants are designed to handle special seeds.

Principles of operation:

In a typical two screen seed cleaner cum grader, as the seed is delivered by the feed hopper the air blast removes light weight seed and chaff, scalping screen remove material larger than the crop seed; grading screen dropout material smaller than the crop seed. In a four screen machine, the 4 screen do the following operations: (a) 1st screen- scalping, (b) 2nd screen- grading, (c) 3rd screen- close scalping, (d) 4th fine grading. At the seed drop off the gravity screens they fall through the lower air separation to remove residual light seed and trash.

Length Separator:

Length separators are designed to lift and remove the short fraction from a varied length mixture by exploiting the difference in the largest dimension of the product and the reject. These are two types of length separators, the indented disc separators and indented cylinder separators. Both lift out short particles out of a seed mixture with a given pocket or indentation and a relatively cleaned product is pushed further. The indented disc separator consists of a series of indented discs, mounted together on a rotating horizontal shaft. Each disc is designed with an open centre and numerous undercut recesses on each face. The broken seeds and the material shorter than the crop seed are lifted by the indents and are delivered into a trough at the side of the machine. Discs of increasing pocket sizes are normally provided on the shaft so that the particles of increasing lengths are removed selectively. The long seed that does not match the pockets is pushed by the incoming seed through the open centre of the disc and is discharged at the outlet.

The indented cylinder separator consists of a rotating cylinder and an adjustable trough. The inner surface of the cylinder has closely spaced indents. The seed mass to be handled is fed at one end and lies at the bottom of the cylinder. As the cylinder rotates on its axis the short seeds are lifted from the mixture by indents. Thus at some point before reaching the top of the rotation, the seeds fall out from the indents, because of the tilting of the later. Actually, the seeds resting in the indents lose balance and are eventually received in the adjustable trough from where they are conveyed out by an auger. The long seed which is not lifted by the indents gradually move through the cylinder end are discharged to a separate spout at the other end of

the cylinder. The quality of separation depends on the position of the trough and the speed of the cylinder.

Specific Gravity Separator:

A specific gravity separator consists of two key components - air chest and the deck. Air chest houses fans and motor. The deck is mounted above the chest. The deck is a rectangular or triangular table covered with a porous cloth or wire mesh and inclined in two directions. The gravity separator classifies components of a mixture mainly according to density. Separation is caused in two steps. Seed mixture introduced at the back of the porous deck is stratified by the low pressure air coming through the deck. Low density particles tend to float and form a layer at the top and the high density particles sink to the bottom layer. Fractions of intermediate density, assume intermediate position. For proper identification of different density fractions, the seed lot must be well screened before hand so that all particles are of the same size. The seed should be dust free. An aspiration canopy is installed above the feed corner to further suck up any residual dust. The oscillating motion of the deck moves the high density particles laterally towards the uphill side at the deck. Simultaneously the floating low density material moves downhill by gravity. As the seed mixture layers travel from the feeding corner to the discharge end of the deck, a continuous gradation of particles takes place ranging from the low density ones at the lower side of the deck to the high density ones at the upper side. Adjustable splitters divide the output into number of density fractions needed. For deck covering a closely woven material for small seeds and a coarse weave for large seeds is used. Typical covering materials are small hole perforated metal and wire mesh. The coverings are supported by a deck frame, which serves as the top of the air chamber and helps to equalize the flow of air through the seed mass. Feed rate, air flow rate, deck angles and frequency of stroke are major adjustments. These adjustments are interrelated.

Seed Refining:

To further refine the seed, machines have been developed to take advantage from additional differences in physical properties. The electrostatic separator exploits the difference in the electrical characteristics of the seeds and contaminants. The quality of separation depends on the relative availability of the components in the seed mixture to conduct electricity or to hold electrical charge on surface. A spiral separator senses the ability of components to roll. This is very simple machine and operates completely by gravity. It has no moving parts and needs no prime mover. The endless draper belt separator utilizes surface texture differences to separate rough seeds from the smooth ones. A magnetic separator requires certain pre treatment of the feed mixture. Iron power or a magnetic fluid is added. Variation in seed coat characteristics is utilized. The iron is selectively adsorbed by rough, broken, cracked porous or sticky components making them more reactive than the smooth components. A colour separator acts on differences in reflective properties. The components of the mixture must be cingulated for individual sensing by the photoelectric cells. To scale up the throughput multi-channel machines are required.

New Emerging Technologies:

Modernization of agriculture causes demand for higher quality seeds and invites application of new technologies to seed conditioning. This needs removal of all contaminants even when the physical property difference is very slight. This emphasis has led to the

investigation of measurement system for physical properties and development of systems for improved seed conditioning. With the advent of microprocessors and the rapidly expanding application of technology, seed conditioning is beginning to benefit as the use of computers is integrated into the new equipments. Machine vision system (MVS) is being used for seed conditioning. The feasibility of the application was shown for identifying seeds of different colour, size and shape. The MVS can also be used to detect stress cracks in certain seeds. There appears a need to develop expert systems for modern seed processing and once a system is made available, the performance and the status of an average worker can be raised to the level of an expert.

Management of Seed Storage

Seed storage management implies the maintenance of the harvested seed mass in good physical and physiological condition from the time of harvesting upto the time of their replanting. Seed ageing and loss of germination during storage can not be checked altogether. However, it could be reduced appreciably by proper pre storage treatment to the product and providing good storage conditions. Seeds should be stored dry and kept dry. Seeds should be handled more like eggs than like stones. The period of time that seed can be stored without decline in viability is a function of their storage environmental variables and initial seed quality. The simplest and the oldest method of storage is to store dry seed in bags near air temperatures. This is termed as ambient storage or normal temperature storage. Many species can be stored in this way for a year or longer. Conditioned storage is necessary for longer periods and for extra sensitive seeds. Seed longevity in storage rooms depends upon a number of factors. The factors other than kind and variety of seeds are:

Factors Affecting Seed Longevity in Storage

Initial Seed Quality: Seed lots figuring high in initial seed quality store longer than deteriorated lots. The important implication of this is that only high quality seed should be carried over. The medium quality seed may be retained for the next planting season. The low quality seeds should be normally not considered for storage. Low quality seeds decline rapidly in storage. Initial seed quality reflects pre harvest history of the seed lot and the amount of care during the harvesting, transport, threshing, conveying and processing. Well maintained and adjusted post harvest handling equipment are essential for retaining the highest seed quality.

Moisture content: Life of seed and its span largely revolves around its moisture content and it is essential to dry seeds to safe moisture content. Over the moisture range of about 8 to 12%, the rate of seed deterioration increases as the moisture content increases. At higher moisture contents, the losses could be rapid due to mold growth and/or due to heating. Most seeds are good thermal insulators and, therefore they do not permit heat energy to transmit through them easily. Thermal resistance of wheat seed is considered 6 to 10 times higher than concrete. Minor source of heat in the form of moist seed may cause serious rise in its temperature and develop hot spots. Also, within the normal range, the biological activity of seeds, insect and mold further increase as the temperature increases. However, it is important to note that very low moisture content (< 4%) may also damage seeds due to extreme desiccation or cause hard seededness in some species.

Relative humidity and temperature during storage: Relative humidity and the temperature in the air of the seed storage room are the major environmental factors influencing the storage life of the seeds. Low relative humidity makes the air thirsty of water and it picks up the unwanted moisture from the seed. Hence the seeds are kept dry in low humidity condition. Seeds achieve a rather specific and characteristics moisture content, termed as equilibrium moisture content, when subjected to a given combination of atmospheric relative humidity and the air temperature. This results due to the hygroscopic nature of the seeds. Fortunately, the establishment of moisture equilibrium in seeds is a time dependent process and it does not occur instantaneously. Therefore, the diurnal fluctuations in the relative humidity have little effect on moisture content.

Temperature also plays an important role in life of seed. Within the normal range, insect and molds increase as the temperature increases. Decreasing temperatures, relative humidity and moisture, therefore, is an effective means of maintaining seed quality in storage. Low temperature, low humidity storage of dry, cleaned and healthy seeds is the key to effective seed storage management.

Temperature Control:

Temperature is one of the most important environmental factors which influence seed storability. The lower the temperature, the longer the seed maintain good quality. Temperature control may be achieved by ventilation, insulation and refrigeration. These methods are not mutually exclusive and are used in combination.

Ventilation: Ventilation can be used to lower seed temperature and seed moisture control when used judiciously. Ventilation is suitable for minor downward adjustment of temperature (and to a lesser extent the moisture). It can also help to prevent hot spots from developing; the formation of convection air current; and maintenance of uniform seed moisture content and temperature. Right time of ventilation is when the outside temperature and relative humidity are low. At that time the exhaust fan can be put on.

Insulation: The walls, ceiling and floor of a seed storage room must have satisfactory heat insulation and a moisture vapour seal. Floor insulation is frequently installed in a bed of hot asphalt, which provides a good vapour seal. The types of material used may be fibreglass, spray-on-foam, Styrofoam, saw dust, glass wool cork etc. The insulation materials must be kept dry for maximum efficiency. The moisture protection must be provided outside the insulation, if the material does not have a characteristic for dryness naturally built into it. Board type insulation is applied in 2 or more layers. The joints are lapped and/or staggered to minimize heat and moisture penetration at joints. Ceiling insulation can be of many kinds. Ceiling and wall finishes usually consist of one half inch or more cement plaster applied as two coats. Wood, metal, or concrete bumpers are installed on walls where trucks and tractors might accidentally hit them. Low temperature seed storage rooms must have no windows and their doors must be well insulated and well sealed. For large openings, the roller-mounted door (siding door) may be preferred over swinging doors. A relatively novel idea is to use a high velocity stream of cool air across the inner face of the door. Double door air locks and small anterooms also help reduce heat and moisture entering low temperature low humidity seed storage rooms. Adequate measures for checking the leakage of heat and moisture can be provided at the time of planning and building such seed stores.

This job is better left to construction consultants and seed technologists should provide the functional requirements.

It is usually desirable to construct several low temperature rooms rather than a single large warehouse. In this ways annual operating costs can be lowered significantly. During the period when only small lots of seeds are stored, one or two rooms rather than the entire warehouse can be kept refrigerated. Most refrigerated seed storage facilities use forced air circulated through a cooling coil and then through the room. For large areas, a duct system distributes the cold air uniformly throughout the room.

Classification of moisture and heat removal systems configuration

System type	Components	Operation
I	Refrigeration compressor, motor and fans, evaporator and condenser coils	System is placed inside the conditioned space. Inside air is re-circulated through the unit until the set relative humidity is reached and the humidistat shut the unit off. It turns the unit on when the RH begins to rise due to product or system variables. Suitable where the sensible heat does not raise the temperatures above safe limits.
II	Desiccant, heater coils, conditioned air blower, and reactivation blower	Desiccant dehumidifier is located outside the conditioned space. Air in the conditioned space through a closed system, is re-circulated through, the unit until the set relative humidity is reached. A humidistat located inside the seed stores controls the running of the plant.
III	Conventional type split air conditioner	Evaporator section of the refrigeration unit is placed inside the conditioned space. Air is recirculated over the cold evaporator coil. Outside air is drawn over the condenser coils releasing the transferred heat to the atmosphere. A thermostat controls the unit. Electrical heater strips are sometimes used to add heat to the system for RH control.
IV	Desiccant dehumidifier with water after cooler	The water cooler reduces the air temperature as it leaves the desiccant dehumidifier. Effective for maintaining low humidities.
V	Refrigeration unit and the desiccant dehumidifier	Air in the conditioned space is cooled by pre-cooling coil before dehumidification. In the dehumidifier, latent heat of condensation is converted into sensible heat. Therefore, the after-cooling coil is provided. Pre-cooling and after-cooling is provided by refrigeration system.
VI	Refrigeration type dehumidifier and cooler	A self-contained refrigeration-type dehumidifier located inside the conditioned space removes the moisture from the air. The sensible heat load is handled by a refrigeration unit that transfers the heat to the outside atmosphere.
VII	Split air-refrigeration and desiccant dehumidifier	A dual system. The refrigeration system independently dehumidifies (within limits) and cools the air. The desiccant dehumidifier has much larger moisture extraction capacity. Offers a factor of safety in extreme conditions.

Refrigeration: Refrigeration is the household term. It is a process by which the heat is made to flow from lower to higher temperature, i.e., against the natural heat transfer process. It is the only method to achieve and maintain low temperature on long term basis. The medium employed to absorb heat is the refrigeration agent or simply refrigerant. Mechanical refrigeration systems are based on the ability of liquid heat as they vaporize. The vaporizing temperature of the liquid can be regulated by controlling the pressure at which the liquid vaporizes. In closed systems, the vapour is condensed back into liquid and thus used over and over again to provide a continuous flow of liquid for vaporization. Of all the fluids currently used as refrigerant, the one nearest to idle general purpose refrigerant is refrigerant-12 or R-12. It has a saturation temperature of –29.8°C. It can be stored as a liquid at ordinary temperature only under pressure in heavy steel cylinders. A typical mechanical refrigeration system contains the following parts: (1) An evaporator to provide heat transfer surface through which heat moves from the space being refrigerated into the vapourising refrigerant; (2) a suction line to convey the refrigerant vapour from the evaporator to the compressor; (3) a compressor to heat and compressor the vapour; (4) a hot gas or discharge line to carry the high-temperature, high-pressure vapour from the compressor to a condensor; (5) a condenser to provide heat transfer surface through which heat passes from the hot gas to the condensing medium; (6) a receiving tank to hold the liquid refrigerant for future use; (7) a liquid line to carry the liquid refrigerant from the receiving tank to the

refrigerant metering device; and (8) a refrigerant metering device to control the flow of liquid to the evaporator. The typical vapor-compression system is divided into a low and a high-pressure side. The refrigerant metering device, evaporator, and suction line constitute the low pressure side of the system; the compressor, discharge line, condenser, receiving tank, and liquid line constitute the high pressure side of the system. A mechanical refrigeration system that will cool at a rate equivalent to melting one tonne of ice in 24 hours is said to have a capacity of one tonne refrigeration. The capacity of the compressor must be such that the vapor is drawn from the evaporator at the same rate at which it is produced.

Controlling Humidity:

Relative humidity is measured by taking dry bulb and wet bulb temperature reading and finding the relative humidity from psychometric charts. Lower the wet bulb depression (dry bulb temperature – wet bulb temperature) lower is the relative humidity and vice-versa. At 100% relative humidity the wet bulb temperature and dry bulb temperature equalize. Humidity control systems are of two types. These are the refrigeration type and the desiccant type. The refrigeration type dehumidifier draws warm, moist air over a metal coil with fins spaced far enough apart to permit partial frosting and still allow for sufficient air passage. To be effect at low temperatures, a refrigeration type dehumidification system must cool the air below the desired temperature and reheat to the desired temperature. Air handling units are available with built-in refrigeration coils, electric defrosters, and reheat coils. Dehumidifiers using liquid or solid desiccants in conjunction with refrigeration can frequently reduce the cost of maintaining very low relative humilities. The dehumidifier incorporates one or two beds of granulated silica gel or activated alumina, which can absorb much water vapour. Now a days the rotary bed dehumidifiers are in practice. The rotary bed dehumidifiers have one or more beds divided into two air streams. The bed rotates slowly, and while part of each bed is absorbing water vapour from the air stream, the remainder is being recharged.

*****

CERTIFIED VARIETAL / HYBRID QUALITY SEED PRODUCTION OF SUNFLOWER

J. Jawahar Lal, C. Manimurugan, Mangesh Dudhe, K. Sakthivel, PS Srinivas, K. Ramesh

ICAR-Indian Institute of Oilseeds Research, Hyderabad-30

Sunflower is one of the important crops in India's oil seed production that has contributed to rapid growth in oilseed production during the last two decades. Sunflower is the oil of preference among the consumers' world over due to its health benefits. Sunflower is also a crop of choice for farmers due to its wider adaptability, high yield potential, shorter duration and profitability. The crop, is cultivated in about 3 lakh ha.

Sunflower comprising of 48-53 per cent oil contributes nine per cent to oilseeds production and is the fourth largest oilseed crop after soybean, rapeseed and cotton in the world. The seeds are rich in calcium, protein, vitamin, micronutrients and high level of mono and poly unsaturated fats beneficial for heart patients. Sunflower oil is considered superior to other vegetable oils on account of attractive light yellow colour, good flavour and high smoke point, while, seed meal is rich in high quality protein (40 - 44 %) used in cattle and poultry feed manufacturing. Among sunflower products, sunflower meal is largely traded in the world market.

Seed is the most important basic input component in Agriculture. The production of quality seeds is the combined efforts of seed growers and seed inspectors who grow and inspect, rogue and care the seed production fields regularly and timely harvest and processing of seeds.

Production of genetically pure parental seed is pre-requisite for producing quality hybrid seeds in the seed production programme. For production of superior quality of hybrid seed in the chain of different classes namely, nucleus, breeder, foundation and certified seeds, adoption of recommended field standard like proper land, isolation distance, specific crop standards, timely rouging of off type plants is very much essential in the seed production. Utmost importance should be given to avoid deterioration and to retain original characteristics of any variety/population when grow generation after generation.

Requirements for hybrid seed production:

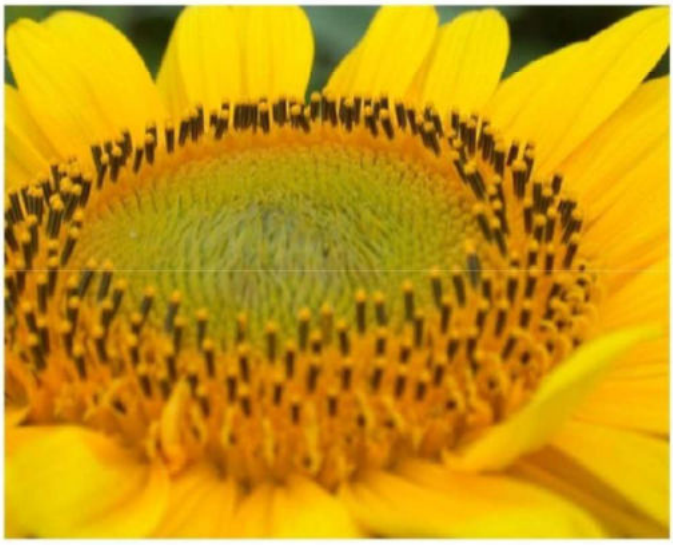
Male sterile line: A line or Female line

Male fertile line: Maintainer line or B line or Isogenic of A line

Restorer line: R line

Male sterile line: A line or Female line

Restorer line: R line



Male fertile line: Maintainer line or B line or Isogenic of A line

Planting time:

Though sunflower is photo-insensitive and non-season bound crop its genetic potentially can not be raised when the crop was caught under adverse situation of abiotic and biotic factors. Such as under intermittent rains, water logged conditions, high temperature (more than 39^0C) and severe stress conditions during flowering period.

Hence, it is important to plant them in right time in such a way that flowering period should not coincide with rainfall and high temperature. Rabi season starting from September will be most suitable for hybrid seed production.

Isolation:

For certified seed production, maintenance of strict isolation distance is must. Though the out crossing through wind is a common phenomenon but the pollination through honey bees is very high. There are some reports that rock bees can move up to 5 km in search of food. Hence at least 1- 1.5 km isolation distance is required for certified seed production of hybrids. The recommended isolation is only 400 mts. If space isolation is not available, time isolation of at least 25-30 days is required to get the quality seeds.

Planting method:

The planting of male and female can be followed in block system it is found to be better to avoid mechanical mixture of male and female seeds compared to the alternate planting of female and male in 3:1 proportion.

Row method:

2 row restorer line	**3 rows female**	**1 row restorer line**	**3 rows female**	**1 row restorer line**	**3 rows female**	**2 row restorer line**

Block system of planting:

Male sterile line A' and restorer line R' lines should be planted in 75:25 proportion in adjacent blocks. Based on the synchrony R line can be planted in two staggered sowings for continuous pollen supply till the pollination ends.

Male sterile A line	R line
AAAAAAAAAAAA	RRR
AAAAAAAAAAAA	RRR
AAAAAAAAAAAA	RRR
AAAAAAAAAAAA	RRR

Roguing:

The objective of rouging is to maintain genetic purity and remove off-type plants from parental stocks. The description of the parental stock is the basis for determination of typical plant.

Successful rouguing requires education of personnel and timely scheduling of fieldwork. Educational phase involves learning of distinguishing features of the parental lines. The off-types include morphologically different plants and pollen shedders. The morphological off types are detected easily and removed prior to flowering.

Removal early or late plants, tall and short plants, pollen shedders from A line, should be done very carefully. Removal of off type plants based on the ray floret colour and opening stage is very critical. Removal of branching types from A line and Removal of non-branching types of R line and vice versa should be done before flowering to avoid contamination.

When flowering begins the male fertile plants in the female line should be removed. The stage of development of the head as well as the time of the day that rouging is done are important. The male fertile plants which are characterized by darker brown colour of the anthers as contrasted to the yellow colour of the male sterile plant should be removed from the female rows every day in the morning hours before bees visit the flowers. This is the most critical stage of rouging.

Roguing at ray floret stages

1

2

3

4

Roguing of branched vs non branching , short and tall plants

Pollination: Transfer of pollen from restorer line to A line during flowering is a must as wind pollination is almost negligible in sunflower hybrid seed production plots. In breeder and foundation seed production, the pollen of B have to be transferred (by collection and pollination) on to the A line, when the crop is in flowering. Utmost care must be taken for nicking of A and R lines. This is done by gently passing the palm or palm covered with muslin cloth, first on the B plants and then by gently rubbing on the stigmas of A line. The other superior method is collecting the pollen in the plastic mugs from the B plants and pollinated to A by brushes. In certified seed production, the pollen of R line has to be transferred to A line as explained above. In case of difference in flowering of A and R lines, staggered planting must be ensured. The hand pollination in all the cases explained above should be carried out in the morning hours (from 8 to 12 h) on all the days throughout the flowering period. At least 4 to 6 times hand pollination is required to realize high seed set on A line. Practicing hand pollination in open pollinated varieties/population indicated 13 to 25 per cent increase in seed yield. For obtaining higher seed yields from seed production plot hand pollination is a must during the flowering period which extends for about 10-15 days. collected pollen should be gently rubbed on the female flowers with the palm covered with muslin cloth. After the pollination is completed, all the B lines in breeder and foundation seed production plots of female seed production and R lines in certified hybrid seed production plots should be cut/uprooted within a week's time immediately after pollination in 3:1 method. Under no circumstances they should be allowed in the seed production plots after pollination. This is essential to maintain the genetic purity and minimum field standards of the seed production programme.

Pollen collection

Pollination

Secondary and micronutrients: Application of calcium or magnesium improved the seed yield to the extent of 23 to 29% through increased seed filling and test weight. The seed obtained had higher germination and vigor index. Similarly, boron application to sunflower seed production plots improved seed quality parameters like germination and vigor index.

Self fertility:

Lack of self fertility in the resultant hybrid leads to poor seed set. This is mainly depending on the restorer parents selected. Though some of the restorer lines selected may be good combiners but fails to restore fertility in the hybrids. The percentage of self fertility varies from 20 to 95% in different hybrids under different situations.

Therefore, selection of better parents to get higher self fertility in the hybrids under varied climatic conditions is essential.

Poor seed filling:

Though sunflower sets seeds but seed filling will be incomplete results in low test weight. This is mainly due to two reasons. That is, when the crop is subjected to water logged conditions during flowering and secondly, during seed filling stage the crop is subjected to water stress conditions results in poor seed filling.

This can be overcome by providing proper drainage by planting on ridges and furrows. Secondly by giving irrigation to the crop at critical stage i.e., 70 days after sowing to get better seed filling

Pollen theft

Pollen theft by honey bees is a common phenomena in hybrid seed production plots. Honey bees are the most efficient pollinators and bee activity is desirable in commercial fields or varietal populations seed plots to promote seed filling. But in hybrid seed production plots, bee activity is not desirable as bee activity restricted to bisexual flowers (Restorer plants) and take away lot of pollen and occasionally visit female line (CMS) it result in devoid of pollen for manual cross pollination in seed plots. Inadequate availability of dehised pollen for effective pollination owing to "Pollen theft" by honeybees has come in the way of producing reasonable quantity of hybrid seed.

Pollen theft in the hybrid seed production plots can be avoided by providing natural smoke during early hours of the day (6 to 9 am) or by spraying any insect repellents on the crop.

Synchronization of parents:

Flowering behavior of parental lines (male and female) should be similar for the heterotic combination identified in the hybrid seed production, there should not be more than 2 to 3 days difference in flower behavior to avoid staggered planting.

Choosing parental lines with similar flowering period for heterotic combination is desirable.

Synchrony in Flowering of Parents in different Hybrids

Achieving synchrony in flowering of parents in seed production is most critical component for successful seed production. Each parent of different hybrids has distinct growth habit and phenology. Achieving synchrony in the flowering of the parents ensures timely pollen availability for pollination that results in higher seed set and higher hybrid seed yield.

Hybrid	Planting schedule
KBSH-53	Plant female parent 2-3 days in advance
KBSH-78	Plant female parent 3 days in advance
KBSH-85	Plant male parent 7-9 days in advance
RSFH-1887	Plant male parent 3-5 days advance
RSFH-700	Plant female parent 3-4 days in advance
LSFH-171	Plant male parent 5-7 days in advance
PSH-1962	Plant male parent 3-4 days in advance
PSH-2080	Plant male parent 5-6 days in advance
NDSH-1012	Plant female parent 4-5 days in advance
PDKVSH-952	Simultaneous planting of both male and female parents
COH-3	Plant male parent 7-8 days in advance
DSFH-3	Plant female parent 2-3 days in advance
TilhanTec-SUNH-1	Plant male parent 5-6 days in advance
KBSH-44, KBSH-41	Male 9 Days days in advance

Sunflower Varieties

I. **Application and Amplification of General Seed Certification Standards:** The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of sunflower seed.

II. **Land Requirements** A seed crop of sunflower shall not be eligible for certification if planted on land on which the same kind of crop grown in the previous year unless the crop(s) grown in the previous year was of the same variety and of an equivalent or high class of certified seed and was/were certified.

III. **Field Inspection** A minimum of three inspections shall be made as follows:

(1) The first inspection shall be made at the stage of 6-7 pairs of leaves in order to determine isolation, volunteer plants, designated disease and other relevant factors;

(2) The second inspection shall be made during flowering to check isolation, Off-types and other relevant factors;

(3) The third inspection shall be made at maturity and prior to harvesting to verify designated disease, true nature of plant and head, characteristics of seeds and other relevant factors.

IV. Field Standards

A. General requirements

1. Isolation

Sunflower seed fields shall be isolated from the contaminants shown in column 1 of the Table below by the distances specified in column 2 and 3 of the said Table:		
Contaminants	*Minimum distance (meters)*	
	Foundation	*Certified*
1	2	3
Fields of other varieties	400	200
Fields of the same variety not conforming to varietal purity requirements for certification and wild *Helianthus* spp.	400	200

B. *Specific requirements*		
Factor	*Maximum permitted (%)**	
	Foundation	*Certified*
*Off-types at and after flowering	0.10	0.20
**Objectionable weed plants at and after flowering	None	None
Plants infected by downy mildew disease (*Plasmopara halstedii* (Farl.) Berl. & de T.) at each inspection	0.050	0.50
Plants infested with *Orobanche cumana* Guss. Non-Wallr. at final inspection	None	None
*Sterile plants of the same variety shall not be considered as Off-types **Objectionable weed shall be : wild *Helianthus* spp.		

V. Seed Standards		
Factor	*Standards for each class*	
	Foundation	*Certified*
Pure seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Huskless seeds (maximum)	2.0% (by number)	2.0% (by number)
Other crop seeds (maximum)	None	None
Total weed seeds (maximum)	5/kg	10/kg
*Objectionable weed seeds (maximum)	None	None
Seeds infested with *Orobanche cumana* Guss. Non-Wallr. (Maximum)	None	None
Germination (minimum)	70%	70%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers (maximum)	7.0%	7.0%
*Objectionable weed is the same as given at IV.B above		

Sunflower (*helianthus annuus* l.) hybrids

I. Application and Amplification of General Seed Certification Standards:

A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of hybrid sunflower seed.

B. The General Standards are amplified as follows to apply specifically to the hybrids of sunflower.

1. Eligibility requirements for certification:

(a) An inbred line to be eligible for certification shall be from a source such that its identity may be assured and approved by the Certification Agency.

(c) Hybrid seed to be eligible for certification shall be the progeny of two approved inbred lines, one of which shall be male sterile.

2. Classes and sources of seed:

(a) An inbred line shall be a relatively true breeding strain resulting from self-pollination with selection.

(b) The foundation class seed shall consist of an approved male sterile line to be used as a female parent and an approved inbred line to be used as a male parent for the purpose of producing hybrid seed.

(c) A male sterile line shall be a strain (A) carrying cytoplasmic-genetic male sterility, which sheds no viable pollen and is maintained by the normal sister strain (B) which is used as pollinator.

(d) The certified class seed shall be the hybrid seed to be planted for any use except seed production.

II. Land Requirements: A seed crop of hybrid sunflower shall not be eligible for certification if planted on land on which the same kind of crop grown in the previous year unless the crop(s) grown in the previous year was of the same variety and of an equivalent or higher class of certified seed and was/were certified.

III. Field Inspection: A minimum of four inspections shall be made as follows:

(1) the first inspection shall be made at the stage of 6-7 pairs of leaves in order to determine isolation, volunteer plants, outcrosses, planting ratio, errors in planting, designated disease and other relevant factors;

(2) the second and third inspections shall be made during flowering to check isolation, Off-types, pollen shedders, and other relevant factors;

(3) the fourth inspection shall be made at maturity and prior to harvesting in order to determine the designated disease, true nature of plant and head, characteristics of seeds and other relevant factors.

IV. Field Standards:

A. General requirements:

1. Isolation:

Seed fields shall be isolated from the contaminants shown in column 1 of the Table below by the distances specified in column 2 and 3 of the said Table:

Contaminants	*Minimum distance (meters)*	
	Foundation	*Certified*
1	2	3
Fields of other varieties including commercial hybrid of the same variety	600	400
Fields of the same variety (code designation) not conforming to varietal purity requirements for certification and wild *Helianthus* spp.	600	400

B. *Specific requirements:*		
Factor	*Maximum permitted (%)**	
	Foundation	*Certified*
*Off-types in seed parent at and after flowering	0.20	0.50
Off-types in pollinator at and after flowering	0.20	0.50
Pollen shedding heads in seed parent at flowering	0.50	1.00
**Objectionable weed plants at and after flowering	None	None
Plants infected by Downy mildew disease (*Plasmopara halstedii* (Farl.) Berl. & de T.) at each inspection	0.050	0.50
Plants infested with *Orobanche cumana* Guss. Non-Wallr. at final inspection	None	None
*Sterile plants of the same variety shall not be considered as Off-types **Objectionable weed shall be : wild *Helianthus* spp.		

Seed Standards:		
Factor	*Standards for each class*	
	Foundation	*Certified*
Pure seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Huskless seeds (maximum)	2.0% (by number)	2.0% (by number)
Other crop seeds (maximum)	None	None
Total weed seeds (maximum)	5/kg	10/kg
*Objectionable weed seeds (maximum)	None	None
Seeds infested with *Orobanche cumana* Guss. Non-Wallr. (Maximum)	None	None
Germination (minimum)	70%	70%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers (maximum)	7.0%	7.0%
*Objectionable weed is the same as given at IV.B above		

Harvesting:

Harvesting of male line should be done before the female. Crop should be harvested when the back of the head turns yellow and the seeds should be air dried before storage.

Following are the practices that can over come the filling problem to some extent in sunflower seed production programme.

- Hand pollination should be carried out regularly in the morning hours from 8.00am to 11.00 am during flowering period for 10 to 15 days
- Pollen should be applied only on the florets which are opened on the day
- Use of bee pollination by introducing 20 to 25 bee hives per hectare, where labour is limited for hand pollination.
- Spraying 5 per cent jagery or sugar solution on male sterile plants attracts more honey bees which in turn helped in increasing seed setting and yield.
- Use of growth regulators line TIBA (240 ppm) to be applied on the capitulum when ray florets started opening.
- Spraying of 0.4 per cent borax to capitulum at the time of ray florets opening facilitated pollen germination.
- Growing of Niger crop to the borders of sunflower seed production plots attracts more honey bees.
- Summers planting should be done in such a way that flowering period should not coincide with high temperature and low humidity which affects pollination and seed set adversely due to desiccation of pollen. (Sunflower crop thrives well upto the temperature of 39^0 C.
- For proper synchronization of flowering in female and male lines staggered planting should be followed.
- The ultimate seed yield of female parent / F1 seeds depends on the effective pollination carried out during flowering period in any seed production programme.

Hybrid Purity Assessment

Genetic potential of seed is the most important factor in deciding the productivity of the crop. Therefore, it is essential to establish the genetic purity of the seed material before it goes to farmers' fields. Conventionally this is done by filed grow-out-Test (GOT). This procedure is time consuming, influenced by the environment and subjective to manual bias.

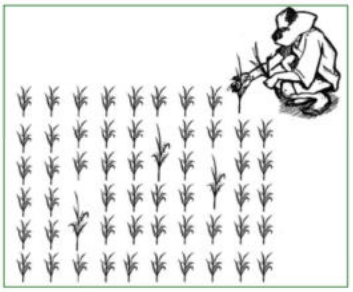
DNA based markers developed for the identification of a genotype (variety or hybrid) overcomes all these limitations.

Two types of molecular markers viz., Random Amplified Polymorphic DNA (RAPD) and sunflower specific simple sequence repeats (SSRs) were chosen for the genetic purity assessment of 13 (BSH-1, KBSH-1, KBSH-41, KBSH-42, KBSH-44, HSFH-848, LSH-1, SCH-35, PSFH-118, DSH-1, RSFH-1, TCSH-1 and NDSH-1) public sector-bred hybrids. Hybrids that showed male specific bands were considered as true hybrids. In hybrids with common restorer lines (KBSH-1, KBSH-42 and KBSH-44) female specific bands were also identified for unambiguous establishment of hybrid purity of each of the hybrids. From the year 2004, a hands-on training course on "Hybrid Purity Assessment using Molecular Markers" is being organized annually at DOR, Hyderabad so as to enable the breeders, biotechnologists and seed technologists working in SAUs, AICRP centres and state run seed production centres gain the technical knowledge for using these signature molecular markers in hybrid purity test.

Usually genetic purity of hybrids are established using the GOT (grow out test) and this test is based on a set of the morphological characters or descriptors.

Conventional method of estimation of hybrid purity

Done by Grow-Out Test (GOT)



GOT has many disadvantages ....

- Based on morphological traits – influenced by environment
- Labor intensive, time consuming
- Loss of one crop season
- Investment locked up during storage period
- Storage leads to loss of seed viability

Hence, there is a need for an assay which can rapidly and reliably detect impurities in hybrid and their parental lines

Insect pest and diseases

Fungal diseases

1. **Alternariaster leaf spot or blight:** It is caused by *Alternariaster helianthi* (Hansf) Tubaki and Nishihara - Pleosporales/Leptosphaeriaceae

The leaf blight is a major defoliating pathogen affects sunflower crop during warm, humid weather throughout the world and cause water-soaked linear spots on the leaf, stem and sunken lesions on the back of sunflower head. It has both pre-, post-harvest impact and found to cause 30–80% losses in seed yield and 17–33% reduction in oil content (Deokar et al. 2014).

Diagnosable symptoms/signs: The pathogen infects and appears in all stages of the sunflower crop irrespective of varieties or hybrids. The initial minute water soaked lesions starts to appear from 20 days after sowing in the two leaf stage and slowly spread to petiole, stem, bracts including petals and sepals (flower head) under favourable weather. Further, the small lesions will enlarge and become small spots, circular to oval (0.2 to 0.5 mm) having concentric rings surrounded by yellow halos mostly starts from older leaves. The dark brown spots enlarge in size having concentric rings in the centre become irregular shape blights and spreads rapidly to upper leaves during rainy weather. Finally, leads to severe premature defoliation and death of the plant. In addition, black to brown lesions appears on stem as narrow, long which coalesces to form large areas results in stem breakage during windy days (Fig 1). Being a seed borne pathogen, it reduces the germination, initial plant stand, vigour and seedling survival. Young seedlings are more susceptible than older plants, but senescing lower leaves on mature plants frequently are defoliated by *Alternaria* spp (Gulya et al., 2017).

Fig 1. Leaf spot and blight symptoms on sunflower leaf and stem portions (A) brown color speck or spot (B, C) brown spot with yellow halo and concentric rings leads to blight and black lesion on petiole (D) Blight symptoms spreads to upper leaves (E) specks on pinhead stage (F) brown sports on petals and sepals (G) Stem splitting and (G) brown coloured conidia

Management: Selection of healthy seeds, removal and burning of the infected plant debris, early sowing during *Kharif* by following / adopting crop rotation and additionally mid-September planting remains free from most of the major diseases and providing adequate spacing (60x30 cm or 45x30 cm) will lead to low disease incidence. Seed treatment with iprodione 25% + carbendazim 25% or mancozeb 63% + carbendazim 12% @ 2g per kg of seed, foliar application of iprodione 25% + carbendazim 25% @ 0.2% or propiconazole 25% EC @ 0.1% or mancozeb @ 2.5g / litre of water for two times at 30 and 45 days after sowing found to be effective. Foliar spraying of mancozeb @ 1000 g/ha or treat the seeds with carbendazim + mancozeb @ 3g/kg followed by propiconazole 0.1 % sprays at 30 and 45 days after sowing or treat the seeds with *Pseudomonas fluorescens* @ 10 g/kg seeds along with foliar spray of hexaconazole or propiconazole @ 0.1% at 45 days after sowing followed by foliar spray of *P. fluorescens* at 60 days after sowing found to control the disease.

2. Powdery mildew: It is caused by *Golovinomyces cichoracearum* (DC.) V.P. Heluta (syn: *Erysiphe cichoracearum*) - Erysiphales/Erysiphaceae

In India, the first report of powdery mildew was on Mexican sunflower during the year 2008 (Baiswar et al. 2008) subsequently on cultivated sunflower in 2009. In the first two years of its occurrence, it was observed only during spring season at flowering and post flowering stages, but subsequently it has become serious during all crop growing seasons and often infecting vegetative stage of the crop (Prathap reddy et al., 2012). It is a more common disease and occurs under dry conditions towards the end of winter months during flowering or seed formation stage. Yield loss was found to be proportional to the disease severity and stage of the crop (Diaz Franco, 1983). A field survey on prevalence of powdery mildew at farmer's field in seven districts of Karnataka state, India which is the largest sunflower growing region recorded 30–74 % disease severity (Dinesh et al. 2010).

Diagnosable symptoms/signs: Symptom appears as small, dull-white, circular spots, white to grey floury patches (white mould) on the upper surfaces of older leaves near the collar region, in severe infection spread to upper region as well as on stem and bracts. These white patches enlarge, coalesce cover entire leaf and most of the plant parts (Fig 2). The first sign

of powdery mildew usually appears as primarily white mildew on the infected leaves in September; the mildew becomes severe on all aerial parts of the plant under heavy infection during the blooming stage of the plant (Fang, 1973). Numerous numbers of oidia produced on leaf surface as white patches turns grey in colour during disease progress. When the crop reaches maturity stage, fungus forms cleistothecial bodies (sexual reproductive stage) and appears as dark dots on powdery mildew patches and reduces seed yield. Powdery mildew can be found in most sunflower fields during the winter season in Taiwan and causes severe yellowing on the blade, petiole, stem, and calyx, as well as serious defoliation. During late stages of the infection, superficial mycelia may enlarge and merge until most of the plant surface is covered. Finally, defoliation takes place. This disease is severe in both rain-fed and irrigated crops.

Fig 2. Powdery mildew symptoms on sunflower crop during flowering and post flowering stages A) white mildew growth starts from lower leaf at vegetative stage B) powdery patches on lower leaves C) white growth covering entire lower leaves D, E) Full white coating in the flowering stage which infects lower leaves to middle F, G) white coating on entire plant in the heading stage covering petiole and stem and G) *Golovinomyces* conidiophores with conidia in chain

Management: The area with high humidity may be avoided and having full sunlight most of the day may be selected. Providing morning irrigation and maintaining optimum population and following crop rotation may be ensured and over use of nitrogen fertilizer may be avoided. Application of wettable sulphur dust @ 25-30 kg/ha or wettable sulphur 80 WP @ 3g or dinocap 48% EC@ 1ml per litre or difenoconazole @ 0.05% or propiconazole 25EC @ 0.1% for two times generally at 45 and 60 days after sowing found to reduce the disease incidence.

3. Downy mildew: It is caused by *Plasmopara halstedii* (Peronosporales/Peronosporaceae)

Downy mildew is one of the major diseases and the pathogen primarily causes systemic infection, which renders new cultivar release at national level. If the infection as early stages in cool, wet years, severe losses of 50–95% have been documented (Markell et al., 2015). Thus, it is considered to be one of the most important diseases of sunflower due to its great potential for destructiveness (Gulya et al., 1997). Latur region is ideal place for the systemic symptom development as mentioned above and one of the important centre for screening.

Diagnosable symptoms/signs: The early symptoms were noticed at two leaf stage of the crop and are severely stunted growth, upper leaves become chlorotic, appear as yellowing of the first pair of leaves which is systemic in nature when young seedlings are infected through the root system, often results in death of plants. If the infections notice at later stage, white fungal growth is seen on the lower surface of the leaves (contains sporangia with sporangiophore structures) (Fig 3), covers large areas and becomes systemic. In the plants flower heads becomes sterile, stiff and face upwards and seeds are not produced on such heads.

Fig 3. Downy mildew symptoms on sunflower A) severe stunted growth and yellowing on upper surface of the leaves at vegetative stage B) White velvety growth on corresponding lower surface of the leaves

Management: Pre-sowing irrigation followed by one irrigation at 10 days after sowing reduces the disease incidence. Rouging of mildew infected seedlings during thinning, removal and destruction of infected plants will minimise the incidence. Seed treatment with metalaxyl-M 31.8% ES 2g/kg and metalaxyl 35% WS 6g/kg of seed has been found to give effective control. Further, ridomil MZ @ 2.5 ml / litre as a foliar pray twice at 30 and 45 days after planting recorded low disease incidence.

4. Charcoal rot: It is caused by *Macophomina phaseolina* (Tassi, Goidànich) (Botryosphaeriales / Botryosphaeriaceae)

Charcoal rot is a serious root-infecting disease found worldwide but is most severe in hot, dry climates. It is both soil- and seed-borne nature leads to severe under rain fed grown sunflower crop.

Diagnosable symptoms/signs: Water soaked red lesions near the collar region, yellowing and wilting of the plants in patches will occur. The infected plants easily pulled out with detached roots from the soil and rotting and bark shredding will be noticed (Fig 4). Plants get affected earlier in the season, but the symptoms are not visible. Such plants become weak, exhibit black ash discolouration of stem even upto 30 cm above soil line. Black micro sclerotia are observed in the pith region of plants. Fungus is seed borne. The disease is favoured by moisture stress and high soil temperatures. Fungus is soil borne and survives in the form of sclerotia in the soil.

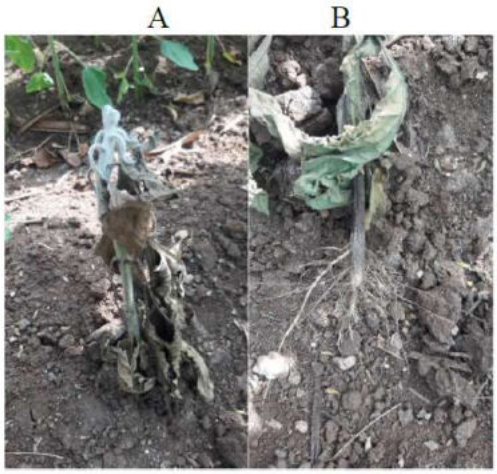


Fig 4. Field level symptoms of root rot disease A) wilting and death of the plant in patches B) bark shredding symptom on infected roots

Management: Frequent irrigations are needed to avoid moisture stress during the crop growth. Sowing early in the season, selection of short duration cultivars will minimise the disease incidence. Spot drenching with carbendazim 1g/ litre followed by soil application of *Pseudomonas fluorescens* or *Trichoderma viride* 2.5 Kg / ha along with 500 Kg of well decomposed FYM or vermicompost or sand at 30 days after sowing found to reduce the incidence.

5. Head rot: It is caused by *Rhizopus* spp (Mucorales/Rhizopodaceae)

Rhizopus head rot has been reported from all sunflower-producing regions. It causes the most damage in areas with hot, dry growing conditions and where heads are damaged by insects (*Helicoverpa*) and/or birds (Parrot and Peacocks) (Rogers et al., 1978; Shtienberg, 1997).

Diagnosable symptoms/signs: Initial symptom appears as brown, irregular water soaked spots on the back of ripening head, usually adjacent to the flower stalk. They become big in size and become soft and pulpy and covered by a loose greyish fungal spore mass. It leads to rotting of sunflower heads (Fig 5), drop off and seeds are transformed into a black, powdery mass. Injury to the flower head is necessary for infection. Larvae of Heliothis are reported to pre dispose the heads to infection because they cause small wounds. It is important in wet weather and causes significant yield losses. In warm humid weather, the disease spread is rapid. The most typical disease symptoms include rotting of sunflower head with a loose cover of greyish fungal spore mass.

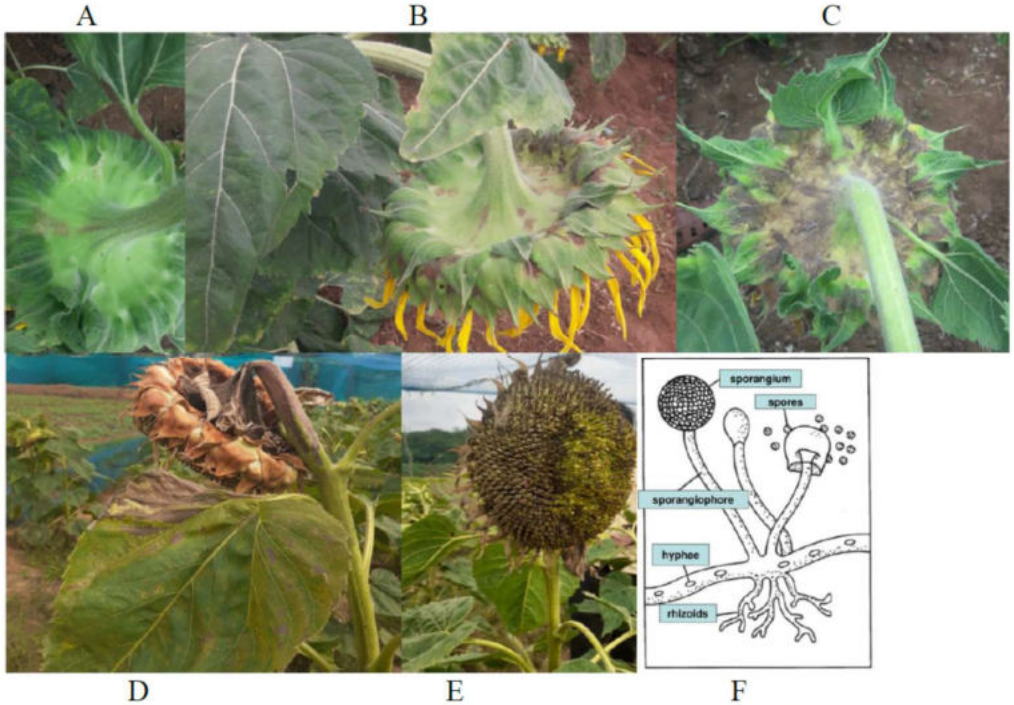


Fig 5. Head rot symptom on sunflower crop A) dark spots of varying sizes as a result of wounding B) watery, soft rot that later dries and C) turns dark brown D) Rotted area of head drying E) Infected head front view and F) Sporangiophore and sporangia

Management: The caterpillar infestation on the sunflower heads may be avoided. Seed treatment with mancozeb @ 2.5 g/kg of seed followed by spray with fenthion 1ml / litre or

wettable sulphur @ 3g / litre of water or mancozeb@ 0.25% or copper oxy chloride @ 0.3% at 10 days interval may reduce the incidence.

6. Southern blight / Sclerotium blight / wilt: It is caused by *Sclerotium rolfsii* Saccardo (Atheliales/Atheliaceae)

Sclerotium blight or wilt is found in Africa, Asia, Australia, Europe, and both Americas in areas that have tropical or semi-tropical climates (Punja, 1985). The ornamental sunflowers grown indoors in hot, humid conditions have the potential for significant losses due to this disease (Gulya et al., 2017).

Diagnosable symptoms/signs: This disease appears 40 days after sowing and the initial symptoms appear as wilting of leaves leads to sicky appearance. Stem is usually infected at soil line. Plants become weak. White fungal mat and mustard seed like sclerotial bodies appears at the base of the stem. Such wilted plants can be easily located from a distance (Fig 6). When such wilted plants pull out they comes easily. Severely affected plants will die. The fungus survives as sclerotia or mycelium in infected plant residue and soil (Punja, 1985).

Fig 6. Wilt symptoms A) sicky appearance B) wilting C) White mycelia growth and sclerotial body production at collar region D) decaying of roots and E) mustard like numerous brown sclerotial bodies on stem region

Management: Deep summer ploughing will minimise the incidence. Seed treatment with carboxin 3g/kg of seed or *Trichoderma viride* @ 4g/kg of seed found reduce the incidence. Soil application of *Pseudomonas fluorescens* or *Trichoderma viride* 2.5 kg / ha along with 500 Kg of well decomposed FYM or vermicompost or sand at 30 days after sowing minimise the incidence. Drenching the affected plants with cheshunt compound or copper oxy chloride 3g/litre at the base of the plants found to reduce the spread.

7. Rust It is caused by *Puccinia helianthi* Schwein which occurs in every sunflower growing area as a sporadic and often localized incidence capable of causing high seed yield losses when the management practices are not followed properly.

Diagnosable symptoms/signs: More severe in *Rabi* season and causes a considerable yield reduction. Small reddish brown spots appear on the lower leaves and they slowly spread on all the leaves and they may turn yellow (Fig 7). When the crop reaches maturity stage, uredosori are replaced by telia and the black rust appears. The primary inoculum may be sporidia of teliospores, or volunteer plants at high altitudes and comes through wind currents.

Fig 7. Symptoms of rust disease on sunflower leaf

Management: Clean cultivation and removal of volunteer plants reduces the primary inoculum. Spraying of mancozeb or zineb or wetable sulphur @ 0.25% for 2-3 times at 10 days interval found to manage the disease spread. Application of sulphur fungicides such as sulphur dust (15kg/ha) found to reduce the disease severity.

8. Phoma Black Stem (*Phoma macdonaldii* Boerema) Pleosporales/Leptosphaeriaceae

Diagnosable symptoms/signs: In the vegetative stage of the crop, specific to cultivar or some lines usually infected with superficial 1- to 2-inch black lesion can be observed and the lesions centered on petioles leads to multiple lesions that may occur on the same stem (Fig 8).

Fig 8. Symptoms of black stem A) 1- to 2-inch black lesion on stem spreading to petiole B) stem breakage in the black lesions

9. Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) Helotiales/Sclerotiniaceae

Sclerotinia sclerotiorum is a fungal pathogen that occurs in all sunflower growing regions (Gulya et al., 1997) and depending on the location and mechanism of infection, the pathogen causes three different symptoms: head rot occurs on the sunflower head, stalk rot occurs anywhere on the stalk and wilt occurs through infected roots and causes premature plant death (Berglund, 2007; Harveson, 2011b). The disease can be very destructive when conditions are conducive for infection and disease development. ˇ

Diagnosable symptoms/signs: Sclerotinia wilt is typically first noticed near the flowering, when plants suddenly wilt and die. First observed symptoms as white to tan colored lesions with concentric rings (Harveson, 2011b). Stalk rot is often initiated through infection on the leaves, which can be observed as tan lesions with concentric rings whereas the head rot infection can be observed as small water soaked spots on the back of the head that quickly enlarge and become tan colored.

Management: Crop rotations have to be followed and growing the susceptible cultivar may be avoided and maintain the optimum population to have air flow in the canopy

Viral diseases

1. Ne**crosis disease:** It is caused by Tobacco streak virus (TSV) (Bromoviridae, Ilarvirus)

This disease is observed in all stages of crop growth right from seedling to harvesting stage (Chander rao *et al*., 2002).

Diagnosable symptoms/signs: Initial symptoms appear on leaves as small irregular, necrotic patches on leaf lamina more near to the midrib. As the disease progresses, it results in twisting of the leaf. It spreads to petiole and stem through one side of leaf lamina and finally it reaches to the tip of the shoot and reaches to flowers and leads to paralytic symptom. Sometimes stem bending and twisting (S shaped curve) beneath the flower head is seen (Fig 9). When the disease appears at early stage of the plant, plants will die at seedling stage itself. Early affected plants become stunted, weak and die. If the disease appears before flowering stage of the crop generally flower formation is affected and flowers fails to open. When the virus attacks after flowering stage seed filling is affected and in severe cases seed setting will not occur. Disease incidence is higher in *Kharif* and *Summer* seasons, where as it is low in rabi season. Highest disease incidence is observed during prolonged dry spells immediately after heavy rains. It does not spread through seeds.

Fig 9. Different symptoms of necrosis disease A) necrotic spots B) Marginal necrosis of leaf C) Necrosis spread to entire leaf lamina and petiole D, E) Twisting of stem to S shape and E) vector *Frankliniella schultzei*

Management/Integrated disease management: Removal of weed hosts especially Parthenium from bunds, adjoining areas as well as from fields. Rouging of the virus infected plants as early as they have been identified. Growing of 5-7 rows of jowar or maize as a border to sunflower crop as they attracts thrips population and acts as a barrier in spreading of wind borne thrips and also to the infected Parthenium pollen. Seed treatment with imidachloprid (Gaucho 70WS) @ 5 g/kg of seed helps the crop from early stage infection. Foliar spray of imidacloprid @ 0.4ml or thiomethaxam @ 0.25g per litre of water at 30 and 45 days after sowing will control thrips population.

2. Leaf curl: It is caused by sunflower leaf curl virus (SuLCV) belongs to Begomo virus group. It is one of the serious diseases of sunflower and first reported at MARS, Raichur on

Sunbred-275 during *Rabi*, 2009 (Govindappa *et al*., 2011). Around 40% losses were reported due to this disease.

Diagnosable symptoms/signs: This disease appears at vegetative, star bud and flowering stages of crop. A yield loss depends on the stage of plant at which virus attacks. This disease appears mostly during *Rabi* and *Summer* crops. Infected plants become shortened. When the plants were attacked at early stages, flower head size is very less and seed setting is difficult. Prominent symptoms observed were small size, malformed leaves, leaf and veinal thickening, enations, upward leaf curling. In some plants few upper leaves may become small in size and curling takes place (Fig 10). Emerging leaves exhibited yellow discolouration and severe

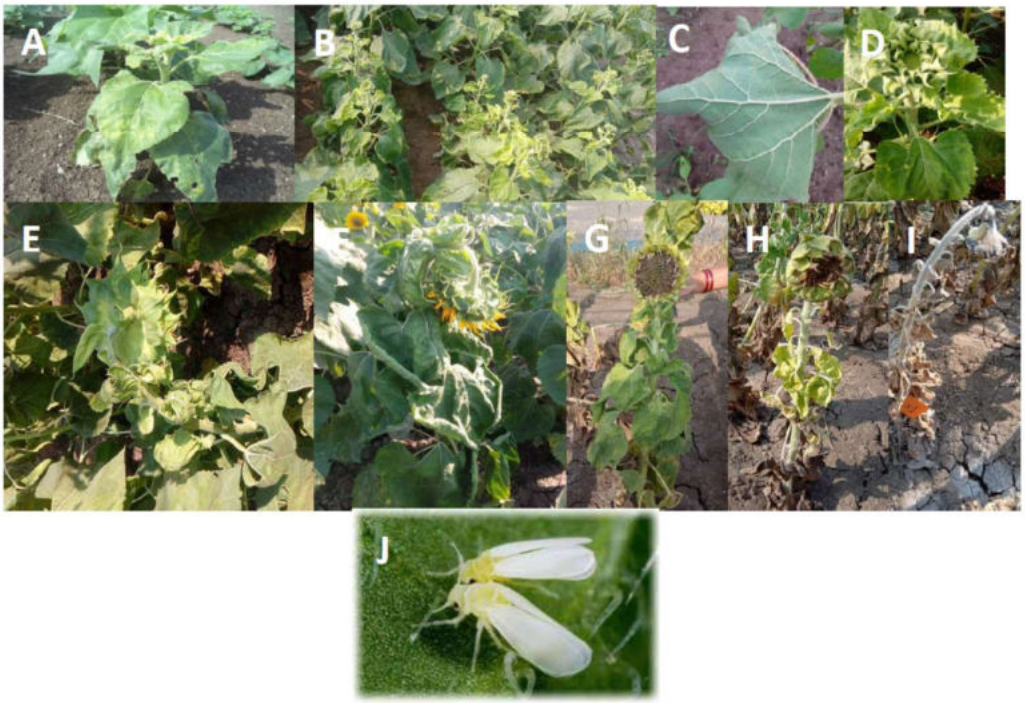


Fig 10. Leaf curl symptoms at different stages of crop and its vector (A-infection at vegetative stage, B-upward curling and severe stunting, C-enations at lower side of the leaf, D-yellowing and mosaic at star bud stage, E-severe curling and bending of head, F-upward curling and 's' shaped bending, G-yellowing, mosaic at grain filling stage, H-Severe mosaic, yellowing and poorly opened head, I-Complete drying and partially filled head and J-Vector-*Bemisia tabaci*

reduction in leaf size. The disease significantly affects the plant height, head diameter, seed weight and oil percentage (Deepa *et al*., 2015).

Management: seed treatment with imidacloprid 600 FS @ 5ml/kg of seed of sunflower protects the early stages of crop from sucking pest infestation. To reduce whitefly intensity in the field spray with diafenthiuron@1 g/lt or flonicamid @ 0.3 ml/litre for 2 to 3 times 30 days after sowing at 15 days interval. The growing of sunflower crop adjacent to cotton fields may be avoided.

*****

NATIONAL SEED RESEARCH & TRAINING CENTRE
G. T. Road, Collectry Farm,
Varanasi- 221106 (U.P.)
Tel: 0542 2370222
E-mail: dir-nsrtc-up@nic.in
Website: www.nsrtc.nic.in