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NATIONAL TRAINING ON

QUALITY SEED PRODUCTION TECHNOLOGY OF PULSE CROPS

(October 16-20, 2023)

Training Manual

Organized by:

Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture & Farmers Welfare
National Seed Research & Training Centre, Varanasi

NATIONAL TRAINING
ON
QUALITY SEED PRODUCTION TECHNOLOGY OF PULSE CROPS
(OCTOBER 16-20, 2023)

Course Director

Sh. Manoj Kumar, IAS
Director

Training Coordinators

Mr. Anil Varma Nalla
Junior Seed Analyst

Dr. A. K. Verma
Senior Seed Analyst

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NATIONAL SEED RESEARCH AND TRAINING CENTRE
VARANASI-221106 (UTTAR PRADESH)
Tel: 0542-2370222, Fax: 0542-2370298
E-mail: dir-nstrtc-up@nic.in
Website: www.nsrtc.nic.in

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Compiled & Edited by:

Dr. A. K. Verma, Senior Seed Analyst

Mr. Anil Varma Nalla, Junior Seed Analyst

Dr. M. P. Yadav, Seed Technologist

Er. M. K. Vishwakarma, Seed Processing Engineer

Mrs. Ekta Kumari, Senior Seed Analyst

Mr. Javesh Kumar, Junior Seed Analyst

NATIONAL SEED RESEARCH AND TRAINING CENTRE
(CENTRAL SEED TESTING LABORATORY)
VARANASI-221 106 (UTTAR PRADESH)

National Training on
Quality Seed Production Technology of Pulse Crops
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जी. टी. रोड, कलेक्ट्री फार्म,
पोस्ट आफिस . इन्डस्ट्रीयल इस्टेट,
वाराणसी 221 106 (उ.प्र.)

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

FOREWORD

Pulses are one of the important food crops globally due to their higher protein content and an important group of crops in India, which is also responsible for yielding large financial gains by amounting to a large part of the exports. Pulses are the major sources of protein in the diet and having 20 to 25 percent protein by weight which is more than two times of protein content of wheat and three times of rice.

The country has exported 7, 75,024.48 MT of pulses to the world for the worth of Rs. 5,397.86 Crores during the year 2022-23. There is a need to increase the productivity of pulses to cater the demand of the increasing population of the country and also need to focus on target to double the income of farmers. The most important factor for increasing yields of pulses 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. Keeping in view I am happy to say that National Seed Research and Training Centre, Varanasi has organized five days National Training course on "Quality Seed Production Technology of Pulse Crops" during October 16-20, 2023 at NSRTC campus. The prime 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 pulse crops.

This training module consists of valuable information and covers almost all important oil seed and pulses crops on various aspects of quality seed production. I hope this compilation will serve as a useful resource book and guide to all concerned.

Date: 20.10.2023

Place: Varanasi

(Manoj Kumar)
Director

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 vision and missions 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

Hybrid Seed Production Technology in Pigeon Pea *Cajanus cajan* (L.)

Ex. Prof (Dr.) C.P. Sachan
Ex. Nodal Officer AICRP on Seeds (Crops)
Chandra Shekhar Azad University of Ag. & Tech . Kanpur U.P.-208002
Email.- dr.c.p.sachan@gmail.com

Hybrid technology, harnessing the advantage of heterosis between two diverse genotypes to achieve maximum hybrid vigour, is widely recognized and commercially used for crop variety improvement both in field and vegetable crops. Hybrids can be developed using appropriate technology, irrespective of the mating and pollination system in the plant species. Production of hybrid seed depends on plant, pollinator and environmental factors, which influence it individually or in interactive ways. Hence, an understanding of these components is important to undertake hybrid seed production of a given crop species. The basic requirements for hybrid seed production at a commercial scale are (a) a unisexual flower or a bisexual flower with sterile pollen in anther or self-incompatible flower/plant; or pistillateness; or large conspicuous bisexual flowers for easy emasculation of flowers in plants to be used as the female parent and (b) abundant pollen production, dispersal and its easy transfer from the male parent to the female parent for satisfactory seed setting. These are dependent on floral biology, flower features, mode of pollination and reproduction of the crop species. Agronomic crop management with scientific insights is equally important for successful hybrid seed production.

Pigeonpea or red gram [*Cajanuscajan*(L.) Millspaugh] is one of the major pulse crop of the tropics and sub tropics. Although it is cultivated on 5.25 million ha in asia, Africa,and south America , 82 percent of the crop is grown in India .It is unique in thatits duration is a continuum of extra short duration (<90days) lines to perennial types. This characteristic of the species allows it to adapt to a wide range of cropping systems, soils and climatic variations. The perennial pigeon pea is widely grown as a backyard or garden crop in Africa and Caribbean and in tribal areas of India for dry grain, greenpeas, fodder and fuel wood. The long duration (<250days) types are invariably grown as inter crop or mixed crop with sorghum, pearl millet or maize in northern India. The cultivated medium duration (160-180days) is similar to that of long duration typesbut relatively in harsher environment.Short duration (120-140days) pigeon pea have been developed recently and grown as sole crop in intensive production system..The productivity of pigeon pea has remainedlow and stagnant over the last few decades thus this prompted scientists to search for novel waysof crop improvement. To tackle this challenge, ICRISAT and IIPR are working on number ofinnovative ideas like, genome sequencing, development of CGMS hybridswith30to40%yieldadvantageovertraditionalvarieties,developmentofphotoinsensitivesuper early maturing lines, introgression of cleistogamous flower structure to maintain geneticpurity of elite lines, use of obcordate leaf shape as NEPto assess genetic purity of hybridparentallinesanddevelopmentofdiseaseresistanthybridsandelitebreedinglines.These aredescribed brieflybelow.

CGMS hybrids: The level of realized heterosis for seed yield in pigeon pea is comparable toother crops where commercial hybrids have already made a mark in global agriculture. Thehybrid breeding program in recent past focused towards developing amoreefficient cytoplasmic-Geneticmale-sterility(CGMS) system.

DevelopmentofCGMSsystem: -Stable male sterility systems were developed from wild relatives *Cajanus cajanifolius* (A4) and *Cajanus Scaraboides* (A2). The F_1 hybrid plants derived from thisCGMS produce excellent pollen load and pod set. At present these CMS systems are being usedby pigeonpea breeders in India, Myanmar, and Chinafor genetic diversificationofA-lines and to producecommercial hybrids.

Developmentof marker-basedhybriditytest: -In pigeon pea Grow Out test take more time due to the long duration nature of the crop. Thereforea simple, rapid, and cost-effective hybrid seed quality testing approach in pigeon pea based onmolecular markers assay was needed. SSR base purity assessment kit are developed which canbeusedforassessingthepurityofthehybrids.

CleistogamousTrait: Pigeonpea is an often-crosspollinatedspeciesandoutcrossingextentupto 25-30 % and is a prime constraint in maintaining geneticpurity of cultivars and genetic stocks. To maintain a variety true to type especially in partiallyout-crossed species, it needs lot of resources in terms of isolation distance, installation of insectproof cages and labor charges for rouging and seed cleaning operations. Considering these factsattention was paid on natural mutant with wrapped flower morphology or cleistogamy.Cleistogamy trait is governed by single recessive gene and very easy to transfer in thebackground of commercial lines. A partial cleistogamous line ICPL 87154 was developed earlierwith low natural out crossing (<1 %). Similar effort was initiated to develop early maturingcleistogamouslines in thebackgroundof elite linesand super earlystablebreedinglines.

Super early maturing Lines: Photo and thermo sensitivity is the major issues in the croprestrictingthehorizontalexpansiontodifferentcroppingsystemsinvariedagroecologies.Traditional cultivars of pigeonpea are of early (120 to 140 days), Medium (140 to 160 days) andLong duration (> 160 days) types which cannot fit in preceding or proceeding crop situations ofrainfed and irrigated ecologies. Super early lines mature within 100 days and have yield potentialup to1.0 to 1.5 t/ha (Vales et al. 2012). Out of these, ICPL 11242 and ICPL 20325 in NDTgroup and ICPL 20338 and ICPL 11253 in DT group were found promising. These lines providenumber of opportunities like expansion of pigeonpea on non-traditional area like rice fallow,could fit the pigeonpea-wheat cropping system, contribute to reduce environmental degradation,attractive option to grow the crop on stored soil moisture, can escape diseases, drought and podborerattack.

Hybrid Seed Production:-The commercial seed production of pigeon pea hybrids involves large scale seed production ofA-, B-, R- lines, and the hybrid combination (A x R).For seed production of A-line, breeder seed of both A- and B-lines are planted using a female: male row ratio of 4:1.In the production areas where greater bee activity is observed a higher row ratio can be used for getting high yields. For hybrid seed production (A x R) also, the same ratio can be used.

Male sterile line (Female line): In some red gram varieties the anthers are unable to produce pollen grains. These are called male sterile lines. These lines are use as female parent in hybrid seed production.

Male Line: - At the time of hybrid seed production, the male sterile female parent is crossed with another variety having usual pollen grains. The variety which is having pollen grains is called male line.

Selection of Land :-Red sandy loam soils , well drained black soils are suitable.Saline, Saline alkaline and soils prone for inundation during crops period are not suitable with neutral PH. Deep loam soil (as red gram is a deep-rooted crop) along with higher organic matter will lead to production of vigorous seed.

Isolation:-The minimum isolation distance required is 200 m F/S=250 mts, C/S=100 mts

(from fields of other red gram varieties and to the same)

Preparation of Land:-Plough the land to get fine tilth. Since it is a deep rooted crop, deep ploughing is necessary.Then form 1.5 feet ridges and furrows.

Fertilizer application:-Apply 10 cart loads of farmyard manure.Then add 25 kg urea and 60 kg super phosphate as basal fertilizer in sides of the ridges.

Selection of seeds:-For seed production always use C/S, Since C/S are having higher percentage germination and vigour and germinates quickly, gives vigorous seedlings. Thus it enhance the yield

Seed Rate:-For hybrid seed production we are using male and female lines. So care should be taken for not mixing the two lines.Male parent-5 kg/haFemale parent -30-38 kg / ha.

Seed Treatment:-During germination the fungus present in the soil affect the germination per cent by causing seed decay. To control this, treat the seed with captan or thiram 2 g/ kg seed.Rhizobial seed treatment may also applied.

Sowing :-The female and male parents are to be sown separately in the ratio 4:2 with border rows of pollen parent (male parent).The border rows should be male parent to give more pollen for pollination .For both male and female parents, the spacing between plant to plant is 15-20 cm necessary to sow 3 seeds per hill for female line and 1 seed per hill for male line.

Irrigation Management:-Water is applied immediately after sowing followed by life irrigation onthe third day. Then, irrigation is given whenever the fields become dry.

Irrigation during flowering,

1. Pod formation
2. Seed development

Foliar application of fertilizers:-The nutrients given through foliage are easily absorbed by the plants and its goes to the developing seed, there by vigorous seed is obtained.For foliar applications DAP solution can be used.

Growth Regulators:-In pulses 50% of the flowers shed. Hormonal deficiency is the major problem. Due to flower shedding, pod formation and seed yield is reduced. Therefore, it is necessary to spray growth regulators to the pulses to reduce flower shedding. Spray 4 ml of planofix for 10 liters of water at 50% flowering stage.

Plant protection:-Pests, Pod borer and Blister beetle are need to be managed properly

Disease:-Downy mildew, Sterility mosaic virus and Root rot are common diseases need to takencare of in right time.

Rouging:-It is required to be accomplished at following stagesPod formation stage and Prior to harvest .Remove the male fertile plants (pollen shedders) by examining the colour of the anther (yellow) in the female rows at the time of first flower formation one day before flower opening. The plants with translucent white anthers (sterile) alone are retained in the female rows.The above operation should be completed in 7-10 days' time daily visit to the field. In case of male parent , remove immature pods set in the plant from time to time to induce continuous flowering to ensue pollen availability for a longer period,later flowering plants are also to be removed in female parent.

Methods to increase seed content: -Male parent is sown one week after female parent.Sowing the male as border crop.In male parent the first formed immature pods can be removed.Sunflower is sown around the hybrid seed production plot.

Harvest: -It should be done at appropriate time of seed maturity when the pods turn to tan color, delayed harvest will cause shattering of seeds.To control pulses beetle damage spray Quinalphos 2 ml/lit as per harvest sanitation spray.

Seed Processing;-To get plumpyseeds, size grade them using 3.35 mm or 2.8 mm round performed sieve depending upon the variety.Remove broken and disease affected seeds from processed seeds and use quality seed for storage.

Seed storage:-The care given for seed production should also be given to store the seeds till the next season .The Seed quality varies depending upon seed moisture content.The high moisture seed loose their germination capacity quickly. For short term storage dry the seeds to 9 percent moisture content and store in vapour proof polythene bag.

Seed Treatment:-Before storing the seeds, it should be treated with captan or thiram @ 2g /kg seed.

Storage Containers:-To store the seeds in the high moisture places like sea stores and near lakes, moisture vapour proof containers should be used (700 guge polythene bag).Always use new bags and care should be taken when the seeds are stored in godwon. Seed bags can be stacked one upon other up to 6 layers. Stacking beyond this will damage the seeds present in the lower layers. To Prevent damage to seeds in the bottom layers, layers can be rotated periodically by shifting the lower layers to the top and vice -versa.Stacking must also be alone be done dunnage. These are wooden rafts that keep the seeds above floor and allow aeration.Tarpaulins and thick plastic seeds can also be used.

Seed Certification :-Seed certification guarantees the quality of seed as it ensures that the certified seed has the Genetical, Physical, Physiologicaland seed health qualities.Bygenetical quality seed has all the character tics as desired by the breeder who had developed the variety, like short duration, higher yield , high protein etc.

Minimum Seed certification standards prescribed for certified seed

Factors	Standards
Pure Seeds	98%
Inert matter	2%
Other crops	1 %
Weed Seed	1 %
Germination	75 %
Moisture vapor	8%
Moisture previous	9%

*****

Quality Seed Production Technology in Faba Bean and Winged Bean

Nagendra Rai, Rakesh Kumar Dubey and Indivar Prasad
ICAR-Indian Institute of Vegetable Research, Varanasi-221305
Email: nrai1964@gmail.com

A. Faba Bean (*Phaseolus vulgaris*)

Introduction

The broad bean, *Viciafaba* L., is also known as faba bean, horse bean or baklaIn India, it is mainly cultivated as pulse crop but green and tender pods and shelled green beans are also used as vegetables. China and Ethiopia are largest broad bean producer countries in the world. It is one of the most important winter crops for humanconsumption in the Middle East.It is mainly cultivated in Uttar Pradesh, Bihar and Madhya Pradesh during winter season The plants usually attain the height of 30-100 cm, dependingupon type of the variety. The stem is square, erect and usually does not branch. The pods are borne in clusters of 3-5. The pod size is approximately 20 cm and each pod contains 2-3seeds. Small seeded types (*V. faba* var. *minor*) called tick bean or pigeon bean and arecommonly used for animal feed. Medium sized seed types (*V. faba* var. *equina*) arerepresented by what is commonly called the horse bean, whereas large seeded types (*V. faba*var. *major*) are called Windsor bean or broad bean and are used as a green vegetable or as adry bean.

Family	Fabaceae
Scientific name	*Viciafaba* L.
Chromosome number	$2n = 2x = 12$
Origin	Central Asia

Origin and distribution

Near East and western Mediterranean regions are considered as centre of origin of Broad bean while Afghanistan and Ethiopia are considered as centre of diversity. The wild progenitor of broad bean is unknown. Globally, it is cultivated in subtropical and temperate climate but it is also well adapted to cooler climates. Faba bean is believed to have been cultivated in Israel as early as 6800-6500 BC. It was introduced into Mediterranean and central Europe 3000 years later. It was the only beanknown in the old world at the time of discovery of the Americas.

Nutritional Profile

Fresh faba beans are good dietary source of protein and vitamins C and riboflavin. Per100 g green pods contain 7 g protein, 11.3 g carbohydrates, 98 mg phosphorus, 26 mgcalcium and 25 mg vitamin C. faba bean contains small amounts of anti-nutritional factorssuch as protease inhibitors. Faba bean also contains a toxin called vicine that causes a diseasecalled favism (oxidative damage and rupturing of red blood carpusels). The toxin present inmature seeds can be destroyed to a large extent by proper cooking.

Use

Faba bean is used as a human food in developing countries and as animal feed especiallyfor pigs, horses and poultry in developed countries. It is used as a vegetable, green or dried, and fresh or canned. It is a common breakfast food in Middle East, Mediterranean region, China and Ethiopia. Pods are shelled when beans are green for cooking as a green vegetable, commonly as stews. The seeds may be boiled or roasted and used as a snack food. A blackline on the bean is a sign of age and toughness and it is better skinned before use. The Japanese call it soramame bean and use it widely in pickled form.

Biological Description

Broad bean is an annual, with erect pant type and the plant height reaches upto 50 to 180 cm. It has both tall and short varieties. It has square and erect stem, leaves are large and broad upright pods are borne in leaf axil. It has both small seeded and large seeded type. The seeds of broad bean are rich source of protein. It is rich source of L-DOPA which is beneficial in treating Parkison's disease Seeds of faba bean also contains anti-nutritional factors like tannins, vicine and covicine which causes "favism", a form of haemolytic anaemia. Harmful effects of these compounds are eliminated when seeds/pods are well cooked.

Cytology, Germplasm and Breeding system

The broad bean has chromosome number 2n=12 and 24. Mainly, three types of chromosome A, D and I are found at the time of meiosis. The largest collection of germplasm is being maintained by International Centre of Agricultural Research in Dry Areas (ICARDA).In India, NBPGR, IIVR and several NARS partners are maintaining germplasm accessions of broad bean.Broad bean is classified under often -cross pollinated crops as natural cross pollination ranges between 20-40 percent, mainly by bumblebees and honey bee.

Floral Biology

Flower 2-3 cm long at anthesis, have a typically papilionaceous structure. They can be white, brown or violet. In most cases, they concentrate their colour on black or brown melanin spots on the wing.Generally, anthers dehisce before the flower opens, but pollen germination is delayed until anthesis. When a frontal visit by an insect occurs, auto or allo-pollen is brought into contact with a disrupted stigmatic surface and pollen germination and fertilization results.Natural out crossing of 2-84 % with mean of 32% is reported.The out crossing is done by insects/honey-bee.

Breeding Objectives

- High yield
- Stable yield
- Desirable seed size and colour as per consumer preference
- High seed protein (27-34%)
- High Methionine and cysteine
- Low Tannins
- Low vicine and covicine
- Earliness
- Stiff-straw
- Resistance to chocolate spot, rust, aschochyata blight etc.
- Tolerance to drought, heat and salt

Breeding methods

- Pureline selection
- Mass selection
- Recurrent selection
- Population improvement scheme
- Hybridization followed by selection
- Line breeding
- Speed breeding
- Mutagenesis
- Marker Assisted breeding
- Hybrid Breeding
- Synthetic breeding
- Phenotypic recurrent selection

Popular Varieties

Exotic varieties of faba bean are tall with long pods. ICAR-IIVR has recently released a variety named Kashi Sampada, suitable for vegetable purpose with yield potential of 9-10t /ha green pod.The variety, Pusa Sumeet was developed by selection. It produces dark green pods in clusters. The first picking starts in 65-70 days after sowing and yield potential is 18 tonnes per hectare. Recently, ICAR-RCER, Patna has released two varieties namely Swarna Suraksha and Swarna Gaurav in 2016.Faba Bean variety "SwarnaSurakhsha" has been developed mainly for the rainfed situation under Bihar agro-climatic condition. The average productivity has been recorded 2.5 to 3.1 t/ha which is 40 % more over the test check variety i.e. Vikrant. Another faba bean variety "Swarna Gaurav" has been developed for the assured irrigation and intercropping situation. Under Bihar agro-climatic conditions, the average productivity has been recorded 4.0 to 4.6 t/ha and 2.0 to 2.6 t/ha under mono and intercropping system, respectively.

Seed Production

Faba bean is often cross-pollinated and out crossing to the extent of 30 per cent is possible.Pollination is done by bumble bees. Lack of pollinators and reduced seed setting can be a major constraint for economic seed yields.For the production of genetically pure seed, an isolation distance of 500 m between two varieties of faba bean is ideal. Although faba bean is not prone to shattering but harvesting is started as soon as pods turn black even though some of the stems may still be green. Average seed yield is 15 quintals per hectare.

Quality Seed Production Technology of Faba bean

Climate

Faba bean is the only bean that can also be grown in winter. It germinates and grows wellunder cool soil conditions such as those favourable for production of peas. The hardycultivars tolerate temperature of –10°C without serious cold injury. The optimum temperaturerange for crop production is 18-27°C. Temperature above 30°C results in flower drop andpoor pod setting.

Soil

Faba bean can be grown in any type of soil but best growth is possible in well-drained,fertile and silt loam soils. Sandy loams are also suitable but require more frequent irrigation.Faba bean grows best on soils which are neutral or slightly acidic having pH between 6.0-7.0.However, it is desirable to improve soil pH by liming if it is below 5.8. Among legumes, fababean is considered the least drought tolerant. Therefore, moderate moisture supply isnecessary to obtain optimum yields

Manures and Fertilizers

If faba bean is being grown for the first time in the soil or where the beans have not beengrown for the last several years, inoculate the seed before sowing with *Rhizobium leguminosorum* culture to improve fixation of atmospheric nitrogen. In the absence of seedinoculation and naturally occurring bacteria in the soil, the plants show signs of nitrogendeficiency, remain stunted with pale leaves and produce poor yields. Application of nitrogen,phosphorus and potash as starter fertilizers before or at seedling time is beneficial for earlyvigorous growth. The fertilizers @ 20 kg nitrogen, 40-50 kg phosphorus and 30-40 kg potashper hectare are applied in bands 80 mm below and 50 mm to the side of seed rows.

Sowing Time, Seed Rate and Spacing

Large seeded faba beans have problems with drilling by most commercial seed drills andsmall areas are best sown manually. Seeds are usually sown 5-10 cm deep in rows 75 cmapart, with seeds 15 cm apart in the rows. Uniformity of sowing depth gives best emergenceresults. The seeds germinate 10-15 days after sowing. Pre-soaking of seed for 24-48 hours enhances germination. The seed rate varies from 90-120 kg per hectare in small seededcultivars and 80-90

kg per hectare in large seeded cultivars. Sowing is done in the month's ofSeptember-October and February-March.

Irrigation

Adequate and regular water supply is important for faba bean cultivation. However, irrigation is not recommended until two weeks after sowing. Too much irrigation during earlygrowth stages slow down the growth and may increase root rots. During rest of the cropseason, keep moisture levels in top 30 cm soil at 50 per cent of available water or more. Thecritical period of irrigation application is flowering and pod setting stage. Light soils requirelight but more frequent irrigation than the heavier soils.

Weed Control

The broad bean is quite a vigorous plant and will compete readily with most weeds. It isbest to inter-row cultivate four weeks after emergence and again when plants have attained aheight of about 50 cm. Usually, two weedings are adequate. Weeds are also controlled by pre-emergenceapplication of Roundup (glyphosate) @ 1.0 litre per hectare or Stomp 30EC (pendimethalin) @ 2.0 litre per hectare.

Harvesting

Faba bean reaches marketable maturity in 90-120 days, depending upon the cultivar andthe climatic conditions. They are usually harvested when the seeds have developed fully butare still green. When the first beans begin to show black lines along the edges of the hilem then the maturity has peaked. Harvesting should be completed very quickly at this stage. Athumb rule for optimum maturity is that the beans should be about 3.5 cm in length, have no black on the hilem and taste sweet similar to garden pea. Harvesting is done manually.

Yield

Depending upon cultivar and environmental factors, green pod yield in faba bean variesfrom 70-100 quintals per hectare. Average seed yield is 15 quintals per hectare.

Seed Standards

Seed standards means the tolerances permitted as determined by established seed inspection procedures. The seed standards of Faba bean has been given below in table:

Factor	**Foundation**	**Certified**
Pure Seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	None	None
Weed seed (maximum)	None	None
Other distinguishable varieties (maximum)	5/kg	10/kg
Germination (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers(maximum)	7.0%	7.0%

Important Diseases and Insect-pests of Faba bean

Chocolate spot (*Botrytis fabae* and *B. cinerea*): The disease is seed and soil borne. The symptoms first appear as reddish-brown spots onleaves and stem. Later, the spots become dark in colour and coalesce to form large greybrown spots. The symptoms may eventually appear on

a large part of the plant if the weatheris warm and humid. Small, black sclerotia may be seen inside the stem of severely affectedplants.

Control: Destroy or burry the diseased plant debris, use disease free seed, follow crop rotation,treat the seed with Thiram or Captan @ 2-3 g per kg seed and grow the resistant varieties.

Rust (*Uromycesviciaefabae*): It is a common disease of faba bean and the first symptoms appear on leaves as creamyyellowspots or pustules. These spots change to orange-brown surrounded by a pale halo.Later in the season, the symptoms also appear on the stem as black-brown spots. Severeinfection causes premature defoliation and improper pod filling.

Control: Use disease free seed, destroy the infected plant debris from the field, follow croprotation with non-leguminous crops and grow resistant varieties. Spray the crop with fungicides such as Indofil M-45 @ 1.0 kg per hectare. If required, repeat the spray at 10-dayintervals.

Pythium root rot (*Pythium*species): The fungus causes pre-emergence damping-off and seedling wilt. Water-soaked lesions appear on the stem and branches where the affected tissues become soft and slimy. When thestem is girdled, the plants wilt suddenly and die. Older plants may develop dark brownlesions instead of soft rot and may remain stunted and die prematurely.

Control: To control root rots caused by various organisms, follow crop rotation with non-leguminous crops, avoid sowing when the temperature is low and treat the seed with Captanor Thiram @ 2-3 g per kg seed.

Ascochyta blight (*Ascochyta fabae*): The first symptoms appear as grey spots that show through on both sides of leaves. As thespots enlarge, they develop grey centres that contain many black specks. On stems, lesionsare more enlarged, sunken and darker than the lesions on leaves. Stem may split and break atthe point of infection. The disease is severe under cool and humid conditions.

Control: Use disease free seed, destroy the infected plant debris, follow crop rotation with non-leguminouscrops and grow resistant varieties. Spray fungicides such as Indofil M-45 @ 5 gper litre of water.

Bean yellow mosaic virus: The symptoms of the bean yellow mosaic virus include crinkling, downward cupping, yellow mottling and dead areas along the veins of infected leaves. Death of vine tips and newleaves may occur in pole and semi-pole types.

Control: The aphid spreads bean yellow mosaic virus. Controlling the aphid by spraying systemicinsecticides helps to check the virus to some extent. Remove the legume weeds, which act asalternate hosts, from vicinity of the crop. If possible, grow bush type varieties, as the poletypes are more susceptible.

Black bean aphid (*Aphis fabae*): The pest feeds on terminal shoots and young leaves and stem tissues. They feed bysucking cell sap and cause defoliation of leaves, flowers and pods under serious infestationconditions. Aphids also damage the crop by spreading bean yellow mosaic virus.

Control: Remove and destroy the affected plant parts during early stages of infestation. Spray the crop with Rogor 30 EC (dimethoate) @ 2.0-2.5 ml per litre of water.

Red legged earth mite (*Halotydeus destroctor*): It damages the crop by sucking cell sap. The damage is seen soon after the cropemergence. The symptoms first appear as a silvery layering on lower side of the lower leaves.Later on these areas turn chocolate brown in colour, sometimes confusing with symptoms ofchocolate spot fungal disease. Heavy damage results in withering of leaves, dead shoot tipsand reduced nodulation.

Control: Spray the crop with Rogor 30EC (dimethoate) @ 2.5-3.0 ml per litre of water.

B. Winged Bean (*Psophocarpus tetragonolobus*)

Introduction

Winged bean, also known as four-angled bean, asparagus pea and Goa bean, is anherbaceous perennial but grown as an annual. Winged bean is an underexploited leguminous vegetable crop which finds an important place in traditional diets in several parts of the world. It is climbing short-day plant, cultivated as an annual with indeterminate growth. The tubers, young pods, seeds, leaves, flowers and shoots, are rich in protein, amino acids, oils, vitamins and minerals. Almost all parts of the plant can be eaten and are consumed by incorporating in a variety of cuisines. The pods that are usually 15-25 cm long butcan attain a length of 50 cm or so, have four sides with wings protruding from angles andhence the name winged bean. The storage roots (tubers) occur in many cultivars. They are small, irregular, spindle shaped and each weighing around 50 g. The greatest potential for thewinged bean is in the kitchen garden or cultivation on a smaller scale, because the vinesrequire staking, bear pods over a long period of time and require regular harvesting. Due to itshigh protein content, the bean could become one of the important crops of the underdevelopedcountries. It has exceptional nitrogen fixing properties and produces more nodularweight per plant than any other member of Fabaceae family.

Family	Fabaceae
Scientific name	*Psophocarpus tetragonolobus* L.)
Chromosome number	2n = 2x = 18, 22
Origin	Papua New Guinea

Distribution

Winged bean grows well in tropical and humid parts of the world. Traditionally, it isgrown in kitchen gardens in Philippines, Indonesia, Myanmar, Malaysia, India, Bangladeshand Sri Lanka; in Papua New Guinea, West Indies and USA. It was introduced into India in1799 and is cultivated on a limited scale in Eastern states of Assam, Tripura, Maghalaya,West Bengal and Odisha.

Nutritional Profile

Winged bean is low in cholesterol and sodium. It is a good source of protein, thiamin, riboflavin, vitamin B6, calcium, iron, magnesium and potassium and a very good source ofvitamin C, folate and manganese. The composition of green pods on per 100 g fresh weightbasis comprises 71.2 g moisture, 2.4 g protein, 0.2-0.3 g fat, 3.1-3.8 g carbohydrates, 0.8-2.6g fibre and 0.4-1.9 g minerals.It is rich in lysine which can supplement cereal diets that are lysine deficient. The seeds contain high content of unsaturated fatty acids and the seed oil is rich in tocopherol, an antioxidant that improves the utilization of vitamin A in the human body. They are low in fat, excellent sources of protein, dietary fibre, micronutrients and phytochemicals which accords to potential health benefits.

Use

All plant parts of winged bean such as leaves, flowers, pods, seeds and tuberous roots areedible. The mature pods of winged bean are used as a vegetable in almost all parts of theworld where the crop is grown. Leaves and flowers are used as fried or boiled vegetable inPapua New Guinea, eaten raw or cooked as stews in Indonesia, and eaten raw or cooked inMalaysia and as a livestock feed in Bangladesh. In highlands of Papua New Guinea andMyanmar, the root tubers are also consumed. Ripe seeds are used after roasting in manycountries.

Plant Description

Height of the vines of winged bean varies between 3-5 meters. Pods have frilly borders which are 10-40 cm in length with 4 rows of wing type features. Seed burst out from ripe pods and

become brownish at the time of ripening which emits an aroma similar to Asparagus. Flower is white, light blue and dark brick colour and hermaphrodite. The winged bean is cleistogamous and largely self pollinated since anthesis occurs prior to flower opening. Pod formation is visible 7 days after anthesis. The length of the four-winged, slightly bent pod varies from 6-38 cm and the seed number 5 to 20 per pod. A fruit remains in edible stage about 10-15 days after fruit set. Number of fruit per cluster varies from 2- 5. Average weight is about 20-25g per pod. Fruit yield varies 2 to 2.5 kg per plant with tune of 200 - 300 q/ hectare pod yield.

Popular Varieties

Some of the improved varieties of winged bean recommended for cultivation in Indiainclude IIHR Selection 21, IIHR Selection 60, IIHR Selection 71, Revathy (KAU) and WBC2 (Meghalaya). ICAR-Indian Institute of Vegetable Research, Varanasi has recently released Kashi Annapurna, 1st variety of winged bean from UP.

Seed production

Winged bean basically is a self-pollinated crop and natural out-crossing is reported to be less than 5 per cent. An isolation distance of 50 m between two varieties is sufficient to avoid physical mixtures. The seed crop of winged bean is grown the same way as the vegetable crop but the pods are allowed to ripen on the plants.The crop is monitored twice, first at the time of flowering and the second at the time of pod maturity. The seed crop is harvested when the plants turn brown.Delay in harvesting results in seed shattering and poor seed yields.The seed yield varies from 10-15 quintals per hectare.

Quality Seed Production Technology of Faba bean

Climate

Winged bean grows well in tropical and sub-tropical climates. It is photosensitive andrequires short days of less than 12 hours day length and a day/ night temperature of 27/ 22°Cfor reproduction. The bean is sensitive to frost. For tuber production, the optimum day/ night temperature is 24/13°C. Though winged bean is cultivated from sea level to 2000 m altitudesbut it prefers humid and tropical climate. It cannot tolerate prolonged dry spell but short dryspells do not affect the crop.

Soil

Winged bean can be grown on a variety of soils but does better on well-drained, loamyand slightly acidic soils with a pH range of 6.5-7.5. However, it does not grow well in wet soils.

Manures and Fertilizers

Besides 20 tonnes of FYM applied at the time of field preparation, apply 50 kg nitrogen, 100 kg phosphorus and 50 kg potash at the time of sowing.

Sowing Time, Seed Rate and Spacing

Pre-soaking of seed for 48 hours helps in quick and uniform seedling emergence. Pre-soaked seed at 25°C germinates after 5-6 days. Sowing is done on flat beds in late spring orearly summer when frost occurrence does not threaten the crop. The seed rate varies from 15-20 kg per hectare.Depending upon the variety and the climatic factors, the row × plant spacing ismaintained at 90-125 × 45-60 cm.

Training

Winged bean gives response to training. The seedlings show signs of twining few daysafter germination. Training improves pod yield and pod quality; facilitates interculturaloperations and minimize losses due to diseases and insect-pests. The vines are trainedeither individually using one-metre high stakes or the whole row is trained using overheadtrellis.

Harvesting

The pods are harvested when they are 15-20 cm long and 2 cm thick. First picking of green pods is possible 70 –80 days after sowing and the subsequent pickings at 5 to 6-dayintervals.

Yield

Depending upon the variety and the growing conditions, the green pod yield of wingedbean varies from 150-200 quintals per hectare. The seed yield varies from 10-15 quintals per hectare.

Important Diseases and Insect-Pests of Winged bean

Collar rot (*Sclerotinia rolfsii*, *Fusarium moniliforme*): Both the pathogens cause collar rot and are soil borne in nature. The disease is moresevere on young plants when they are 3-4 weeks old. Symptoms appear as water soakedlesions on the stem, which later turn brown and necrotic. Finally whole of the stem rots andthe plants wilt and die. Large number of small, light brown mustard seed like sclerotia develops in the collar region in case of *S. rolfsii* infection.

Control: Shallow planting in well-drained soils helps to reduce the disease incidence. Also treat the seed with Captan or Thiram @ 2 g per kg of seed.

Anthracnose (*Colletotrichum gloeosporivides*): Angular, brown, necrotic and scattered spots appear on leaves, which are surrounded bychlorotic areas. The necrotic tissue often cracks and falls down. Small, glabrous, round acervuli are also noticed on necrotic areas of the leaf.

Control: Follow proper sanitary conditions in the field to reduce the soil borne inoculum. To checkthe disease, spray the crop with Bavistin @ 0.1 percent.

Witches' broom (Mycoplasma like organism): The characteristic symptoms of the disease are smalling of leaves, stunting, Witches'broom and phylloidy. The infected leaves are very small, thin and light green. Internodes ofaxillary branches are reduced and proliferation of axillary branches gives bushy appearance tothe plant. Flowers invariably are phylloid and pod, if formed are small and deformed.

Control: The disease is suppressed by spraying oxytetracycline hydrochloride @ 500ppm. Ifrequired, repeat the spray at ten day intervals.

Winged bean is free from major damage caused by insect-pests. Some insect-pests like aphids (*Aphis crasivora*) may appear in the spring season. They may be controlled byspraying systemic insecticides as recommended in other beans.

Seed Standards in Winged Bean

Seed standards means the tolerances permitted as determined by established seed inspection procedures. The seed standards of Winged bean have been given below in table:

Factor	**Foundation**	**Certified**
Pure Seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	None	None
Weed seed (maximum)	None	10/kg
Other distinguishable varieties (maximum)	5/kg	10/kg
Germination (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers(maximum)	8.0%	8.0%

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Management of Major Diseases in Pulse Crops

Dr Jai P Rai
Associate Professor,
Department of Mycology and Plant Pathology (BHU-KVK), Institute of Agricultural Sciences,
BHU, Barkachha, Mirzapur-231 001

Pulses have very important roles not only in agriculture and crop cultivation but also have much to contribute to the human nutrition, specifically protein nutrition and thus are the key to the strategies designed to combat the rampant protein malnutrition in the continent. Pulses have a key role to play in the nutritional security of the country and are an important source of protein for the majority of the vegetarian Indians who still do not have easy access to dairy and meat products owing to a number of reasons including the economic ones. Besides proteins, pulses are also a good source of fibre, vitamins and minerals like zinc, iron, magnesium and folate. Pulse crops are well-known to contribute to the soil health adding nitrogen to the soil in association with symbiotic bacterial species. This nitrogen is readily available to the plants to ensure better nitrogen nutrition and enhanced productivity. A good one-fifth (20%) of the land in the country is under pulses, and these crops produce seven to ten percent of the nation's overall foodgrain production. Although both the Kharif and Rabi seasons are used for growing pulses, more than 60% of the total production comes from the Rabi season.

Sustainable production speaks for the necessity of management of numerous biotic and abiotic conditions in these crops that take a heavy toll of the obtainable yield every year with increasing quantum of avoidable category of the yield losses. A significant issue that may be brought on by the effects of such stresses, particularly diseases among the biotic ones, is a decrease in pulse production. Numerous conventional techniques have been used to increase the yield of pulse crops, but new technologies must be adopted if yields are to be further increased and sustainability enhanced. Sustainability is crucial, so crop development initiatives must take into account any technology that does not negatively affect sustainability.

Major Diseases of Pulse crops:

A. Diseases of Redgram/Arhar/Tur:

a. Fusarium wilt: As the name indicates, the disease is caused by *Fusarium udam.* The leaves start out pallid, lose their turgidity, droop, and eventually wither on a wide scale. There is a bottom-to-top withering that may occur gradually or suddenly. Within a few days, the entire plant wilts or dies. In the field, the incidence of the disease is patchy. When the tap root and bark of the stem below the soil line are removed, dark lines are visible. The damaged stem displays vascular browning, a sign of mycelia xylem clogging. It is a soilborne disease.

Management:

1. Planting of sorghum in summer seasons.
2. Intercropping or mixed cropping with sorghum.
3. Planting resistant/tolerant varieties like Jawahar Tur JKM-189, IC-550413, CRG 2012-25 and IPH 15-03 (Hybrid) is helpful.
4. Treatment of seeds with *T. viride* talc-based formulation at 4 g or the same formulation of *P. fluorescens* @10 g/kg.
5. Chemically, the seeds can be treated with thiram or carbendazim @0.2% (2 g/kg seed) or Carboxin 37.5% + Thiram 37.5% WS @0.4% (4g/kg seeds).
6. Neem cake is applied to the soil at a rate of 150 kg/ha.
7. Application of *P. fluorescens* or *T. viride* at a rate of 2.5 kg per hectare along with 50 kg of well-decomposed FYM or sand in the soil 30 days after sowing.

8. Carbendazim spot treatment @0.1% (1 g/liter) aqueous solution.

b. Dry root rot: Caused by the fungus, *Rhizoctonia bataticola* (Pycnidial stage : *Macrophomina phaseolina*) the disease is characterized by its occurrence in both, young as well as older plants. Yellowing, drooping, and premature defoliation are visible in the lower leaves. Later, the discoloured region turns black, and plants start to die. Because the roots are rotting, it is simple to remove the afflicted plants. In the shredded bark, tiny dark sclerotia can be seen (collar region and root). The pycnidial stage is indicated on the stem section by a large number of brown spots.

Management:

1. Crop rotation for at least 5 years or more.
2. Treatment of seeds with *T. viride* talc-based formulation at 4g or *P. fluorescens* at 10g/kg seeds
3. Alternatively, seeds can also be treated with carbendazim or thiram at 2g/kg or Carboxin 37.5% + Thiram 37.5% WS @0.4% (4g/kg seeds).
4. Soil application of Neem cake at 150 kg per hectare.
5. One month after sowing, apply *P. fluorescens* or *T. viride* to the soil at a rate of 2.5 kg per hectare mixed with 50 kg of well-decomposed FYM or sand.
6. Carbendazim spot treatment @0.1% (1 g/liter) aqueous solution.
7. The disease builds up more favourably in prolonged dry weather or drought followed by irrigation or rain.

c. Sterility Mosaic disease (SMD): The disease is caused by a virus called pigeonpea sterility mosaic virus (PPSMV) which is transmitted by the mite *Aceria cajani*. Symptoms of the disease include stunting of the plants. Because the internodes have shrunk, the affected plants are stunted. The upper branches are crowded and the auxiliary buds are encouraged to flourish, giving the plant a bushy appearance. Severe mosaic in leaflets with total sterility, mild mosaic with partial sterility, and ring spots, which are distinguished by a green island encircled by a chlorotic halo, are the main three types of symptoms that are associated with the disease.

Management:

1. Destruction of infected plants is vital in viral disease of plants.Up to 40 days after planting, removing diseased plants helps check the disease development in initial stages.
2. Planting resistant varieties like Narendra Arhar Tur (F 98-1), IPA 203, CRG 2012-25 and IPH 15-03 (Hybrid) can be done.
3. Spraying Fenazaquin @0.1% (1 ml/litre water) as soon as the disease is first observed, then repeating if necessary after 15 days.

d. Phytophthora blight: The disease is caused by *Phytophthora drechsleri* f. sp. *cajani* and is symptomatized by stem rot, stem blight and root rot. Seelings are infected as soon as they emerge. On seedlings that are a month old, distinctive symptoms of foliage blight are visible. The primary and triplicate leaves first show signs of blight as water-soaked lesions that are necrotic after a week under the relative humidity of >80% and 20-30^{o}C temperature range. The leaflet lesions can be up to 1 cm in diameter and range in shape from irregular to round. Stem symptoms manifest as discrete brown to dark brown lesions contrasting with the wholesome green parts of the main stem, branches, and petioles. The lesions on stems and branches enlarge quickly and can reach a diameter of 20 cm. They girdle, split, and dry up the stem. Stems that have swollen into cankerous formations are another prevalent occurrence. Wind readily breaks infected stems and branches. Xylem vessels are healthy, while phloem vessels have smoky grey discolouration.

Management:

1. Use of disease-free seeds.
2. Crop rotation with cereals and other nonhost crops.
3. Planting on ridges has been found to reduce disease severity.
4. Using 3 g of Metalaxyl 35 WS per kg for seed treatment helps reduce the incidence of the disease.
5. Fields should have good drainage, and plants should be shielded from stem damage.
6. Grow resistant varieties including, among others.
7. Use of resistant/tolerant varieties. Varieties like JKM - 189, ICPL 7916, 12055, 12114, and JA 4 have shown fair levels of resistance to the disease. Variety PA 291 which is tolerant, IPH 15-03 (Hybrid) which is moderately resistant and Chhattisgarh Arhar-1 (RPS 2007-10) which has shown less incidence of the disease may be preferred for planting in the areas of heavy incidence.
8. Safe destruction of pigeonpea stubble that has been infected with the disease
9. Eliminating alternate host species including *Atylosia* spp. and wild *Cajanus* spp. From the surroundings helps reduce the quantum of primary inoculum.

B. Diseases of Urd/Mungbean:

a. Anthracnose: The causal fungus is *Colletotrichum lindemuthianum* - (Sharma *et al.* 2007[i]), *Colletotrichum destructivum* species complex (Damn *et al*., 2014[ii]) and *Colletotrichum truncatum* (Marak *et al*., 2019[iii]). Any stage of plant growth and all aerial components are affected by the disease. On leaves and pods, there are circular, black, sunken dots with a dark centre and a brilliant red or orange edge. On the undersides of leaves and petioles, irregularly shaped dark-brown to black water-soaked patches extend into dark lesions with orange edges. When an infection is severe, the affected areas deteriorate. Soon after seed, seedlings become blighted as a result of infection. During prolonged wetness spells, the asexual fruiting bodies of the pathogen called acervuli, which are orange in colour and produce fungal spores, can be spotted on the undersides of the leaves. Defoliation, stem cankers, and "shot holes" in the leaves are examples of advanced disease signs. According to Kulkarni (2009)[iv] the infected pods have poorer seed quality and germination, which could cause a complete loss of output. Authors have reported losses ranging between 2 and 100% in India, (Sharma *et al.*, 2007, Kulkarni 2009, Shukla *et al.*, 2014[v])

Management:

1. Use of disease-free seeds.
2. Use of resistant varieties.
3. Removal and safe disposal of crop refuse.
4. Seed treatment with carbendazim @ 0.2% or10 minutes of hot water treatment at 54°C.
5. Spray of carbendazim (0.05-0.1%) of mancozeb (0.2%) aqueous solution in the standing crop if conditions so warrant.

b. Cercospora leaf spot: Caused by the fungus, *Cercospora canescens,* the disease is characterized by leaf spots. These spots are small in size and numerous. They have pale brown centres and reddish-brown margins. Similar spots also occur on branches and pods. Under favourable environmental conditions, severe leaf spotting and defoliation occurs at the time of flowering and pod formation.

Management:

1. Cultivate resistant varieties.
2. Intercrop the moong with tall growing cereals and millets.
3. Follow clean cultivation.
4. Use disease free seed.
5. Maintain low crop population density and wide row planting.

6. The crude extracts of cassava, garlic, and zinger are applied for controlling the disease effectively.
7. Mulching reduces the disease incidence resulting in increase yield.
8. Spray Mancozeb 2kg/ha or Carbendazim 500 g/ha.

c. Yellow mosaic disease - Mungbean yellow mosaic virus (MYMV): Initially small yellow patches or spots appear on green lamina of young leaves. Soon it develops into a characteristics bright yellow mosaic or golden yellow mosaic symptom. Yellow discoloration slowly increases and leaves turn completely yellow. Infected plants mature later and bear few flowers and pods. The pods are small and distorted. Early infection causes death of the plant before seed set. It is caused by *Mungbean yellow mosaic India virus* (MYMIV) in Northern and Central region and *Mungbean yellow mosaic virus* (MYMV) in western and southern regions. Transmitted by whitefly, *Bemisia tabaci* under favourable conditions. Disease spreads by feeding of plants by viruliferous whiteflies. Summer sown crops are highly susceptible. Weed hosts *viz*., *Croton sparsiflorus*, *Acalypha indica*, *Eclipta alba* and other legume hosts serve as reservoir for inoculum.

Management:

1. Rogue out the diseased plants up to 40 days after sowing.
2. Remove the weed hosts periodically.
3. Increase the seed rate (25 kg/ha).
4. Grow resistant green gram variety like Pant Moong-3, Pusa Vishal, Basanti, ML-5, ML337, PDM-54 and Samrat and blackgram varieties like VBN 4, VBN 6 and VBN 7.
5. Cultivate the crop during rabi season.
6. Follow mixed cropping by growing two rows of maize (60 x 30 cm) or sorghum (45 x 15 cm) or cumbu (45 x 15 cm) for every 15 rows of black gram or green gram.
7. Treat the seeds with Imidacloprid-70WS @4g/kg.
8. Installation of yellow sticky traps 12 nos/ha
9. Rogue out the infected plants up to 45 days
10. Foliar spray of notchi leaf extract 10% at 30 DAS or neem formulation @ 3 ml/lit
11. Spray Imidacloprid 17.8% SL @ 100 ml in 500 lit of water or methyl demeton 25 EC 500 ml/ha or dimethoate 30 EC 500 ml/ha or thiamethoxam 75 WS 1g /3 lit and repeat after 15 days, if necessary.

C. Diseases of chickpea:

a. Fusarium Wilt: Yearly yield losses are estimated at 10-15% in India and Spain, with losses of 70-100% in years of severe outbreaks of the disease. Wilt is a seed and soil borne disease. Wilt incidence is generally higher when chickpea is grown in warmer and drier climates (> 25°C) and when crop rotations are not practiced. . The field symptoms of wilt are dead seedlings or adult plants, usually in patches. The disease can affect the crop at any stage. The disease can be observed within 3 weeks of sowing. Whole seedlings (3 - 5 weeks after sowing) collapse and lie flat on the ground. These seedlings retain their dull green color. When uprooted, they usually show uneven shrinking of the stem above and below the collar region (soil level). The shrunken portion may be about 2.5 cm or longer. The affected plants show typical wilting, ie, drooping of the petioles, rachis and leaflets. Drooping is visible initially in the upper part of the plant but within a day or two, the entire plant droops.

Management:

1. Deep summer ploughing
2. Follow crop rotation measures continuously.
3. Always use disease free seeds.
4. Avoid sowing when temperatures are high.
5. Follow 6-year crop rotations with sorghum

6. Apply FYM 10-15 cart load/ha.
7. Seed treatment with *T. viride* @4g/kg or P. fluorescens @ 10g/ kg of seed or Carbendazim or Thiram 2g/kg of seed.
8. Spot drenching with Carbendazim 1g/lit or *P. fluorescens* / *T. viride* 2.5 kg/ha with 50 kg FYM.
9. Seed treatment with Carbendazim at the rate of 1g/kg of seed /
10. Seed treatment with Thiram + Carbandizm @ 1g+2g per kg of seed

b. Dry Root Rot: The disease is caused by *Rhizoctonia bataticola* (Taub.) Butler [Pycnidial stage: *Macrophomina phaseolina* (Tassi) Goid]. It generally appears around flowering and podding time in the form of scattered dried plants. The seedlings can also get infected. The susceptibility of the plant to the disease increases with age. Drooping of petioles and leaflets is confined to those at the very top of the plant. Sometimes when the rest of the plant is dry, the topmost leaves are chlorotic. The leaves and stems of affected plants are usually straw colored, but in some cases the lower leaves and stems are brown. The lower portion of the tap root usually remains in the soil when plants are uprooted. The tap root is dark, shows signs of rotting, and is devoid of most of its lateral and finer roots. Dark, minute sclerotial bodies can be seen on the roots exposed or inside the wood.

Management:

1. Deep ploughing in summer
2. Grow cultivars resistant to dry root rot.
3. Drought should be avoided.
4. Sowing should always be done on the recommended time.
5. Germinating and young seedlings should be saved from high temperatures.
6. Seed treatment with *T. viride* @4g/kg or P. fluorescens @ 10g/ kg of seed or Carbendazim or Thiram 2g/kg of seed.
7. Spot drenching with Carbendazim 1g/lit or *P. fluorescens* / *T. viride* 2.5 kg/ha with 50 kg FYM.

c. Ascochyta Blight: All plant parts are affected. Symptoms appear on leaves as water-soaked lesions. Symptoms include smaller circular brown spots on leaves. Under favorable conditions, these spots enlarge rapidly and coalesce, blighting the leaves and buds. In case of severe infection, the entire plant dries up suddenly. The lesions are also developed on stems and petioles. Late infections result in shriveled and infected seed. The disease is seed borne in nature. Left over debris in the fields serve as a source. Wet and warm weather, and dense crop canopy are conducive to the spread of the disease.

Management:

1. Sow disease-free seed.
2. Follow crop rotation with nonhost cereals.
3. Deep sowing (>15cm) is helpful.
4. Intercrop with nonhost crops like wheat, barley, mustard etc.
5. Seed treatment with Carbendazim @ 1g/kg of seed. or Hot water seed treatment (52^{o} C for 10 min) to lower the infestation.
6. Spray the crop with Mancozeb @ 2.5g/lit if noticed during the growth period or Spray Wettable sulphur at the rate of 2.3g/lit of water.

D. Diseases of Fieldpea:

a. Powdery mildew: Caused by *Erysiphe poligoni* (syn. *E. pisi*), the disease appears as on the foliage and pods. Infection is first apparent on the leaves as small slightly darkened areas, which later become white powdery spots. These spots enlarge and cover the entire leaf area. Severely infected leaves may become chlorotic and distorted before falling. Affected pods are small in size and malformed.

Management:

1. Use resistant varieties such as Azad P-2 (PRS4), Pant Pea-5, Malviya-15, JP-885, HUP-2 Arka Ajit, Jawahar Matar 15, Jawahar Matar 54, Jawahar Peas 83.
2. Destruction of crop stubble soon after harvest.
3. Avoid volunteer plants which can harbour the pathogen..
4. Avoid late planting
5. Spray Meptyl Dinocap 35.7% EC @ 308.6-342.8 dissolved in 500 litre water, Sulphur 52% Flowable @2litre in 400 litre water, Sulphur 80% WDG @ 1.875-2.50 kg in 750-1000 litre water, Triadimefon 25% WP@ 0.1% helps reduce the disease.

b. Pea Rust: Caused by the pathogenic fungus, *Uromyces fabae,* the disease often becomes serious in humid regions. The plants dry up quickly and the yield is considerably reduced. The initial symptoms of the rust infection are flecking of the leaves. These flecks soon develop into reddish brown pustules, frequently merging into one another, finally bursting to expose a mass of brown spores. The entire leaf blade and other affected parts give a brownish appearance even from a distance.

Management:

1. Removal of crop debris from the field helps reduce the primary inoculum.
2. Fungicidal application using Sulphur 80% WP @3.13kg dissolved in 750-1000litre water/ha or Triademefon 25% effectively control the disease.

E. Diseases of Lentil:

a. Wilt: Among the diseases, Fusarium wilt caused by *Fusarium oxysporum* f.sp. *lentis* is the most important biological constraints to productivity of lentil worldwide (Bhalla et al., 1992[vi]). In India lentil wilt was first reported from undivided Bengal in 1934. The pathogen causes serious disease and is widespread in India. It is a soil borne, root pathogen colonizing the xylem vessels and blocking them completely to cause wilting. The disease appears in the field in patches at both seedling and adult stages. Seedling wilt is characterized by sudden drooping, followed by drying of leaves and seedling death. The roots appear healthy, with reduced proliferation and nodulation and usually no internal discoloration of the vascular system. Adult wilt symptoms appear from flowering to late pod-filling stage and are characterized by sudden drooping of top leaflets of the affected plant, leaflet closure without premature shedding, dull green foliage followed by wilting of the whole plant or individual branches. Seeds from plants affected in mid-pod-fill to late pod-fill are often shriveled.

Management:

1. The best method of controlling lentil wilt is to use resistant varieties, a number of which are now available as Pant L-4, Pant L-6, Pant L-8 and Noori.
2. Seed treatment with benornyl (0.3%) or thiram + benomyl (1:1, 0.3%) reduces wilt incidence and increases grain yield.
3. Soil amendment with organic matter enhances antagonism with other soil microflora.
4. Ploughing of the field during summer.
5. Following crop rotation with cereal crops which are not affected by wilt pathogen.
6. Using antagonistic microflora like *Bacillus subtilis*, *Trichoderma harzianum*, *T. viride* @ 4 g/kg seed etc.

b. Lentil Rust: Rust, caused by fungus *Uromyces viciae-fabae* is regarded as the most important foliar disease of lentil. Complete crop failures can occur due to this disease. Rust disease is a potential threat to lentil cultivation and causes substantial yield losses ranging from 60-69 per cent (Sepulveda, 1985[vii]). In 1978 severe outbreak of lentil rust was recorded in the Narmada Valley of Madhya Pradesh during 2008-09 in Uttarakhand state resulting in yield losses upto 100 per cent. In tarai region of Uttarakhand state and its surrounding areas, rust

has been a major constraint affecting yield adversely. In the past, disease has appeared in almost epiphytotic form in this area (Khare and Agarwal, 1978[viii]).

Rust pustules can be seen on leaf blade, petiole & stem. Rust starts with the formation of yellowish-white pycnidia and aecial cups on the lower surface of leaflets and on pods, singly or in small groups in a circular form. Later, brown uredial pustules emerge on either surface of leaflets, stem and pods. Pustules are oval to circular and up to 1 mm in diameter. They may coalesce to form larger pustules. In severe infections leaves are shed and plants dry prematurely, the affected plant dries without forming any seeds in pods or with small shriveled seeds.

Management:

1. Use of foliar fungicides as Hexaferb and Dithane M-45 give best control.
2. Fungicides as Mancozeb (0.2% a.i.), Bayleton (0.05% a.i) and Calixin (0.2% a.i.) are found effective against the pathogen.
3. Foliar spray of benomyl, carboxin, metalaxyl, oxycarboxin, thiram, triademafon either alone or in combination of Dithane M-45 are also effective.
4. Lentil varieties Pant L-639, Pant L-406, Pant L-6, pant L-7 and Pant L-8 are resistant.

Disclaimer: The material used in development of this literature has been taken from various sources including those from the internet. The author does not claim any of the information presented herein of his own and that, this has been compiled and edited for the benefit of the stakeholders.

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Factors Affecting Seed Quality during Seed Production in Pulse Crops

Ex. Prof (Dr.) C.P. Sachan

Ex. Nodal Officer AICRP on Seeds (Crops)
Chandra Shekhar Azad University of Ag. &Tech. Kanpur U.P.-208002
Email.- dr.c.p.sachan@gmail.com

Quality seeds pay high remuneration to stake holder's .Thus production of genetically pure and otherwise good quality pedigree seed is an exacting task requiring high technical skills and comparatively heavy financial investment. During seed production,strict attention must be given to the maintenance of genetic purity and other qualities of seeds in order to exploit the full yield potential of new superior crop plant varieties. In other words, seed production must be carried out under standardized and well-organized conditions.

Principles of quality seed production

1. Genetic principles: - It involves all the factors which may lead deterioration of genetic purity (true to type) of a crop variety. In negligence of genetic principles during seed production programme leads deterioration of the varieties.

2. Agronomic principles. Factors associated mainly during field operations which influence genetic and physical purity of any seed lot.

Genetic Principles –

The important factors& real deterioration of varieties listed by Kadam (1942):

1. Developmental variations Mechanical mixtures
2. Mutations
3. Natural crossing
4. Minor genetic variations
5. Selective influence of diseases
6. The Technique of plant breeder

(1) Developmental variation: When the seed crops are grown in difficult environment, under different soil and fertility conditions, or different climate conditionsor under different photoperiods or at different elevation for several consecutive generations. The developmental variation may arise sometimes as differential growth response termed as **geneticshift**.To minimize the opportunity for such shifts to occur in varieties it is advisable to grow them in their areas of adaptation and growing seasons.

(2) Mechanical mixtures: (Varietal mixture) Mechanical mixtures may often take place at the time of **sowing**, **harvesting** and at the time of **processinggrading** and **packaging**. If more than one variety is sown with same seed drill, through volunteer plants of the same crop in the seed field or through different varieties grown in adjacent fields. Often the seed produce of all the varieties are kept on same threshing floor. Grading with same grader and packaging the seed in the old gunny bags etc. To avoid this sort mechanical contamination it would be necessary. To rogue the seed fields at least at the three stages.(before flowering , at the time of flowering and after flowering)

(3.) Mutations: This is not a serious factor of varietal deterioration. In the majority of the cases it is difficult to identify or detect minor mutation due to its natural frequency 10^{-8}

(4) Natural crossing: In sexually propagated crops, natural crossing is another most important source of varietal deterioration due to introgression to genes from unrelated stocks which can only be solved by prevention. Natural crossing occurs due to following three reasons:
a) Natural crossing with undesirable types.
b) Natural crossing with diseased plants.
c) Natural crossing with off- type plants.
Natural crossing occurs due to six most prevalent factors:
a) The breeding system of species
b) Isolation systems
c) Varietal mass
d) Pollinating agent
e) Size of the pollen grains
f) Duration of pollen viability
(5) Minor genetic variations: Minor genetic variations may exist even in the Varieties appearing phenotypically uniform and homogeneous at the time of their release. During later production cycle some of this variation may be lost because of selective elimination by the environment. To overcome these,regress yields trials are suggested

(6) Selective influence of diseases: The selective influence of diseases in varietal deterioration is also of considerable importance. New crop varieties often become susceptible to new races of diseases often caused by obligate parasites and are out of seed programmes. Similarly the vegetative propagated stocks deteriorate fast if infected by viral, fungal and bacterial diseases. During seed production it is, therefore, very important to produce disease free seeds/stocks.

(7) Techniques of plant breeders: In certain instances, serious instabilities may occur in varieties due to **cytogenetical** irregularities not properly assessed in the new varieties prior to their release. Other factors, such as break down in male sterility in certain environmental conditions and other heritable variationsmay considerably lower the genetic purity.

Steps for Maintenance of Genetic Purity
These are as follows.

1-Avoiding genetic shifts by growing crops in areas in their adaptation only.

2-Use of approved seed only in seed multiplication by adopting the three model of generation systemas breeder seed –foundation seed – certified seed

3-Certification of seed crops to maintain genetic purity and quality of seed Inspection and approval of fields prior to planting.

4-Providing adequate isolation to prevent contamination by natural crossing or mechanical mixtures

5. Field inspection and approval of growing crops at critical stages for verification of genetic purity, detection of mixtures, weeds, and for freedom from noxious weeds and seed borne diseases etc. Rouging of seed fields prior to the stage at which they could contaminate the seed crop. Sampling and sealing of cleaned lots. Growing of samples of potentially approved stocks for comparison with authentic stocks (Grow out tests) Periodic testing of varieties for genetic purity.

Agronomic principles-

1. Selection of a Agro-climatic Region

Growth of the plant and production of good quality seeds are strongly influenced by both genetic and environmental factors. Environmental factors include.

a)Temperature,

b) Rainfall,

c) Wind velocity,

d) Soil condition and texture,

e) Insect activity and their relationship with varietals adaptation in any given locality For good seed crop , a crop variety to be grown for seed production in an area where it must be adapted to the photoperiod and temperature conditions prevailing in that area. According to the various agro-climatic zones, we can classify the different kind of field crops and vegetable seed production programme to the different seed producing regions.

2. Selection of seed plot

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

3. **Isolation of Seed crops**

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

4. Preparation of Land:

Good land preparation helps in- Improved germination Good stand establishment and destruction of potential weeds. It also aids in water management and good uniform irrigation.

(5) Selection of variety:

The variety of seed production must be carefully selected, it should possess- Disease resistance, Earliness, Grain quality, higher yielder and adapted to the agro-climatic conditions of the region.

(6) Seed treatment:

Depending upon the requirement, the following seed treatment may be given- Chemical seed treatment.(Therum or corbendazem) Bacterial inoculation for the legumes. Seed treatment for breaking dormancy.

(7) Time of planting

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

8) Seed Rate:

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

(9) Method of sowing:

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

(10) Depth of sowing:

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

(11) Rouging: Adequate and timely rouging is extremely important in seed production. Rouging in most of the field crops may be done at many of the following stages as per needs of the seed crop. Vegetative / pre-flowering stage Flowering stage Maturity stage.

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

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

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

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

(16) Irrigation: Irrigation can be important at planting for seed crops on dry soils to ensure good uniform germination and adequate crop stands. Excess moisture or prolonged drought adversely affects germination and frequently results in poor crop stands.

(17) Harvesting of Seed crops: It is of great importance to harvest a seed crop at the time that will allow both the maximum yield and the best quality seed. The crop can be harvested in both physiological as well as field maturity depends on situations. In case of orthodox seeds 15-20 percent moisture content should be present at the time of harvest.

Post harvest operations during seed production

18) Seed Processing:-the seeds are to be graded by using recommended sieves for varieties. The seed deviate from original tan colouralso to be removed

19) Seed Testing:- Seed samples are drawn from the processed seed for seed testing in authorised seed testing lab for ascertaining the minimum seed certification standards , as mentioned in following table

20) Seed Treatment: -After seed testing, if seed sample maintains the required minimum seed certification standards, they are subjected to seed treatment either by thirum or by corbendazem @ 2g / Kg seed.

21) Bagging and Tagging:- Treated seeds are packed in cotton bags / gunny bags by adopting the rules of seed certification.The tags(Yellow - Breeder seed ,white-foundation seed and azure blue –certified seed) and label (green colour) are intacted on bags.

22) Storage: - Seeds are stored in optimum conditions for maintaining the viability and vigour up to next sowing season.

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Quality Seed Production Technology in French Bean and Indian Bean

Nagendra Rai, Indivar Prasad and Rakesh Kumar Dubey
ICAR-Indian Institute of Vegetable Research, Varanasi-221305
Email: nrai1964@gmail.com

A. French Bean (*Phaseolus vulgaris*)

Introduction

French bean are valued grain legume vegetables or pulse crop in many tropical countries.It is one of the oldest established crop being cultivated from ancient times. It is also known as snap bean, salad bean, green bean haricotvert bean (Vegetables). Haricot bean, dry bean and navy bean are applicable only to pulse types of French bean. String bean, dwarf bean and pole bean are applicable only to particular growth forms. The original type of French bean is native to South and Central America. The bean has been cultivated in that part of the world since ancient times. The earliest archeological evidence of domesticated bean seed is from 5500BC in northern Peru and 5000BC in Mexico. From Peru, the crop spread to Europe and then to Asia. French bean was brought to Europe after the Spanish conquest and was grown there by the mid-1500s. The French Huguenots introduced French bean into England. Portuguese took the crop to Africa and other parts of the Old World. Introduction of French bean into India is comparatively recent and the Europeans brought it to India in the 19th century. A wild relative species *P. aborigines* in North West Argentina is considered as the progenitor of French bean. It is an annual herb grown for green tender pods and dry seeds (rajmah). The pod size of French bean varies from thin, pencil like to about 2 cm in diameter. The pods are round, flat or curved in shape and the colour varies from green to yellow, red and purple.

Family	Fabaceae
Scientific name	*Phaseolus vulgaris* L
Chromosome number	$2n = 2x = 22$
Origin	Southern Mexico and Central America

Nutritional Profile

Like other beans, French bean is an important source of protein. It is also a good source of folate, magnesium, manganese and dietary fibre. French bean is very low in saturated fatty acids and cholesterol. Per 100 g edible pods constitute 94 per cent water, 1.7 per cent protein, 0.1 per cent carbohydrates, 4.5 per cent fat, 1.8 per cent fibre and 0.1 per cent minerals.

Uses

French bean is grown for green tender and stringless pods, which are cooked whole or shelled as pea. The immature seeds are boiled or steamed and used as a vegetable. The mature seeds are dried and stored for future use. They must be thoroughly cooked before consumption and are best if soaked in water for about 12 hours prior to this. They can be boiled, baked, pureed or ground into powder. The seeds can also be sprouted and used in salads or cooked. Young leaves are consumed raw or cooked as a potherb. In the USA it is commercially grown for processing.

Area and Production

French bean is grown intensively in five major continental areas; North and Central America, Eastern Africa, Eastern Asia and Western and South-eastern Europe. Latin America produces roughly 30 per cent of the world production. Brazil is the largest producer of French bean in the

world. In India it is grown in states like Uttar pradesh, Madhya pradesh, Karnataka, Jharkhand, Bihar, Punjab, Haryana and West bengal etc. In India, it is extensively grown in pockets around Pune in Maharashtra, Bangalore in Karnataka, Hyderabad in Andhra Pradesh and Solan in Himachal Pradesh. Different colours of seed is present in French bean viz., white, black, brown, red, ochre etc. dry beans with spots, flecks and stripes are also present. As per NHB (2018), a total of 2.2 million of French bean was produced from an estimated area of 2.28 lakh hectares with average productivity of 9.98 tonnes/hectare.

Floral Biology

French bean is naturally a self-pollinated crop. Anthesis occurs in morning (5-7AM) and anther dehiscence is from 6.30 to 7.30 AM. Pollen remains fertile on the day of anthesis and stigma receptivity is at peak on the day of anthesis. Rubbing and hooking method of pollination are used for making crosses. Keel of French bean is coiled or twisted.

Genetic variability in French Bean

Significant variability has been observed in French bean for yield and horticultural traits which has been summarized in the table given below:

Trait	**Variability**
Growth habit	Indeterminate, Runner, Determinate
Pod color	Green, Light Green , Red
Pods	Flat, Round
Seed color	Black, White, Red, Orange, Violet, Mixed
Flower	White, Purple

Popular Varieties

Commercial varieties of French bean are classified into two groups viz. determinate or bush type and indeterminate or pole type. The improved varieties of French bean have been listed below:

Bush type	**Pole type**
Kashi Sampann, Kashi Rajhans, Kashi Agrim, Contender, Arka Komal, Arka Sharath, Arka Suvidha, Arka Anoop, Pant Anupama, Swarna Priya, V. L. Boni – 1, Pant bean – 2, Pusa Parbati, Phule Surekha	Kashi Baingani, Kentucky Wonder, Pusa Himlata, Swarna Lata, V. L. Lata Bean – 12, SVM-1

Seed Production of French bean

French bean is a self-pollinated crop and an isolation distance of 50 m between two varieties of French bean is required to prevent physical mixtures. For seed production, the beans are harvested when pods turn yellow. Delayed harvesting results in shattering of pods and consequently reduced seed yield. Irrigation is stopped during seed ripening. The crop is inspected twice, one at flowering and pod formation and the other at pod maturity, to rogue out diseased and off-type plants. The seed is extracted with threshers, cleaned and dried to less than 9 percent moisture content and stored. Average seed yield varies from 12 to 18 quintals per hectare.

Quality Seed Production Technology of French bean

Climate

French bean is a cool weather crop grown as a winter crop in plains and throughout the year except winter months in hills. It thrives best when temperature ranges between 15-25°C.The

seeds will not germinate if the soil temperature is below 12°C and the seedlings will not tolerate temperature below 10°C. Pole types require longer growing season and are, therefore, more suitable for growing in mid-hills. Bush types can be grown in north Indian plains where growing season is short. Most French bean varieties are day neutral except some semi-determinate types, which are grown only under short day conditions. The crop is sensitive to frost, high temperature and excessive rains.

Soil

French bean can be grown in a variety of soils ranging from light sandy loam to clay soils. However, it is sensitive to water logging, extremely acidic and saline soils. The silt or clay loam soils with pH range of 5.3-6.0 are best suited.

Manures and Fertilizers

In soils where beans are being sown for the first time, inoculation with Rhizobium culture facilitates quick nodulation on the roots that helps in fixation of atmospheric nitrogen. Application of phosphorus also enhances nodulation. Apply 20 tonnes of FYM at the time of field preparation. In the soils with average fertility level, apply 50 kg nitrogen, 100 kg phosphorus and 60 kg potash per hectare. Apply whole of phosphorus and potash and half of nitrogen at the time of sowing. The remaining nitrogen is applied at the time of flowering.

Sowing Time, Seed Rate and Spacing

In north Indian plains, sowing is done either in January-February or from July to September. In hilly regions, sowing is done from March to early May. In southern plains, September to November is the best sowing time. In mid-hills of north-eastern region particularly in Meghalaya, pole types are grown from March through December. To facilitate germination, especially when the soil temperature is below optimum, pre-soak the seed in warm water (40-45°C) for 12 hours. The seed rate for French bean varies with the kind of variety and growing conditions. The seed rate is 65 kg per hectare for bush types and 25-30 kg per hectare for pole types. Spacing in French bean varies depending upon the growth habit of the variety. Row-to-row spacing is more in pole types than in bush types. Spacing for bush type varieties is maintained at 45-60cm between rows and 10-15 cm between plants. In pole types, row × plant spacing ismaintained at 1 m × 10-15 cm. In pole types, 5-6 seeds are dibbled per hill and later on, 3-4seedlings are retained and trained on stakes.

Isolation Distance

For production of foundation and certified seeds of French bean, isolation distance of 5-10 m has been recommended.

Contaminants	**Minimum Distance (meters)**	
	Foundation	**Certified**
Fields of other varieties	10	5
Fields of same variety not conforming to varietal purity requirement for certification	10	5
B. Specific Requirements	**Maximum permitted (%)**	
Factor	Foundation	Certified
Off-types	0.10	0.20
Plants affected by seed borne diseases	0.10	0.20

Irrigation

French bean is a shallow rooted crop and water stress adversely affects both pod yield and quality in terms of shape, colour, firmness and fibre content of pods. Flowering and pod development periods are the critical stages for water application. A total of 6-7 irrigations, applied at regular intervals throughout the crop season, are required.

Weed Control

Weeds in French bean are controlled by applying Stomp (pendimethalin) @ 3.0 litres per hectare or Basalin (fluchloralin) @ 2.5 litres per hectare. After application, incorporate Basalin into the soil by raking. Alternatively, two hand weedings are needed before the plant canopy covers the soil and suppresses weed growth.

Staking

At the time of tendril development, the pole type varieties are trained on stakes. The vines are trained by erecting poles on either side of rows and connecting them by rope wires. Staking prevents rotting of pods, improves pod quality and facilitates intercultural operations such as spraying, weeding, harvesting etc.

Harvesting

French bean takes 50-60 days from sowing and 7-10 days from flowering to reach marketable maturity. Three to four pickings of bush types and 8-10 pickings of pole types are possible. Harvesting is done at 5-6 day intervals. Harvesting pods at regular intervals promotes production of new flower flushes resulting in higher yields. The pods are at their best quality when they have just attained the full size and seeds are not yet apparent in the pods. For green-shelled beans, harvesting is done when pods bulge out and seeds become apparent in the pods.

Yield

Pod yield in French bean varies from 80-100 quintals per hectare in bush types and 120-150 quintals per hectare in pole types. Average seed yield varies from 12 to 18 quintals per hectare.

Seed Standards in French Bean

Seed standards means the tolerances permitted as determined by established seed inspection procedures. The seed standards of French bean have been given below in table:

Factor	**Foundation**	**Certified**
Pure Seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	None	None
Weed seed (maximum)	None	None
Other distinguishable varieties (maximum)	5/kg	10/kg
Germination (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers(maximum)	7.0%	7.0%

Important Diseases of French Bean

Anthracnose (*Colletotrichum lindemuthianum*): It is the most common seed borne disease of beans. The disease is more serious under high rainfall sub-tropical and temperate regions of the world. All aerial plant parts are susceptible to infection. The disease develops black, sunken,

crater like cankerous lesions encircled by yellow halo on cotyledons, leaves and pods. Pinkish sporulation may appear in lesions during wet weather conditions.

Control: Use disease free seed, follow clean cultivation and treat the seed with Thiram or Captan@ 2 g per kg seed to minimize initial inoculum. If the disease appears, apply Indofil M-45 @0.2 per cent or Bavistin @ 0.1 per cent.

Fusarium root rot (*Fusarium solani f. sp. phaseoli*): Fusarium root rot or dry root rot are the important root rots of green bean, Lima bean, cowpea and garden pea. The fungus is soil borne and the infection usually occurs during seed germination. A slightly reddish discolouration appears on the taproot, which gradually increases in intensity and extent. It may also occur in streaks that extend to the soil line. The red colour may change to a dark brown and the lesions usually crack longitudinally. The small lateral roots are usually killed and a cluster of roots may develop above the lesions, just below the soil line.

Control: There is no effective control measure to check this disease. Long-term crop rotation withnon-leguminous crops reduces severity of the disease.

Rhizoctonia root rot (*Rhizoctonia solani*): The disease is more serious under warm weather conditions. The fungus attacks the stem above and below the soil surface, resulting in damping-off. The young succulent plants die soon after infection. During later stages of plant growth, reddish-brown cankers extend longitudinally along the stem near the soil surface. The fungus may enter the pith where it causes a brick-red discolouration. The pathogen is soil borne and can survive in soil for many years.

Control: Shallow seeding and cultivation reduce severity of the disease. Treat the seed with Captanor Thiram or Bavistin @ 2-3 g per kg seed.

Pythium root rot (*Pythium* species): The root rot occurs during wet weather, both hot and cool. The fungus survives in soil for several years. The stem of the plant is invaded at or above the soil surface, producing a soft rot, ranging from colourless to dark brown. Grown-up plants may also wilt or die. Often a cottony white growth is seen on infected stem during periods of high humidity.

Control: Improve soil water drainage and treat the seed with Captan or Thiram @ 2-3 g per kg seed.

Rust (*Uromyces appendiculatus*): The symptoms initially appear as small, yellow or white, slightly raised spots on upper or/ and lower surface of leaves. The spots then enlarge and form reddish-brown or rusty pustules. The spores released from the pustules give a rusty appearance. The yellow border may surround the pustules. Severe infection may cause leaves to curl upwards, turn brown and drop prematurely. Pod setting, pod filling and seed size are adversely affected if infection occurs early. The infection may also occur on green pods and occasionally on stem and branches.

Control: Follow crop rotation and destroy diseased plant debris to reduce chances of infection. Grow resistant varieties and avoid sprinkler irrigation. To avoid prolonged congenial moist conditions, sprinkle during early part of the day. Application of Indofil M-45 @ 2 g per litre of water effectively controls the disease.

Angular leaf spot (*Phaeoisariopsis griseola*): The symptoms appear as dark-brown to greyish angular spots with a distinct margin. The spots may develop greyish mold on underside of the leaves. The disease may cause defoliation under serious infection conditions. The lesions on pods show reddish-brown centres and black borders. The lesions on stem are dark and elongated. The disease is serious under humid weather conditions.

Control: Use disease free seed, follow long term crop rotation and deep ploughing; and destroy the diseased plant debris to reduce the pathogen inoculum. Grow resistant varieties and avoid excessive humid conditions. Use sprinkle irrigation or sprinkle during early part of the day.

Treat the seed with Vitavax or Agrosan GN @ 2 g per kg of seed. Spray the crop with Bavistin @ 0.2 per cent.

Common or Bacterial blight (*Xanthomonas axonopodis pv. phaseoli*)

It is the most serious bacterial disease of French bean, Dolichos bean and other Phaseolus species. The disease is characterized by irregular, water soaked spots on under surface of leaves which later on turn red to brown in colour and are surrounded by yellow halo. In humid weather, a yellow bacterial crust covers the surface of the diseased area. Later on, several spots may coalesce to form irregular patches resulting in pre-mature defoliation. Lesions on stem appear as sunken, reddish longitudinal streaks. Cankerous lesions may also appear on pods. Under severe infection conditions, the pods may shrivel and seeds may not develop. The whole plant gives blighted appearance.

Control: There is no effective chemical control measure to check this disease. Growing resistant varieties is the only practical approach. Use of disease free seed, deep ploughing, long term crop rotation and destruction of diseased plant debris helps to reduce the disease. Hot water seed treatment at 50°C for ten minutes followed by dipping in Streptocycline solution is effective in reducing the seed infection.

Bean common mosaic virus: The disease is seed borne and is also transmitted by aphid (*Myzus persicae*). The virus is known to infect various cultivated species as well as weed hosts. Leaves of infected plants have a mosaic of light yellow green and dark green patches. The affected leaves appear crinkled, chlorotic with downward curling. In an advance stage of infection filiform leaves are produced. Plants remain stunted and give bushy appearance. Such plants may produce flowers but will not develop pods.

Bean yellow mosaic virus: Bean yellow mosaic virus is not seed borne in beans but may be seed borne in other legumes. The mosaic is characterized by reduced petiole length, stunted plant growth and deformation of pods. Small yellow patches develop on the leaves, which may spread over the entire surface. The pods are usually not affected but number of seeds per pod may be reduced.

Control: Bean common mosaic virus is seed borne. Both, bean yellow mosaic virus and bean common mosaic virus are spread by aphid (*Aphis craccivora*). To check the two virus diseases, use disease free seed, remove the diseased plants and other weed hosts. Control the insect vector population by spraying systemic pesticides such as Rogor (dimethoate) @ 0.1percent. Growing of resistant varieties is the most reliable measure of disease control.

Insect-pests and their Control

Bean aphid (*Aphis craccivora*):It is a tiny, pear shaped, winged or wingless, dark green to bluish-black insect that clusters on stem and lower side of leaves. The symptoms of damage by aphid include curling and thickening of leaves, twisting of twigs and shedding of flowers and developing fruits. Severely infested plants show yellowing.

Control: Spray insecticidal soap, horticultural oil or neem oil. Many predators such as lady beetle, green lacewing and parasitic wasps help keep aphid population in check. Chemically, aphid is controlled by spraying systemic pesticides such as Rogor 30 EC (dimethoate) or Metasystox25 EC (methyl demeton) @ 500 ml per hectare.

Jassid (*Empoasca fabae* and *E. kraemeri*): The crop when severely infested by jassid attack suffers from typical hopper burn symptoms. The control measures are the same as for aphid.

B. Indian bean *(Lablab purpureus)*

Introduction

Lablab purpureus, previously classified as *Dolichos lablab* is commonly known as Indian bean, Hyacinth bean, Lablab bean, Country bean, Egyptian bean, Tonga bean, Field bean or Sem. This multiplicity of names is indicative of the range of forms available globally and the fact that it

has long been cultivated for human food and as a green manure. Dolichos is a Greek word meaning long pod and lablab is Arabic or Egyptian word meaning dull rattle of the seed inside the dry pod. Dolichos bean is vigorous trailing, twining herbaceous annual propagated through seed. Two types of Dolichos bean are recognized, i.e., *purpureus var. typicus*, which is a garden type with soft edible pods having less fibre in their pod walls. The second type is *purpureus var. lignosus*, which is a field bean grown for dry seeds generally used as a pulse.Its pods have a characteristic aroma and the pod walls have high fibre content. *Lablab niger* var. *lablab* (var *typicus*) (syn *Dolichos lablab* var. *typicus*) in which long axis of the seed is parallel to the suture. *Lablab niger* var. *lignosus* (syn *Dolichos lablab* var *lignosus*, *D. lignosus*) in which seeds are at right angles to the suture. Two botanical varieties lignosus and lablab are cross compatible. Original ancestral species of Indian bean is *Dolichos purpureus*.

Family	Fabaceae
Scientific name	*Lablab purpureus* L. (Syn. *Dolichos lablab* L.)
Chromosome number	$2n = 2x = 24$
Origin	India

Nutritional Profile

Dolichos is an important source of proteins, minerals and dietary fibre. The pods have a strong flavour. Some varieties have purple colour of the pods, which disappears after cooking. Per 100 g of edible green pod contain moisture 86.1 g, carbohydrates 6.7 g, protein3.8 g, fibre 1.8 g, minerals 0.9 g (calcium 210 mg, phosphorus 68 mg, sodium 55.4 mg, potassium 74 mg, sulphur 40 mg, magnesium 34 mg, iron 1.7 mg) and fat 0.7 g. The vitamin composition is: vitamin C 9 mg, vitamin A 312 IU, riboflavin 0.06 mg, thiamin 0.1 mg and nicotinic acid 0.7 mg. The mature seeds, however, contain anti-nutritional factors such as tannins, phylate andtrypson inhibitors. Removing seed coat, soaking and proper cooking minimize activity of hese compounds.

Uses

Uses of Dolichos bean are various, depending upon the geographic region where it is grown. However as a vegetable, it is primarily grown for its green pods that are consumed as cooked or fried. The young tender leaves are used in salads and the relatively old leaves are cooked as a potherb like spinach. Its immature seeds are also consumed after cooking or frying, however, the mature dry seeds are consumed after properly boiling and draining out the water used for cooking, since they contain cyanogenic glucosides, which are toxic. Seed sprouts are consumed as those of other beans. Besides its cultivation as a vegetable crop, it is also grown as a green manure and fodder crops.

Origin and Distribution

Dolichos bean is believed to have originated in India, as a large number of indigenous strains are grown in north India. From India, it was introduced into China and West Asia and then to Africa during eighth century. Presently, Dolichos bean is commonly grown in Africa extending from Cameroon to Swaziland and Zimbabwe, through Sudan, Ethiopia, Uganda, Kenya and Tanzania. In Australia, Dolichos bean was first grown in Botanical Garden, Sydney in 1819. Dolichos bean is widely distributed over many tropical and sub-tropical countries where it has become naturalized. In South and Central America, East and West Indies, India and China, Dolichos bean is popularly grown as an annual. In India, Dolichos bean is grown in Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Karnatka.

Floral Biology

The flowers open generally two days after anther dehiscence. Flower opening is most frequent between 11.00 AM. and 5.00 PM. Optimum time for emasculation is between 16.30 PM – 17.30

PM and hand pollination at 7.00 AM – 9.00 AM., the next day. Flower bloom between 6.30 AM to 7.00 AM. and anthesis occurs at 9.00 AM to 17.00 PM. Anther dehiscence is between 5.00 AM and 14 .00 PM . Pollen is fertile on the day of anthesis. Pollen remains viable for 42 hr. at room temperature of 28.5^{0}C and relative humidity 91%. When store in a refrigerator at 9^{0}C and 0% relative humidity, the period of pollen viability increased to 66 hr. Stigma becomes receptive from 12 hr. before blooming to 6 hr. after blooming. Cross pollination is to an extent of 6-13 % The extra floral nectarines at the base of the corolla attract ants, flies and bumble bees.

Variability for pod and seeds

Significant variability has been observed in Indian bean for pod and seed related traits which has been summarized in the table given below:

Characters	**Features**
Pod length	4.45-16.0cm
Pod diameter	1.24-3.73cm
Pod weight	3.0-13.4g
Pod colour	Green, light yellow, brown, dark brown, whitish green, whitish brown, greenish brown, purplish white, greenish yellow and yellowish green
Seed colour	greenish brown, yellowish brown, blackish brown, white, yellowish white
Seed length	0.75-1.35cm
Seed diameter	0.64-1.32 cm
Seed weight	18.5-38.3g

Popular Varieties

Several Varieties of Indian bean has been released which includes both pole type and bush type. ICAR-Indian Institute of Vegetable Research, Varanasi has released several varieties of Indian been which has been given below:

Variety	**Yield potential (t/ha)**	**Feature**
Kashi Haritima	35-37	Pole type, Parchment free
Kashi Khushhal	35-38	Tolerant to DYMV
Kashi Sheetal	30-35	Purple pod
Kashi Bauni Sem -3	30-35	Green pod, Bush type
Kashi Bauni Sem -9	23-25	Green pod, Bush type

Apart from this, list of some other popular varieties of French bean has been listed below:

Varieties/Hybrids	**Breeding method**	**Special characters**
123-36	Selection from local germplasm of Gujarat	Superior yield
CO-1	Pure line selection from *Dolichos lablab* var. *typicus*	High protein and fat content
CO-2	Cross Co-8 x Co-1	Superior yield
Hebbal Avare-3	Cross Hebbal Avare-1 x US-	Superior yield

	67-13	
Pusa Early Prolific	Selection from IARI, New Delhi	Promising vegetable type
Pusa Sem-2	Intensive breeding	Highly resistant to anthracnose & virus and tolerant to frost
Pusa Sem-3	Intensive breeding	Tolerant to anthracnose, virus, aphids, jassids and pod borers but susceptible to frost
Wal Konkan-1	Derivative of the cross Wal 2 K2 x Wal 125-36	Resistant to yellow mosaic virus

Seed Production of Indian bean

Dolichos bean is primarily a self-pollinated crop and an isolation distance of 25 m between two cultivars is sufficient to avoid mechanical mixture of seeds. The seed crop is inspected before flowering, during flowering and at pod maturity to rogue out off-type and diseased plants. The crop is harvested when pods turn yellowish and then allowed to further dry in sun for 2-3 days. The crop is then threshed; seed cleaned, dried to less than 9 per cent moisture and stored. Average seed yield is 6-8 quintals per hectare.

Quality Seed Production Technology of French bean

Climate

Dolichos bean is a cool season crop. It grows well under warm, humid conditions at temperatures ranging from 18-30°C and is fairly tolerant to high temperatures. It responds to photoperiod. The bean is drought hardy and is grown in arid, semi-arid and humid regions. There are some drought tolerant strains that can be successfully grown as a dry land crop in regions with 630-890 mm annual rainfall. It needs irrigation or rainfall during germination and early growth but once established, it can tolerate drought. Due to its wide adaptability, the bean can be grown from sea level to an altitude of 2000 m above sea level. High temperature and high humidity favour its plant growth but fruiting starts with the onset of winters when the temperature and humidity become moderate and continues throughout spring. The varieties suitable for cultivation under long day and short day conditions are different, however, some photo-insensitive varieties, like Arka Jay and Arka Vijay can be grown throughout the year.

Soil

Dolichos bean can be grown on a wide range of soils, from deep sand to heavy clay and tolerates pH ranging from 5.0-7.5. However, the pH range of 5.3-6.0 is the most suitable. The plant can tolerate short periods of flooding and, therefore, can be grown in alluvial soils. However, well-drained soils are desirable, as Dolichos does not tolerate water logging. The seed germination is delayed and reduced significantly when the level of salinity goes above 4.0 mmhos/cm. The seeds tolerate the effluents of electroplating factory up to the level of 2.5per cent but the germination of seeds is delayed with further increase in affluent concentration.

Manures and Fertilizers

In soils where Dolichos bean is being grown for the first time, seed treatment(inoculation) with Rhizobium culture helps in early root nodulation, which fixes atmospheric nitrogen. Dolichos bean responds favourably to the application of fertilizers. Appropriate dose of fertilizers not only boosts up the pod yield but also improves the quality of produce in terms of protein and vitamin C content. As per the general recommendation, 25 tonnes of decomposed FYM per hectare is incorporated into the soil at the time of field preparation and mixed thoroughly by ploughing the field repeatedly. In addition, apply 20 kg nitrogen, 60 kg phosphorus and 60 kg

potash per hectare to obtain satisfactory yield. Half of nitrogen along with the entire dose of phosphorus and potash is applied at the time of sowing in lines about7-8 cm away from the plant rows and slightly deeper to the seed, and the remaining nitrogen is applied as top dressing about 30 days after sowing.

Sowing Time, Seed Rate and Spacing

Dolichos bean is relatively a cool season crop. In north India, the seeds are sown in June-July while in south India, in July-August. In Kitchen gardens, it can be retained as a perennial crop though the pod bearing capacity is reduced. In south and central India, it is usually grown as a mixed crop with ragi or sorghum. Seed rate in Dolichos varies with the varieties, depending upon their growth habit. Forpole type varieties, 10-12 kg seed is enough for the sowing of one hectare, whereas, for bushy types 20-30 kg per hectare seed is required. Sowing is done manually by dibbling using single row hand planters or by seed drills. Depth of seed placement varies from 2.5 to 5.0 cm, depending on size of seed and soil type. This method is adopted both for flat bed sowing as also for growing on trellis. For a pure crop, the row-to-row spacing is maintained from 1.0 to 1.5 m and plant-to-plant 60 to 75 cm.

Isolation Distance

Contaminants	**Minimum Distance (meters)**	
	Foundation	**Certified**
Fields of other varieties	10	5
Fields of same variety not conforming to varietal purity requirement for certification	10	5
B. Specific Requirements	**Maximum permitted (%)**	
Factor	**Foundation**	**Certified**
Off-types	0.10	0.20
Plants affected by seed borne diseases	0.10	0.20

Irrigation

Dolichos bean is drought hardy and can be grown as a dryland crop in areas of low rainfall. However, for getting higher yield of better quality produce, frequent application of irrigation is a must. Flowering and pod development are the critical stages of crop for applying irrigation, thus, it is important to maintain available soil moisture above 50 per cent during flowering and pod development. Depending on the climatic conditions, two to three irrigations may be sufficient in water deficit areas. However, to obtain higher yield irrigation should be applied regularly at an interval of 7-10 days. Frequency of irrigation in general depends on many factors, like climate, season, depth and type of soil, and organic matter content of the soil.

Staking

Over-crowding of plant vines due to non-staking affects formation of pods and yield adversely. Staking improves plant spread and photosynthetic activity. As a result, there is higher yield due to higher number of pods per plant. Quality of pods is improved as they do not come in contact with the soil.

Weed Control

Weeds, in Dolichos bean, may pose problem in early stages. They are controlled either manually or mechanically but controlling weeds manually is usually uneconomical and time consuming.

In spite of this, inter-cultivation at least once is essential to make the soil loose around the plants and to check weeds, especially at initial stages. Chemical weed control is very effective, economical and time saving. Application of pendimethalin (Stomp 30 EC) @2.0-2.5 litres per hectare checks the weed growth for 20-25 days. At later stages of crop growth weeds are kept under check by the crop itself due to thick foliage canopy. Weedicides are applied onto the soil surface by spraying after sowing crop seeds but before the emergence of weeds. Sufficient moisture in soil at the time of weedicide application ensures their effectiveness.

Harvesting

The pods are harvested when they are green, tender, succulent, and before becoming fibrous. If harvesting is delayed, the seeds grow large and the pods bulge around the seeds. Although the total yield increases with the delay in harvesting but quality of pods deteriorates rapidly. The mature pod stage is reached 20-25 days after anthesis. In bush type varieties the crop is ready for harvest two months after sowing and in pole types after three months. The maturity index is determined by pod weight, which in turn is determined by pod breadth. Pods are harvested manually at seven-day intervals. In pole types, a total of 9-10 pickings and in bush types 2-3 pickings are possible. Picking should be done either early in the morning or late in the afternoon. Otherwise, pre-cooling is required to improve post-harvest shelf life of pods.

Yield

The yield normally depends on many factors, like variety, season, climate, depth, type, and fertility of soil, and irrigation facility. However, on an average 50-80 quintal yield of green pods per hectare is obtained. Average seed yield is 6-8 quintals per hectare.

Seed Standards in Indian bean

Seed standards means the tolerances permitted as determined by established seed inspection procedures. The seed standards of Indian bean have been given below in table:

Factor	**Foundation**	**Certified**
Pure Seed (minimum)	98.0%	98.0%
Inert matter (maximum)	2.0%	2.0%
Other crop seeds (maximum)	None	None
Weed seed (maximum)	None	none
Other distinguishable varieties (maximum)	5/kg	10/kg
Germination (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers(maximum)	8.0%	8.0%

Important Diseases and Insect-pests of Indian bean

Powdery mildew (*Leveillula taurica* var. *macrospora*): Powdery mildew attacks almost all plant parts. First, whitish powdery mass appears on leaves and then spread onto the stem and pods. Defoliation occurs in severe cases. The disease is more severe under dry weather conditions.

Control: Spray the crop with wettable Sulphur @ 0.25 per cent. If needed, repeat the spray at 14-day intervals.

Anthracnose (*Colletotrichum lindomuthianum*): The pathogen is both seed as well as soil borne. Symptoms are evident on stem, petiole and leaves. On stem, dark brown, slightly sunken

cankerous spots studded with numerous acervuli are produced. As a result of these cankers, the distal portion of the vines wilts and dries up. On pods, disease produces circular to irregular brown lesions.

Control: Use disease free seed and grow resistant varieties. Purple pod coloured varieties are resistant to the disease. Spray the crop with Bordeaux mixture @ 1.0 percent or copperoxychloride @ 0.25 percent.

Common blight (*Xanthomonas phaseoli*): Common bacterial blight is the most destructive disease of Dolichos bean. The pathogen is seed borne. The disease not only reduces total yield but also affects quality of pods, thus rendering them unmarketable. The disease appears in humid weather conditions and causes severe defoliation. The disease is characterized by irregular, sunken, reddish to brown spots on leaves surrounded by yellow halo. In severe cases, several such spots coalesce and leaves turn yellow ultimately resulting in defoliation. Lesions also appear on main vein, stem and pods. Infected seeds are discoloured and shrivelled.

Control: Use disease free seed, grow resistant varieties, follow crop rotation and destroy the diseased debris. Hot water seed treatment at 50°C for ten minutes followed by dipping in Streptocycline solution is effective to kill the seed borne bacterium.

Yellow mosaic: It is a viral disease and spreads by the whitefly (Bemisia tabaci). Leaves of the diseasedplants are reduced in size and develop bright yellow patches interspersed with green areas. In severe cases, the entire leaf looks golden yellow in colour. It has wide host range amongleguminous vegetable crops.

Control: Remove and destroy the infected plants. Control the insect vector by spraying Rogor orMetasystox @ one ml per litre of water. Repeat the spray at 10-day intervals.

Aphid (*Aphis craccivora*): Aphid is a polyphagous pest of leguminous crops but Dolichos bean is the preferred host of this pest. It is a sap-sucking pest and infests almost all plant parts like leaves, tender shoots, flower buds and pods. A small spell of rainfall coupled with high relative humidity increases aphid population.

Control: Natural enemies control the aphid to some extent. For effective control, remove and destroy the affected plant parts during initial stages of infestation. Spray the crop with Malathion 50 EC @ 2 ml per litre of water. Spraying soap water suspension @ 25 ml liquid detergent per litre of water or neem extracts (*Azadirachta indica*) also gives effective control of aphids.

Pod borer (*Helicoverpa armigera* and *Adisura atkinsoni*): Pod borers are important pests of Dolichos bean as they directly feed on tender pods and developing seeds and thereby, reducing the marketable yields drastically. Of the two borer species infesting the Dolichos bean, *Adisura atkinsoni* is more prevalent.

Control: Both the species of pod borer are effectively controlled by spraying Sevin 50 SP (carbaryl) @ 0.2 per cent. Spray with 5 per cent neem seed extract reduces the incidence of pod borer. Strain HE 111 of *Bacillus cereus* var. *thuringensis* is reported to be parasitic to the pod borer larvae.

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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

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Quality Seed Production Technology for Fodder Legume Crops

A.K. Singh[1], V.K. Yadav[1], V.K. Wasnik[2], H.M. Halli[3], Sunil Swami[1], Mahehsa H S[1], Ravi Prakash Saini[1], Prabha Singh[1], Maharishi Tomar[1], Vinod Kumar[1], R.P. Nagar[1] and Suheel Ahmad[1]

[1] ICAR-IGFRI, Jhansi, [2] ICAR-NIBSM, Raipur, [3] ICAR-NIASM, Baramati

Seed, the plant material resulted from well planned seed program whose essential function being the reproduction, meant for sowing/planting purpose is important to achieve sustainable food and feed systems. Better seed production is therefore vital to furnish quality seeds of improved varieties. Quality seeds of improved varieties are the cheapest input in modern agriculture.

Seed production in forage/fodder crops is a complex process. This is because the diverse species of forage/fodder crops have different genetic constitutions; often have different agronomic requirements for seed production. In the same crop, agronomic practices for seed production often differ from those for forage production. The major fodder legume crops grown in India are Egyptian clover (Berseem), *Trifolium alexandrinum*; Alfalfa (Lucerne), *Medicago sativa*; Cowpea (Lobia), *Vigna unguiculata*; Cluster bean (Guar), *Cyamopsis tetragonaloba*; Rice bean (Red Bean), *Vigna umbellate*; Indian clover (Senji), *Melilotus alba*; and *Stylosanthes* spp. (Stylo).

As other crops, a seed production program in legume fodder crops must ensure attainment of the defined genetic constitution of the aggregate of seeds being produced. The generation system of seed production in fodder legume crops is Breeder seed - Foundation seed - Certified seed. Each class of seed must conform to certain level of quality standards, called Minimum Seed Standards whose major parameters are based on Field Standards and Seed Standards. Isolation distance is the most important Field Standard. Genetic purity is the most important among Seed Standard. The quality seed production technology in the seven fodder legume crops is presented in a tabular form is given in Table 1.

Table 1 Quality Seed Production Technology of the Fodder Legume Crops

Fodder legume crops	**Season**	**Land Requirements**	**Minimum Field Inspection**	**Field standards**					
				General Requirements		**Specific Requirements**			
				Minimum isolation distance (m)		**Minimum permitted (%)***			
				Fields of other varieties	**Fields of the same variety not conforming to varietal purity require**	**Off-types**	**Objectionable weed plants****	**Plants affected by seed borne diseases ****	Remarks

						ments for certification						
				FS	**CS**	**FS**	**CS**	**CS**	**FS**	**CS**	**FS**	
1	**2**	**3**	**4**	**5**				**6**				
Egyptian clover (Berseem)	Rabi	Free of volunteer plants	2 (from the time the crop approaches flowering until it is ready for harvesting	400	100	400	100	0.20	1.0	None	0.05	NA	NA	*Maximum permitted at and after flowering **Objectionable weed shall be Chicory (Kasni) *Chicorium intybus* L.)
Alfalfa (Lucerne)	Rabi	Free of volunteer plants	2 (from the time the crop approaches flowering until it is ready for harvesting)	400	100	400	100	0.20	1.0	None	0.05	NA	NA	*Maximum permitted at and after flowering **Objectionable weed shall be Dodder (*Cuscuta* spp.)
Indian clover (Senji)	Rabi	Free of volunteer plants	2 (from the time the crop approaches flowering	50	25	50	25	0.20	1.0	NA	NA	NA	NA	*Maximum permitted at the final inspection

			until it is ready for harvesting)											
Cowpea (Lobia)	Kharif & Zaid	Free of volunteer plants	2(the first before flowering, the second at maturity)	10	5	10	5	0.10	0.2	NA	NA	0.10	0.20	NA
Clusterbean (Guar)	Kharif & Zaid	Free of volunteer plants	2 (the first before flowering, the second at flowering and fruit stage)	10	5	10	5	0.10	0.2	NA	NA	0.10	0.20	*Maximum permitted at the final inspection ** Seed borne diseases shall be Bacterial blight (*Xanthomonas campestris* pv *cyamopsidis*), Anthracnose (*Colletotrichum lindemuthianum*), Ascochyta blight (*Ascochyta* spp.)
Rice bean (Red bean)	Kharif & Zai	Free of volunteer plants	2 (the first before flower	50	20	50	20	0.10	0.2	NA	NA	NA	NA	NA

	d		ing, the second at flowering and fruit stage)											
Stylo	Kharif	A. Foundation seed A seed crop of stylo shall not be eligible for certification if planted on land on which the same kind of crop was grown within the previous 5 crop seasons B. Certified seeds Free of volunteer plants	3 (the first before flowering, the second during flowering, the third at maturity and prior to harvesting)	50	25	50	25	0.10	1.0	NA	NA	NA	NA	*Maximum permitted at and after flowering

Varieties	Soil requirements	Land preparation	Sowing time	Seed production stages	Seed source	Seed rate (Kg/ha)	Spacing (cm)
7	8	9	10	11	12	13	14
Egyptian clover (Berseem): BL 10, BL 43, BL 42, Jawahar Berseem 5-9, JHB 146, Wardan, Mescavi, Pusa Giant , UPB-110, BL 1, BB 2, BB 3, BB 5, BB 6, BB 7, BB 8	Well – drained clay loam soil, free from acidity and salinity, pH 7-8	One deep ploughing followed by 2-3 harrowing	Mid October	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by a certification agency	20-25	Row to row 40
Alfalfa (Lucerne): Anand2, Anand Lucerne 3, Krishna, Lucerne CO 3, CO 4, IGFRI DL-2, IGFRI DL-5	Sandy loam to clay soil, free from salinity or alkalinity	One deep ploughing followed by 2-3 harrowing	October to November	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by a certification agency	12-15	50 x 3
Indian clover(Senji): FOS 1, Senji Safed 76, YSL 106, PC 5, HFWS 55	Loam to sandy loam, pH 7-8	One to two harrowing	Mid November	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved	30-35	Row to row 45-50

					by a certification agency		
Cowpea (Lobia): EC 4216, UPC 8705, C 152, Bundel Lobia 2, MFC 09-1, Bundel Lobia 1, GFC 1, COFC 8, Shweta, HC 88, CL 367, KBC 2	Sandy loam soil, well drained, pH 5-6.5	ploughing and harrowing 2-3 times and planking after removing stubbles and weeds	July	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by a certification agency	18-20	45-50 x 15
Clusterbean (Guar) : HG 2-20, HG 563, Guara 80, Agete Guar 112, BG 1, BG 2, BG 3, Durgapura Safed, HFG 157, Maru Guar, HG 182, FS 227	Light to medium fertile sandy loam soil, pH upto 8.5	One deep ploughing and 1-2 harrowing	First to Second week of July	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by acertification agency	15	45 x 15
Rice bean (Red bean): Bidhan 1, Bidhan Rice Bean 2, Bidhan Rice Bean 3, RBL1, RBL 6, RBL 35, RBL 50, PRR 1,	Loam to sandy loam soil, well drained	Ploughing and harrowing to make soil pulverised	Mid June to July	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by	25-30	30 x 15

PRR 2, Shyamalima					acertification agency		
Stylo: *Stylosanthes scabra*, *Stylosanthes* Phule Kranti	Sands to light clays, well drained	ploughing 2-3 times and forming beds of 10 or 20 m^2	June – July to September-October	Breeder seed ↓ Foundation seed ↓ Certified Seed	Breeder seed used as a source for foundation seed must come from a recognized source approved by acertification agency	6 (Line sowing) 10 (Broadcasting)	30 x 15

NA: Not available, FS: Foundation seed, CS: Certified seed

	Sowing method	**Seed treatment**	**Seed inoculation**	**Nutrient management**	**Water management**	**Interculturing**
	15	**16**	**17**	**18**	**19**	**20**
Berseem	Dry bed method: Line sowing and planking followed by irrigation for easy interculturing and weed removal Wet bed method: Broadcasting seeds after flooding the beds with 5-6cm deep water for rapid germination and early establishment	Carbendazin @ 2.5g/Kg seed or thiophenate-m@ 2g/ Kg seed	Seed inoculation with *Rhizobium* culture of *Rhizobium trifolli* where berseem is grown first time during seed production	50:60:40 Kg/ ha NPK Basal 20 kg N and entire P and K Top dressing 10 Kg N / ha and after each cut	16-18 irrigations at 10-12 days interval	Keep the field completely free from weeds, after last cutting

Lucerne	Similar to Berseem	Vitavex or benlate @ 2.5g / Kg seed	Seed inoculation with Rhizobium culture	20:60:40 Kg/ ha NPK Basal entire amount of NPK	11-13 irrigations at 14-18 days interval	Keep the field completely free from weeds particularly dodder, after last cutting
Senji	Beating the seeds with sticks or scarify them to break up the outer skin of seeds (as it is covered with husk) and soaking seeds overnight before sowing to facilitate germination	-	-	50:60:20 Kg/ ha NPK Basal entire amount of NPK	One irrigation may be given after a dry spell of 3-6 weeks	Keep the field completely free from weeds
Cowpea	Sowing seeds on flat or raised beds with seed drill or dibbled in rows at a depth of 3-4cm	Metalaxyl @4-6g / Kg seed	-	20:60:20 Kg / ha NPK Basal entire amount of NPK	8 irrigations at 9-12 days interval	Keep the seed field free of weeds. 1-2 hoeings in early stages of crop growth
Guar	Sowing seed in rows with seed drill at a depth of 3-4cm	Trichoderma @ 4g / Kg seed or mancozeb or carbendazin @ 2g / Kg seed followed by chlorpyriphos @ 2ml / Kg seed	-	20:40:25 Kg / ha NPK Basal entire amount of NPK	Irrigation can be given if crop suffers moisture stress and must be given if long dry spell prevails	Keep the field free of weeds. 1-2 hoeings in early stages of crop growth
Rice bean	Overnight soaking	Captan/ thiram @ 2-3	Seed inoculatio	20:50:20 Kg / ha NPK	1-2 irrigations	Thinning and spacing

	seeds (10-12hrs) before sowing either by broadcasting or by dibbling	g / Kg seed	n with Rhizobium and phosphate solubilising bacteria (PSB) to enhance nitrogen fixation and availability of phosphorus	Basal entire amount of NPK	at 10-15 days interval at critical stages (flowering and pod filling)	within the first fortnight. Keep the seed field free of weeds at initial stage and allow the crop to come up well
Stylo	Because of hard seed coat scarification is done, then seeds are pre-soaked in cold water overnight and sowing in line or by broadcasting seeds	-	-	20:60:20 Kg / ha NPK Basal entire amount of NPK	During establishment period provide sufficient moisture. Irrigate at 12-15 days interval if necessary	Keep the field free of weeds. 1-2 interculturing and 1-2 hand weeding

	Weed management	**Insect pest and disease management**
	21	**22**
Berseem	Imazethapyr @0.1 Kg/ha at 20 DAS for controlling grasses and broad- leaved weeds. Quizalofop Ethyl @ 37.5g/ha at 20 DAS for controlling grassy weed.	**Berseem stem rot:** *Sclerotinia trifoliorum* **Collar rot of berseem:** *Sclerotium rolfsii* **Pod borer:** *Helicoverpa armigera* **Management** • Proper irrigation management in the month of March and April • Application of FYM enriched with *Trichoderma harzianum* @ 2t/ha or neem cake enriched with biocontrol agents (or spot application) • Use of resistant varieties such as BB-3 (stem rot resistant) • Seed treatment with carboxin 37.5% + thiram 37.5% WS @ 2g/kg of seed

Lucerne	Trifluralin @ 4Kg/ha before sowing	**Lucerne Rust:** *Uromyces striatus* var. *medicaginis* **Little leaf:** *Candidatus* Phytoplasma Australasia Lucerne weevil: *Hypera postica* Aphids: *Acyrthosiphon pisum* **Management:** • Remove and destroy infected plant at early stage • Pathogen survives on Parthenium, collect and destroy weeds • Foliar application of Imidacloprid 17.8% SL @ 0.3 ml/ liter to manage vectors • Rust: Spray mancozeb 75% WP @ 2g/liter or hexaconazole 5% EC @ 1 ml/liter under severe condition
Senji	1-2 hand weedings	**Powdery mildew:** *Erysiphe* spp. **Weevil:** *Sitona hispidulus* **Aphid:** *Aphis* spp. **Management:** Spray mancozeb 75% WP @ 2g/liter or hexaconazole 5% EC @ 1 ml/liter under severe condition
Cowpea	Pendimethalin @ 0.75-1.0 Kg/ha at 2-3 DAS. Alachlor @1.5-2.0 Kg/ha at 2-3 DAS and imazethapyr @ 0.1 Kg/ha at 15-20DAS for controlling grasses and broad leaved weeds	**Anthracnose**: *Colletotrichum lindemuthianum* **Dry root rot**: *Macrophomina phaseolina* **Viruses**: BCMV, CoMV **Aphid**: *Aphis craccivora* **Gram pod borer**: *Helicoverpa armigera* **Spotted pod borer**: *Maruca testulalis* **Whitefly**: *Bemisia tabaci* **Management:** Avoid using heavy doses of highly soluble nitrogen fertilizers. Spray a steady stream of water on the host plant to knock-off aphids. Use yellow sticky traps Handpicking and destruction of various insect stages Seed treatment with *Trichoderma viride* @10g/kg or *Pseudomonas fluorescens* @ 10g/ kg of seed or Carbendazim or Thiram 2g/kg of seed. Spot drenching with Carbendazim 1g/lit or *P. fluorescens / T. viride* 2.5 kg/ha with 50 kg FYM. Use pathogen free certified seeds

Guar	For controlling grassy and broad-leaved weeds, apply pendimethalin @ 0.75Kg/ha at 0-3 DAS, imazethapyr @ 0.1Kg/ha at 20 DAS,	**Bacterial blight:** *Xanthomonas cyamopsidis* **Anthracnose**: *Colletotrichum lindemuthianum* **Alternaria leaf spot**: *Alternaria cucumeriana* var. *cyamopsidis* Jassids, Aphids and White fly Spray of streptocycline @ 5 g or plantomycine @ 50 g with 100 L water per hectare should be done at 35-40 days after sowing. Spray of zineb @ 2 grams per liter of water should be done at an interval of 15 days at least twice. Seed treatment with chlorophyriphos 20% EC @ 2 ml kg^{-1} of seed and application of chlorophyriphos 20% EC @ 2 ml per liter
Rice bean	Pendimethalin @ 0.75-1.0 kg/ha at 2DAS	**Rust:** *Uromyces appendiculatus* **Rhizoctonia blight:** *Rhizoctonia solani* **Bacterial blight:** *Pseudomonas* spp. **Blister beetle:** *Mylabris pustulata* **Pod borer** **Aphids** **Management:** Spray of streptocycline @ 5 g or plantomycine @ 50 g with 100 L water per hectare should be done at 35-40 days after sowing. Application of chlorophyriphos 20% EC @ 2 ml per liter Spray mancozeb 75% WP @ 2g/liter or hexaconazole 5% EC @ 1 ml/liter under severe condition
Stylo	2,4 D @ 0.5-0.7 Kg /ha in 500L of water for destroying broad leaved weeds	**Anthracnose**: *Colletotrichum gloeosporioides* **Blight**: Sclerotium rolfsii **Web blight:** *Rhizoctonia solani* **Botrytis head blight:** *Botrytis cinerea* **Little leaf disease:** Phytoplasma **Management:** Seed treatment with *Trichoderma harzianum* @10g/kg or *Pseudomonas fluorescens* @ 10g/ kg of seed or Carbendazim or Thiram 2g/kg of seed. Spot drenching with Carbendazim 1g/lit or *P. fluorescens / T. harzianum* 2.5 kg/ha with 50 kg FYM.

	Cuttings	GFY (q/ha)	Roguing	Harvesting, seed processing and storage	Seed Yield (q/ha)
	23	24	25	26	27
Berseem	Stop cutting for green fodder by the last week of February for seed production	450-500	At pre-flowering, flowering and maturity stage. The removal of off types, other crop plants and chicory plants must be completed before harvest for seed	Harvesting the seed crop when 2/3rd of the pods have turned brown. The harvested crop should be left in field for 3-4 days. Harvesting and collection of crop should be done early in the morning. Threshing of seeds should be done when the seeds are fully matured and dry. The seeds should be cleaned and further dried to 8-10% moisture content before storage	5-7
Lucerne	Stop cutting for green fodder by the last week of February	350	At pre-flowering, flowering and maturity stage. The removal of off types, other crop plants and dodder plants must be completed before harvest for seed	Harvesting and threshing can be done in a manner similar to that of berseem	2-3
Senji	-		Removal of off-types at pre-flowering and flowering to fruiting stage from the seed	Harvesting the seed crop when 2/3rd of the pods have turned brown. The harvested crop should be left in the field for 3-4 days. Threshing should be done when the seeds are dried to 8-10 % moisture content.	8-10

			field		
Cowpea		250-300 from single cut 400-450 from multicut	Removal of off-types and diseased plants affected by blight, cowpea mosaic and Anthracnose from the seed field	Either seed crop may be harvested or the pods may be picked when fully dried. Threshing can be done by flailing plants with sticks or by threshers. The cleaned seeds should be dried to 9 % moisture content before storage.	6-8
Guar		150-200 in rainfed 400-500 in irrigated	The off-types and diseased plants affected by bacterial blight and Anthracnose should be removed	The crop is ready for harvest by sickle when the pods are mature. After cutting, the crop is left in the field (for drying) for 1-2 days. Stalks in small heaps are picked and threshed by beating with sticks. The seeds should be cleaned and dried to 10% moisture content before storage.	6-7 in rainfed 10-12 in irrigated
Rice bean		300-400	Removal of off-types from the seed field	The crop should be harvested when pods have turned brown with hardening of grains and dropping of leaves. Being synchronous in pod maturity, the whole crop is harvested at one time and threshed manually or by thresher. The cleaned seed should be dried before storage	10-12
Stylo		250-300	Removal of off-types from the seed field	Seed maturity is not synchronous and therefore it is harvested not at a time. The harvested crop should be left in field for 3-4 days. Threshing should be done when the seeds are fully matured and dry. The cleaned seed should be dried before storage.	4-5

Seed Standards										
Factor										
	Pure seed (Min) %	**Inert matter (Max.) %**	**Other crop seeds (Max.) No./Kg**	**Weed seeds (Max.) No./Kg**	**Other distinguishable varieties (Max.)**	**Objectionable weed seeds (Max.)**	**Germination (Min) %**	**Moisture (Max.)**	
								Ordinary contai	**Vapor-proof contai**

									No./Kg		No./Kg				ner %		ner %	
	FS	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**	**FS**	**CS**
28																		
Berseem	98.0	98.0	2.0	2.0	10	20	10	20	-	-	5	10	80	80	10.0	10.0	7.0	7.0
Lucerne	98.0	98.0	2.0	2.0	10	20	10	20	-	-	5	10	80	80	10.0	10.0	7.0	7.0
Senji	98.0	98.0	2.0	2.0	10	20	10	20	10	20	-	-	65	65	10.0	10.0	7.0	7.0
Cowpea	98.0	98.0	2.0	2.0	10	20	10	20	-	-	-	-	75	75	9.0	9.0	8.0	8.0
Guar	98.0	98.0	2.0	2.0	10	10	None	None	10	20	-	-	70	70	9.0	9.0	8.0	8.0
Rice bean	98.0	98.0	2.0	2.0	None	None	5	10	10	20	-	-	70	70	9.0	9.0	8.0	8.0
Stylo	90.0	90.0	10.0	10.0	10	20	10	20	10	20	-	-	40	40	10.0	10.0	8.0	8.0

Quality seed production in fodder legume crops has benefits to farmers, seed growers and production agencies. The problems in seed production in forage/fodder crops are in maintaining varietal integrity of cross-pollinated species (e.g. Berseem, Lucerne) and agronomic problems of seed production. Good quality fodder legume seeds play a very important role in increasing yields. Whether a seed system is formal or informal, rapid seed dissemination is key to adoption of new varieties of fodder legume crops.

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Quality Seed Production Technology in Bengal Gram

Prof. Jai PrakashLal
Distinguished Professor,
Deptt. of Genetics & Plant Breeding,
Institute of Agricultural Sciences
Banaras Hindu University & Chancellor
Central University of Jharkhand, Ranchi, Jharkhand

What is seed
Seed is an "embryo "a living organism embedded in the supporting or the food storage tissue.

What is quality seed?
It is an improved variety with genetic and physical purity along with germination percentage and vigour. Quality seeds should also have higher planting value and good seed health and must be free from weeds and other crop seeds.

What is planting value?
It is the real worth of a seed lot for raising crop. It is determined by calculating pure live seeds percentage as follows.
Pure live seed (PLS) = $[\frac{Pure\ seed\ \%}{100} x\ \frac{Germination\ \%}{100}]\ x\ 100$

Other characteristics of quality seeds

a. seed size
b. seed Weight
c. specific gravity and
d. seed colour

Concept of seed quality
It is the degree of excellence in regard to the characteristics referred to above that determines the seed quality. If the seed lots possess high genetic purity and high germination percentage and a minimum of inert, weed and other crop seeds and are free from diseases, it is said tohave high quality seed. Generally,the standards fixed for certified seedsare considered quality standards.It implies that if a seed lot meets the certification standards,it is obviously good quality seeds.

The seed technology
The seed technology includes the development of superior crop plant varieties,their evaluation and release, seed production ,seed processing, seed storage seed testing, seed certification,seed quality control,seed marketing and distribution and research on seed physiology .Seed production and seed handling based upon modern botanical and agricultural sciences.
In a narrow sense," Seed Technology comprises techniques of seed production,seed processing, seed storage,seed testing and certification,seed marketing and distribution and the related research on these aspects.

Goals of Seed Technology
The major goal of Seed Technology is to increase agricultural production through the spread of good quality seeds of high yielding varieties. It aims at the following:

1. *Rapid multiplication.* Increase in agricultural production through quickest possible spread of new varieties developed by the plant breeders. The time taken to make available the desired quantities of seeds of improved varieties to the farmers .
2. *Timely supply:* The improved seeds of new varieties must be made available well in time, so that the planting schedule of farmer is not disturbed and they are able to use good seed for planting purposes.
3. Assured high quality of seeds. This is necessary to obtain the expected dividends from the use of seeds of improved varieties.
4. *Reasonable price.* The cost of high quality seed should be within reach of the average farmer.

Bengal Gram

Bengal gram which is also commonly known as chickpea. It is an annual legume of the family Fabaceae, sub family Faboideae. It is widely grown Rabi pulse crop on an area of 16.61 m ha with the production of 19.06 mt.The productivity is 1148kg /ha. (2021-22).Gram is grown under bothrainfed and irrigated conditions. There are two distinct types of chickpea or Bengal Gram-*i.e.Desi* Chickpea and *Kabuli* Chickpea

1. **Desi chickpea:** Chickpeas with coloured and thick seed coat are called desi type. The common seed colours include various shades and combinations of brown, yellow, green and black. The seeds are generally small and angular with a rough surface.
2. **Kabuli chickpea:** The kabuli type chickpeas are characterized by white or beige-coloured seed with ram's head shape, thin seed coat, smooth seed surface,. The kabuli types generally have large sized seeds and receive higher market price than desi types. The price premium in kabuli types generally increases as the seed size increases.

Seed Production Technology

A crop grown for seed production requires extra efforts and investments than a crop grown for grain. While taking up seed production, high priority should be given to maintenance of genetic and physical purity of the seed.

Crop season and sowing time: Chickpea is grown in *rabi* (postrainy season) . The sowing is done in the month of October or November. Late sowing (December-January) should be avoided as the late-sown crop may experience moisture stress and high temperatures at the critical stage of pod-filling, leading to reduced yield and seed quality.

Isolation distance: Isolation of a seed crop is done by maintaining a distance from other nearby fields of the same crop and other contaminating crops. Chickpea being a self-fertilized crop has a very low outcrossing percentage (0-1%). In India, an isolation distance of 10 m for foundation seed and 5 m for certified seed is required.

Suitable soil type: Chickpea can be successfully grown in a variety of soil types including coarse-textured sandy to fi ne-textured deep black soils (vertisols). However, the best suited soils are deep loams or silty clay loams with a pH ranging from 6.0 to 8.0. Saline soil and fields with a high water table are not suitable for chickpea.

Field preparation: Chickpea plants are highly sensitive to poor aeration in the soil. Seedling emergence and plant growth are hindered if field surface is compact. Therefore, the field should have loose tilth and good drainage. The stubble and debris from the previous crop should be removed as these can harbour the pathogens that cause root diseases, such as collar rot.

Sowing: Sowing is usually done on conserved soil moisture. A pre-sowing irrigation may be needed, if the available soil moisture is not adequate for germination. Kabuli chickpea should never be irrigated immediately after sowing, particularly in deep black soils. This is because the kabuli chickpea seeds have thin seed coat and deteriorate faster as compared to desi type and are also more susceptible to seed rot and seedling damping.

Recommended varieties to be grown: The seeds of recent recommended varieties such as GNG-2461, Advika (NC-7), Kota *Kabuli Chana* -4, L-558, Pusa JG-16 (BGM 10221), Karan Kabuli-4, RG 2016-134 (CG- AkshayChana), Pusa Chickpea 20211, Pusa JG-16, L 668, CSJK 174 (Karan Kabuli -4), PBG-9, RVG-204, Purva (GNG- 2299), Pant Gram-5, BG3043 & GNG -2207 may be grown at a larger scale.

Sowing depth: Seed should be sown deeply enough to make contact with moist soil. A depth of 5-8 cm seems to be ideal for the emergence of chickpea.

Spacing: Line sowing is a must in the crop grown for seed production as it facilitates *interculture operations, rouging and field inspection. Row-to-row spacing of 30 cm and plant*-to-plant spacing of 10 cm are generally used, which give a plant population of about 33 plants per m2 (330,000 plants ha-1). Wider row spacing (45–60 cm) can be used in large seeded kabuli chickpea and irrigated crops (both desi and kabuli types), which are expected to have greater plant width. Broadbed and furrow system or ridge and furrow system are very useful for irrigation, drainage and interculture operations and are widely used at ICRISAT and some other places.

Seed rate: It differs from variety to variety, depending on seed size. For initial seed multiplication of a new variety, the multiplication rate (yield per plant) is more important than yield per unit area. The following guidelines may be used for seed rate:
Seed size (100-seed weight) Seed rate -
Small (less than 20 g)-50 – 60 kg ha-1
Medium (20 – 30 g)- 60 – 90 kg ha-1
Large (30 – 40 g)- 90 – 120 kg ha-1
Extra-large (more than 40 g)-120 – 150 kg ha-1

Seed treatment: The seeds should be treated with fungicides (2 g thiram + 1 g carbendazim kg-1 seed) before sowing for reducing seed and soil borne fungal diseases. Phosphorus solubilizing bacteria (PSB) have been identified, which improve availability of phosphorus to plants. Thus, seed treatment with PSB is recommended. If chickpea is being grown for the first time, the seeds should be inoculated with Rhizobium culture. The seeds should be treated first with fungicides and then with PSB and Rhizobium, following the procedure recommended by suppliers. The culture-treated seeds should be dried in the shade and sown as soon as possible thereafter. If the seed is to be treated with pesticides, always apply insecticides first, followed by fungicides, and finally Rhizobium culture/phosphate solubilizing bacteria or follow instructions on the packets. J444_09ChickpeaManualinner_Fgs.indd 9 444_09ChickpeaManualinner_Fgs.indd 9 28-01-2010 12:53:14 PM 8-01-2010 12:53:14 PM 10

Fertilizer application: Fertilizer requirements depend on the nutrient status of the field, and thus, vary from field to field. Therefore, the doses of fertilizers should be determined based on the results of soil test. The generally recommended doses for chickpea include 20–30 kg nitrogen (N) and 40–60 kg phosphorus (P) ha-1. If soils are low in potassium (K), an application of 17 to 25 kg K ha-1 is recommended. There will be no response to application of K in soils with

high levels of available K. Total quantities of N, P and K should be given as a basal dose. Foliar spray of 2% urea at flowering has been found beneficial in rainfed crops.

Micronutrients: Intensive cropping without application of micronutrients, limited or no application of organic fertilizers and leaching losses lead to deficiency of one or more micronutrients in the soil. The important micronutrients for chickpea include sulphur (S), zinc (Zn), iron (Fe), boron (B) and molybdenum (Mo).
The requirements of these micronutrients vary from field to field and should be determined based on the results of soil analysis.

Irrigation: Chickpea is generally grown as a rainfed crop, but two irrigations, one each at branching and pod filling stages, are recommended for higher yield. Higher number of irrigations may lead to excessive vegetative growth in heavy soils.

Weed management: Chickpea is a poor competitor with weeds at all stages of growth. Pre-emergence herbicides, such as Fluchloralin @ 1 kg a.i. ha-1 or Pendimethalin @ 1.0 to 1.5 kg a.i. ha-1 were found effective in controlling early flush of weeds. Mechanical and/or manual weeding can be done where wide row spacing is used.

Plant protection: Chickpea being a rich source of protein is prone to damage by insect-pests and diseases. In general, root diseases (fusarium wilt, collar rot and dry root rot) are more prevalent in central and peninsular India, whereas foliar diseases (ascochyta blight, botrytis graymold) are important in northern, north-western and eastern India. Among the insect pests, pod borer (Helicoverpaarmigera) is the most severe yield reducer throughout India in the field, while bruchids (Callosobruchuschinesis) cause severe damage in storage.

Minimum standards for foundation and certified seed in chickpea
Each crop has different field and seed standards for production of foundation and certified seed. These variations are mainly because of the variation in extent and the mode of cross pollination. The field and seed standards for chickpea are given in Table 1.

Table 1. Minimum field and seed standards for chickpea seed production in India.

Parameter	Seed class	
	Foundation	Certified
Isolation distance (m)	10	5
Number of field inspections	2	2
Germination (including hard seed) (%)	85	85
Pure Seed (%)	98	98
Inert matter (%)	2	2
Plants affected by seed-borne diseases (%)	0.1	0.2
Off-types (%)	0.1	0.2
Other crop seeds (number kg^{-1})	None	5
Other distinguishable variety seeds (number kg^{-1})	5	10

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Management of Insect pests of PulseCrops

Pratap A. Divekar
Division of Crop Protection, ICAR-Indian Institute of Vegetable Research, Varanasi.
Email: pratapento@gmail.com

Insect pests of leguminous vegetable

Legumes are one of the most important components of subsistence farming system in India. They are an important source of good quality dietary proteins. Legumes are also a good source of vitamins such as folate and dietary minerals like calcium, iron, magnesium and zinc. Antioxidants and other health-promoting substances in legumes also help to reduce the risks associated with some diseases such as cancer. Hence food legumes, especially vegetable legumes, are a boon to human health and are cultivated as valuable commercial crops, both for domestic and export markets.

Legumes are highly susceptible to several insect and mite pests in the tropics.Vegetable legumes are highly susceptible to insect pests and diseases. Several insect pests including bean flies, aphids, thrips, leafhopper, whitefly, leaf beetles, pod borers, and pod bugs cause significant damage to food legumes in the field.

1. Bean flies, *Ophiomyiaphaseoli* Tryon, *M. obtuse* Malloch (Diptera: Agromyzidae)

Bean flies are one of the most destructive pests of food legumes, especially during the crops seedling stage.Larvae of these insects feed on legumes as internal feeders and leaf miners. *O. phaseoli* has the widest distribution and host range, and causes the maximum damage.

Damage symptoms

The most serious damage by *O. phaseoli* adults starts at the leaf stage. The leaves show several feeding and oviposition punctures on the upper surface with corresponding light yellow spots, especially in the basal portion of the leaf. These feeding and oviposition wounds could predispose the plant for the entry of pathogens. The larvae start feeding in the leaf tissue, leaf lamina and then the petiole and stem. The larvae feed voraciously in the cortex, and continue downwards into the tap root. Because of the severe disturbances in the transport of water and nutrients, the plants, especially in the seedling stage, wilt and die. If the infestation starts in the later plant growth stages, the damage is limited to the leaf petioles, but not to the stem. The damage to the petiole leads to wilting of the leaves. Even stem damage at this stage may not result in plant mortality, but leads to stem swelling. The larva feeds inside the stem by tunnelling that leads to weakening, and sometimes death of the plants.

The young larvae of *M. obtuse* attach themselves to the soft seeds inside the pods, and initially feed on the seed surface. They subsequently mine into the seeds, and the mines are often filled with faecal matter. Older larvae feed deep into the seeds, at times eating the embryo. Usually, a larva completes its development in one seed. The fully grown larvae come out of the seed, leaving behind a clear exit hole. Thus, the damaged pod is poorly filled.

Management

1. Choose resistant or moderately resistant cultivars.
2. Earthing up the plants three days after the appearance of the cotyledons above ground, so that most of the plants can overcome bean fly infestation.
3. Growing pearl millet and mungbean as intercrops with pigeon pea reduce the damage of *M. obtusa*. Cultivation of onion as an intercrop with common bean (*Phaseolus vulgaris*) lowers bean fly infestation.
4. Moth bean, chickpea, lentil, and cluster bean could be used as 'dead-end trap crops'—the bean fly adults lay eggs on these crops, but the eggs fail to hatch.
6. Parasitoids such as *Opiusphaseoli* Fischer against *O. Phaseoli*.

2. **Cowpea aphid, *Aphis craccivora* Koch** (Hemiptera: Aphididae)

This is a serious pest on cowpea and hyacinth beanstarting from the seedling stage to pod-producing stage. It acts as a direct pest and also transmits virus diseases. Although this aphid remains active throughout the year, it causes severe damage during the cool dry season.

Damage symptoms

A. craccivora prefers to feed on legume crops; it is commonly known as "cowpea aphid." Both the nymphs and adults possess piercing and sucking mouthparts. They occur in large numbers on the tender shoots, lower leaf surfaces, petioles, flowers and pods, and suck the plant sap. Slightly infested leaves exhibit yellowing. Severe aphid infestations cause stunting, crinkling and curling of leaves, delayed flowering, shrivelling of pods, resulting in yield reduction. Young plants may be killed due to heavy infestation. *A. craccivora* also transmits n.*Bean common mosaic virus* and *Cucumber mosaic virus* in a non-persistent manner. Large populations of the pest secrete substantial quantities of honeydew, which favours the growth of sooty mould on leaves and reduces the photosynthetic efficiency of the plants.

Management

1. Avoid monoculture and follow crop rotation. The selected field should be located away from other legume crops.
2. Use entomopathogenic fungi (EPF) such as B*eauveria bassiana, Metarhizium anisopliae, Verticillium lecanii* and *Hirsutella thompsonii*.
3. Use neem oil, either alone or in combination with the EPF bio-pesticides.
4. The ladybird beetles (*Menochilus sexmaculatus, Brumus suturalis, Harmonia dimidiate, Brumus suturalis* and *Coccinella septempunctata*) and green lacewings (*Chrysoperla carnea*) are efficient predators of aphids.
5. Spray any one of the following (Spray fluid 250 l /ha)
    - Methyl demeton 25 EC 500 ml/ha
    - Dimethoate 30 EC 500 ml/ha

3. Whitefly, *Bemisiatabaci* Gennadius (Hemiptera: Aleyrodidae)

*B. tabaci*is highly polyphagous and is known to feed on several vegetables including legumes, tomato, eggplant and okra, field crops and weeds. Hot and dry conditions favour the whitefly, and heavy rain showers drastically reduce its population build-up. This insect is active during the day and settles on lower leaf surfaces at night.

Damage symptoms

Both the adults and nymphs suck the plant sap and reduce the vigour of the plant. In severe infestations, the leaves turn yellow and drop off. Large populations secrete substantial quantities of honeydew, which favours the growth of sooty mould on leaf surfaces and reduces the photosynthetic efficiency of the plants. If the infestation occurs during the pod formation stage, infected pods turn yellow and produce shrivelled grains. In addition to direct damage, *B. tabaci*also acts as a vector for several viral diseases including *Mungbean yellow mosaic virus* (MYMV), *Cowpea mild mottle virus* (CPMMV), and *Bean golden yellow mosaic virus* (BGYMV) on crops such as mungbean, yard-long bean, common bean, cowpea and soybean.

Management

1. Whitefly is a polyphagous insect; it has several host plants for feeding and survival ranging from cultivated crops to weeds. The field selected for vegetable legumes should be clean and not be located near any host plants and weeds.
2. Use of MYMV resistant or tolerant varieties is suggested to overcome the disease.
3. Grow seedlings for crops such as yard-long bean in insect-proof (50–64 mesh) net houses, net tunnels, greenhouses, or plastic houses.

4. If the seedlings are produced under open field conditions, use yellow sticky traps at the rate of 1-2 traps/50-100 m^2 to trap the whiteflies. Hang the traps slightly above or at the canopy level for better trapping.
5. Maintain a high standard of weed control in seedling production areas and crop fields to reduce the availability of alternate host plants.
6. Plant fast growing crops like maize, sorghum, or pearl millet in the border of the field to act as barriers to reduce whitefly infestations. Reflective and yellow plastic or straw mulches may reduce landing of whiteflies.
7. Neem formulations can be applied as a soil drench or foliar application to control whitefly in vegetable legume seedlings. Seed treatment with neonicotinoid pesticide formulations also reduces whitefly populations and incidence of MYMV disease.
8. Natural enemies such as *Encarsia formosa*is efficient parasitoid of whiteflies.
9. Spray methyl demeton 25 EC 500ml or dimethoate 30 EC 500 ml or phosphomidon 85 WSC 250 ml/ha

4. Leafhoppers, *Empoascakerri* Puthi, (Homoptera: Cicadellidae)

Damage symptoms

Both nymphs and adults suck the sap from the lower leaf surfaces through their piercing and sucking mouthparts, which leads to yellowing. When several insects suck the sap from the same leaf, yellow spots appear on the leaves, followed by crinkling, curling, bronzing (becoming reddish-brown) and drying. Leafhoppers also cause similar damage in cotton and potato.

Management

1. Monitor the insects with yellow sticky traps placed at random in the field.
2. Okra, sesame, sorghum and pearl millet can be grown as inter-crops in vegetable legume (*e.g.*, mungbean) fields. This reduces the leafhopper damage significantly.
3. Avoid the use of broad-spectrum pesticides to encourage the performance of natural enemies. Generalist predators such as ladybird beetles and green lacewings are efficient in preying on leafhopper nymphs and adults.
4. Use neem-based biopesticides at recommended doses. If the commercial neem formulations are not available, neem seed kernel extract (NSKE) @ 5% can also be sprayed.
5. Spray the infested crop with methyl-o- demeton 750 ml in 700 - 1000 L water per hectare.

5. Tobacco caterpillar/Common armyworm, S*podoptera litura* Fabricius(Lepidoptera: Noctuidae)

S. litura is a polyphagous and highly mobile insect and it is a pest of economic importance on many agricultural and horticultural crops. It is the predominant species on several vegetable legumes. As they are nocturnal, the larvae feed actively during night hours. During the day, the larvae hide under soil cracks and crevices or plant debris in the field.

Damage symptoms

The neonate larvae feed on leaf surfaces and cause skeletonization, leaving behind the whitish membranous leaves only. Mature larvae feed on the whole leaves until only main veins are left. Sometimes, the larvae may also cut the seedlings or young plants at soil level, which may lead to complete destruction of the crop.

Management

1. Castor (*Ricinus communis*L.) can be grown as a trap crop along the field border to attract egg-laying female adult moths. As eggs will be laid in masses, the egg masses and young larvae that still remain and feed in groups can be hand-picked and destroyed either on the trap crop or on the main crop.
2. Sex pheromones of *S. litura* are commercially available in many countries and can be used for monitoring as well as mass-trapping.

3. *Spodoptera litura* nucleopolyhedrovirus (SlNPV) is commercially available in some countries, and can be used to replace chemical pesticides. SlNPV is effective either alone or in combination with neem. In addition, *Bacillus thuringiensis* formulations can be used to manage *S. litura*.
4. The egg-parasitoids (*e.g., Trichogramma chilonis* Ishii) and larval parasitoids (*e.g., Campoletis chlorideae* Uchida) can be conserved and/or released in vegetable legume fields at regular intervals to check the build-up of *S. litura*.
5. Apply Profenophos 50 % EC @ 1000 ml/ha or deltarnethrin 2.8 EC @ 750 ml/ha or quinolphos 25 EC @ 1000ml/ha. In case of severe infestation apply polytrin 44% @ 1 lit/ha or profenophos 50 EC 2.00 lit/ha. Dust Deltamethrin 2.8% EC or quinalphos 1.5% @ 25kg/ha when their population is likely to reach 10/m row length (ETL). Repeat it as needed.

6.Thrips, *Megalurothrips distalis* Kany, *M. usitatus*(Bagnall), (Thysanoptera: Thripidae)

They mainly feed on the flowers of legumes, and can cause 100% yield losses if left uncontrolled.

Damage symptoms

Thrips remain hidden inside the flower buds and flowers. Both the larvae and adults feed on the tender leaves in the beginning. However, they prefer to feed mostly on flowers (inflorescence). Slightly infested leaves exhibit silvery feeding scars. In severe infestations on the flowers, the open flowers are discolored and distorted showing elongated brownish streaks; they dry out, and fall prematurely without forming pods. Infested pods are scarred and deformed.

Management

1. Grow vegetable legume (*e.g.*, yard-long bean and common bean) seedlings in insect-proof (50–64 mesh) net houses, net tunnels, greenhouses, or plastic houses to avoid early infestation, especially in the dry season.
2. Use blue sticky traps to monitor thrips at regular intervals and determine when other pest management controls are required.
3. Entomopathogenic fungi *Metarhizium anisopliae* was found effective against adult thrips.
4. Use mulch and reflective materials in vegetable legume fields to reduce the incidence of thrips.

7. Pod bugs, *Clavigrallagibbosa* Spinola, (Hemiptera: Coreidae)

Damage symptoms

The nymphs and adults have piercing and sucking mouthparts. They penetrate the pod walls and suck the sap from developing seeds inside. Occasionally they also feed on stems, leaves and flower buds. Feeding on the pods causes yellow blotches. Severe infestations lead to shriveled pods and seeds. The damage is serious during prolonged dry weather conditions.

Management

1. Inter-cropping of legumes with millets such as sorghum could delay the infestation of pod bugs.
2. Parasitoids such as *Gryonclavigrallae*Mineo against *C. gibbosa* and *C. scutellaris* in Asia are found to be effective candidates for biological control. Avoid using broad-spectrum chemical pesticides.
3. Entomopathogenic fungi. *M. anisopliae* and *Beauveria bassiana* were found effective against *Clavigralla* bugs.
4. Do not spray broad-spectrum chemical pesticides. If necessary, spray a systemic pesticide.

8. Bean bugs, *Riptortus pedestris*(F.), *R. clavatus*(Thunberg) (Hemiptera: Alydidae)

Bean bugs are serious pests of food legumes and they feed mainly on soybean. They can cause significant reduction in pod and grain yields and quality.

Management

1. Delayed sowing from normal planting season of legumes helps avoid damage from bean bugs due to lower pest densities.
2. Inter-cropping of legumes (e.g. soybean) with trap crops (e.g. sesame and corn) can enhance the performance of parasitoids such as *G. japonicum* and *O. nezarae*and thus reduce the infestation of *Riptortus* bugs.
3. Aggregation pheromones produced by the males of *R. pedestris* attract the adults and nymphs. Use synthetic aggregation pheromones of *R. pedestris*, if available.
4. Aggregation pheromones of *R. pedestris* also attract the egg parasitoid *O. nezarae*. Combined deployment of aggregation pheromone traps and non-viable eggs of *R. pedestris* for field multiplication of the parasitoid enhances the suppression of *R. pedestris*.
5. Entomopathogenic fungi such as *B. bassiana* could be used to manage *Riptortus* bugs.

9. Southern green stink bug, *Nezaraviridula*(L.) (Hemiptera: Pentatomidae)

Damage symptoms

The damage symptoms are similar to other pod bugs, causing drying of shoots, shriveled pods and seeds. In addition, the bugs may carry the spores of fungal pathogens from plant to plant, and mechanically transmit plant pathogens while feeding.

Management

1. Early maturing legume crops could be used as a trap crop for *N. viridula*. However, adults of *N. viridula*will quickly move from the trap crop to the main crop if they are at more attractive stages. Hence, chemical control of early instar *N.viridula*in trap crops is necessary to prevent movement into the main crop.
2. The Reduviid predator, *Sycanuscollaris* Fab., also keeps this pest under control. Avoid using broad-spectrum chemical pesticides if these natural enemies are present in the field.
3. Entomopathogenic fungi *M. anisopliae* was proved effective against *N. viridula*.
4. Do not spray broad-spectrum chemical pesticides.

10. Legume pod borer, *Marucavitrata* (F.) (Lepidoptera: Crambidae)

M. vitrata is considered the most serious pest of vegetable legumes in India.

Damage symptoms

Infestation starts in the terminal shoots but later spreads to the reproductive structures. The larvae move from one flower to the other, and each may consume about four to six flowers before completing the larval stage. Infestation is highest on flowers, followed by floral buds, pods, and leaves. The mature larvae, especially from the third instar, are capable of damaging pods, and occasionally the peduncle and stems. First instar larvae prefer to feed on flowers rather than pods or leaves. The larvae feed on floral buds, flowers, and pods by webbing. Often the damaged pods and inflorescence show frass.

Management

1. Early sown crops may escape from *M. vitrata* damage, because the pod borer population tends to increase over the season.
2. Mixed cropping and intercropping can reduce the incidence of *M. vitrata*. For instance, intercropping of common bean with maize significantly minimizes pod borer damage on beans.
3. Grow Sunhemp (*Crotalaria juncea*) as a trap crop against *M. vitrata*. The plant is highly attractive to the egg laying female moths, but highly unsuitable for the developing larvae of *M. vitrata*, and thus can be used as a 'dead-end' trap crop.
4. Sex pheromone lures of *M. vitrata* are commercially available and can be used for monitoring.
5. *Maruca vitrata* multiple nucleopolyhedrovirus (MaviMNPV) recently has been developed as a biopesticide, and can be used to replace chemical pesticides. SlNPV is effective either alone or in combination with neem. In addition, B*acillus thuringiensis* formulations andentomopathogenic

fungi such as *B. bassiana* and *M. anisopliae* isolates and/or formulations can be used to manage *M. vitrata*.

6. Natural enemies viz.,egg-larval parasitoid, *Phanerotomasy leptae* Zettel, and two larval parasitoids, *Therophilusjavanus*Bhat & Gupta and *T. marucae*van Achterberg& Long) of *M. vitrata* were found effective.

7. Chemical insecticides, phosalone 0.07% (Spray fluid 625 ml/ha) was found effective.

11. Spiny Pod borer, *Etiellaz inckenella*Treitschke (Lepidoptera: Pyralidae)

This insect has been reported on several legume crops, it causes significant yield losses in lentil, peas and soybean.

Damage symptoms

Infestation of *E. zinckenella* usually starts late in the season. The larvae feed on floral buds, flowers, and pods by making rough and irregular incisions. The pods may have several entry holes. They feed on the seeds inside the pods. Often the damaged pods and inflorescence show light coloured frass and loosely spun webs.

Management:

1. Choose tolerant or resistant cultivars.

2. Sex pheromone lures of *E. zinckenella*are commercially available, and can be used for monitoring.

3. Several parasitoid species have been reported for *E. zinckenella*in India, *A. taragamae* Viereck, *Bracon*sp. *Trathalaflavoorbitalis* (Cameron). *Trichogrammatoideabactrae* Nagaraja and *Trichogramma ostriniae* Pang and Chen were found to parasitize 80% eggs of *E. zinckenella*.

4. Biopesticides such as *B. thuringiensis* and neem are highly effective against *E. zinckenella*.

12. Blue butterfly, *Lampides boeticus* (L.), *Euchrysops cnejus*(F.) (Lepidoptera: Lycaenidae)

Damage symptoms

The larva bores into the floral buds, flowers and green pods soon after emergence from eggs, and feeds on the inner contents. Damage on the pods is characterized by round holes.

Management

1. Blue butterfly larvae occur infrequently in vegetable legumes. In addition, they are attacked by several parasitoids such as *Trichogramma chilotraeae* Nagaraja & Nagarkatti, *T. bactrae* and *Cotesia specularis* Szepligeti.

2. If necessary, spray the most effective biopesticides based on *Paecilomyces lilacinus, Vetricillium lecani* and neem.

3. Emamectin benzoate 5%SG 220 g/ha, Indoxacarb 15.8%SC 333 ml/ha, NSKE 5% twice followed by Triazophos 0.05%, Neem oil 2%.

13. Gram pod borer, *Helicoverpa armigera* Hubner(Lepidoptera: Noctuidae)

The gram pod borer is a polyphagous and highly mobile insect and it is a pest of economic importance on many agricultural and horticultural crops. Occasionally it causes significant yield losses in mungbean, vegetable soybean, chickpea and pigeon pea.

Damage symptoms

The neonate larvae feed on the surfaces of leaves or floral buds. However, the grown-up larvae prefer to feed on the contents of reproductive parts such as floral buds, flowers and young fruits. The larvae make the holes on these reproductive parts and feed inside by thrusting their head inside; hence the holes are circular and often surrounded by faecal pellets. Later, the larva feeds on most of the inner contents of the pod and hollows the pod out. Severely damaged pods rot and fall; partially damaged pods may become deformed.

Management

1. Avoid growing legumes in the vicinity of other alternate host plants, because the *H. armigera* adults can easily migrate to the newly planted legume crop. Erecting suitable physical barriers such as nylon nets or planting barrier crops that are non-host plants around the plots can reduce *H. armigera* damage on vegetable legumes.
2. Crop rotation should strictly be followed. Rotate the legume crop with a non-host cereal crop, cucurbit or cruciferous vegetable.
3. *H. armigera* sex pheromone traps can be used to monitor mass-trap or disrupt the mating activities of male moths.

a. *Monitoring*: Sex pheromone traps baited with *H. armigera* pheromone lures can trap adult male moths to predict the population build-up in the field.

b. *Mass-trapping*: Sex pheromone traps baited with *H. armigera* pheromone lures can be used for trapping as many males as possible to reduce chances of females mating and producing viable eggs in the field.

c. *Mating disruption*: Placing a high concentration of sex pheromone in a slow-release formulation on a 5- and 10-m grid in the field will result in a drastic reduction in male moths being attracted to virgin females, which adversely affects mating in *H. armigera*.

4. Planting of African marigold (*Tageteserecta*L.) as a trap crop reduces the incidence of *H. armigera*. *H. armigera* adults preferred marigold at flowering stage for oviposition. It is important to synchronize sowing/transplanting of both crops so that their flowering coincides to attract *H. armigera* female adults.
5. The egg-parasitoids (*e.g., Trichogramma pretiosum*Riley) and larval parasitoids (*e.g., Campoletis chlorideae* Uchida) can be conserved and/or released in vegetable legume fields at regular intervals to check the build-up of *H. armigera*.
6. Commercially available biopesticides based on *B. thuringiensis*, *Helicoverpa armigera* nucleopolyhedrovirus (HaNPV) and neem can also be used against *H. armigera*.
7. Dimethoate 30% EC 1237 ml/ha, Emamectin benzoate 5% SG 220 g/ha, Indoxacarb 15.8% SC 333 ml/ha, Chlorantraniliprole 18.5 SC 150ml/ha, Spinosad 45%SC 125-162 ml/ha, NSKE 5% twice followed by Triazophos 0.05%, Neem oil 2%, Phosalone 0.07% (Spray fluid 625 ml/ha).

14. Spider mite, *Tetranychus* spp. (Acari: Tetranychidae)

Damage symptoms

Spider mites usually extract the cell contents from the leaves using their long, needle-like mouthparts. This results in reduced chlorophyll content in the leaves, leading to the formation of white or yellow speckles on the leaves. In severe infestations, leaves will completely desiccate and drop off. The mites also produce webbing on the leaf and pod surfaces in severe conditions. Under high population densities, the mites move to the tip of the leaf or top of the plant and congregate using strands of silk to form a ball-like mass, which will be blown by winds to new leaves or plants, in a process known as "ballooning."

Management

1. Predatory mites such as *Phytoseiulus persimilis*Athias- Henriot and several species of *Amblyseius*, especially *A. womersleyi*Schicha and *A. fallacies* Garman can be used to control spider mites. They are more effective under protective structures and in high humidity conditions.
2. Green lacewings (*Mallada basalis* Walker and *Chrysoperlacarnea*Stephens) also are effective generalist predators of spider mites.
3. Usually, the macrocyclic lactones (*e.g*. avermectins and milbemycins) are effective.

Insect pests of Pea

1. Peapod borer: *Helicoverpa armigera(*Family: Noctuidae, Order: Lepidoptera)

Symptoms of damage:

- Young larvae feed on tender foliage

- Mature larvae bore circular holes
- Thrust only a part of its body into fruit and eat the inner content

Management:

- Collect and destroy the infected fruits and grown up larvae
- Setup pheromone trap with *Helilure*@ 12/ha
- Collection and destruction of damaged fruits and grown up caterpillars.
    - Release *Trichogramma pretiosum* @ 1 lakh nos. /ha/release at an interval of 7 days starting from flower initiation stage based on ETL of 10% damage.
- For *Helicoverpaarmigera:* HaNPV 1.5 x 10^{12} POBs/ha *i.e.* NPV of *H. armigera* 0.43% AS @ 3.0 ml/lit or 2 % AS @ 1.0 ml per lit
- For *Spodopteralitura*: Sl NPV 1.5 x 10^{12} POBs/ha
- Provide poison bait with carbaryl 50 WP 1.25 kg, rice bran 12.5 kg, jaggery 1.25 kg and water 7.5 lit/ha
- Spray *Bacillus thuringiensis* 2g/lit or any one of the following insecticide

Insecticide	Dose
Azadirachtin 1.0 % EC (10000 ppm)	2.0 ml/ lit
Indoxacarb 14.5 % SC	8 ml/10 lit
Flubendiamide 20 WG	5 g/10 lit
Novaluron 10 % EC	7.5 ml/10 lit

2. Pea leaf miner: *Chromatomyiahorticola (*Family:Agromyzidae,order: Diptera*)*

Symptoms of damage:

- Larvae feed between the lower and upper epidermis of leaves by making zig-zag tunnels results into formation of large galleries
- Severe tunnelling and gallery formation interfere with photosynthesis and proper growth of plants making them look unattractive
- Drying and dropping of leaves

Management:

- Collect and destroy mined leaves
- Spray NSKE 5%
- Spray 1 lit Dimethoate 30 EC in 250 lit of water / ha and repeats the spray at 15 day interval. Waiting period 20 days should be observed for picking of pods.

3. Pea Stem Fly:*Ophiomyia phaseoli*(Family:Agromyzidae,order: Diptera)

Symptoms of damage:

- Maggots bore into the stem thereby causing withering and ultimate drying of the affected shoots and reducing the bearing capacity of host plants
- Adults cause damage by puncturing the leaves and injured parts turn yellow
- Damage is more severe on seedlings than on grown up plants

Management:

- Remove and destroy all the affected branches
- Sowing time apply 7.5 Kg of phorate 10G or 25 kg of corbofuron 3G/ha in furrows
- Three spray after germination 750 ml of oxydemetonmetyl 25 EC in 250 L of water per ha.
- Avoid sowing of the crop earlier then mid October to check the attack of the pest

4. Pea Aphid : *Acyrthosiphonpisum*(Family: Aphididae,Order: Hemiptera)

Symptoms of damage:

- Adult suck the sap from young shoot ventral surface of tender leaves

- Plants remain stunted and sooty moulds grow on the honeydew excreted by the insects
- This is superficial black coating on leaves
- This affecting adversely the pod formation

Management:

- Set up yellow stick trap to monitor aphid population.
- Conserve the natural enemies viz., *Cocciniellaseptempunctata, Menochilussexmaculata,*
- Spray dimethoate@ 2 ml /lit
- Inundative release of *Coccinellaseptempumctata* @1000 adult /4000 sq.m for aphid management(2 release at 10 days interval)

5. Pea pod borer*Etiellazinckenella*(Family:Pyralidae,Order:Lepidoptera)

The larvae damage the crop by feeding on flowers and pods.

Spray Carbaryl 50 WP in 250 litres of water/ha when the attack starts. Repeat the spray after 15 days, if necessary.

Economic Threshold Level (ETL) of insect pests:

• **Aphids**: 20 aphids per 2.5 cm shoot length
• **Pod borers**: 10% of affected pods
• **Spotted pod borer**: three larvae per plant
• **Stem fly**: 10% of affected plants
• **Tobacco cutworm**: eight egg masses per 100 m2 area

Integrated Pest Management (IPM)

a. Before Sowing:

• Soil application: Phorate/carbofuran at 1 kg a.i./ha
• Seed treatment:
• Imidacloprid 70 WS at 3 g/kg seed
• Imidacloprid 17.8 SL at 3 ml/kg seed
• Dimethoate 30 EC at 5 ml/kg seed

b. After Sowing:

• Foliar spray: 30–35 days after sowing for the control of thrips
• Dimethoate 30 EC at 2.0 ml/lit
• Imidacloprid 17.8 SL at 0.2–0.4 ml/lit
• Triazofos 40 EC at 1.5 ml/lit

c. In Standing Crop:

• Removal and destruction of MYMV-infested plants
• Collection and destruction of egg masses and skeletonized leaves along with early instar larvae of hairy caterpillar and *Spodopteralitura*
• Deploying of light traps or bonfire against hairy caterpillar moth
• Need-based spray of any of the following insecticides: Quinalphos 25EC at 2.0 ml/lit Chlorpyrifos 20 EC at 2.5 ml/lit (blister beetle) Phosalone 35EC at 2.5 ml/lit

B. Beneficial Insects:

Some of the important parasitoids of *A. craccivora* are *Thioxysindicus*, *Lysiphlebusfabarum* and *L. testaceipes*. Important predators include coccinellid beetles, e.g., *Menochilussexmaculatus* and *Coccinellaseptempunctata*; neuropteran larvae, e.g., *Micromustimidus*; and predatory diptera, e.g., *Aphidoletesaphidimyza*, and a syrphid (*Ischiodonscutellaris*).

Conclusion:

IPM system development in pulse crops, especially pigeonpea and chickpea, has advanced significantly. On the many IPM components, including biology, cultural control, host-plant resistance, biological control as well as chemical control in the instance of gram pod borer, H. armigera, and pod fly, M. obtuse. However, current technology is still mostly centred on the

application of pesticides in crops of Vigna spp., such as pea and lentil. The relatively weak socioeconomic situation of the farmers that grow pulse crops is the main barrier to the effective development and application of IPM systems in these crops.Additionally, there is a lack of initiative on the part of the farmers to plant these crops on better soils outside marginal land, which results in a very poor uptake of more advanced agronomical procedures and plant protection techniques.Therefore, if the pest management system for pulse crops is to be of any use in practise, it must be assessed in the context of these limitations. Pulse farmers, IPM experts, politicians, and government agencies all need to put in a lot of work to build an IPM system for pulse crops.

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Maintenance of Nucleus & Breeder Seed in Pulse Crops

Ex.Prof (Dr.) C.P. Sachan
Ex.Nodal Officer AICRP on Seed (Crops)
Chandra Shekhar Azad University of Agriculture & Technology
Kanpur- 208002

Quality seeds, a basic input of agriculture play a vital role in enhancing both production and productivity .The seed class involves Nucleus, Breeder, Foundation and Certified seed with different seed quality standard at different levels to safeguard the production of large quantity of quality seed for sustainable agriculture. The maintenance breeding is a mandatory step for the institute who are involved in development of variety. The developer maintains the seed purity of released varieties by curbing the chance of out crossing and genetic drift. The quality seed is the first and prime requisite for grain production, which alone contribute about 30% of yield improvement. Further, seed traits such as seed dormancy, viability, priming, foliar spray etc. are being given importance to improve cultivars for seed traits. Thus, it is important to deliver a healthy, improved variety seed to meet the seed requirement of the country and to dissect the seed traits for development of cultivar to cope with changing climate. Availability of good quality seed at the right time in affordable prices plays a major role in the highest grain production of a nation. The Indian seed delivery system which is backed by both formal and informal seed system has a good structural network for sufficient availability of seed but the seed replacement rate and the varietal replacement rate are under desirable limit. Majority of seed requirement of our farmers is fulfilled by informal seed system is one of the major factor responsible for this. Gaps in seed systems which include non-availability of many high yielding varieties in the seed chain, non-availability of sufficient quantity of quality seed, deterioration in seed quality, long time span for seed quality testing and non-assurance of genetic purity of Marker Assisted Selection developed varieties. The Strength of breeder seed availability is mainly depends on strong varietal maintenance programme, which finally ensure the availability of nucleusvis-à-vis breeder seeds. A precise description about it has been given as follows.

A branch of plant breeding which deals with principles and method of breeder seed production and maintenance is called Maintenance breeding. It is a breeding procedure followed to maintain the genetic purity of the variety or parents of hybrid. It deals with principles and methods of nucleus &breeder seed production along with ways and means of maintaining genetic and physical purity of released and notified variety. It is also known as varietal maintenance technology.

It undertake breeder seed production of parental line of released variety. Genetic purity, physical purity, Seed health and germination are main point taken into account. Breeder seed is used as base material for starting Maintenance breeding programme. It prevents varietal deterioration (Mutation&cross pollination).

MAINTENANCE OF NUCLEUS AND BREEDER SEED: It is the handful of original seed obtained from selected individual plants of a particular variety for maintenance and purification by the originating breeder. It is further multiplied and maintained under the supervision of qualified pant breeder to provide breeder seed. It has the highest genetic purity and physical purity. Maintenance of nucleus can be divided into two groups: -

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

Maintenance of Nucleus Seed of Pre-released or Newly Released Varieties

The procedure outlined by Harrington (1952) for the maintenance of nucleus seed of pre-released or newly released varieties is described below:

Sampling of the variety to obtain nucleus seed. New numbers, lines or selection which are highly promising, on the basis of performance in breeding nurseries and yield trials, should be sampled for seed purification. These samples provide a beginning for purifying new varieties and for possible increase and distribution to farmers. Not more than fifteen new varieties in any one crop at a station should be sampled in one year.

a. **Table examination of samples:** The two hundred plants of each sample should be threshed separately and the seed should be examined in piles on the table. Discard any pile appearing obviously off type, diseased or otherwise unacceptable. The seed of each two hundred plant samples or less is now ready to be sown in a variety purification nursery called as nucleus.
b. **Locating and seeding of nucleus:** Each nucleus seed should be grown on clean fertile land at an experiment station in the region or in area in which this new variety could be grown, in the event of its release. The land must not have had a crop of the same kind in the previous year.
c. **Inspection of nucleus two-row plots and removal of off types:** Throughout the season of growth, from the seedling stage until maturity, the nucleus plot should be examined critically. Differences in the habit of early plant growth, leaf colour, rate of growth, time of heading, height head characteristics and diseases reactions should be looked for. If a plot differs distinctly from the average in the pre-heading stages of growth, it should be removed before heading.
d. **Harvesting and threshing of nucleus;** Each remaining plot, of which there should be at least 180 out of the original 200. should be harvested individually with a sickle and tied in a bundle. The total bundles of each nucleus should be labelled and stored until the current years yield tests for trials are obtained. The nucleus bundles of any new variety should be discarded, if it is found unworthy of being continued.

Later the seed should be cleaned in a fanning mill or by hand methods, the grain from each nucleus plot being placed in a pile on the seed table. The 180 or more piles of seed of one nucleus must be examined for approximate uniformity of seed appearance, and any pile, which appears to be off type discarded. All the remaining piles of the of seed should be masked together in one lot. This should treated with fungicide and insecticide, bagged, labelled and stored as **"Breeder's Stock Seed"** for use in the next year. Breeder's stock seed is the original purified seed stock of a new variety in the hands of the plant breeders.

Maintenance of Breeder's Seed of Pre-released or Newly Released Varieties

The following steps are normally involved in the maintenance of breeder's seed.

a. Breeder's stock seed from the nucleus should be sown on the clean, fertile land, which did not grow a crop of the same kind in the previous year. The space required for the seeding the breeder's stock is about 1.2 ha in the case of wheat and as much as 3 ha in the case of transplanted rice.
b. The field should properly isolated.
c. The best farm procedures should be used in the sowing, raising and harvesting of breeder's stock.
d. It should be produced at the experiment station in the area in which the new variety has been bred.
e. The seeding should be done in such a way as to make the best use of the limited amount of seed available and to facilitate roguing. The row spacing should be sufficient to permit examination of plants in rows for possible mixture or off types.

f. **Roguing:** All plants not typical of the variety should be pulled and removed. There should be very few plants to rogue out if the previous years nucleus breeder's stock seed was well protected from natural crossing and careful roguing was done and there were no impurities during cleaning etc. The rouging should be done before flowering, as was done for the nucleus/breeder's stock seed.

g. Harvesting the breeder's stock: In the breeder's stock is harvested and threshed, the equipment used must be scrupulously clean and free from seeds of any other varieties. This cleanliness should be extended to cards and bags as well as threshing machine it self. The seed should now be about 99.9 per cent pure as to variety. These breeder's seed is ready now for increase of foundation seed. A portion of this breeder's seed should be retained by the breeders to sown a continuation breeders seed of the variety.

2- Maintenance of breeder's seed of established varieties: The breeder's seed of established varieties could be maintained satisfactorily by any one of the following methods)

a)By raising the crop in isolation. The breeder's seed of local varieties could be maintained by growing them in isolated plots and by very rigorous roguing during various stages of crop growth, where the various plant characters are observable. The method of handling the breeder seed crop is the same as described earlier for breeder's seed of newly released varieties.

B) **By bulk selection**. The genetic purity of established varieties could be satisfactorily improved by bulk selection. In this method 2,000 to 2,500 plants typical of the variety are selected, harvested, and threshed separately. The seeds from each plant are examined and any pile which shows any obvious off-types, or otherwise appears dissimilar, are discarded. The remaining piles of seed are bulked to constitute the breeder's seed. The other practices of handling remain the same.

Maintenance of Nucleus and Breeder seed in cross pollinated crops:-The maintenance of varieties of cross pollinated crops is much more complicated than self-pollinated crops. It involves Maintenance of nucleus seed of inbred lines Maintenance of breeder seed of inbred lines. Maintenance of nucleus seed of inbred lines after a hybrid has been thoroughly tested and if it is suitable the seed of parental lines must be increased in the following manner: -

1. Hand pollination: Method of maintaining nucleus seed of inbred lines involves self-pollination, sib pollination or combination of both. The individual selfed or sibbed ears should be examined critically. Those which are offtypes or inferior in any regard of differing in any character such as texture, seed size, color, shape etc. should be discarded. The individual selfed or sibbed ears may then be threshed separately and sown in ear to row method in double row plots.

2. Seeding of hand pollinated seed:-The hand pollinated seed should be sown in fertile land which is free from volunteer plants. The same crop should not be grown in previous one season. The seed should be sown in the area where the hybrid is to be released.

3. Isolation: Proper isolation distance should be provided to avoid natural cross pollination and spread of diseases. Distance or time isolation can be practiced to avoid contamination.

4. Inspection of double row plots and roughing: - The double row plots must be carefully checked for offtypes prior to pollen to shedding. It is very easy to recognize the offtypes, because they are more vigorous than the inbred lines.

5. Harvesting drying and shelling: The nucleus seed crop can be harvested soon after it attains physiological maturity if artificial drying facilities exist. Piles should be critically examined for ear characters and all off colored, off textured and diseased or undesirable ears sorted out. If the overall percentage of offtypes is more than 0.1%, hand pollination should be done again. After discarding the undesirable ones, remaining ears may be bulked and dried in clean dry bin at a temperature not exceeding 43^0C. After drying shelling should be done in a cleaned machine to

avoid mechanical mixtures at this stage. After shelling the seed may be cleaned treated with fungicide, insecticide, properly labelled and stored under ideal storage condition.

Maintenance of breeder seed of inbred lines:- For increasing Breeder seed the breeder stock seed obtained from nucleus seed is planted in an isolated field. During increase of Breeder seed adequate attention must be paid to: - 1. Land requirement 2. Isolation 3. Roughing 4. Field inspection 5. Harvesting and drying 6. Sorting of the ears.

Advantages of Maintenance Breeding:- It prevents cultivars from genetic deterioration and so it prolongs life of variety. It helps in purification of improved cultivars and parental line of hybrids. It is useful in studying the efficiency of various maintenance procedures. It helps in quality seed production which in turn leads to higher crop yield.

Limitations of Maintenance Breeding Some maintenance procedures require lot of experimental material for evolution. Large numbers of single plant have to be evaluated in term of agronomic performance hence only limited number of cultivars can be handled at a time. Progeny row method requires more time (2-3 seasons) for evolution of purity of a variety. Most of testing procedures are based on phenotypic performance only. Maintenance procedures are used for varietal purification. Hence, chance of evolve new variety through Maintenance Breeding are rare.

Carry-over Seed

The breeder must carry-over at least enough seed to safeguard against, the loss of variety if there is a complete failure during the foundation seed multiplication phase. In addition, the breeder should further safeguard variety by arranging to have a portion of the seed originally released stored under the ideal conditions.

Inspection of Breeder seed

Breeder seed is produced from nucleus seed under the supervision of a qualified plant breeder in a research institute of Agricultural University. This provide for initial and recurring increase of foundation seed. Breeder seed is monitored by a joint inspection team of scientists and officials of certification agency and National Seed Corporation. The genetic purity of breeder seed crop should be maintained at 100 per cent. The golden yellow is the color of breeder seed tag of 12 X 6 cm in size. One tag is generally issued for each and every bag of seed.The level contents in information like level no. crop, variety, class of seed, lot no., date of test, pure seed percent, inert matter percent, germination percent and producing intuition.

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Quality Seed Production Technology in Lentil

Prof. Jai Prakash Lal
Distinguished Professor,
Dept. of Genetics &Plant Breeding
Institute of Agricultural Sciences&
Chancellor, Central University of Jharkhand, Ranchi
Banaras Hindu University

Lentil among the pulses, has an oldest history. It's cultivation started in the earliest Neolithic farming age about 7000 - 8000 years BC It is grown mainly in the semi -arid regions of the world ,particularly in the Indian sub - continent and in the dry areas of the Middle East,. It is known by at least 30 names in various parts of the world .In Persia it is known as "Mangu"or "Madhu" and the Sanskrit literature reveals the name such as "Masura" "Renuka" "mangalya".In the ancient literature of our country such as "Sanhita" "kautilyas" "Arthshastra" and "Vishnu Puran"lentil had been described as one of the important pulse crop.

Renfrew regarded Lens nigricans as the progenitor of lentil and it was domesticated in the South Europe. Dana reported that the genus Lens has 12 species and originated in the central Africa, Mediterranean, Asia minor regions where a maximum of six of its species are grown. Lentil has been classified under 2 sub species i.e. "macro-sperma'and "micro-sperma" The macro-sperma are bold seeded with yellow cotyledons, while micro-sperma are small seeded with red cotyledons. Sub species macro-sperma are mostly cultivated in temperate regions of the Europe North and South America while the micro-sperma are cultivated in tripical countries of Asia and Africa .

In India, lentil is grown as a winter crop all over the country.Among the states, Uttar Pradesh Bihar Madhya Pradesh and West, Bengal account for most of the acreage and production. In general, lentil has an area of 1.41million hectares and production of 1.27million tonnes with average productivity of 899kg/ha (2021-22).The low production and poor productivity of lentil is due to the cultivation under rainnfed and dryland conditions on residual moisture in marginal environments.In spite of all the efforts more than 60% area will remain rainfed/dryland where pulses in general and lentil in particular are the only choice left to be grown and therefore an alternative strategy of focussing on quality seed production of superior lentil genotypes along with improved package of practices are needed.

Seed Production Technology of Lentil

1) **Land Requirement-**Well drained sandy loam to loam soils, free from volunteer plants.
2) **Isolation Requirements-** The crop is generally self-pollinated. The dehiscence of anthers takes place in the bud itself sometime before the opening a flower the next morning. An isolation distance of 10 metres are required for Foundation seed and 5 metres for certified seed from other lentil field and of the same variety fields not conforming to varietal purity requirement of certification is necessary .
3) **Preparation of land-** One ploughing and 2 of 3 harrowings, followed by levelling for desired tilth.
4) **Time of showing -** The most suitable time for showing lentil is the middle of October.
5) **Source of seed -** Obtain nucleus/breeder/ foundation seed from source approved by certification agency.Some important recently released recommended high yielding varieties areHUL 57 (Malviya Vishwanath), IPL 220, Kota Masoor 3& 4, L 4729, VL Masoor-148, LL1613 and others.

6) **Method of sowing -** The crop should be sown in lines.Depth of seeding should be 2 to 3 cm.
7) **Spacing -**
   Row to row - 25- 30 cm
   Plant to plant 1 to 2 cm
8) **Seed rate-**Small seeded varieties 25 to 30 kg/ ha.
   Bold seeded varieties - 35 to 40 kg / ha.
9) **Fertilizers-** The soil tests are required to decide the amount of fertilizers required. On medium to low fertility soils - 20 to 40 kg .nitrogen and 60 to 75 kg phosphorus / ha. To overcome zinc deficiency a spray of 0.5% zinc sulphate + 0.25 % limesolution is recommended.
10) **Irrigation -** Give one to two irrigations as per need.
11) **Intercultural Operations -**One or two weeding / hoeing at the early stages of crop growth is necessary to keep effective control over the weeds.
12) **Plant Protection -** There are no serious pests that affect the crop.To control hairy caterpillar and pod borers spray 0.04% mono- crotophos solution (1000 litres/ha.) at the appropriate time.
13) **Rogueing -** Off -type plants, diseased plants affected by blight,and weed plants should be rogued out from the seed field from time to time as required.
14) **Harvesting and Threshing-** Harvesting should be done when plants become yellow and seed resist to pressure when pressed between the fingers .At this stage the lower parts are usually brown. The plants may be pulled by hand or cut and placed for drying.Threshing is done by flailing with sticks and seed is cleaned by winnowing.
15) **Seed yield -** The average seed yield varies from 20 to 25 q/ha.

Seed Standards - Lentil

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)	5/kg	10/kg
Weed seeds (maximum)	10/kg	20/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Germination including hard seeds (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers (maximum)	8.0%	8.0%

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Quality Seed Production Technology in Horse gram and Moth bean

DebjyotiSen Gupta
Senior Scientist & Co-Nodal Officer, Pulses Seed Production
ICAR-Indian Institute of Pulses Research, Kalyanpur, Kanpur-208024

Moth bean (*Vignaa conitifolia* L.)

Moth bean is grown in about 10-11 lakh hectares area in India. The crop is known for poor plant type, more biomass and poor harvest index. Old varieties used to spread like met on the ground, covering between the rows even if planting has been done at 60 cm apart. The same used to flower in 45-50 days and maturing in 90-100 days. Basically, they were the fodder types as showing extreme indeterminate growth habits. Almost all varieties due to long maturity used to suffer from YMV infection. Moth bean could stand in the field even up to 30-40 days without irrigation, making it excellent source of heat and drought tolerance.

Moth bean is recognized for its twin tolerance to drought and heat. It is, therefore, the ultimate choice of the marginal and sub-marginal farmers for realization of sustained production under the extreme hostile and harsh agro-climatic situations. Besides, conserving soil and water it is also used in several confectionary items, forming essential components of day to day snacks. Its green fodder is at par to alfalfa and dry fodder is better to cow pea and clusterbean. It can provide 7-8 t/ha of hay. The crop is grown on plain lands and on sand dunes and in different combinations with crops, trees, fruit crops and grasses.

Compared to guar, moth bean is more sensitive to N-fixation. In rising water stress requires more thermal time or heat degree days to reach flowering and maturity. There is enough dry matter production but its distribution to reproductive parts is poor, also low rate of nitrogen assimilation makes this crop poor yielding. A grand success in curtailing growth period up to as short as 60 days and making plant types more responsive, being totally synchronized, plants being erect, semi-erect to medium spreading type has been achieved. Present day cultivars now show good environmental response and may yield as high as 1200-1400 kg ha.

Horse gram (*Macrotylom auniflorum (Lam)*

In India, horse gram is being cultivated approximately in 0.3-0.4 million hectares with 0.20-0.26 million tones production. Horse gram is grown across several states of India mostly as post rainy season crop and is suitable for rice fallows in Madhya Pradesh, Chhattisgarh, Jharkhand, Maharashtra, Odisha, Andhra Pradesh, Karnataka and Tamilnadu. However, maximum area of this crop is confined to six states only viz., Karnataka, Maharashtra, Odisha, Andhra Pradesh, Madhya Pradesh and Tamilnadu. It is also a component of Panchadani: mixture of 5 crops (horse gram + India bean + cow pea+niger + castor) grown by Karnataka farmers to combat drought. It is probably the toughest annual legume, can be grown largely on poor soils, encountered with much adverse conditions which may not allow to grow other crops. In southern India, it is used as a preparatory crop to improve the fertility of newly reclaimed soils and cleared forest by adding organic carbon through leaf shed. It is also grown peninsular hulk' and even up to elevation of 5000 feet in Himachal Pradesh and Nepal.

It is a gradient of dietary and medicine uses. It is, however, not used as split dal and is known particularly for anti-calcifying properties. Horse gram is basically known for quite delayed maturity up to 120 days, susceptibility to PM and YMV diseases and thermo-sensitivity, leading to poor yield. However, due to continued research efforts, maturity period has been reduced to 85 days and grain yield increased to 900-1200 kg ha^{-1} and grain protein increased to 28-29 per cent.

Horse gram is known for continued chlorophyll stability up to maturity, keeping it physiologically active with high penetrating top root system. High NAD and NADP dependent enzymes activities justify its exceptionally high drought tolerance capacity.

Seed Production

Seed quality is mainly judged by its appearance, shades, presence of other crop/variety seeds and inert matter, while, as far as seed technologists are concerned good quality seed is true to kind and variety, high analytical purity, germination percentage, appropriate moisture content and free from seed borne diseases. Quality seed is an impetus for making different inputs cost effective and efficient. Different inputs like fertilizers, irrigation, weedicides, and plant protection measures are effective only when quality seed is utilized for sowing.The importance of quality seed was perceived with the start of human development. In general, a farmer selects the best plant for planting of next season/year. In early age, bold seeded and attractive plants were the main criteria for quality seed but with the improvement of seed science the parameters of valued seed were also changed. Now-a-days quality seed incorporates genetic and physical purity, viability, germination, moisture, and seed health.Quality seed production should meet out the following standards:

1. **Genetic purity:** It must be genetically true to type and anticipated to own certain diagnostic characters to differentiate from other varieties. It should fulfil general identity i.e. distinctness, uniformity and stability (DUS). Genetic purity is maintained by isolation of crop through specific distance from other varieties of the same crop or other crop. Isolation distance helps in maintaining a strategic distance from undesirable crop and admixture at the time of harvesting and threshing.
2. **Physical purity:** Seed must be physically pure. Physical purity implies that there must not be any sort of admixtures like other crop seed, weed seed and inert matter. It must be free from objectionable weed seed and other crop seeds.
3. **Germination:** Seed must be viable and meet out the germination standards. Germination capability of seed decides the seedling emergence, crop stand and at last the yield. If seed is not handled properly at the time of harvesting, threshing, processing, and storage then it may cause deterioration of germination capacity.
4. **Vigour:** Quality seed must be vigorous such that it should be able to establish and maintain uniform plant population even in harsh environmental condition. It should have high tolerance to various biotic and abiotic stresses. Also, it must have prolonged longevity.
5. **Seed health:** Seed must be free from storage pests and seed-borne diseases. The healthy seed not only helps in raising disease free crop with good germination, but also restricts further spread of disease.
6. **Seed moisture content:** It is the most critical factor that decides the longevity of seeds during storage. The seeds must be dried to safe moisture level before storage to maintain the germination percentage.

2. Categories of seed

At the time of release and notification of a variety only nucleus seed is available with the concerned breeder. The commercial seed is delivered to farmers after a series of seed multiplication stages. The distinct stages or categories required in seed production chain according to the provisions of Indian Seed Act, 1966 are nucleus, breeder, foundation, and certified seed. Detail description of each stage is given as under.

(i) **Nucleus/basic seed**

It is purest type of seed and produced in close observation of the breeder. This is the basis of seed multiplication chain developed by concerned breeder/institute.

How to produce nucleus seed

- Plant to progeny row method for nucleus seed production and varietal maintenance is practiced.
- Basic seed should be sown in a minimum area of 200 m^2 plots. Field should be uniform in terms of topography, moisture availability and fertility. The sowing should be proper, especially with plant-to-plant distance 10 cm, which should be maintained either through dibbling or thick sowing, followed by thinning.
- Before the start of blossom select 400-500 true to type individual plants from the nucleus seed plot. The selected plants should confirm to the diagnostic varietal characters. The quantity of plants to be selected will depend upon the seed production ability of individual plants i.e., if yield/plant is higher, a smaller number of plants to be selected and *vice versa*. The selected plants should be properly tagged to avoid mishandling.
- The plants which were tagged should be separately harvested and threshed. Individual plants seed should be critically examined and in case any plant produce is not confirming the diagnostic seed characters of the variety, such seed lot (produce of individual plants) should be discarded.
- Seeds before storage should be properly dried and treated.
- In the succeeding cropping season, the individual plant offspring should be sown in well prepared and homogenous field. Row to row spacing should be more than what is recommended for the crop. Here the principal goal of the dispersed planting is to help keeping up genetic purity, as opposed to having higher productivity.
- Row length may shift from one to three meters depending upon the amount of produce of individual.
- All agronomic practices, for example, utilization of fertilizer, plant protection measure, weeding, irrigation and so on, prescribed for the crop should be followed and due care should be taken in order to augment the seed-to-seed multiplication.
- Offspring of individual plant should be monitored consistently by the concerned breeder, right from germination till harvesting.
- Any plant descendant ambiguous from the characters of the original variety and/or sister offspring or showing diseases incidence in the field, should be completely removed and discarded. Indeed, if a solitary plant in the offspring is seen to be off-sort or sick, rather than removing such plant, the whole descendants ought to be removed.
- From the remaining progenies, 500-1000 plants should be tagged for next season planting of single plant progenies.
- Individual tagged/labeled plant should be reaped separately, as amidst the past season and necessary steps as delineated above should be followed for the next year planting too.
- After harvesting of these 500-1000 tagged plants, the individual plant progenies should be threshed separately.
- The seed lot of individual offspring should be critically examined with reference to size, shape, colour etc., of the seed. If any progeny showed mixture or deviation from the seed characters of the original variety or sister progenies that should be rejected.
- Remaining offspring left after rejection both at pre- and post-harvest stage should be bulked. This bulk produce of selected progenies (say bulk produce of 400 progenies out of 500 plants) is known as nucleus seed.
- This nucleus seed is utilized for generation of breeder seed. Since this is a valuable seed, exceptional care should be taken for its stockpiling.

(ii) Breeder seed

This is second class/category of seed in seed multiplication chain, and it must be genetically 100% pure. It is the offspring of nucleus seed of a variety and produced by the sponsored breeder. Production of breeder seed comes under the mandate of Indian Council of Agricultural Research (ICAR) and is being executed with the help of ICAR Institutions, State Agricultural Universities (SAUs), sponsored breeders recognized by selected State Seed Corporations and Non-Governmental Organizations (NGOs). It is produced under the direct supervision of qualified breeder. Recommended isolation distance is maintained in the production of breeder seed.

How to produce breeder seed?

- The harvested nucleus seed should be planted in a disease free, well prepared, and homogenous plot.
- Isolation distance of at least 10 m should be maintained from other fields to avoid physical blending at the time of harvesting.
- The planting should be done according to package of practices depicted earlier in cultivation practices.
- The plot should be managed according to the suggested package of practices cultivation with 1m space after each bed for easy monitoring of the field.
- The breeder seed plot/field should be visited by breeder before flowering, at regular interval of 10-15 days to rogue out off type plants.
- The monitoring of the breeder seed production plot should be convened at two stages i.e., flowering and maturity
- The monitoring team comprised of the concerned breeder, one representative of each state seed certification agency, NSC and ICAR nominee.
- Harvesting of crop should be done at proper maturity with different precautionary measures to avoid mechanical mixtures. Two different varieties should not be threshed simultaneously at same place.
- The drying of seed should be done properly to 9-10% moisture level.
- To validate the genetic purity of the seed, grow out test should be executed in green house or laboratory conditions after taking samples from different lots.
- To avoid storage pest infestation seed should be treated with insecticide and be packed in gunny bags with properly labeled seed tags.

(iii) Foundation seed

This is III class of seed in seed multiplication chain and is offspring of breeder seed. The responsibility regarding foundation seed production has been entrusted to the NSC, State Seeds Corporation, State Departments of Agriculture, and private seed entrepreneur, who have the compulsory infrastructure amenities under technical control of plant breeders and technical officers. Foundation seed can be produced at farmer's field under the supervision of aforementioned organizations. The seed growing plots are dully certified by the concerned Seed Certification Agencies. Foundation seed is required to meet the standards of seed certification prescribed in the Indian Minimum Seeds Certification Standards, both at the field and laboratory testing. This produce is the source for production of certified seed.

(iv) Certified seed

This is ultimate stage of seed multiplication chain and an offspring of foundation seed. It must meet the standards of seed certification recommended in the Indian Minimum

Seeds Certification Standards. The seed of this class is supervised and certified by the Seed Certification Agency established under section 8 of Seeds Act, 1966. The seed of this class is normally generated by State and National Seeds Corporation and private seed companies on their own farms or farms of progressive farmers. This seed is finally utilized for commercial production, or it is the seed which is delivered to the farmers. The bag of certified seed shall carry white tags.

How to produce foundation/certified seed?

- The breeder/foundation seed should be sown in a disease & insect free, well prepared, and homogenous plot.
- The planting should be done as per package and practices outlined earlier.
- Isolation distance for foundation and certified seed should be required of 10 m and 5 m, respectively, from other urdbean field and field of the same variety not confirming to varietal purity to avoid physical blending at harvest.
- The off-type plants and infectious plant by any disease should be rouged out from the seed field.
- Inspection of the foundation/certified seed production plot should be organized 2-4 time at distinct growth stages of crop.
- Harvesting should be done when 90% of the pods turn yellowish and light brown and for subsequent threshing the seed should be dried at 10 % moisture before storage.
- Amid harvesting and threshing operation, extra care should be taken to keep off mechanical mixture.
- Minimum seed standard should be rigorously followed as given in Table 1.

(v) Truthfully labelled seed (TL Seed)

This class/category of seed is not prescribed in seed act but ICAR institutes, SAU's, Public and private companies are selling their seed under this category. This class/category of seed can be generated from any class of seed may be from nucleus, breeder, foundation or certified. Certification is not required in TL seed, but labeling is compulsory. It must meet out the seed standard as recommended for certified seed. Purity of seed should be examined by grow out test and all the information should be written on the label based on seed testing laboratory results. Generally concerned breeder or institute generated such type of seed under their immediate supervision so this class/category of seed is also reliable.

Minimum standards for foundation and certified seed in Horse gram

Each crop has different field and seed standards for production of foundation and certified seed. These variations are mainly because of the variation in extent and the mode of cross pollination. The field and seed standards for Horse gram are given in Table 1.

Table 1.Minimum field and seed standards for horse gram production in India.

Parameter	Foundation Seed	Certified seed
Isolation distance (meter)	10	5
Number of field inspections (minimum)	2	2
Germination including hard seed (%)	80%	80%
Pure seed %	98%	98%
Inert matter %	2%	2%

Off-types%	0.10	0.20
Other crop seed (number per Kg)	None	10/kg
Weed Seeds (maximum)	None	None
Other distinguishable variety seeds (number per Kg)	5/kg	10/kg
Moisture (%)	9%	9%

Minimum standards for foundation and certified seed in Mothbean

Each crop has different field and seed standards for production of foundation and certified seed. These variations are mainly because of the variation in extent and the mode of cross pollination. The field and seed standards for mothbean are given in Table 2.

Table 2.Minimum field and seed standards for mothbean production in India.

Parameter	Foundation Seed	Certified seed
Isolation distance (meter)	10	5
Number of field inspections (minimum)	2	2
Germination including hard seed (%)	75%	75%
Pure seed %	98%	98%
Inert matter %	2%	2%
Off-types%	0.10	0.20
Other crop seed (number per Kg)	5/kg	10/kg
Weed Seeds (maximum)	5/kg	None
Other distinguishable variety seeds (number per Kg)	10/kg	20/kg
Moisture (%)	9%	9%

Average yield: Horse gram: 8-13q/ha
Moth bean: 6-12 q/ha

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Agronomic Practices for Quality Seed Production in Pulse Crops

Chandra Bhushan[1] and Mohammad Vaheed[2]
Professor[1], Research Scholar[2]
Department of Agronomy, Institute of Agricultural Sciences
BHU, Varanasi-221005

• The seed coat colour of blackgram in will be black while for greengram it is olive green in colour.

15. Thrashing

• Pods are dried to 12-13% moisture content.

• Pods are threshed with pliable bamboo stick or mechanically using pulse thresher.

16. Grading

• The seeds are dried to 10-12% moisture content.

• The seeds of blackgram are graded using BSS 7 x 7 and that of greengram using BSS 8 x 8 to bring uniformity in the seed lot.

• Discoloured and broken seeds are to be removed from the lot to upgrade the quality of seed

17. Seed treatment

• Seeds are treated with captain / thiram @ 2 g.kg of seed +

Quality seed production is one of the most critical components for ensuring quality seed supply ofpulses at the doorstep of farmers. Provision of quality seeds is an important step in enhancing theyield and production of pulses. Replacing old varieties from seed chain and farmers' fields remains amajor concern among research managers, extension workers and other stakeholders. Realizing importance of quality seed in enhancing productivity of pulses. Supply of good quality commercial seed i.e. certified or truthful labelled seed remain a major constraint in limiting productivity of pulses in the country. With the launching of project by ICAR "Breeder seed production- National Seed Project" and DAC&FW funded Mega seed project "Quality seed production in agricultural crops" for production of quality seed could be increased to some extent. At the same time breeder seed production could be increased for major pulses to the level of 16149 quintals (2010-11) from 6970.72 quintals (2005-06) and to some extent of minor pulses which led in achieving ever highest production of pulses (19.25 million tons) during 2013-14 in India. In following years, the trend in breeder seed production could not continue due to various reasons including less financial support and monitoring which led in reduction in breeder seed production for all pulses. The recent initiatives are for enhancing breeder seed production to the tune of 5801 quintals per year from 2018-19 (Chaturvedi*et al.*, 2016). Approximately 32-33 lakh quintals of quality seed of various pulses are required to achieve 30% seed replacement with new varieties. Crop wise estimated requirement for quality seed production is provided in Table 1 of present compilation.

Table 1. Total quality seed requirement of pulse crops in India

Crop	Area (mha)	Seedrate (kg/ha)	Seedrequired (q)	@30%SRR (q)	10%buffer (q)	Totalseed Requirement (q)
Chickpea	8.25	80	6600000	1980000	198000	2178000
Mungbean	3.02	20	604000	181200	18120	199320
Urdbean	3.24	20	648000	194400	19440	213840
Pigeonpea	3.55	20	710000	213000	21300	234300

Lentil	1.47	50	735000	220500	22050	242550
Fieldpea	0.97	80	776000	232800	23280	256080
Otherpulses	4.00	20	800000	240000	24000	264000
Total	**24.5**	**-**	**10873000**	**3261900**	**326190**	**3588090**

Note: Estimated on the basis of 24.5 million ha average area coverage

Seed Systems in India

Genetically pure good quality seed of high-yielding varieties is a critical input in crop production for obtaining high yields. Inadequate availability of seed of improved cultivars in pulses has been a major bottleneck in adoption of improved cultivars by the farmers. Government of India (Govt. of India) established the National Seeds Corporation (NSC) in 1963 to improve availability of quality seed to farmers. The Seeds Act was introduced in 1966 and the New Policy on Seeds Development in 1988 to promote the growth of the seed industry. The Seeds Act stipulated that seeds should confirm to the minimum prescribed standards of physical and genetic purity, and assured percentage germination either by compulsory labelling or voluntary certification. The National Seed Policy 2002 envisaged a symbiotic relationship between the public and private sector. The establishment of Protection of Plant Varieties and Farmers Rights Act (PPV&FRA) in 2001 for protection of rights of farmers and plant breeders is expected to promote investment in the development of new varieties.

In India, formal and informal both seed systems co-exist. In formal seed system there is definite seed chain as 'nucleus' → 'breeder' → 'foundation' → 'certified' seed. The informal seed system mainly based on farm-saved seeds of local or improved varieties. In India, still more than 80 percent of the farmers rely on farm-saved seed for pulse crops. The informal seed system often lacks strict quality control. In the informal seed system, the seed is mainly produced by farmers' producing organizations (FPOs), farmers' groups, non-governmental organizations (NGOs), farmers' cooperatives, seed grower's associations, and individual farmers. The success of informal seed systems depends on the assurance of the quality maintained by the producer and credentials of the producers as involvement of the seed certification agency in not there. This warrants that the seed growers follow standard seed production guidelines to ensure seed quality. The seed producers must purchase fresh seed after every 2-3 years, as the genetic purity of a cultivar may deteriorate due to mechanical mixtures during seed production, processing or/and storage. The official seed chain for quality seed production has been described here.

Seed Classes

There are four classes of seed viz., breeder, foundation, certified and truthful labelled seed are well recognized in India. There are different types of tags in size and colour used for labelling of breeder, foundation and certified seed.

1. **Breeder seed:** It is produced from nucleus seed under direct supervision of a qualified plant breeder. The Indian Council of Agricultural Research (ICAR) institutes and the state agricultural universities (SAUs) have the primary responsibility for the production of breeder seed as per the indents received from different agencies. The State Governments and the National and the State Seed Corporations are required to submit indent of nationally released varieties to the Seed Division of the Department of Agriculture and Cooperation and Framers Welfare (DAC&FW), Ministry of Agriculture and Framers Welfare, Government of India; and of state released varieties to the respective state

agricultural universities (SAUs) for the subsequent post rainy season. A specific tag's colour has been assigned to breeder seed's bag and it is of golden yellow colour (colour No. 356, IS: 5-1978) of 12 x 6 cm size. Breeder seed shall be supplied in sealed containers, duly stitched and sealed. A cloth-lined label containing given information shall be fixed on the container. The container should also have printed on it and the kind, variety and name of Institution also. The label shall be rubber-stamped with signature, name and designation of the concerned breeder. Every breeder/breeding institute shall maintain the account of labels printed and issued.

2. **Foundation seed:** This is the progeny of breeder seed or occasionally of Foundation seed stage I produced under the supervision of the breeder or any designated agency and under the control of a seed quality control agency. Foundation seed produced directly from the breeder seed is designated as foundation seed Stage-I, while foundation seed produced from foundation seed Stage-I is designated as foundation seed stage-II. Foundation seed stage-II is not used for further increase of foundation seed. The minimum seed certification standards shall be the same for both these classes of foundation seed, unless otherwise prescribed. White colour tags are used for both classes of foundation seed. The white colour tag of 15 × 7.5 cm size has been assigned for tagging of foundation seed.
3. **Certified seed:** This is the class of seed produced from foundation seed and certified by state seed certification agency notified under section 8 of the Govt. of India Seeds Act, 1966. Certified seed can be used to produce certified seed or can be planted by the farmers for commercial cultivation. Only notified varieties are eligible for entering into formal seed system and production of certified seed. Certified seed production is mainly undertaken by the National and State Seed Corporations. However, state agricultural universities, public and private sector seed enterprises, authorized farmers' organizations and registered seed growers can also produce certified seed from the stock of foundation seed. A specific tag's colour has been assigned to certified seed's bag and it is azure blue (shade ISI No. 104) of 15 x 7.5 cm size.
4. **Truthfully labelled (TL) seed:** Progressive seed growers produce the seed of released varieties, maintaining a sufficient level of genetic purity by adopting the recommended package of practices and sell it to the farmers as 'Truthfully labelled. Similarly, the farmer's producer groups (FPGs) can also sell seed under this category. In case of chickpea, field pea, rajmash and other pulses, where the seed multiplication ratio is low, the informal seed sector plays a significant role in supplying good quality seed to the farmers.

Flow chart for quality seed production of pulses

Selection of 1000 plants, which are similar in all respects from one species

↓

All the seeds of each plant to be sown in one row in a well prepared field

↓

Visit of the field and discarding the progenies having dissimilar plants or plants of different varieties

↓

Table examination of seeds of each plant progeny for uniformity and rejection on the basis of dissimilar seeds

↓

Bulking of similar looking progenies

↓

Nucleus seed

↓

Breeder seed

↓

Foundation seeds

↓

Certified seeds

↓

Truthful leveled seeds (meeting all standard of the certified seed)

Certified/ Truthful leveled seeds is Commercial seed seeds among farmers.

Seed production procedure of different kind of seeds

Quality Parameters and Standard Procedures for Quality Seed Production

Quality seed is critical to agricultural production. Poor seed limits the potential yield and reduces the productivity. The main parameters of quality seeds are:

1. Physical qualities of the seed in the specific seed lot
   - Minimum of damaged seed
   - Minimal weed seed or inert matter
   - Minimum of diseased seed
   - Near uniform seed size
2. Physiological qualities which refers to aspects of performance of the seed
   - High germination and vigour
3. Genetic quality which relates to specific genetic characteristics of seed variety
   - Seed of the same variety
   - High yielding ability
4. Seed health which refers to the presence of diseases and pests within a seed lot

The standard procedure for production of quality seed has been presented below in brief:

Selection of land:

Due to the problem of volunteers from the previous season's crop, it is essential in seed certification to avoid a field that was under same crop during the preceding season, particularly for lentil.

Disease-free soil:

In some of the crops, diseases are seed borne and that cause spread of diseases during multiplication, therefore seed produced from infested plots should be rejected. For the purpose,

diseased plants can be uprooted before harvesting. As far as possible, quality seeds should be produced in non-endemic areas.

Crop	Contaminants	Minimumdistance(meters)	
		Foundation	Certified
Chickpea,lentil, Field pea, mung bean, Urd bean, Rajmash, cowpea, horse gram, Moth bean	Fields of other varieties	10	5
	Fields of the same variety not conforming to Varietal purity requirements for certification	10	5
Pigeon pea	Fields of other varieties	250	100
	Fields of the same variety not conforming to varietal purity requirements for certification	250	100

Field inspection:

A minimum of two inspections are generally done between flowering and harvest. During field inspection, observations on a few key points are recorded, including off-type, objectionable weed plants, and seed-borne diseases. A minimum of 500 plants should be taken per count for recording observations.

Isolation distance:

Since most of the pulse crops are self-pollinated and natural cross-pollination (expect pigeon pea and lathyrus) are either negligible or non-existent, isolation distance between two cultivars helps in maintenance of purity by avoiding mechanical or manual mixing at harvest. A minimum isolation distance of 10 m should be maintained between different cultivars for increase of foundation seed, and of 15 m for certified seed (Table 2). Further between two varieties of the same pulse crop, cereals can be grown to provide mechanical barrier for avoiding mixture.

Table 2. Isolation distance for production of quality seed of various pulses

Off-types:

The off-types should be eliminated if possible; if not, the maximum permitted percentage is 0.10 for foundation seed and 0.20 for certified seed. A minimum of two inspections shall be made from beginning of flowering till harvesting for removal of off-types. During such inspections the off type plants, diseased plant, any deviants should be identified and removed. The maximum permitted limit for off types and plant affected by seed borne diseases at final inspection for various pulse crops are as follows:

Crop	Factor	Maximum permitted (%)	
		Foundation	Certified
Chickpea, lentil, field pea, mung bean, urd bean, pigeon pea, rajmash, cowpea, horse gram, moth bean,	Off-types	0.10	0.20

lathyrus			
Mungbean, rajmash, cowpea	*Plants affected by seed borne diseases	0.10	0.20

Specific crop standards

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

1. Field Standards:

Field standards have been established for all those factors which affects the purity (genetic and analytical) and seed health of standing crop. The various field standards can be grouped into four categories viz., land requirement, minimum isolation requirements, minimum specific number of field inspections, and minimum specific crop standards. Minimum specific crop standards have been prescribed for (i) Off types, (ii) Designated diseases, (iii) Objectionable weeds (designated weed species only), and (iv) Inseparable crop plants (designated species of crop plants only).

2. Seed standards:

The seed standards for foundation and certified classes are given in Table 8. For breeder seed, 100% pure seed is required and any inert matter is unacceptable. The minimum seed certification standards are given here and these need to be followed at different point of time.

Activity	Standard
Field inspection	Varietalpurity, isolation, seed borne diseases, weeds
Pre and post control tests	Varietal purity, seed borne diseases
Seed quality test in the laboratory	Varietalpurity, analytical purity, seedhealth, germination and moisture content.

Table 8. Minimum seed standard for foundation and certified seed of pulses

SeedStandard	Chickpea		Pigeon pea		Mungbean, Urdbean, Mothbean		Lentil		Pea		Rajmash		Cowpea		Horse-gram	
	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS
Minimumpure seed(%)	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Inertmatter (maximum,%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Othercropseeds perkg(maximum)	0	5	5	10	5	10	5	10	0	5	0	0	0	10	0	10
Weedseedsper kg(maximum)	0	0	5	10	5	10	10	20	0	0	0	10	0	10	0	0
Otherdistinguishable varietiesperkg(maximum)	5	10	10	20	10	20	10	20	5	10	5	10	5	10	5	10
%Germination including hard seeds(minimum)	85	85	75	75	75	75	75	75	75	75	75	75	75	75	80	80
Moisture(%) (maximum)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
ForVapourproof containers(maximum)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Standard Seed Production Technology

A crop grown for seed production requires extra efforts and investments than a crop grown for grain. While taking up seed production, high priority should be given to maintenance of genetic and physical purity of the seed.

Selection of crops and varieties and integrated crop production technologies

The identification of region or area for quality seed production of a particular crop is of utmost importance. Similarly, the improved varieties released for a particular area need to be considered for seed production in a targeted area for where it is well tested and adopted. Integrated crop management technologies (crop production and protection) must be followed to realize better seed multiplication ratio.

Seed treatment

The seeds should be treated with fungicides (2 g thiram + 1 g carbendazim kg-1 seed) before sowing for reducing seed and soil borne fungal diseases. Phosphorus solubilising bacteria (PSB) have been identified, which improve availability of phosphorus to plants. Thus, seed treatment with PSB is recommended. If a particular pulse crop is being grown for the first time, the seeds should be inoculated with Rhizobium culture. The seeds should be treated first with fungicides and then with PSB and Rhizobium, following the procedures recommended. The culture-treated seeds should be dried in the shade and sown as soon as possible thereafter. If the seed is to be treated with pesticides, always apply insecticides first, followed by fungicides, and finally Rhizobium culture/phosphate solubilising bacteria or follow instructions on the packets.

Harvesting and threshing

The time of harvesting is crucial in maintaining the quality of seeds. The crop should be harvested when leaves start to senesce and start shedding, pods turn yellow, plants are dry, and seed feels hard and rattles within the pod. After harvest, the plants can be dried in the sun for a few days to ensure that seeds get dried well. Threshing can be done using commercially available power threshers.

Seed processing

The dried seeds are cleaned to remove the undesirable contaminants such as plant parts, soil particles, stones, weed seed, other crop seed, and shrivelled, broken, or damaged seed. Cleaning and upgrading is based on physical differences between good seed, poor seed and undesirable contaminants. The cleaning and grading of seeds is first achieved by winnowing and then through a set of mechanical sieves. In addition to air cleaners and aspirators, indented separators, disc separators, gravity separators, spiral separators and drum separators are frequently used.

Seed storage

The seed must be properly dried before storage. The ideal seed moisture level is 10-12% for short-term storage (up to 8 months). After drying, the seed should be either stored in polythene-lined gunny bags or in safe storage structures (metal bins or earthen containers). The bags should be kept in a rodent free room and placed on wooden planks (not more than five in a stack) and away from walls to avoid dampness to the seeds. Bruchids (*Callosobruchus* spp.) are the most serious storage pests of almost all pulses. Bruchids lay white eggs on the seeds and the larvae bore into seeds and adults emerge from the seeds by cutting round holes in the seeds. The infested seeds are unfit for sowing. Proper control measures should be undertaken to protect pulses seed from bruchids. The traditional methods of protecting the seed from bruchids damage by mixing with ash, dried neem leaves and/or wheat straw are useful for small quantities of seed. In case of large scale storage, the seed store or the seed bins should be fumigated periodically with commercially available fumigants (ethylene dibromide or phosphine) to protect seed from storage pests. The main advantage of fumigation is that all stages of the insect, including eggs, larvae and pupae, are controlled and also affect other storage pests and rodents.

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Quality seed production in Greengram

K R Soren
Division of Plant Biotechnology, ICAR-Indian Institute of Pulses Research, Kanpur
E-mail: khela.soren@icar.gov.in

Introduction

Mungbean (Vigna radiata), a vital pulse crop within the Vigna group, has been cultivated in India since ancient times and is now grown in various regions worldwide, including Asia, Australia, the West Indies, South and North America, as well as Tropical and Subtropical Africa. India leads global production, accounting for over 65% of the world's mungbean cultivation. The key mungbean-producing states in India include Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Orissa, Bihar, and Tamil Nadu. Mungbeans are short-duration legumes with broad adaptability and low input requirements. They possess the ability to fix atmospheric nitrogen in symbiotic association with Rhizobium bacteria, meeting their nitrogen needs while benefiting subsequent crops. Mungbeans are well-suited to diverse cropping systems and are a crucial source of quality protein, minerals, and vitamins in the vegetarian diets of the Indian subcontinent's vast population.Over the last three decades, the development of disease- and insect-pest resistant, short-duration, and photo-thermo insensitive mungbean varieties has contributed to the expansion of their cultivation.

Selection of suitable varieties

To achieve maximum crop yield, several factors, including genetic, soil conditions (edaphic), and environmental conditions, play a crucial role. Among these factors, selecting the appropriate crop variety recommended for a specific region and growing season is paramount in realizing the crop's full yield potential. In the case of greengram (mungbean), it is generally advisable to choose early-maturing varieties to reduce susceptibility to diseases and insect pests. The use of host plant resistance is an effective and environmentally friendly approach for disease management. Therefore, it is wise to prioritize the cultivation of disease-resistant mungbean varieties. For the kharif season, mungbean varieties with a duration of 60-70 days and urdbean varieties with 75-85 days are typically preferred. In the spring/summer season, mungbean varieties with duration of 55-65 days are more suitable. In India, a systematic crop improvement program for mungbean has led to the development of over 100 high-yielding and disease-resistant varieties tailored to different mungbean-growing regions in the country.

Field selection and preparation

To ensure proper germination and crop establishment, it's essential to prepare a well-structured seedbed. This process typically involves 2 to 3 ploughings, followed by planking, to eliminate clods and weed growth. Additionally, for summer cultivation following the harvest of the previous crop, it's crucial to provide pre-sowing irrigation before tilling the soil. In areas with sandy soils prone to termite infestations, it's advisable to mix carbaryl 5% powder into the soil during the final stage of field preparation. To minimize insect pest infestation, a mixture of Phorate or Aldicarb at a rate of 10 kg/ha should be incorporated into the soil. For sowing summer mungbean or spring urdbean in medium to heavy-textured soils, you can use beds spaced 67.5 cm apart (with 37.5 cm bed tops and 30 cm furrows) using a wheat bed planter. Sowing is typically done in two rows per bed with row spacing of 20 cm. The same quantity of seeds and fertilizers, along with other cultivation practices, should be followed as in flat sowing.

When applying irrigation, take care not to over-flood the beds, ensuring that the furrows receive adequate moisture. This practice not only conserves about 20-30% of irrigation water but also results in a 10% increase in crop yield compared to flat sowing.

Crop geometry and seed rate

For successful seed germination and crop establishment, it's important to sow the seeds in well-prepared seedbeds with adequate moisture content. Typically, seeds should be sown in rows at a depth of 4-5 cm. If the surface layers of the soil are dry, in soils that don't easily form a crust, you can increase the seeding depth. Given a typical germination rate of 75-80%, it's recommended to use a seeding rate that achieves a plant population of 400,000 plants per hectare under irrigation. For summer cultivation, the crop can be sown with row spacing ranging from 20 to 25 cm. In general, a seed rate of 20-25 kg/ha is used for mungbean and urdbean. For kharif season cultivation, a lower seed rate of 18-20 kg/ha is recommended to obtain an optimum plant stand. During the kharif season, the crop should be sown with wider row spacing of 30-35 cm and a plant-to-plant spacing of 8-10 cm.

Seed inoculation/ dressing

To prevent soil and seed-borne diseases and boost crop yield, it's advisable to treat seeds with antifungal bioagents, Rhizobium, and Phosphorus Solubilizing Bacteria (PSB). Seed treatment options include using 5-10 g of Trichoderma (with 1 x 10^8 cfu/g), 2.5 g of thiram, or 2 g of carbendazim per kilogram of seed to mitigate soilborne diseases. After this initial treatment, mix the seeds with Rhizobium culture, with one packet (250g) sufficient for 10 kg of seed. Rhizobium treatment enhances nodule formation, resulting in a 10-15% increase in yield and reducing the need for nitrogenous fertilizers in subsequent crops. This treatment is especially valuable for summer crops when the natural microbe population tends to decrease. To treat the seeds with Rhizobium culture, blend 50 g of molasses with half a liter of water and 250 g of Rhizobium (preferably a local strain), then mix this thoroughly with 10 kg of seed. Allow the treated seeds to dry in the shade for 2-3 hours before sowing.

Fertilizer requirement

Mungbean crops generally do not require high doses of nitrogenous fertilizer since they are capable of fixing a substantial amount of nitrogen on their own. For instance, when planting summer mungbean after potatoes, additional nitrogen isn't necessary, as the residual nitrogen from the previous crop provides sufficient nutrients for the short-duration mungbean crop. However, these legumes, such as mungbean and urdbean, do have requirements for phosphorus, potassium, calcium, magnesium, and sulfur, similar to other leguminous plants. If the soil lacks these elements, they should be supplemented with fertilizer additions. Phosphate fertilizer is typically needed in larger quantities in irrigated crops or on soils severely deficient in phosphorus. It's advisable to conduct soil tests and adhere to recommended fertilization schedules, taking into account the expected yield. For spring/summer crops, it's common to apply 10 kg of nitrogen and 45 kg of phosphorus at the time of sowing. The use of gypsum at a rate of 200 kg per hectare helps ensure the availability of calcium and sulfur at economical rates. It's always a good practice to apply fertilizers based on soil test results and recommended guidelines. Normally, 100 kg of DAP (Diammonium phosphate) per hectare is sufficient for one hectare of land.

Assurance of Irrigation facility

Spring/summer crops, typically grown under assured irrigation, have shorter life cycles and require less water compared to many other crops. Both mungbean and urdbean are sensitive to waterlogging, making laser-leveled fields with a relatively steep gradient the preferred choice. This setup allows water to be quickly applied and drained away due to the steep slope.

The most critical periods for irrigation are during the flowering and early pod-filling stages. It's crucial to manage irrigation carefully to provide enough water to fill the pods adequately while avoiding excessive moisture that could delay maturity. Generally, for summer/spring crops, 3-4 irrigations are needed, depending on climatic conditions and the soil's water-holding capacity. The first irrigation should be applied only after 20-25 days of sowing, followed by subsequent irrigations at intervals of 10-15 days as needed. The last irrigation should be concluded around 55 days after sowing to achieve high yields and synchronous maturity.

Weed management

Weed control is crucial to minimize competition between crops and weeds, ensuring higher yields. Weeds can lead to substantial grain yield losses, ranging from 30% to 50%, with the extent of these losses influenced by the intensity and types of weed species present. The critical period of competition between crops and weeds typically occurs within the first 20-25 days after sowing. Summer crops, such as mungbean and urdbean, are often infested with weeds like Cyperusrotundus, Amaranthusviridis, Trianthemamonogyna, Digitariasanguinalis, and Tribulusterrestris. Therefore, it's essential to pay special attention to weed management. Hand weeding around 20-25 days after sowing can be highly beneficial. Good cultivation practices, including manual hoeing once or twice, are advisable. Rotary hoeing should be carried out as needed to eliminate weeds up to the flowering stage. Late-emerging weeds have a lesser impact on yield compared to early-emerging ones. While herbicides can be used for weed control, it's important to note that only a limited number of herbicides are registered and recommended for mungbean and urdbean. Herbicides like Pendimethalin 30 EC, applied as a pre-emergence spray at a rate of 3.75 ml per liter, can be effectively employed to manage weeds.

Management of diseases

Anthracnose

- Treat the seeds with thiram or captan @ 2-3 g/kg seeds before sowing.
- As the symptoms start to appear, apply the foliar spray with Zineb or thiram or carbendazim or mencozeb @ 0.2%, repeat after 15 days interval.

Cercospora leaf spot

- Use seed from disease free crop to reduce seed-borne inoculums of the pathogen.
- Field sanitation, crop rotation, destruction of infected crop debris and avoiding collateral hosts in the vicinity of the crop helps in reducing disease incidence.
- Treat the seed with the fungicides captan or thiram (@2.5 g/kg) before sowing.
- When symptoms are observed on leaves, spray the crop with carbendazim (0.05%) @ 0.5 g/l or mencozeb (0.25%) @ 2.5 g/l. Repeat the spray 2-3 times after 10-15 days interval, if required.
- If disease appears after pod setting, it does not affect yield and spray is not required.

Leaf Crickle

- Remove symptom-bearing plants as soon as they are noticed in the field.
- When disease symptoms are observed in the field or 15 DAS spray the crop with imidacloprid @ 0.1% or dimethoate @ 0.3%. Repeat the spray after 45 days of sowing, if required.

Leaf curl

- Treat the seeds with imidacloprid @5g/kg seed and spray the crop with the same insecticide @ 0.5ml/l after 15 days of sowing.

Powdery mildew (*Erysiphepolygoni*)

- Grow disease resistant varieties.

- Spray wettable sulfur @ 0.3% or carbendazim @ 0.5 g/liter of water. Apply first spray as soon as the disease symptoms appear. Repeat the spray after 10-15 days, if required.

Yellow Mosaic Disease

- Grow resistant varieties.
- Spray the crop with imidacloprid @0.1% (10ml/l water) or dimethoate @0.3% (30 ml/10 l. water) after 15 days of sowing. Repeat after 30 days, if required.
- Uproot and destroy diseased pants at early stage of the crop.

Management of Insect-pests

Aphids

- Uproot the damaged plants along with the young larvae at the gregarious phase and destroy it by burying under the soil.
- Spray Beauveriabassiana @ 5 gm/L for the management of early instar larva of bihar hairy caterpillar.
- Spray quinalphos 25EC @ 2.0 ml/l or fenvalerate 20 EC @ 1.0 ml/l or emmanmectin Benzoate 5 SG @ 0.5 gm/L or Indoxacarb 14.5 SC @ 0.8 ml/L.

Bihar hairy caterpillar

- Uproot the damaged plants along with the young larvae at the gregarious phase and destroy it by burying under the soil.
- Spray Beauveriabassiana @4 ml/l for the management of early instar larva of bihar hairy caterpillar.
- Spray quinalphos 25EC @ 2.0 ml/l or fenvalerate 20 EC @ 1.0 ml/l or dusting with fenvalerate 0.4% @ 20 kg/ha.

Blister beetle

- Spray acephate 75SP @ 1gm/L or methomyl 40SP 1-1.5 gm/L or quinalphos 25 EC @ 2ml/L of water

Jassid

- Jassids can be controlled by manipulating the dates of sowing.
- Intercropping with sorghum, pearl millet and sesame also control its spread.
- Spray dimethotae 30 EC @ 2ml/L or Imidacloprid 17.8 SL @ 0.35 ml/L for effective control.

Pod Borer

- Spray spinosad 45 SC @ 0.35 ml/ha at appearance of larvae in the field.
- Spray of emamectin benzoate 5 SG @ 0.5 g/l or rynaxypyr 20 SC @ 0.3 ml/L or Flubendiamide 40 SC @ 0.2 ml/L or Indoxacarb 14.5 SC @ 0.8 ml/L. Spray HaNPV @ 1ml/l or NSKE or crude neem 5% @ 50 g/l or neem oil 3000ppm @ 20 ml/l effectively manages the larval population.

Tobacco caterpillar

- Egg masses and young larvae feeding on leaves should be collected and destroyed to reduce infestation.
- Foliar spray of rynaxypyr 20 SC @ 0.3 ml/L or Emmamectin Benzoate 5 SG @ 0.5 gm/L or Indoxacarb 14.5 SC @ 0.8 ml/L. or novaluron 10 EC @ 0.75 ml/l.
- Sex pheromone traps @ 5-10 traps for early pest detection or mass trapping. change the lure at every 25-30 days.
- Foliar spray of SINPV @ 250 LE or 2ml/L with jaggery (10 g/L), soap powder (5 g/L) and tinopal (1 ml/L) durimg evening hours.

- Spray azactirachtin 10000 ppm @ 3 ml/L or Neem seed kernel extract 5 % @ 50 gm/10 days interval.

Spotted pod borer (Maruca)

- Deep summer ploughing to expose the larvae and pupae to sunlight and predation by birds.
- Install light traps in the field @ 12 traps/ha to monitor the activity of adults moths.
- Collect the larval webs present on the plants and destroy or burn them.
- Neem based spray Emmamectin benzoate 5 SG @ 0.5 gm/L or indoxacarb 14.5SC 0.8ml/L or Rynaxpyr 20 SC @ 0.3 ml/L or spinosad 45 SC @ 0.3 ml/l at 10-15 days interval at flowering stage.
- Insecticides are most effective if applied before the larvae enter into the web.

Pod bug

- Spray monochrotophos 36SL @ 1.0 ml/l water or dimethoate 30 EC (2.0 ml/l) and imidacloprid 17.8 SL @ 0.35 ml/l during flowering and at pod formation stage.

Stem fly

- Practice clean cultivation following good agronomic practices.
- Before sowing soak the seeds in dimethoate 25 WG@ 5gm/kg seeds or imidacloprid 17.8 SL @ 5 ml/kg seed or thiomethoxam 25 WG @ 5.0 g/kg seed in 100 ml water, to avoid early incidence.
- Foliar Spray of imidacloprid 17.8 SL @ 0.35 ml/l or thiomethoxam 25 WG @ 0.3g/l at 15 days after sowing.

Thrips

- Timely irrigation at an interval of 15 days results in low buildup of thrips.
- Seed treatment with thiomethoxam 70 WS @ 5 gm/kg seeds.
- Foliar spray of imidacloprid 17.8 SL @ 0.3 ml/L or thiomethoxam 25 WG 0.35 gm/L or Ethion 50 EC @ 2 ml/L or Emmamectin benzoate 5 SG @ 0.5 gm/L or spinosad 45 SC @ 0.35 ml/L at bud initiation stage.

White fly

- Adopt clean cultivation following good agronomic practices. Remove alternate hosts and weeds to reduce the incidence of whitefly and spread of viral diseases.
- Seed treatment with imidacloprid 70 WS or dimethoate 70 WS @ 3-5 g/kg of seed which provides protection for 20-25 days after germination.
- Use yellow sticky traps at the rate of 80-100 traps/acre, each trap at a distance of 50 meter square to trap the adult white flies.
- Application of microbial biopesticitdes like Verticelliumlecani @ 5 ml/L as at 7-10 days an interval.
- Spray Azadirachtin 300 ppm @ 5-10 ml/L or neem seed kernel extract 5 % @ 50 ml/L at 7-10 days interval.
- Neem based foliar sprays of any of the insecticides like imidacloprid 17.8 SL @ 0.3 ml/L or thiomethoxam 25 WG 0.35 gm/L or fenpropathrin 30 EC @ 0.75 ml/L or spiromestifen 23 SC @ 0.8 ml/L or dimethoate 30 EC @ 2.5 ml/L or quinolphos 25 EC @ 2 ml/L at 10-15 days interval.

Good seed production practices

1. Use only recommended varieties since mungbean and urdbean varieties are very specific for different seasons. Many times varieties recommended for *kharif* season may not be suitable for summer cultivation and vice versa.
2. Time of sowing is very crucial as delayed sowing may lead to drastic reduction in grain yield due to temperature fluctuations at the time of flowering and maturity. During summer season, sometimes early monsoon showers may also coincide with maturity period leading to spoiling the quality of grains.
3. Fertilizer scheduling should be done on the basis of soil test and preceding crop grown in a particular area.
4. Irrigation scheduling is very critical, especially in Spring/Summer cultivation. Ist irrigation should not be given before 25-30 days after sowing to avoid soil compactness and ensure proper vegetative growth of the plants. The last irrigation should not be given after 50-55 days of sowing to allow proper maturation and synchrony.
5. Regular monitoring of insect-pest infestation at the time of flowering is essential as infestation of thrips may lead to very high flower drop and less pod formation.

Seed production standards

I. Application and Amplification of General Seed Certification Standards

The General Seed Certification Standards for different pulses crops are basic and, together with the following specific standards constitute the standards for certification.

II. Land Requirements

Land to be used for seed production of horse gram shall be free of volunteer plants.

III. Field Inspection

A minimum of two inspections shall be made, the first during peak flowering and the second at flowering and fruit stage.

IV. Field Standards

A. **General requirements**

1. Isolation

The field of different pulse crop seed fields shall be isolated from the contaminants shown in column 1 of the Table below by the distances specified:

Harvesting, threshing and storage

Pod maturity in mungbean and urdbean is not uniform due to prolonged flowering periods, making it challenging to determine the ideal harvest time. Generally, harvesting should commence when around half to two-thirds of the pods have reached maturity. Harvesting too early can result in the loss of immature pods, while harvesting too late may lead to losses from pod shattering. Harvesting can be done manually or with machines. In manual harvesting, plant stalks are cut using a band saw, typically requiring about 32 laborers per hectare per day. After harvest, the stalks with pods should be sun-dried for four to seven days, with an average of five to eight days. For mechanical harvesting, the plants should undergo defoliation and dry out before the harvest. Occasionally, desiccants or defoliants are used to achieve this, but they can be hard to find in the market. Ethrel, with 39.5% a.i. and diluted at 500, can result in 90% defoliation without negatively affecting seed quality. Care should be taken to prevent seed damage during harvesting by ensuring the crop is harvested at the optimal seed moisture content (14% to 16%), avoiding midday harvesting, and adjusting the harvester settings.

To thresh mungbean, a spike tooth-type power thresher for wheat, with some modifications, can be utilized. Seeds with about 12% moisture can be stored in regular grain bins that have

been fumigated to control bean weevils. If seeds have higher moisture levels above 12%, they can be gently dried by passing unheated air through thin layers until they reach or approach 12% moisture. Stored grain pests, particularly bruchids, can cause significant damage if left unchecked. These pests are known to infest the crop during the drying stage and in storage facilities. Cleaning the storage area and eliminating any remaining bruchid populations is crucial for control. Use boiled and dried gunny bags for seed storage. If necessary, fumigate stored seeds with ethylene dibromide (EDB) ampules at a rate of 3 ml per 100 kg to manage bruchids effectively.

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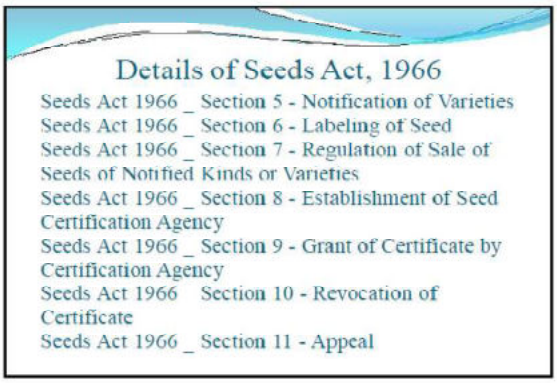
Principles & Procedures of Field Inspection in Seed Certification of Pulse Crops

B.S. Gupta
Ex.- Seed Certification Officer &
Master Trainer OECD Seed Schemes
Rajasthan State Seed & Organic Certification Agency Pant Krishi Bhawan, Jaipur



V. Classes and Sources of Seed

A. ***Breeder Seed Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed.***
Breeder seed shall be genetically so pure as to guarantee that in the subsequent generation i.e. certified Foundation seed class shall conform to the prescribed standards of genetic purity. The other quality factors of Breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis

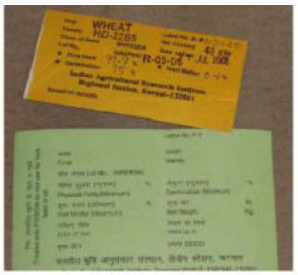
B. Production of Foundation seed stage-I and II shall be supervised and approved by the Certification Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to conform to certification standards specified for the crop/variety being certified.

C.
(a) Certified seed shall be the progeny of Foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified;
(b) Certified seed may be the progeny of Certified seed provided this reproduction does not exceed three generations beyond Foundation seed stage-I and - it is determined by the Certification Agency that genetic identity and genetic purity will not be significantly altered; - and when the Certification Agency is satisfied that there is genuine shortage of Foundation seed despite all the reasonable efforts made by the seed producer.
(c) Certification tag shall be of blue colour (shade ISI No. 104 AZURE BLUE) for Certified seed class.
(d) Certified seed produced from Certified seed shall not be eligible for further seed increase under certification. Certification tags for such production which is not eligible for further seed increase under certification shall be super scribed with, "not eligible for further seed increase under certification".

VI. Phases of Seed Certification Certification shall be completed in six broad phases listed as under:
(a) receipt and scrutiny of application
(b) verification of seed source, class and other requirements of the seed used for raising the seed crop;
(c) field inspections to verify conformity to the prescribed field standards;
(d) supervision at post-harvest stages including processing and packing;
(e) seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
(f) grant of certificate and certification tags, tagging and sealing.

F/S & C/S Tags

Breeder Seed Label
&
Seed Producer Label



WHY INSPECTION ARE NECESSARY

The primary objective in conducting field Inspections is to confirm that seed produced from a crop grown for seed purpose is of the designated variety, and that it has not been contaminated genetically and or physically beyond certain specified limits. Genetic contamination of a seed crop is prevented by permitting pollination by pollen from a specific desirable source recognized as the pollinator, and conversely, by preventing pollination by pollen from an undesirable or unrecognized source, through controlled pollination, physical or mechanical contamination in the field is avoided by preventing admixture during sowing and harvesting. Field inspections ensure that steps necessary to overcome genetic and physical contamination have been taken in time to make them effective.

The objective of field inspection is fulfilled by verifying that the seed crop is:

A. Raised from seed whose source is approved.
B. Grown on a field area which satisfies the prescribed land requirements as to previous crop (s), to prevent contamination by volunteer plants and disease spread by pathogens.
C. Provided with the prescribed isolation and or with the prescribed number of border rows in hybrid seed production.
D. Planted in the prescribed ratios of female (seed) and male (pollinator) parents in the case of hybrid seed production.
E. Properly rogued to remove contaminating factors such as pollen shedders in bajra and sorghum, shedding tassels in maize, crosses, off types, diseased plants/ears, objectionable weeds, and inseparable other crop plants so as to conform to the standards prescribed for these factors.

F. True to the varietal characteristics descriptive of that variety. Harvested properly to avoid mechanical admixture.
G. Grown in compliance with other special requirements for the crop concerned.

The field observations made for these are compared with a set of prescribed norms called the Minimum Seed Certification Standards which are specific for each crop. The Minimum Seed Certification Standards specify the requirements for seed crops as to previous crops, isolation, varietal purity, other crop plants, objectionable weeds and freedom from certain designated diseases. They also specify the requirements for seed lots for physical qualities including pure seed, inert matter, other crop seed, weed seed, and objectionable weed seed, and for germination and entitled the"Indian Minimum Seed Certification Standards", published in September, 2013.

FIELD INSPECTION

GENERAL GUIDE LINES

Procedure for field inspections differ among crops and among growth stages of the same crop. The following broad principles on inspection methods are common to most crops and stages of growth.

1. The number of inspections indicated in MSCS are the minimum and should be conducted at proper stage.
2. The inspecting officer should ensure that he is guided by the producer to the correct seed field.
3. Inspection of cross-pollinated crops at and after commencement of flowering should be made without prior intimation to the producer.
4. The producer or his representative should be requested to accompany to the field during the entire inspection and they be shown all the factors observed in the field and which will be recorded in the inspection report.

5. When seed fields of the same class/variety of the same producer are separated by less than 50 meters they can be considered as one field unit for inspection provided they are of same growth stage and level of conformity to standards. If they are separated by more than 50 meters, a separate inspection report shall be made for each unit.
6. It is compulsory to observe it and its border areas before entering the fields, especially in tall crops like Bajra, Sorghum, Mustard etc. and crops requiring sizeable isolation distances around the outer boundary of the seed fields.
7. If one third or more of a self pollinated/cross pollinated crop is so lodged that taking counts is difficult, the seed crop may be recommended for rejection.
8. Walk through the entire seed field while taking field counts (it should not be localized to a portion or a few portions of a field) it should be randomly distributed all over the field

9. If the plant population in a field is so thin that the entire population is less than the number of counts required entire population may be counted.
10. Counting may be started from any pointed of the seed field but spotting a defect and trying to include/avoid it in the counts, is not desirable.
11. Factors counted during inspection need not normally be pulled out, but be shown to the seed grower/farmer to rogue out such plants.
12. If plants/heads of the designated factors which were pulled out by the producer are lying on the ground within out skirts of the seed field, the producer should be directed to collect and remove them from the field.
13. If the seed field is found to be liable for rejection either in part or in full on account of inadequate isolation, the prescribed number of field counts for the entire are still to be taken for that inspection.

14. A seed crop liable to be partially rejected due to inadequate isolation, further inspection of the entire field (including the affected portion) should be continued according to the prescribed number and procedure and separate counts for the affected area should be mentioned in the inspection report.
15. If on the basis of first set of field counts, the seed crop doed not conform to the prescribed standards for any factor, a second set of counts should be taken for the concerned factor, provided the percentage of the first set of counts for that factor is more than maximum permissible limit but not more than twice the maximum permissible limit.
16. For seed crops involving two parental lines, even if two sets of counts in one parental line show that the field does not conform to the prescribed standards it is necessary to take counts in the other parental line.

17. If on the basis of two set of counts the seed crop does not conform to the prescribed standards, further inspections need not be made unless the seed crop is eligible for re-inspection (after removal of contaminating factors). If the seed crop is not eligible for such re-inspection then LIABLE FOR REJECTION and final inspection should be recorded in the inspection report.
18. If the factor present beyond the maximum permissible limit as verified by two sets of counts could not have already caused contamination of the seed crop or when contamination has already taken place; if removal of contaminating factors and contaminated materials could make the seed crop conform to the prescribed standards, their removal from the field may be recommended to permitted. Re-inspection to conform removal and conformity to standards must then be made when re-inspection is permitted and it should be shown in the inspection report.
19. Observations made during field inspection shall be directly recorded on inspection report on the spot and the signature of the cultivator or his representative on the field should be obtained on all copies of inspection report and, if he refuses to sign then it should be indicated in the inspection report as "Refused to Sign".

MINIMUM NUMBER OF FIELD INSPECTION AND STAGES OF INSPECTION REQUIRED FOR CERTIFICATION

Sr.No.	Crop	Number of Inspections	Stages of Inspection
1.	Ragi, Paddy, Wheat, Cowpea Greengram, Blackgram, Redgram, Groundnut, Soyabean, Frenchbean, Amaranthus	2	Flowering to harvest

WHEN TO INSPECT

The field inspection offered for seed certification are conducted at following stages :

(1) Vegetative or pre-flowering stage.
(2) Flowering stage.
(3) Post flowering and pre-harvest stage.
(4) Harvest stage.

FIELD COUNTS

1. The number of counts taken and the method of taking counts vary from crop to crop for all crops; five counts are taken for any area upto 5 Acre and an additional count is taken for every additional 5 Acre as given below :

Area of the fiedls crops	No. of Counts to be taken
Up to 5 acres	5
Above 5 to 10 acres	6
Above 10 to 15 acres	7
Above 15 to 20 acres	8
Above 20 to 25 acres	9
Above 25 to 30 acres	10

In any inspection if the first set of counts shows that the said crop does not conform to the prescribed standards for any factor, a second set of counts shall be taken for the factor. However, when the first set of counts shows a factor to be more than twice the maximum permitted, it is not necessary to take a second set of counts. Two sets of counts are called double counts.

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2. Taking double sets of counts for a factor is :

a) Necessary if in the first set of counts occurrence of the factor is more than the maximum permitted, but not more than twice the maximum permitted.
b) Necessary if in the first set of counts occurrence of factor is equal two twice the maximum permissible level.
c) Not necessary if in the first set of counts occurrence of the factor is less than or equal to the maximum permitted.
d) Not necessary if in the first set of counts occurrence of the factor is more than twice the maximum permitted.

Number of plants to be counted per count :

S.No.	Crop	No. of plants/ head/ per count	Remarks
1.	Beans, Cowpea, Gram, Leaf crops, Moong, Mustard, Peas, Sesamum, Sunhemp, Sunflower, Blackgram, Green Gram, Lentil, Niger	500 plants	Medium spaced and non tillering

3. All plants or heads falling in each count must be examined for each designated factor as per MSCS.
4. If the seed field is planted with two different parents, the prescribed number of counts must be taken separately for each parent.
5. Percentage for deciding acceptance or rejection is calculated only to the number of decimals in which the standard is expressed.

WHAT TO INSPECT

Basically sources of genetic and physical contamination must be observed and extent of their occurrence estimated.

Sources of contamination can broadly be classified as follows :

A. OFF TYPES

Off types are the plants of the same species as that of the seed crop variety but morphologically of different characters eg. pigmentation, plant type, stem/ leaf shape and texture, size/colour of flower or fruit etc.

Similarly plants of other varieties of same crop are also included in off types. To designate a plant as off type it is necessary to trace it to any variety.

0.10% for F/S & 0.20% for C/S allowed under IMSCS

B. INSEPARABLE OTHER CROP PLANTS

Such type of plants whose seeds are similar in size, colour etc. and are difficult to separate from the seeds of seed crop by mechanical means are inseparable other crop plants.Such plants are counted if the growth stage of these plants is such that the maturity time resembles to the seed crop and may cause mechanical admixture at the time of harvesting/threshing.

C. OBJECTIONABLE WEED PLANTS

The plants of weed species harmful in the followering ways :

1. Size/ shape of seeds are similar to crop seed which are difficult to remove by mechanical means.
2. Growth habits has detrimental or competing effects on crop plants.
3. Mode of spread, perpetuation, perennation or growth habit make eradication difficult.
4. Plant parts are poisonous/injurious serves as alternate host for pests and diseases. Such plants are counted if the growth habit is similar to the seed crop thus causing admixture at the time of harvesting/threshing.

D. DISEASES

Seed may carry seed borne, soil or air borne diseases. Economical and effective measures of some seed borne diseases are available. However, counts of each designated diseases should be mentioned in the inspection report.

E. ISOLATION

A proper designated isolation distance is compulsorily be maintained in the seed fields. All precautions should be taken so that produce of rejected area of the seed field on account of isolation is not mixed with that of the certified seed field. Threshing certificate if required may be given.

MINIMUM ISOLATION REQUIREMENTS FOR PULSE CROPS

Sl. No.	Crop	Minimum distance Foundation	Isolation (meters) Certified	To be isolated by the distance in column 3 or 4 from fields of
1.	Cowpea, Green gram, Black gram, Bengal gram, Peas and beans	10	5	Other varieties and fields of same variety not conforming to the purity requirement for certification.

REINSPECTION

For crops not conforming to the standards for certification at any inspection, the field may be reinspected by the Agency on producers or seed grower/farmers request on depositing reinspection fee, when he has removed the source of contamination in the seed field and has maintained the isolation distance and or the contaminated plants in the seed field. The Agency may conduct one or more reinspection over and above normal set of inspections to ensure conformity of the seed crop to the standards as per MSCS.

REPORTING RESULTS

The results of the field inspection must be reported in the prescribed inspection report of the Agency & is to be signed by the seed grower/farmer also. A copy is to be given to him on spot.

Sometimes, even after following all regulations and observing normal field counts, an officer may some times observe defects which do not come in field counts. Under such conditions he may follow the suggested procedure :

1. When patches or rows off types, shedders, shedding tassels objectionable weeds, inseparable other crop plants / heads or plants affected by diseases are noticed but not come under field counts, separate observations such as size of the patch,number of rows etc. should be made, reported and be shown on a map.The officer should exercise discretion and attempt to save the crop from rejection by advising the grower to remove the defective patch before contamination oocures.
2. If the male/female parents in seed production involving two parents have been irregularly planted, it should be recommended as " LIABLE FOR REJECTION".
3. If the seed crop is grown as mixed, inter or companion crop other than prescribed norms, it should be recommended as liable for rejection.
4. If the seed crop has failed partially or completely or is damaged by cattle, flood, drought etc. or the producer does not want to offer it for certification, the inspection report should still be prepared.

HARVESTING

Seed crop meeting the field standards after final field certification shall be properly harvested, threshed, dired and transported to the registered seed processing plant as per crop calender for processing and certification. during the above operations seed producer/growers should take all necessary precautions to safe guard the seed quality.

(i) The Crop should be harvested at proper stage.
(ii) It should be properly dried, threshed so that no admixture takes place at threshing floor.
(iii) All thresher or bags should be clean, bags are not old and torned.
(iv) All stones, stalks, mud balls etc. should be removed for better processing.
(v) Bags should not be over filled & not more than 100 Kg. capacity.
(vi) Care to be taken for Soyabean harvesting, threshing & packing.

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Quality Seed Production Technology in Black gram

Debjyoti Sen Gupta
Senior Scientist & Co-Nodal Officer, Pulses Seed Production
ICAR-Indian Institute of Pulses Research, Kalyanpur, Kanpur-208024

Basic Practices in Black gram Seed Production:

1. Sowing time

In Uttar Pradesh, it is also grown during spring season and sown during last part of February or first part of March. Urdbean is grown as Kharif or rainy season crop in Southern and Northern India. In Southern India it is also grown as Pre-Rabi or Rabi crop. In Eastern and Southern growing regions of India urdbean is predominantly grown as a Rice fallow crop. Date of sowing of urdbean varies based on the local meteorological conditions, for example in Uttar Pradesh and Madhya Pradesh state it is sown in the month of mid-July to first week of August. Whereas in many states in Southern India it is sown in last part of October or first part of November, whereas in many Southern states like Orissa it is sown in October or February months. In Andhra Pradesh normal sowing is completed between mid November to mid-December.

2. Field Preparations

Field preparation requirements are site specific. Usually in heavy soil a deep ploughing followed by a shallow one prepares the suitable field condition for urdbean cultivation. During Spring/Summer sowing pre-sowing irrigation is required to maintain optimum moisture content of soil conducive for maximum germination. During Kharif season, with the onset of pre-monsoon showers most of the growers complete the urdbean sowing utilizing the residual soil moisture.

3. Crop Geometry and seed rate

Urdbean is sown with plant-to-plant distance of about 10 cm and row to row distance of about 30 cm. To get optimum plant population i.e. 30-35 plants/sq.mt in a seed rate of 15-20 kg ha in Spring/Summer seasons and for Kharif season 12-15 kg/ha seed rate is required. Line sowing is recommended over broadcasting method of sowing. In case of dense planting of urdbean beyond what is recommended invites more pests and disease incidence, thereby reduces the economic yield.

4. Seed treatments

Seed treatments include use of *rhizobium*, PSB, VAM or treating the seed with some chemicals to get better nodulations, crop establishment and higher yield. Seed inoculation should be done before sowing of the crop with specific *rhizobium* culture. It is the least expensive way to improve the productivity of crop. The efficacy of the leguminous crop to fix atmospheric nitrogen relies upon the spectrum nodulations in the roots which indirectly dependent upon the r*hizobium* population. Therefore, it is important to make sure optimum population of these bacteria in the soil. Since the natural populations of the microbes are habitually not enough in the soil, so seed treatment with suitable *rhizobium* culture is necessary.

One packet of culture (250 g) is adequate for 10 kg seeds. The inoculation should be done just before sowing. To treat the seeds, 100 g jaggery, 2 g gum arabica to one liter water should be heated for about half an hour, to prepare a homogenous mixture. Blend the solution thoroughly with the help of bamboo stick to prepare a homogenous solution and leave it to cool. After cooling the *Rhizobium* culture is mixed with the solution and makes it like slurry. Then mix the seed in the slurry of the culture and rub it thoroughly with the care that almost all the seeds should be uniformly coated with slurry. The seeds coated with slurry should not be exposed to

direct sunlight. Spread the treated seed on polythene sheet in shade and allow them to dry. Sowing of the treated seeds should be done in morning or in the afternoon to avoid exposure to the sunlight.In rice fallow there are distinct soil and seed borne fungal diseases caused extensive damage to seed before seedling rising out of the soil and later the emerged seedling. So, to avoid any infestation treat the seed with fungicide to enhance germination and to ensure ideal plant population. Fungicides like captan, thiram, bavistin etc. are compatible with culture. Seeds should always be treated with fungicide @3.0 g/kg seed should be done at least 4-5 days before *Rhizobium* inoculation.

5. Fertilizer requirements

Fertilizers are applied as a basal application or during sowing of the crop. During Kharif season the recommended fertilizer dose: 12.5 kg N + 25 kg P_2O_5 + 12.5 kg K_2O +10 kg Sulphur/ha and during Spring/Summer season recommendation is: 25 kg N + 50 kg P_2O_5 + 25 kg K_2O + 20 kg Sulphur/ha. This means under irrigated condition during Spring/Summer fertilizer application is doubled. Due to biological nitrogen fixation ability nitrogen requirement from external sources is minimal in case of this crop species.

6. Irrigation requirements

Kharif urdbean is grown in the rainy season. It does not require irrigation unless the occurrence of prolonged terminal drought spells. Cultivated urdbean in summer season is possible only where adequate irrigation facilities exist (3-4 irrigation). Sufficient moisture should be ensured by a pre-sowing irrigation. The first irrigation should be given 25-30 DAS. Subsequent irrigations may be scheduled at the interval of 12-15 days.

7. Weed management

8. Major diseases and their management

symptom

1. Yellow Mosaic Disease

This disease is caused by the mungbean yellow mosaic virus (MYMV) belonging to Gemini group of viruses. Yellow mosaic symptoms develop on leaves and even on pods which spread with time resulting in less flowering and pod development. The sole vector of the disease is whitefly (*Bemisia tabaci*).

Control measures

1. Grow resistant varieties like IPU 94-1 (Uttara).
2. Rogue out the diseased plant to prevent further spread of the disease.
3. Spray Buprofezin 25 EC @ 1000 ml/ha against its vector, whitefly (*B. tabaci*).

2. Leaf Crinkle

This disease is caused by urdbean leaf crinkle virus (ULCV) belonging to Tospovirus. This virus is transmitted by aphids, whitefly and leaf hoppers through sap. The disease is characterized by the symptoms which include crinkling, curling, and puckering of leaves often coupled with stunting and malformation of floral organs. Enlargement in size followed by crinkled laminae are the characteristics symptoms seen on affected trifoliate leaves. Pollen production, fertility and subsequent pod formation is severely reduced which affects seed weight and size of seeds in infected plants leading to decrease in yield.

Control measures

1. Use healthy and disease free seeds.
2. Do seed treatment with Imidacloprid 70 WS@ 5ml/kg.

3. Diseased plants should be rogued out for prevention of further spread.
4. Spray Dimethoate 30 EC @ 3 ml/l water or Imidacloprid 17.8 SL @ 4 ml per l water to manage sucking insect pests acting as vector.

3. Powdery Mildew

This disease is caused *Erysiphae polygonii*. The disease appears on all the part of plants above soil surface which can be identified as presence of white powdery coating on leaves, stems and pods. The disease induces forced maturity of the infected plant causing heavy yield losses and its intensity increases in stress condition.

Control measures

1. Remove diseased plant and keep the field clean.
2. Use resistant varieties
3. Spray with water soluble sulphur 80 WP @ 4 kg/l water or Carbendazin 50 WP @ 1 g/l water (0.05%).

9. Major insect-pests and their management

1. **Pod borer (*Helicoverpa armigera* Hubner)**

Larvae at their young stage feeds mainly on foliage but grown up larvae render more harm by feeding on flower buds and pods. While feeding, half body remains outside the pod, is its peculiar character.

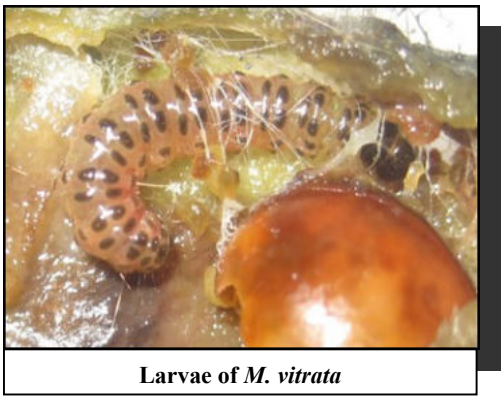
Larvae of *H. armigera*

Control measures

1. Deep summer ploughing should be done to destroy the immature stages like larvae and pupae.
2. Do seed treatment before sowing with Imidacloprid 600 FS @ 5ml/kg seeds.
2. Install pheromone traps @ 5 traps per /ha for monitoring of the pest.
3.Spray HaNPV @ 1ml/l or NSKE or crude neem 5% @ 50 g/l or neem oil 3000ppm @ 20 ml/l or Indoxacarb 14.5 SC @ 65 g a.i/ha at 15 days interval or 100 ml of Chlorantraniliprole 18.5 SC in 500 l water per ha.

2. **Spotted pod borer (*Maruca vitrata* Fabricius)**

Presence of webbed flowers and leaves are characteristic symptoms of this pest. Adult lays eggs between the petals inside the flowers. Larvae feed inside the flower, flower buds and pods while remaining inside the web. Third to fifth instars larvae bores into the pods and feeds on developing grains.



Larvae of *M. vitrata*

Control measures

1. Do seed treatment with Imidacloprid 17.8 SL @ 3 ml/kg.
2.Spray *Bacillus thuringiensis* 5 WG @ 1.0 g/l water or Profenophos 50 EC @ 2.0 ml/l water or Coragen 20 SC @ 150 ml per ha orSpinosad 45 SC @ 0.2 ml/l water or 100 ml of Flubendiamide 39.35% SC in 500 l water per ha or 600 ml Lufenuron 05.40% EC in 500 l water per ha. (Spraying is more effective when done before larvae enter the pods)

3. Tobacco caterpillar (*Spodoptera litura* Fabricius)

Larvae of this pest are voracious foliage feeders. Young larvae scrape the green matter of the leaves making it whitish. Grown up larvae make irregular holes in the leaves and in severe attack leaves are skeletonized. Heavy defoliation in young plants destroys the crop.

***S. litura* (Adult)**

Control measures

1. Collect and destroy the egg masses and newly hatched larvae along with skeletonized leaves.
2.Spray SlNPV [500 LE/ha or 500 ml (1x109 POB/ml)], especially when the larvae are young, or Novaluron10 EC @ 0.75 ml/l water or 300 ml of Flubendiamide 20.00% WG in 500 l water per ha.

4. **Bihar hairy caterpillar (*Spliosoma oblique* Walker)**

Larvae of this pest are also voracious foliage feeders but seen in gregarious form. They mainly feed on chlorophyll and the field is seen as full of dusty white coloured leaves.

Control measures

1.Uproot and destroy the damaged plants along with the young larvae at the gregarious phase.
2.Pull out plants infested with young larvae, crush grown-up caterpillars and spray Quinalphos 25 EC @ 1500 ml in 500 to 1000 l water/ha. Spraying with desi cow urine @ 15 lt/ha, followed by spraying with neem, milkweed and dhatura leaves extract @ 15lt/ha has also been found effective.

5. Cowpea Aphid(*Aphis craccivora* Koch)

Nymphs and adults suck the sap from plants young plants, leaflets, stem and pod in large numbers. Young leaves of seedlings become twisted. Excretion of honey dew by aphids also attracts sooty mold.

Control measures

1. Conserve Coccinellid beetles, their grubs and Chrysoperla as they are efficient aphids predators.
2. Spray 5% Crude Neem Extract or 2% Neem oil (3000 ppm) or Imidacloprid 17.8 SL @ 0.2 ml/l water or Dimethoate 30 EC (1.7 ml/ l water).

Aphid colonization

6. Thrips (*Megalurothrips distalis, M. usitatus, Caliothrips indicus*)

Nymphs and adults of this pest feed on stigma inside the flower. This causes shedding of flower before its opening, and it fails to bear pods.

Control measures

1. Timely irrigation at an interval of 15 days results in low build-up of thrips.
2. Do seed treatment with Thiomethoxam 70 WS (0.2%) followed by its foliar spray (25 WG 0.02%) for effective control of thrips.

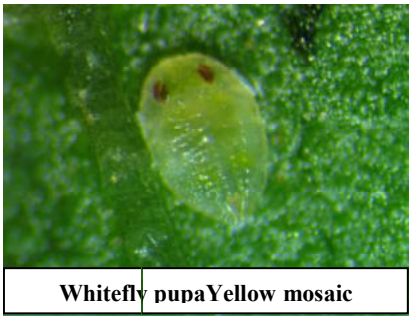
Thrips infestation

7. Whitefly (*Bemisia tabaci* Gennadius)

Nymphs and adults of whitefly suck the sap by colonizing preferably on the lower sides of the leaves. They are the sole vector of the yellow mosaic virus.

Control measures

1. Grow maize, sorghum or pearl millet as a barrier crop to minimize the incidence of whiteflies



Whitefly pupaYellow mosaic

2. Spraying of Buprofezin 25 EC @ 1000 ml/ha is effective against whitefly in urdbean.

8. Pod bugs, Green stink bugs (*Clavigralla gibbosa,Nezara viridula*)

Nezara viridula

Pod bugs render harm by sucking sap from different parts of the plants but major damage is done to the green pods before they attain maturity. The grains in the pods become shriveled resulting in considerable yield losses.

Control measures

1. These insects can be collected by physical shaking of the plant and then be destroyed.
2. Spray Monocrotophos 36SL @ 1.0 ml/l water during flowering and at pod formation stage.

9. Pulse beetle (*Callosobruchus chinensis, C. analis and C. maculatus*)

The damage by this pest starts in the field by the pods mature and the infestation shifts to storage with the harvest. The eggs are laid on the grains and upon hatching, the young larvae bore into the grain and feed by remaining inside.

Control measures

1. Crop should be harvested before the pods shatter and the grains should be sufficiently dried up to the moisture level of 10-12 % before storage.
2. Boiled and dried gunny bags should only be used for storage.
3. Spray Deltamethrin 2.5 WP @ 1 litre /30 m-sqr (bags) and 1.5-2.5 litre /50 m-sqr (walls and ceilings).

Minimum standards for foundation and certified seed in Black gram

Each crop has different field and seed standards for production of foundation and certified seed. These variations are mainly because of the variation in extent and the mode of cross pollination. The field and seed standards for black gram are given in Table 1.

Table 1. Minimum field and seed standards for black gram production in India.

Parameter	Foundation Seed	Certified seed
Isolation distance (meter)	10	5
Number of field inspections (minimum)	2	2
Germination including hard seed (%)	75%	75%
Pure seed %	98%	98%
Inert matter %	2%	2%
Off-types%	0.10	0.20
Other crop seed (number per Kg)	5/kg	10/kg
Other distinguishable variety seeds (number per Kg)	10/kg	20/kg

Average yield: Black gram -10-12q/ha

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Quality Seed Production Technology in Peas (Vegetable Peas and Field Peas)

Jyoti Devi, N. Rai and T.K. Behera
ICAR-Indian Institute of Vegetable Research, Varanasi–221 305, India
*Correspondence: jyoti17iivr@gmail.com

1. Introduction

With its domestication history of nearly 10,000 years ago, pea (*Pisum sativum* L.) is one of the leading annual legumes of the world, cultivated over an area of 7.18 and 2.78 m ha for dry and green seeds, respectively (FAOSTAT, 2019). Peas have balance of micro and macro nutrition profile along with high dietary fiber, antioxidants, and numerous important biomolecules, thus have health benefits in managing diabetes, cardio problems, certain cancers, and many degenerative diseases. Historically, it is a cool season crop, but its area is now extending to warmers regions of the world due to the development of cultivars more resilient to certain abiotic stresses. It is the fourth important cultivated legume globally, after common beans, cowpeas and chickpeas (FAOSTAT, 2019). Despite a substantial increase in area and production, a slight shift has been recorded in pea productivity (from 1.5 to 2.0 t for dry peas; 7.7 to 7.8 t/ha for green peas) during last two decade *viz*., from 2001 to 2019 (FAOSTAT, 2019). Increasing the crop productivity to meet the world's burgeoning population food needs, in the presence of various biotic and abiotic stresses has become the major challenge for the crop scientists and producers.

2. Floral biology and breeding behavior

Flower: Flowers are borne in the axil of leaf, always in pairs, bracteate, pedicellate, bisexual andhypogynous complete flowers. **Calyx:** Flower consist of 5 sepals in gamosepalous condition, 2 sepals are behind the standard,2 subtending the wings and fifth anterior, One subtending the keel. **Corolla**: It consists of five petals in (2+2+1) condition having 1 standard,2 wings and 2 keel that are fused except at their base.They cover the pistil and the stamens. The standard has notch in the center. **Androecium:** Androecium consists of 10 stamens in 9+1 arrangement. The filaments of 9 stamens are joint for much of their length to form a staminal tube around the ovary. The 10th stamen is free. **Gynoecium:** Monocarpellary, ovary superior, unilocular, with many ovules on marginal placentation, style simple and curved, stigma capitate. **Fruit:** Legume; **Seed:** non-endospermous with thick cotyledons.

Floral Formula: $\mathbf{Br.,Brl.,\%,\male,\female\ K_{(5)},C_5,A_{(9)+1},\underline{G}_1}$

Pea plants are basically self-pollinating plants and pollination occurs before the opening of the flowers.Therefore, emasculation helps in preventing self-fertilization and pollinating the stigma of a flower with desired pollen from other variety is needed from crop improvement point of view.However, recent studies clearly demonstrate the pollinator's diversity and role of various pollinators in peas.A cross-pollination rate of about 25% in peas has been reported in peas.

3. Ideal climatic requirement

Peas are cool-season crops that thrive in climates with moderate temperatures, moderate rainfall, and plenty of sunlight. Temperatures between 10°C and 20°C are ideal for pea growth. Pea seed can germinate even at temp 0f 5°C, however optimum temperature for germination is about 22°C. Peas can withstand light frosts, but prolonged cold or heavy frost can harm or kill

the plants. Similarly hot and dry weather interfere with pollination and seed setting. Peas require a lot of moisture to grow, but they are susceptible to fungal diseases in wet conditions. When the soil is evenly moist but well-drained, optimal soil moisture levels are achieved. Water is essential, especially during the seedling establishment, flowering, and pod filling stages.

4. Soil quality

Peas prefer well-drained soils with good water-holding capacity. Loamy soils, which are a mix of sand, silt, and clay, are ideal for pea production as they provide good drainage and retain moisture well. The soil should have a pH of 6.0 to 7.5 and should be rich in organic matter and nitrogen. It does not thrive well in highly acidic or alkaline soil. Good soil drainage is critical for pea production as the crop is sensitive to waterlogging and root rot.

5. Sowing time

The best time to sow peas for seed production is in the middle of October to mid-November, so that seeds are harvested by March to April in the dry season. In the hills, autumn crops sown in May–June can be taken for seed.The optimum temperature for seed germination is about 22°C however; it can germinate up to 5°C but at slow rate. At higher temperature the germination is rapid but plant stand is affected due to decay. The depth of sowing is 5 to 7.5 cm. The seed sowing can be done by hand dibbling or drilling. Hand dibbling can be practiced on a small scale, whereas commercial method of sowing is drilling.

6. Varieties

Vegetable types

Early Groups: In this group, the first flowering takes place in about 25-40 days after sowing. These varieties become ready for first picking in about 55-70 days after seed sowing; and two to three pickings at an interval of 10-15 days can be obtained. Some of the important pea varieties are listed below;

Kashi Purvi (VRPE-10): The variety is early type that took 35-40 days for days to 50% flowering and first picking is ready in 65-75 days. The plants bear 10-13 pods having pod length of 8-8.5 cm with double pod bearing habit on most of its peduncle. The average pod yield of Kashi Purvi is around 108-117 q/ha with 50-52 shelling percentage. The variety is recommended for commercial cultivation in UP.

Kashi Nandini (VRP-5): This is an early variety developed at IIVR, Varanasi through pedigree selection from the cross P 1542 × VT-2-1. Plants are erect, dark green foliage with 7-8 pods per plant and first flower appears after 30-31 days after sowing. Plant height are about 40-45cm. Pods are long, attractive, well filled with high shelling percentage and better quality. It is tolerant to leaf miner and pod borer. It gives an average yield of 65 q/ha. This is identified for the zones I, IV and VIII.

Kashi Uday (VRP-6): This is an early maturing variety developed at IIVR, Varanasi through pedigree selection and first flower appears after 31-32 days after sowing. Foliage is dark green, short internodes and bears 8-10 pods/plant. Plants grow up to 55cm. Pods are long, attractive and well filled with bold seed. Crop duration is about 80 days. It gives an average yield of 100 q/ha. State Varietal Release Committee has identified this variety for cultivation in UP.

Kashi Mukti (VRP-22): It is an early maturing variety developed through pedigree selection from the Cross No. 7 × PM-5. Plants have short internodes and medium height (50 cm) and first flower appears after 34-35 days after sowing. Pods are about 10 cm long, attractive and filled with 9-10 bold and soft seeds. It is resistant to powdery mildew under field conditions. Its average yield is about 140-160 q/ha.

Arkel: This is an introduced variety from England and promoted by IARI, New Delhi. Plants are dwarf; first flower appears in about 30-35 days after sowing and takes 60-65 days to first picking. Pods are well filled, sickle shaped and attractive dark green with 7-8 green ovules per pod. It gives an average yield of 80-100 q/ha. Seeds are wrinkled at maturity.

Azad Pea-3: This variety has been introduced from CSAUA&T, Kanpur. Plants are medium tall, dark green in colour. First flower appears in about 40 days after seed sowing. Pods are well filled with bold green and attractive seeds. First picking is done in about 70 days after sowing. Green pod yield is 120-125 q/ha. Matured seeds are wrinkled.

Ageta (E-6): Plants are small, erect and green in colour. It is suitable for early sowing. First flower appears in about 28 days after seed sowing and it takes about 8 weeks for first picking. Usually, two pickings of green pods are done. Average green pod yield is about 40-50 q/ha. Pods are well filled with 6-7 seeds. On seed maturity, seeds become dimpled.

VL Ageti Matar -7: It is cross between Pant Uphar×Arkel. It is one of the earliest varieties of pea. Plants are dwarf; seeds are bold, sweet and pod contains 5-6 seeds. It yields about 40 q/ha.

MID GROUPS: Varieties of this group flower at about 45 to 60 days and give first picking in about 75-80 days after sowing. Total three pickings are obtained at the interval of 10-15 days.

Kashi Shakti (VRP-7): It is a high yielding variety of medium maturity group. It has dark green foliage with good attractive and well-filled pods. Plant height is about 90-100cm, and 50% plants bear flowers at 55-60 days after sowing. Single plant produces about 11-12 pods filled with 7-9 bold seeds. It gives an average yield of 140-160 q/ha.

Bonneville: It is an introduction from U.S.A. and released by IARI, New Delhi. This is wrinkled seeded and medium tall variety. The first picking starts in about 85 days after sowing, and average green pod yield is about 80 q/ha.

Azad Pea-1: This is tall variety, evolved at CSAUAT, Kanpur. Plants are tall, first flower appear in about 50 days after sowing. First harvesting can be done in 75 days after sowing. Three to four pickings are done. Pods are dark green in colour and borne 2-3 in numbers. Average yield of green pods are 140-160 q/ha.

Pant Uphar (IP-3): It is developed at GBPUAT, Pantnagar. It is a medium tall (70cm) and possesses medium sized pods (7cm) with 7 green ovules in each pod. The average green pod yield is about 80 q/ha.

Punjab-89: This variety is identified for all over India through AICRP (VC). The pods are long, very attractive, 9-10 seeds/pod and higher shelling percentage. The average yield is 13-14 t/ha.

Punjab-88: It is a cross between Pusa-2 × Morassis-55, developed at PAU, Ludhiana. Plants are tall with medium sized pods. The seeds are green and bold. The average yield is about 75-80 q/ha.

VL-3: It is cross between Old Sugar × Early Wrinkled. The plants are about 65-70cm tall and have light green pods of 6cm length. The yield potential is about 80-100 q/ha green pods.

Vivek Matar 8: It is a cross between Perfection and Bonneville. Plants are dwarf with light green foliage. It bears two white flowers per peduncle. The pods are light green, smooth, straight; 6-7.5cm long bears about 6 seeds/pod. Its average pod yield is about 110-115 q/ha.

NDVP-8: It is a mid-season variety developed at NDAUT, Faizabad. It gives an average yield of about100 q/ha.

NDVP-10: It is a mid-season variety developed at NDAUT, Faizabad. It gives an average yield of about 120 q/ha.

LATE GROUP VARITIES: Varieties of this group flower in 60-70 days after sowing and first picking is obtained in about 90 days.

Kashi Samrath (VRPMR-9): This variety has been evolved at IIVR, Varanasi. Its 50% flowering takes place 65-70 days after sowing. Pod colour is light green, 7-8 cm long and 7-8 seeds per pod. Pods are ready to harvest in 105-110 days. It is resistant to powdery mildew. The pod yield is varies from 110-120 q/ha.

Kashi Samridhi (VRPMR-11): It is a late maturing and powdery mildew resistant vegetable pea variety developed at IIVR, Varanasi through pedigree method of selection from a cross of FC-1 × PM-5. Kashi Samridhi has been identified and recommended for release for agro-climatic zone IV. The plants are 65-75 cm in height, attractive, dark green in colour. It takes 60-63 days for 50% flowering. Pods are green, straight and slightly curved at tip, 7.5-8.0 cm in length and 13-14 numbers/plant. The pods become ready for harvest after 90-95 days of sowing and average yield is 120-140 q/ha.

Lincoln: It is an old exotic variety gives high yield in hilly areas. Plants are tall and pods are long and well filled.

Arka Ajit: It is developed through back cross pedigree method of selection involving the parents; Bonneville, IIHR 209 and Freezer 656. Pods are 8-9cm long, seeds bold, green and sweet. Shelling percent is about 50. It is a mid-season variety and has combined resistance to powdery mildew and rust. It gives pod yield of about100 q/ha.

Arka Karthik: It is derived by pedigree selection from the advanced generation of the cross between Arka Ajit and IIHR 554. Plants are bushy, erect and resistant to rust and powdery mildew. Pods are long (11-12cm) with 8-10 green sweet seeds. It gives pod yield of about 110 q/ha.

Vivek Mater 11: It is developed by hybridization between Azad Pea -1 × PRS-18-6-4-5-1 through pedigree method. It shows 50% flowering in 90-100 days and first flower appears at 9-11th node. Pods are 8-9 cm in length, 7-8 seeds/pod and 10-15 pods/plant. Average yield is 10-11 tonnes/ha. It is resistant to powdery mildew.

Edible –podded pea's varieties

Kashi Tripti: Kashi Tripti is a mid-season cultivar of edible podded peas taking around 50-56 days, with first picking ready at 90-95 days after sowing. Plants are of medium height (80-90 cm) with one to two primary branches, and produces pods that measure 8.2-8.6 cm in length and 1.75-1.9 cm in width. The plant bears around 12-15 pods per plant, with an average weight of 7.1-8.0 grams with average pod yield of 95-100 quintals/ha that could be taken in 2-3 pickings.

Table 1: Central & State released varieties of Field peas/Matar in India

Variety	Year of Release/Notification	Source	Area of Adoption Zone/State	Maturity (Days)	Yield (q/ha)	Special Feature
Prakash (IPFD1-10)	2006	IIPR	**CZ**(MP.,CG,MH, GJ,BK-UP **NWPZ**(PB,HR, DL, RJ,W-UP,Plains ofUK),**NHZ**(J&K,HP,UK, **NEH**(SK,NG, MG,MN, MZ TR, AR)	94-121	15-20	Resistant to PM and tolerant to rust; moderately resistant to pod borer and stem fly; plant height:38-85cm
Paras	2006	IGKV,CG	**CZ**/ Chhattisgarh	92-119	18-24	Res. to PM; plant height:48-71cm; seeds-bold
PantPea-14	2006	GBPUAT,	**NWPZ**/Uttarakhand	110-115	15-22	Med season variety; resistant to rust and PM
VL-Matar-42	2007	VPKAS	**NEPZ**(E-UP, BR,WB,JH,AS,J&K)	108-155	20	Resistant to PM; Moderate resistant to rust
PantPea-25	2007	GBPUAT	NWPZ/Uttarakhand	115-140	18-22	Resistance to PM; moderately resistant to rust
Hariyal (HFP-9907B)	2007	CCSHAU	**NWPZ**(PB,HR, DL, RJ,W-UP, Plains of UK),	128-130	17-20	Tolerant to rust; tolerant to podborer
PantPea-42	2008	GBPUAT	**NWPZ**(PB,HR,DL, RJ,W-UP Plains of UK), **NHZ**(J&K,HP., UK), **NEH**(SK,NG,MG,MN,MZ,TR, AR)	113-139	22-23	Moderately resistant to pod borer and stem fly; resistant to PM and to rust.
SwarnaTripti	2008	IARI	**NWPZ**(PB,HR,DL, RJ,W-UP Plains of UK)	65-70	25-30	Resistant to PM.; the variety is least affected by pod borer infestation;plantheight:100-105cm.
HFP-	2008	CCSHA	**NWPZ**(PB,HR,D	135-	20-21	Resistant to PM

9426		U	L, RJ,W-UP Plains of UK)	140		and better tolerant to root-rot; moderately resistant to Nematodes.
VivekMatar-10 (VP101)	2008	VPKAS	**NHZ**(J&K,HP., UK,**NEH**(SK,NG,MG, MN,MZ, TR,AR)	120-130	25-30	Moderately resistance to PM and resistance to white rot, wilt and leaf blight; less incidence of podborer.
PantP13	2008	GBPUAT	**NWPZ**(PB,HR, DL, RJ,W-UP Plains of UK),	24-26	110-115	Resistant to PM
PantPea-42	2008	GBPUAT	**NWPZ**(HR,PB,RJ., UP,UK)		113-149	Resistant to PM, rust; moderately resistant to pod borer and stem fly.
PantPea74	2009	GBPUAT	**NWPZ**(PB,HR, DL, RJ,W-UP, Plains of UP	120-130	22-23	Resistant to PM & moderately resistant to rust; dwarf type.
Aman(IPF5-19)	2010	IIPR,	**NWPZ**(PB,HR, DL, RJ,W-UP, Plains of UK)	124-137	22-23	Resistant to PM and tolerant to rust; moderately resistant to pod borer andstemfly; plantheight: 116cm.
Gomati (TRCP-8)	2010	ICAR, Reas.	**NEHZ**(J&K,HP., UK,**NEH**(SK,NG,MG, MN,MZ)	87-297	22-24	Tolerant to pod borer and stem fly; tolerant to *M.incognita* and *M.Javanica* at different locations.

Note: AR Arunachal Pradesh, AS- Assam, BR-Bihar, CG-Chhattisgarh, DL-Delhi, GJ-Gujarat, HP-Himachal Pradesh, HR-Haryana, JH-Jharkhand, J&K –Jammu & Kashmir, MP-Madhya

Pradesh, MH-Maharashtra, PB-Punjab, RJ-Rajasthan, SK-Sikkim, MG-Meghalaya, MN-Manipur, MZ-Mizorum, NG-Nagaland, TR Tripura, UP-Uttar Pradesh, BK- UP = Bundelkhand region of Uttar Pradesh; UK-Uttarakhand, WB- West Bengal.W = Western; E= Eastern, N= Northern; BGM = Botrytis grey mold, YMV-Yellow Mosaic Virus. Res. = Resistant, Tol.= Tolerant, Mod.= Moderately, PM= Powdery Mildew, PB-Pod Borer.

Source: - i) Project Coordinator's Report, AICRP on MULLaRP, ICAR, IIPR, Kanpur. 2017-18 and 2020, ii) www.seednet.gov.in

6. Spacing and seed rate

The early and dwarf varieties are planted at a row to row spacing of 30 cm and main season varieties are 45 cm, however the plant to plant spacing is kept at 8-10 cm. Seed requirement of dwarf varieties is 125-150 kg/ha and that of medium tall variety is 100-120 kg/ha. For early sowing seed rate is kept in higher order.

7. Manure and fertilizer

Although pea is legume crop, it respond well to application of fertilizer particularly phosphate fertilizer Phosphorus help in better nodulation in the roots through rhizobium symbiosis. Its requirement of nitrogen fertilizer is comparatively much less because of being the legume crop what it is required for stimulating early growth. Well rotten farm yard manure at the rate of 15 to 20t/ha should be applied at the time of land preparation. There are different recommendations from different parts of the country. However, for an average fertile soil, 40-50 kg N, 80-100 kg P2 O5 and 40-50 kg/ha K2O are recommended. Full dose of phosphorus and potassium and half nitrogen are applied as basal dose at the time of sowing in bands about 7 to 8 cm to the side and slightly deep than the seed and rest N is applied 30-40 days after sowing as top dressing. Foliar application of 0.1% ammonium molibdate at the time of flowering enhances both pod and seed yield.

9. Water Requirement: Peas require sufficient moisture for seed germination. Usually two light irrigations are given in peas; one at flower initiation (35-40 days after sowing) and other at pod development (between 65-70 days after sowing). Water logging is harmful as aeration and nitrification by rhizobium in root nodule are adversely affected and generally reduces several quality aspects like uniformity of seed, maturity and colour intensity indices. High soil moisture at any growth period causes wilting in plants.

10. Integrated Weed Management (IWM): IWM is a combination of different weed control methods, including cultural, mechanical, biological, and chemical methods, to achieve effective and sustainable weed control. IWM helps to reduce the reliance on herbicides and minimize the risk of herbicide resistance. Cultural practices such as crop rotation, tillage, and cover crops can help to suppress weed growth and reduce the need for herbicides in export-oriented pea crops. Pre emergence spray of pendimethalin could be done to control the weeds at early emergence stage.

11. Essential of Seed production:

The seed field is so selected that it must fulfill the following requirements;

- ✓ **Crop Rotation:** To prevent the accumulation of seed-borne diseases, the chosen field should not have hosted the same crop type within the past two years. However, if such crop repetition has occurred, it is essential that these crops underwent rigorous field inspections by the certification agency to confirm that they did not exceed the permissible limit for seed-borne diseases. This precautionary measure is taken to mitigate the risk of seedling diseases, blight, and nematode infestations specific to peas.

Instead, it is recommended to rotate pea cultivation with cereals to maintain soil health and reduce susceptibility to these issues.

- ✓ **Soil Quality:** The soil in the selected field should possess specific qualities for optimal crop growth. It should be characterized by its light and friable texture, ensuring loose and crumbly soil that promotes adequate aeration and root development. Furthermore, the field should have proper drainage to prevent waterlogging.
- ✓ **Isolation distance:** Since pea is short duration crop, relatively short isolation distance is recommended mainly to avoid mechanical mixture. It is important that adjacent cultivars should be at least 20 m apart with distance increased to at least 40 m for nucleus or stock seed production
- ✓ **Roguing**

Careful and rigorous roguing on a plant basis is essential, particularly for the production of foundation seed. Roguing of the seed crop should begin with uprooting of the off types based on growth and leaf characters before anthesis which should continue up to mature fruit stage. Roguing at flowering and after pod formation needs to be done.Off types and plant affected by blight and pea mosaic must be removed as soon as observed. Rouging should be done atthree differences stages.

- ✓ **Before opening the first flower**: At this stage, roguing should be done considering the growth habit and foliage characters typical of the cultivar.
- ✓ **Early flowering stage:** Roguing is done on the basis of the observable characters of inflorescence and flower.
- ✓ **Fruits Setting Stage**: Off-types are rogued out considering the satisfactory level of productivity, and fruit characters including size, nature, shape, and colour are approaching the fruit stage.

12. Pod and seedYield: The average pod yield of early varieties is between 90-110 q/ha while the mid and late varieties yielded upto 130-150 q/ha pods. The average seed yield is about 10-12 q/ha.

14. Disease and insect-pest management

1. *Fusarium* wilt

It is considered as a serious disease of pea. The disease is caused by the fungus, *Fusariumoxysporam f. sp. pisi*. Symptom of the disease is more pronounced in 3 to 5 week old plants and in case of young seedlings, cotyledons droop and wither. The disease is characterized by the yellowing of lower leaves and stunting of plants. The xylem vessels develop brown discoloration and get distorted. The wilted plants may eventually die. When the diseased stem is cut, a dark brown, discolored band around the vascular system is commonly visible. Infection occurs directly through the root hairs.

Management: The disease is spread by soil, seed and water and secondary infection by Conidia through rain splash. Hot weather and warm soils favour its multiplication. Seed treatment with Carbendazim (2 g/kg of seed) protects the seedlings during the initial stages of growth and soil drenching with Copper oxychloride 0.25% has been found beneficial. Seed treatment with *T. harzianum* @ 15-20 g /kg of seed is also reported effective.

2. Powdery mildew: The disease is caused by *Erysiphepisi.* White powdery coating on leaves, twigs, tendrils and young pods are the characteristics symptoms, which appear when temperature is high during day time coupled with cooler nights followed by dew. Disease epidemic in plains appear almost every year at pod development stage during the months of January to March.

Management: Spray Sulphur 80%WP @1 kg in 300-400 L/acre or spray hexaconazole 5% SC @2 ml /L.

3. Rust: The disease is caused by *Uromyces fabae*and *U. pisi*. The disease can easily be identified by presence of yellowish rusty raised pustules on foliage. Leaves of infected plants exhibit many small, orange-brown pustules usually at the lower surface whereas comparatively larger pustules occur on the stems and some time on the pods. In severe infection seed size may be reduced and the affected plants dry up quickly causing about 30-50% yield loss. The disease is favoured by humid weather with heavy dew and low temperature (21-27^{o}C). Intermittent rainfall, plentiful dews and atmospheric temperature of 20-25°C favour the disease development.

Management: All the affected plant debris should be destroyed after harvest. Suitable crop rotation with non-leguminous crops must be followed. Immediately after first symptom noticed, foliar spray of wet table sulphur 80%WP (0.3%) for three times at 10 days interval from initiation of disease is advisable or spray Tabuconazole 25.9 % EC @1 ml /L.

a) Major Insects

1. Pod borer: *Helicoverpa armigera*(Hub.): (Lepidoptera: Noctuidae)

This polyphagous pest feeds on a wide range of vegetable crop plants such as okra, onion,brinjal, potato, chillies, cowpea, pea, beans, cereals and pulses etc. The younger larvae feed initially on the foliage for a while and later bore into the green fruits. The larva while feeding, thrusts its head into the fruit leaving the rest of its body outside.Apart from *H. armigera*, another insect *i.e.*, *Etiella zinckenella* Treit (Lepidoptera: Phycitidae) also feed on pods of pea and sometime causes serious damage to it.

Management: Deep summer ploughing to expose the larvae and pupae to sunlight and predation by birds is recommended. Use of pheromone traps for early pest detection and innundative release of egg parasitoid, *Trichogramma brasiliense* @ 2,50,000parasitised eggs/ha (Inundative release) during peak flowering stage is able to reduce its infestation. Spray HaNPV @ 250 LE with jaggery (10g/lit), soap powder (5g/lit) and a tinopal (1 ml/lit) or *Bacillus thuringiensis* varKurstaki @ 1 kg/ha during evening hours is also advisable.

2. Pea leaf miner: *Phytomyza atricornis Meigen.* : (Diptera**:** Agromyzidae)

The pest is generally active during December to April and spends its rest of the period in the soil as a pupa. The adult flies emerge at the beginning of December and after mating start-laying eggs singly in leaf tissue. After hatching the larvae feed between the lower and upper epidermis thereby making serpentine tunnels. At early stage mining also causes wilting in seedlings.

Management: Removal of old miner infested leaves is able to reduce the pest load form the filed. Installation of yellow sticky traps/ cards @ 4-5 traps/acre for leaf miners adult fly is advisable. Foliar spray of NSKE (4%) along with sticker during initial stage of infestation is beneficial.

3. Pea aphid: *Macrosi phumpisi*

Pea aphid is one of the serious pests of pea crop. The insect is pale green in colour. It attacks young vines sucking the juice from growing tip, later on covering the whole plant. It is also the carier of pea mosaic virus. The affected plants become stunted, leaves and pods have rough spots. Affected pods fail to fill.

Management: Spray 1 litre Dimethoate (Roger) 30 EC or 1.5 lit Metasystox 25 EC or Phormethion 25 EC in 600 liter of water/ha.

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Molecular basis of analyzing the quality of seeds in Pulses Crops

K R Soren and Sudhir Kumar Jha

Division of Plant Biotechnology, ICAR-Indian Institute of Pulses Research, Kanpur INDIA 208024

Introduction

Seeds are thought of as bearers of new technologies and as the primary catalyst for increasing agricultural output. As a result, the strength of an agricultural economy is determined by the timely availability of high-quality seeds of the proper kind in sufficient quantities. In several essential crops, intense crop improvement programmes have resulted in the production of a significant number of hybrids and high yielding cultivars. One of the most significant parts of quality control is genetic purity. Good germination, purity, vigour, and seed health are all indicators of seed quality.

Maintenance breeding is a branch of plant breeding which deals with principles and methods of breeder seed production and maintenance. It's a breeding procedure followed to maintain the genetic purity of the variety or parents of hybrids. It deals with principles and methods of breeder seed or nucleus seed production. It deals with ways and means of maintaining genetic and physical purity of released and notified variety. It's also known as varietal maintenance technology.

Maintenance breeding program (MBP) is mainly done for continuous breeder seed production of the released variety. It also undertakes breeder seed production of parental line of released variety. Genetic purity, physical purity, seed health and germination are the main points taken into account. Breeder and foundation seed is used as the base material for starting MBP. It prevents varietal deterioration due to mutation, cross pollination and other genetic and environmental factors.

Developmental Variation (differential growth response in different environments), Mechanical Mixtures, Mutations, Natural Crossing, Genetic drift, Selective influence of diseases, Breeder Techniques, Male Sterility Breakdown, Improper/defective seed certification System, and other factors all contribute to the loss of genetic purity (Kadamet al., 1942).

With the increase in the seed industry, there has been a refinement in the techniques used for testing genetic purity. Methods for testing genetic purity include different morphological, chemical, biochemical and molecular markers.

Methods to assess genetic purity:

1. **Morphological/Conventional grow out test (GOT)**: Morphological features of seeds such as length, width, thickness, shape, weight, color, seed coat color etc. are considered and are compared with those of authentic seed samples. These are examined with naked eye / with magnifying hand lens / with the help of a scanning electron microscope. For morphological tests in the field, the seed sample is sown in the controlled condition with the authentic sample and the genetic purity is determined on the basis of observation made on the plant morphological characters with reference to the authentic sample. Genetic purity is always expressed in percentage Grow out test

(GOT). Alongwith the ease, there are certain limitations of morphological methods. Environmental stress conditions often mask specific morphological traits. Large amount of land is required to grow the varieties. It is laborious and time consuming. Unfavorable conditions, i.e. disease and insect infestation may limit GOT in the field Morphological markers are becoming limited in relation to rapid increase in the number of varieties, hybrids and transgenics.

2. **Chemical tests:** Tests used to assess genetic purity are Phenol test, Potassium hydroxide test, Ferrous sulfate test, NaOH test. Advantages of chemical tests are that they are quick. They require virtually no technical expertise or training. Relatively inexpensive to conduct. No sophisticated equipment is required. The test permits detection of percentage admixture of other types. Its results are usually distinct and easily interpretable.
3. **Biochemical methods:** Electrophoresis, chromatography, peroxidase test are few to mention. It is done by electrophoresis migration of a charged particle through a medium (agarose, polyacrylamide, starch) under the influence of an electrical field. It is usually carried out in an aqueous solution. A mixture of molecules of various sizes will migrate at different velocities and will be separated. The varieties are verified on the basis of banding pattern, total number of bands, Presence or absence of specific band, Intensity of band etc. Chemical tests create very less polymorphism and are crop specific.
4. **Molecular Marker**: A genetic marker is a DNA sequence with a known location on a chromosome, and can be used to identify individuals or species. Restriction Fragment Length Polymorphism (RFLP) Random Amplified Polymorphic DNA (RAPD) Amplified Fragment Length Polymorphism (AFLP) Variable Number Tandem Repeat (VNTR), Single Nucleotide Polymorphism (SNP) Allele Specific Associated Primers ASAP Inverse Sequence-tagged Repeats (ISTR), Inter-retrotransposon Amplified Polymorphism (IRAP) are few to mention. General methodology for molecular markers based detection includes DNA extraction, PCR amplification, electrophoretic run on the gel and identification of PCR amplified products. Advantages of molecular techniques is that they have a very large number of polymorphism development as compared to the biochemical markers. It is reliable to all crops and it is a very fast method. But it is very costly and sophisticated instruments are required.

Advantages of genetic purity testing:

- It is helpful in plant variety protection, registration, certification and patents. To make IPR (plant breeders right and plant variety protection) part strong.
- It is also useful in detecting even the minute genetic differences between cultivars and for the existence of novelty among essentially derived varieties.
- Assurance of genetic purity for ensuring better agronomic performance and predicted expectations.
- Prevention of misappropriation and willful admixture of seed/cultivars at commercial or farmers level. Quality control of grains for processing.
- Genetic purity analysis is the important factor for quality seed.
- No loss to farmers because of poor seeds and assured higher returns.
- To increase crop production at national level.
- For distinctiveness, uniformity and stability (DUS) test.
- Documentation of genetic resources.

Genetic markers:

Genetic markers are biological characteristics dictated by allelic variants of genes or genetic loci that may be passed down from generation to generation, and so can be used as tags to trace an

individual, chromosome, or gene. There are two types of genetic markers used in genetics and plant breeding: classical markers and DNA markers (Xu, 2010). Morphological, cytological, and biochemical indicators are examples of traditional markers. DNA markers, such as RFLP, AFLP, RAPD, SSR, SNP, and others, have been developed into a variety of systems based on various polymorphism-detecting procedures or approaches (Collard et al., 2005).

Classical markers

Morphological markers: Markers have been used in breeding for a long time as an aid in selecting plants with desirable features. Leaf shape, pubescence color, pod color, seed color, seed shape, hilum color, awn type and length, fruit shape, rind (exocarp) color and stripe, flesh color, stem length, and other obvious features were utilized as markers in the early days of plant breeding. These morphological markers are usually genetic polymorphisms that are simple to identify and alter. As a result, they're frequently used in the building of linkage maps using traditional two- and three-point tests. Some of these markers are connected to other agronomic features and can thus be utilized as indirect selection criteria in breeding. Semi-dwarfism was one of the key factors in the success of high-yielding cultivars during the green revolution. This could serve as an example of how morphological markers can be used successfully in modern breeding. However, the number of morphological markers accessible is limited, and many of them are unrelated to crucial economic characteristics (e.g. yield and quality).

Cytological markers: Chromosome karyotype and bands are used in cytology to show the structural properties of chromosomes. The color, width, order, and position of the banding patterns reflect the differences in euchromatin and heterochromatin distributions. For example, quinacrine hydrochloride produces Q bands, Giemsa stain produce G bands, and R bands are reversed G bands. These chromosome landmarks are commonly utilized in physical mapping and linkage group identification, as well as for characterization of normal chromosomes and detection of chromosome mutation. In genetic mapping and plant breeding, however, direct use of cytological markers has been limited.

Biochemical/protein markers: Isozymes are distinct molecular weights and electrophoretic mobility variations of an enzyme that have the same catalytic activity or function. Because the variation in electrophoretic mobility is induced by point mutation as a result of amino acid substitution, isozymes reflect the products of various alleles rather than different genes (Xu, 2010). As a result, isozyme markers can be genetically mapped onto chromosomes and then utilized to map other genes. They're also employed in seed purity tests and plant breeding on occasion. In most crop species, there are just a few isozymes, and some of them can only be identified by a specific strain. As a result, enzyme markers are rarely used.

DNA markers

A DNA marker is a piece of DNA that can be used to detect variation in a population or gene pool by comparing genotypes or alleles of a gene. A DNA marker, in simple terms, is a small segment of DNA sequence that shows polymorphism (base deletion, insertion, and substitution) between individuals. Southern blotting and the PCR technique are the two most common methods for detecting polymorphisms. Variation in DNA samples or polymorphism for a given area of DNA sequence can be determined using PCR and/or molecular hybridization followed by electrophoresis, based on product properties such as band size and mobility. In addition to this, many more approaches for detecting polymorphism by sequencing have been developed over time.

An ideal DNA marker for marker-assisted breeding should meet the following criteria:

- High level of polymorphism.
- Even distribution across the whole genome.
- Co-dominance in expression, so that actual heterozygotes can be distinguished from the homozygotes.
- Clear distinct allelic features (so that the different alleles can be easily identified).
- Cost efficient marker development and genotyping.
- Easy detection assay and prone to automation.
- High availability (unrestricted use) and suitability to be duplicated/multiplexed.
- Genome-specific in nature (especially with polyploids).
- No detrimental effect on the phenotype of the plant.

In human linkage mapping, Botstein et al. (1980) were the first to apply DNA restriction fragment length polymorphism (RFLP). Since then, significant progress has been made in the development and improvement of molecular techniques that make it easier to find markers of interest on a large scale, resulting in widespread and successful application of DNA markers in animal genetics and breeding, plant genetics and breeding, cultivar genetic purity testing, and germplasm characterization and management. Microsatellites or simple sequence repeat (SSR), restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP), random amplified polymorphic DNA (RAPD), microsatellites or simple sequence repeat (SSR), and single nucleotide polymorphism (SNP) have all been extensively used and are promising for use in plant breeding.. The marker techniques help in selection of multiple desired characters simultaneously using F_2 populations, near isogenic lines, doubled haploids and recombinant inbred lines.

RFLP markers:

It's a type of marker that's based on Southern-Blotting. RFLP markers are one of the most essential techniques for mapping the genome of plants. They are the first generation of DNA markers. Mutations (deletion and insertion) can occur at restriction sites or between neighboring restriction sites in the genome of living organisms. Differences in restriction fragment size can be caused by gain or loss of restriction sites as a result of base pair modifications and insertions or deletions at restriction sites within restriction fragments. The recognition sites for restriction enzymes may be altered or eliminated as a result of these changes. As a result, different restriction products are formed when homologous chromosomes are digested using restriction enzymes, which can be detected using electrophoresis and DNA probing techniques. Most RFLP markers are co-dominant and locus-specific. RFLP genotyping is extremely reproducible, with a simple process and no special equipment is needed. High-throughput markers can be produced from RFLP probe sequences using an enhanced RFLP technology called cleaved amplified polymorphism sequence (CAPS), also known as PCR-RFLP. The majority of CAPS are created using SNPs identified in other sequences, followed by PCR and restriction site identification. The CAPS method involves digesting a PCR-amplified fragment and detecting the polymorphism by looking for restriction sites (Konieczny and Ausubel, 1993). Another benefit of RFLP is that the probe sequence does not have to be known. A researcher only requires a genomic clone capable of detecting polymorphism. Very few RFLPs have been sequenced to determine what sequence variation is responsible for the polymorphism. However, it may be problematic to interpret complex RFLP allelic systems in the absence of sequence information. RFLP analysis requires a significant volume of high-

quality DNA, has a low genotyping throughput, and is difficult to automate. The use and exchange of RFLP probes is limited due to the radioactive autography involved in genotyping and physical upkeep.

RAPD markers:

The RAPD marker system is based on PCR. In this approach, a single, short (typically about ten nucleotides/bases) and random primer is used to amplify an individual's complete genomic DNA by PCR. The primer, which binds to a variety of loci, is used to amplify random sequences from a complicated complementary DNA template (maybe including a limited number of mismatches). If two hybridization sites are comparable (at least 3000 bp) and in opposite orientations, amplification can occur during the PCR. The length and size of both the primer and the target genome determine the size of the amplified fragments created by PCR. The PCR products (up to 3 kb) are separated by agarose gel electrophoresis and imaged by ethidium bromide (EB) staining. Polymorphisms resulting from mutations or rearrangements either at or between the primer-binding sites are visible in the electrophoresis as the presence or absence of a particular RAPD band.

RAPD is primarily used to produce dominant markers. This technique produces high degrees of polymorphism while being simple and straightforward to use. First, neither DNA probes nor sequence information is necessary for the construction of particular primers. Second, because there are no blotting or hybridization steps in the operation, it is a quick, straightforward, and effective method. Third, compared to RFLP, just a little amount of DNA (approximately 10 ng per reaction) is required, and the technique can be automated. Additionally, larger degrees of polymorphism can be discovered. Fourth, there is no need for marker development, and the primers are non-species specific and can be used universally. Fifth, the desired RAPD products can be cloned, sequenced, and then transformed into or used to generate other PCR-based markers, such as low reproducibility and incapability to detect allelic differences in heterozygotes.

AFLP markers:

AFLPs are PCR-based markers, which are basically RFLPs that are visualized by selective PCR amplification of DNA restriction fragments. AFLP is based on the selective PCR amplification of restriction fragments from a total double-digest of genomic DNA under high stringency conditions, i.e. the combination of polymorphism at restriction sites and arbitrary primer hybridization. AFLP is also known as selective restriction fragment amplification because of this (SRFA). A synthetic adaptor sequence, the restriction endonuclease recognition sequence, and an arbitrary, non-degenerate 'selective' sequence make up an AFLP primer (17-21 nucleotides in length) (1-3 nucleotides). The primers utilized in this technique can perfectly anneal to their target sequences (adapter and restriction sites) as well as a limited number of nucleotides close to the restriction sites. The initial stage in AFLP is restriction digestion of genomic DNA (approximately 500 ng) using two restriction enzymes: a rare cutter (6-bp recognition site, EcoRI, PtsI, or HindIII) and a frequent cutter (6-bp recognition site, EcoRI, PtsI, or HindIII) (4-bp recognition site, MseI or TaqI). After that, the adaptors are ligated to both ends of the fragments, resulting in known sequences for PCR amplification. The double-stranded oligonucleotide adaptors are constructed in such a way that following ligation, the original restriction site is not reinstated. As a result, only fragments cut by the frequent cutter and the uncommon cutter will be magnified. This attribute of AFLP makes it exceedingly dependable, durable, and resistant to modest changes in PCR amplification conditions (e.g., heat cycles, template concentration), and

it also allows it to produce a high marker density. The AFLP products can be separated in high-resolution electrophoresis systems.

The fragments in gel-based or capillary DNA sequencers can be detected by dye-labeling primers radioactively or fluorescently. The number of bands produced can be manipulated by the number of selective nucleotides and the nucleotide motifs used.

A typical AFLP fingerprint (restriction fragment patterns created by the procedure) has 50-100 amplified fragments, with up to 80% of them potentially serving as genetic markers. In general, AFLP assays can be performed with tiny amounts of DNA (1-100 ng per individual). AFLP provides a high multiplex ratio and genotyping throughput, as well as being largely consistent among laboratories. Another benefit is that it does not require sequence information or probe collection before producing fingerprints, and it may be done with a single set of primers for diverse species. When DNA markers are scarce, this is very important. AFLP tests, on the other hand, have certain drawbacks. For instance, polymorphic information content for bi-allelic markers is low (the maximum is 0.5). Complete restriction enzyme digestion necessitates high-quality DNA. In some animals with big genomes, AFLP markers tend to cluster densely in centromeric regions (e.g., barley and sunflower). Furthermore, marker creation is time-consuming and expensive, particularly for locus-specific markers. Biodiversity studies, germplasm analysis, genotyping of individuals, identification of closely connected DNA markers, development of genetic DNA marker maps, production of physical maps, gene mapping, and transcript profiling are some of the applications of AFLP markers.

SSR markers:

SSRs, also called microsatellites, short tandem repeats (STRs) or sequence-tagged microsatellite sites (STMS), are PCR-based markers.They're small nucleotide motifs (2-6 bp/nucleotide) repeated in tandem at random. Di-, tri-, and tetra-nucleotide repeats, such as (GT)n, (AAT)n, and (GATA)n, are found abundantly in plant and animal genomes. Individuals differ in the number of copies of these repetitions, which is a source of polymorphism in plants. Primers specific for microsatellite areas are designed for use in PCR reactions since the DNA sequences bordering these regions are frequently conserved. Microsatellite loci are effective genetic markers because of their high level of allelic variation, which is one of their most essential characteristics. The SSR motifs' unique sequences serve as templates for specific primers used to amplify the SSR alleles via PCR. SSR loci are individually amplified by PCR using pairs of oligonucleotide primers specific to unique DNA sequences flanking the SSR sequence. The PCR-amplified products can be separated in high-resolution electrophoresis systems (e.g. AGE and PAGE) and the bands can be visually recorded by fluorescent labeling or silver-staining.

Hyper-variability, repeatability, co-dominant nature, locus-specificity, and random genome-wide distribution are all characteristics of SSR markers. SSR markers have the benefit of being quickly tested by PCR and easily identified by PAGE or AGE. SSR markers can be mechanized, multiplexed, and have high throughput genotyping. For manual test methods, SSR assays require only extremely little DNA samples (less than 100 ng per individual) and inexpensive start-up expenses. However, for automated detections, the SSR approach requires nucleotide information for primer construction, a labor-intensive marker development process, and significant start-up expenses. SSR markers have been widely employed in plant genetic linkage mapping, QTL mapping, marker-assisted selection, and germplasm analysis since the 1990s. Numerous breeder-friendly SSR markers have been created and are available for breeders in

many species. For example, approximately 35,000 SSR markers have been generated and mapped onto all 20 linkage groups in soybean (Song et al., 2010).

SNP markers:

A single nucleotide base difference between two DNA sequences or individuals is known as an SNP. SNPs are classified as transitions (C/T or G/A) or transversions (C/G, A/T, C/A, or T/G) based on nucleotide changes. Single base mutations in cDNA (mRNA) and single base insertions and deletions (indels) in the genome are both termed SNPs in practise. Because a single nucleotide base is the lowest unit of heredity, SNPs give the ultimate/simplest form of molecular markers. As a result, they can supply the most markers. SNPs can be found in both animals and plants. In plants, SNP frequencies are typically in the range of one SNP every 100-300 bp. SNPs can be found at varying frequencies in different chromosome regions inside gene coding sequences, non-coding portions of genes, and intergenic areas between genes.

Many SNP genotyping approaches have been developed based on various allelic discrimination and detection platforms. RFLP (SNP-RFLP) or the CAPS marker technique are two convenient methods for finding SNPs. If one allele has a restriction enzyme recognition site while the other does not, digestion of the two alleles will result in different length fragments. Analyzing the sequencing data stored in the major databases and identifying SNPs is a simple technique. When the full base sequence of a segment of DNA is analyzed, four alleles can be found, which are represented by A, T, G, and C at each SNP location in that segment. Based on molecular mechanisms, there are several SNP genotyping assays, such as allele-specific hybridization, primer extension, oligonucleotide ligation, and invasive cleavage (Sobrino et al., 2005), as well as various detection methods for analysing the products of each type of allelic discrimination reaction, such as gel electrophoresis, mass spectrophotometry, chromatography, fluorescence polarisation, arrays SNPs are currently widely found using sequencing.

SNPs are co-dominant markers that are commonly related to genes and present in the simplest/ultimate form of polymorphism, making them particularly appealing as genetic markers in genetic research and breeding. Furthermore, SNPs may be simply automated and swiftly discovered, with a high efficiency for polymorphism detection.

As a result, SNPs are likely to become more widely employed for a variety of applications, especially as complete DNA sequences for a growing number of species become available (e.g., rice, soybean, maize, etc.). However, costly start-up or marker development expenses, as well as the need for high-quality DNA and high technical/equipment needs, limit the use of SNPs in some laboratories and practical breeding projects.

The benefits and drawbacks of a marker system are highly dependent on the study goals, available genetic resources or databases, equipment and facilities, and so forth. Plant breeders are continually grappling with the selection and application of DNA markers in research and breeding. When a breeder chooses one or more molecular marker types, a number of considerations must be taken into account.

Comparison of most widely used DNA marker systems in plants (Collard et al. 2005, Semagn et al. 2006a, Xu 2010, and Guo-Liang Jiang 2012):

Feature and description	**RFLP**	**RAPD**	**AFLP**	**SSR**	**SNP**
Genomic abundance	High	High	High	Moderate to high	Very high
Genomic coverage	Low copy coding region	Whole genome	Whole genome	Whole genome	Whole genome
Expression/inheritance	Co-dominant	Dominant	Dominant / co-dominant	Co-dominant	Co-dominant
Number of loci	Small (<1,000)	Small (<1,000)	Moderate (1,000s)	High (1,000s – 10,000s)	Very high (>100,000)
Level of polymorphism	Moderate	High	High	High	High
Type of polymorphism	Single base changes, indels	Single base changes, indels	Single base changes, indels	Changes in length of repeats	Single base changes, indels
Type of probes/primers	Low copy DNA or cDNA clones	10 bp random nucleotides	Specific sequence	Specific sequence	Allele-specific PCR primers
Cloning and/or sequencing	Yes	No	No	Yes	Yes
PCR-based	Usually no	Yes	Yes	Yes	Yes
Radioactive detection	Usually yes	No	Yes or no	Usually no	No
Reproducibility/reliability	High	Low	High	High	High
Effective multiplex ratio	Low	Moderate	High	High	Moderate to high

Marker index	Low	Moderate	Moderate to high	High	Moderate
Genotyping throughput	Low	Low	High	High	High
Amount of DNA required	Large (5 – 50 µg)	Small (0.01 – 0.1 µg)	Moderate (0.5 – 1.0 µg)	Small (0.05 – 0.12 µg)	Small (≥ 0.05 µg)
Quality of DNA required	High	Moderate	High	Moderate to high	High
Technically demanding	Moderate	Low	Moderate	Low	High
Time demanding	High	Low	Moderate	Low	Low
Ease of use	Not easy	Easy	Moderate	Easy	Easy
Ease of automation	Low	Moderate	Moderate to high	High	High
Development/start-up cost	Moderate to high	Low	Moderate	Moderate to high	High
Cost per analysis	High	Low	Moderate	Low	Low
Number of polymorphic loci per analysis	1.0 – 3.0	1.5 – 5.0	20 – 100	1.0 – 3.0	1.0
Primary application	Genetics	Diversity	Diversity and genetics	All purposes	All purposes

Marker assisted genetic purity test involves the following activities:

1. Sampling seeds or plant tissues (usually at early stages of growth).
2. Extracting DNA from seeds/plant tissue samples.
3. Running PCR for the molecular markers associated with the trait of interest.
4. Separating and scoring PCR products by means of appropriate separation and detection techniques, e.g. PAGE, AGE, etc.
5. Identifying individuals/seeds/plant tissue samples carrying the desired marker alleles.
6. Selecting the individuals/seeds/plant tissue samples with desired marker alleles for target traits and desirable performance/phenotypes of other traits.

Characteristics of an appropriate and reliable marker system:

- Ease and low-cost of use and analysis.
- Small amount of DNA is required.
- Codominance.
- Repeatability/reproducibility of results.
- High levels of polymorphism.
- Occurrence and even distribution across the genome.

Furthermore, a high degree of correlation with the target gene is an important attribute for the markers that will be used. Selecting the markers will ensure the success of the gene selection if they are close to the target gene or are present within the gene. While DNA markers can be found at any stage of plant development, traditional markers are usually only visible at specific stages. As a result, the most common genetic markers employed in marker-assisted genotyping are DNA markers. Each type of marker has advantages and disadvantages for specific applications. SSRs, on the other hand, exhibit the majority of desirable traits and are thus the marker of choice for many crops. SNPs necessitate a deeper understanding of the specific single nucleotide DNA alterations that cause genetic variation between people. However, as more SNPs become available in a variety of species, they are becoming an increasingly essential type for marker-assisted genotyping.

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Seed Processing, Seed Testing & Packing in Seed Certification in Pulse Crops

B.S. Gupta
Ex.- Seed Certification Officer &
Master Trainer OECD Seed Schemes
Rajasthan State Seed & Organic Certification Agency Pant Krishi Bhawan, Jaipur

Seed Processing, Seed Testing & Packaging in Seed Certification of Pulse Crops

B.S. Gupta
Former Senior Seed Certification Officer
Rajasthan State Seed & Organic Certification Agency,
Jaipur (Raj.)
E-mail – bsgupta57@gmail.com
Mob.- 9413385486

Seed Certification Standards for **Pulses**

- Black gram
- Bengal gram
- Cowpea
- Green gram
- Horse gram
- Indian bean
- *Khesari* (Chickling vetch)
- Lentil
- Moth bean (Kidney bean)
- Peas (Field pea and Garden pea)
- Pigeonpea (*Arhar*)
- *Rajmash* (French bean)

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)	5/kg	10/kg
Weed seeds (maximum)	5/kg	10/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Germination (minimum)	75%	75%
Moisture (maximum)	9.0%	9.0%
For vapour-proof containers (maximum)	8.0%	8.0%

What is Seed Processing

- Seed processing is mainly a cleaning process of removing the undesirable material i.e. inert matter, weed seed, other crop seed, damaged seed, light & chaffy material from the raw seed by mechanical means to obtain the good quality seed.
- Seed cleaning is done on the basis of differences in physical properties of good & undesirable seed i.e.

1. Seed size (Length, width and thickness)
2. Weight/density
3. Shape
4. Surface texture
5. Colour

Steps of Seed Processing

1. Receipt/intake of raw seed from the seed growers
2. Physical verification of raw seed
3. Approval of seed processing plant
4. Drying (if necessary)
5. Pre-cleaning – preparing seeds for basic cleaning
6. Basic seed cleaning/ grading
7. Fine cleaning/grading
8. Sampling & submission of sample to STL
9. Seed treatment
10. Tagging & bagging
11. Issue of Certificate –II under Section-9 of the seed Act 1966
12. Storage- stacking of finally packed seed.

Receipt/intake of raw seed from the seed growers

- The seed production Agency accept the raw seed from the seed growers at the seed processing plant as per the estimated yield given by the certification agency at the time of final field inspection.
- Each and every bag of raw seed should have been marked the specific identification code of the seed grower including the name of crop, variety, class & stage of seed.
- The production agency check the moisture and physical quality of raw seed with reference to admixture of other crop seed, insect damage, inert matter and after weighing issue receipt to seed grower for the quantity received.
- No raw seed intake will be entertained by the certification Agency after the cutoff date as per the crop calendar

Physical verification of raw seed

- Seed production Agencies submit the complete information of raw seed procured by them to the certification Agency just after the cutoff date of intake.
- Certification Agency after receipt of intake list of raw seed conduct the physical verification in order to check the information submitted by seed production Agencies.
- Only physically verified stocks are entertained for further seed processing and certification.

Approval of seed processing plant

- The Production Agency after physical verification of raw seed request for the registration/renewal of their seed processing plant.
- The certification agency conduct the inspection of seed processing plant and evaluation is done with reference to essential parameters specified for the registration/ renewal of evaluation. (format)

Essential requirements for the registration/ renewal of seed processing plant.

(A) **Building** – The plant should be installed in a suitable building in a spacious processing shed having sufficient light facility, exhaust and ceiling fans, sufficient working space to provide storage of raw seed around the machine and to keep the graded seed, space for packing and movement of working personals.

(B) **Storage** – Sufficient and separate godowns for storage of each category of seed i.e. raw seed, graded seed, packed seed, under size seed, packing material & chemicals.

(C) **Machine & other equipments** – The processing machinery should have a set of standard equipment i.e. precleaner, seed grader, indented cylinder, gravity separator, seed treator, moisture meter, bag closer, vaccum cleaner, weighing machine. All the machines should be so arranged that seeds flow continuously from beginning to end.

During the inspection of seed processing plants marks is to be allotted for specified essential requirements. Out of total 100 marks minimum 60 marks is required for the registration/renewal.

Essential Guidelines in Seed Processing

- Every machine and their parts should be cleaned thoroughly before starting the grading and at the time of changing the crop/ variety to avoid mechanical mixing.
- The total processing area should be cleaned with special reference to seed as well as impurity.
- Only one crop/variety /seed grower code should be handled in the processing area at one time.
- The prescribed size of grading screen should be selected as per the crop and variety to be processed.
- The air velocity of air screen machine should be adjusted in accordance with the quality of raw seed.
- Observe the moisture of the raw seed before starting the grading.
- Cleaning of machines of screens at regular interval is to be done to get the good quality of seed.

Drying Importance

- Safe mechanical handling
- Low moisture content increases self life
- Reduces chances of insect infestation and mould growth
- Reduces loss of seed quality

Selection of screens Screen Action

- Screens separate seed by width and thickness.
- Screens are usually made of iron sheet and are perforated with round or oblong holes.

Screen Action

- Seed can be separated by thickness by using oblong or slotted screens. Since the seeds roll over the screens, the smallest dimension — the thickness — determines whether it will fall through the sieves.

Selection of Screen

Size: Scalping> Seed Components Pass,
Grading< Optimum thickness/dia. of good seeds

Shape of seed	Upper screen	Lower screen
Round	Round holes	Slotted holes
Oblong	*Slotted holes	Slotted holes

Processing operation
Phase-I : Pre-cleaning

- It is done by the pre-cleaner machine meant to prepare the raw seed for basic grading by removal of larger inert material from the raw seed and separate dust & light chaffy materials with a controlled air suction.
- Machine is having two screens upper and lower screen. The upper screen separate larger size inert material while lower screen separate the under size materials from the raw seed & pass on the good seed to the grading machine through elevators to increase the capacity of grading machine.

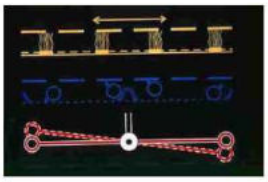
Processing Phase-II : Basic grading

- It is done by the seed grader machine which is designed for essential process of grading on the basis of differences in the seed size and weight.
- The process of grading is operated in three ways.

1. **Air suction** – The grading machine have two air systems (suction fans) designed as upper and lower air suction.
   (a)The upper air removes dust and light chaffy materials from the raw seed before they reach the upper screen. It is controlled by an air adjustable system.
   (b)The lower air suction removes the light seed and trashes from the lower screen. It is also controlled by an air adjustable system.

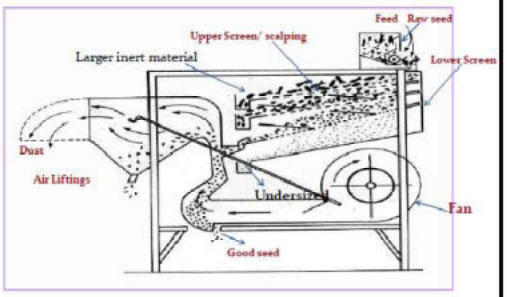
2. **Scalping** – The upper screen of grader further removes the larger inert material. The good seeds are dropped on lower screen through the perforation of upper screen. This screen is also called as scalper screen.
3. **Grading**- Lower screen of the grader, receives seed from the upper screen which flows over the openings while under size material and smaller seed, weed seed, damage seed dropped through the lower screen. The seed must flow on the screen in a single layer otherwise under size and lighter seeds material may pass with good seed to next stage & deteriorate the quality the cleaning of lower screen should be done at regular interval to avoid the clogging.

Cleaning of Screen



- During the cleaning process the screens have to be kept clean. Brushes, balls or knockers are used to remove the seed that gets stuck in the perforations of the screens.

Air-Screen Cleaner/Grader Working Principle



Processing Phase-III : fine grading/up grading

- Fine grading is done mostly by using indented cylinder and gravity separators.
- Indented cylinder is specifically used for the removal of weed seed and cut seed having thickness equal to the seed size not separated by the lower screen.
- The cylinder operates on a principle of centrifugal force in which the speed of the cylinder holds good seed in the indent while weed seed and cut seed smaller then the seed length fall separately.

Indented cylinder separator

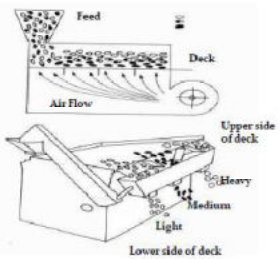
- It consists of indents which lift particles that fit into the indents. Particles which do not fit drop out of the cell and fall downwards.

Specific gravity separation

- Even after the seed is cleaned in the air-screen cleaner and the indented cylinder, it may be necessary to obtain higher-quality seed. In such cases, the seed can often be passed over the specific gravity separator.

Gravity separator

- Even after the seed is cleaned in the air- screen cleaner and indented cylinder to obtain fine quality of seed, the seed can be passed over the specific gravity separator.
- It operates on a flotation principle Separation of good seed and undesirable inert material take place on the basis of density by flotation.
- Gravity separator is having a deck with perforations and air blowing unit (fans) below the deck. The shaking deck pushes the heavy seeds upward with deck and air stream float lighter seed towards lower side of the deck.
- Slope & Oscillation controls movement of the gravity separator.



Formation of seed lot

- After grading certification Agency allot the lot no. to each identification code of farmer.
- In the IMSCS a procedure for formation of lot no. is defined to induce traceability of certified seed as detailed here :

1. First part- Called the harvesting month & year code- for ex., NOV. 15 it explain the crop is harvested in the month of NOV. 2015
2. Second part- Called the production location code and indicate State or Union Territory where the concerned seed field was located for this purpose each State is allotted a permanent numerical code by CSCB. For Rajasthan State the numerical code is 20.
3. Third part- This is called processing plant code and shall indicate the seed processing plant where the relevant lot was processed. The certification Agency allot the registration no. to the seed processing plant on request of seed production Agency. For ex. Durgapura , Jaipur allotted plant no. 1
4. Fourth part- The seed produce code it will indicate ultimate serial no. of an individual lot based on the raw seed of particular seed grower i.e. 01.

All the four parts in the lot no. shall be written in series with a dash (-) between First, Second, Third & fourth parts to distinctly indicate the code no. of each part. An example is shown below:

Lot no.: APR 23-20-01-01
APR23 - Seed harvested in APR23
20- Seed crop raised in Rajasthan
01- Seed processed in a processing plant at Durgapura , Jaipur
01- Seed produced code trace to the particular farmer

Seed lot size

- Seed lot – Is a physically identifiable quantity of seed which is homogeneous.
- The seed equal to the size of wheat the maximum size of seed lot will be 200 Qtls. subjected to the tolerance limit of 5 %
- The seed less than the size of wheat the quantity maximum size of seed lot will be 100 Qtls. subjected to the tolerance limit of 5 %
- The seed more than the size of maize the maximum size of seed lot will be 400 Qtls. subjected to the tolerance limit of 5 %

SAMPLING

- Procedure of sampling- Ensure that the entire quantity of seed to be sampled belongs to one lot.
- Determine the number of containers in the lot and the number of containers to be sampled for the lot.
- Up to 5 containers – Minimum 5 primary samples, from each container.
- 6 to 30 containers- Minimum 5 primary samples, one from every 3 containers whichever is greater.
- More than 30 – Minimum 10 primary samples, one from every 5 containers whichever is greater.

Sampling & submission of sample to STL

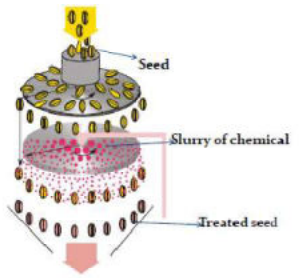
- The soon after completion of the seed processing certification Agency shall draw a representative composite sample as per procedure specified in Seed Testing Manual.
- The quantity of seed samples so drawn shall be sufficient to provide three samples of the size of submitted sample. The composite sample will be divided into three equal parts and one shall be sent for analysis to a notified Seed Testing Laboratory, the second part to the seed producer and retain the third part as a guard sample.
- **Primary sample**- Several individual samples are drawn from the different containers each such sample is called a primary sample.
- **Composite sample** – All the primary samples drawn from one lot are combined to form a bulk and is called composite sample.
- **Submitted sample**- A portion of seed derived from the composite sample to be submitted for analysis to Seed Testing Laboratory is called submitted sample. (minimum size of submitted sample is specified in ISTA rules). After proper sealing the sample is to be sent to STL.

Seed treatment

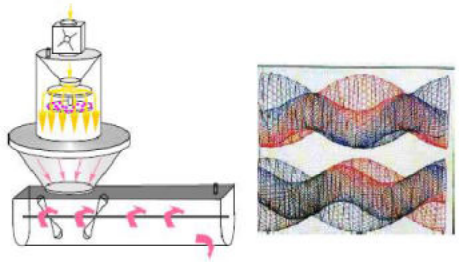
- The application of chemicals i.e. fungicides, insecticides or a combination of both, to seed so as to disinfect them from seed or soil borne pathogens and storage insects & pests.
- Method of seed treatment-

1. Dusting- The chemicals and seed are thoroughly mixed by mechanical mixer normally at the rate of 200 to 300 gm. Chemical/qtls.
2. Slurry- In this method the fungicide is applied to the seed in a soup like water suspension which is mixed with the seed in a special slurry treater. All foundation class seeds shall invariably be subjected to such treatment. To prepare a slurry 200 gm. of chemical mix with the 600 ml. of water for each qtls. of seed

Seed Treater



Seed Treater



Tagging & bagging

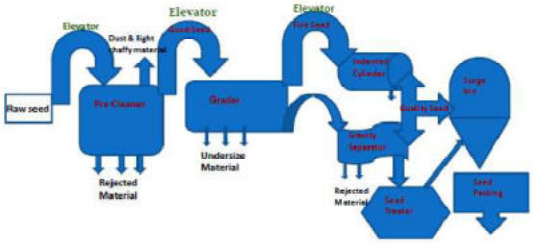
- On the receipt of seed analysis report and the results of the Grow-Out Test if seed lot has met prescribed standards, the certification Agency shall ensure packing, tagging and sealing of standard seed lots in a prescribed size of packing by using a approved packing material.(format of bag, tag & label). The certification Agency keep the complete packing record including the serial no. of tags issued by them.
- Advance packing- On request of seed production Agency may permit advance packing/ tagging of graded seed with certain conditions subjected to the submission of such undertaking by the production Agency that seed shall not be moved without receipt of satisfactory results from STL and In case seed lot found substandard the tag shall be returned back to the certification Agency.
- The validity of STL results is nine months from the date of test for the fresh seed lot and six month for carry over stock.

Seed Packaging

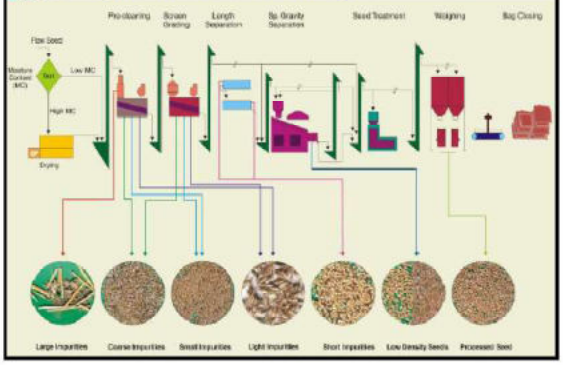
Issue of Certificate –II under Section-9 of the seed Act 1966

- On completion of all certification work the certification Agency shall issue a certificate II under Section-9 of the seed Act 1966 for each seed lot indicating all the required information's, regarding the seed standards, validity and serial no. of tags issued to that particular lot with the detail of seed producer.
- Now the seed shall be marketed by seed production Agency.

Flow chart of seed processing



Flow Diagram of Seed Processing



Storage- stacking of finally packed seed.

- After packing of seed, it may be stored in a suitable godowns having proper ventilation, high plinth, free from leaks and insect pests.
- Seed should be stored on wooden/iron palletes
- The stacks height should not exceed more than fifteen bags in case of cereals and pulses and 8 to 10 in case of Soybean seed.
- The proper distance should be maintained between stacks of different crop, varieties.
- Each stack should have stack card with details of seed stored.
- Fumigation and chemical spray chart should also be displayed.
- Store godown should be clean and free from any undesirable inert material.
- Fumigation of stacks should be done in regular intervals as and when required.

FORMATE OF BAG

Certification Void without tag & Seal

Class of Seed Stage (Not to be used for food, feed or oil prpose)

Crop :

Variety :

Lot Number :

Moisture (Max, When packed) :

Net Weight (When packed) :

M.R.P. :

Certified by :

Rajasthan State Seed & Organic Production certification Agency, Jaipur.

Produced and marketed by :

(Address of the registered seed Producer)

Delete Whichever is not applicable :

1. Treated with poison.
2. Treat the seed with the chemical kept in the bag as per direction before sowing.

SPECIFICATION FOR THE LABLE

(TO BE PRINTED BY PRODUCTION AGENCY)

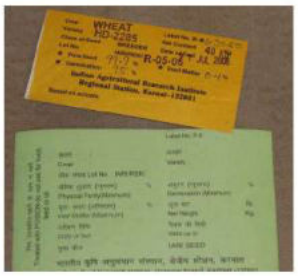
1. The length and breadth of the label shall be 15 X 10cm or proportionately small label may be used.
2. The content of the mark or label shall contain the following information namely.

a. Label No.....
b. Kind .....
c. Variety .....
d. Lot Number .....
e. Date, Month and Year of test .....
f. Valid up to .....
g. Germination (Minimum) .....
h. Physical Purity (Minimum) .....
i. Genetic Purity (In case of variety) (Minimum) .....
j. Net Weight .....
k. Moisture, When packed, (Max) .....
l. Name of the chemical used for seed treatment, If seed is treated .....
m. Name and address of the person who offers for sale, sells or otherwise supplies the seed
n. .....
o. If seed has been treated, the following statement shall also be printed on the label .....

"DO NOT USE FOR FOOD, FEED AND OIL PURPOSED"

1. The caution for mercurial's and similarly toxic substance shall be POISON in type size, Prominently displayed on the label in RED.
2. The colour Should resemble with opal green (IS No. 275).

Seed Label & Tag



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Seed Germination Testing

A. K. Verma[1] & Anil Varma Nalla[2]
[1]Sr. Seed Analyst, National Seed Research and Training Centre, Varanasi
[2]Jr. Seed Analyst, 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 $\pm$ 2^0C. 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 treatments 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 5^0C 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 30-35^0C, 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.

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Quality Seed Production Technology in Cowpeas (*Vigna unguiculata* L.)

Jyoti Devi*, N. Rai and T.K. Behera
ICAR-Indian Institute of Vegetable Research, Varanasi–221 305, India
*Corresponding Author Email: *jyoti17iivr@gmail.com*

1. Introduction

Cowpea, scientifically known as *Vigna unguiculata* L., is a resilient crop known for its remarkable drought-resistant nature. This versatile crop is known by various names, including black-eyed pea and southern pea, reflecting its widespread recognition and utilization. Its distinctively wide and drooping leaves play a crucial role in conserving soil moisture through their shading effect. Cowpea serves a multitude of purposes, like food, feed, forage, fodder, green manuring, and vegetables, making it an essential component in agriculture and human nutrition. Young cowpea pods and leaves are harvested and consumed as vegetables in numerous cuisines worldwide, adding freshness and nutrition to meals. Likewise, cowpea seed is a nutritious component in the human diet, and cheap livestock feed is as well. Cowpea can be utilized as fodder, particularly for ruminants like cattle and goats. As a legume crop, cowpea can be used for green manuring, improving soil fertility by fixing nitrogen. Cowpea seeds are a valuable component in the human diet. They are rich in protein, fiber, and various vitamins and minerals, making them a nutritious food source. Both green and dried cowpea seeds are suitable for consumption, and they can be canned or boiled for various culinary purposes.

2. Floral biology and breeding behavior

Highly self-pollinated because of Cleistogamy, close proximity of the anthers and stigma and simultaneous maturity of anthers and stigma.Inflorescence isAxillary raceme that may be branched with clusters of 5-6 flowers on a short but elongated peduncle.The flowers often have five generally fused sepals and five free petals. They are generally hermaphrodite, and have a short hypanthium, usually cup shaped. They are usually arranged in indeterminate inflorescences. The upper petal is called the standard petal which is large and envelops the rest of the petals in bud, often reflexing when the flower blooms. The two adjacent petals, the wings, surround the two bottom petals. The two bottom petals are fused together at the apex, forming a boat-like structure called the keel. The stamens are always ten in number, and their filaments can be fused in various configurations, often in a group of nine stamens plus one separate stamen.

3. Climatic Requirements

Cowpea is a warm-season crop ideally suited for semi-arid climates, thriving within a temperature range of 20°C to 30°C. The minimum temperature necessary for successful seed establishment is 20°C and above. However, when temperatures rise beyond 32°C, root development can be hampered. To achieve optimal production, daytime temperatures around 27°C and nighttime temperatures around 22°C are most favorable. Cowpea is highly sensitive to cold temperatures, and when exposed to conditions below 15°C, its yield is significantly compromised. While it has some tolerance for shade provided by trees, it cannot endure cold or frost, which can be detrimental to its growth and productivity. Hence, it's crucial to cultivate cowpea in environments that align with its warm and semi-arid preferences to ensure a successful harvest.

4. Land requirement, soil type & field preparation: Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.Well-drained loam or slightly heavy soils are best suited. In colder climates, somewhat sandy soil is preferred, as crops mature earlier in them. It can grow successfully in acidic soil but not in saline or alkaline soil. In hard soil, one deep ploughing followed by two or three harrowings and plankings is sufficient. In normal soil, only two harrowings are enough. For the summer season crop, give irrigation immediately after harvesting the *rabi* crop.

5. Climatic Requirements

Cowpea is a warm-season crop ideally suited for semi-arid climates, thriving within a temperature range of 21°C to 35°C. The minimum temperature necessary for successful seed establishment is 20°C and above. However, when temperatures rise beyond 32°C, root development can be hampered. To achieve optimal production, daytime temperatures around 27°C and nighttime temperatures around 22°C are most favorable. Cowpea is highly sensitive to cold temperatures, and when exposed to conditions below 15°C, its yield is significantly compromised. While it has some tolerance for shade provided by trees, it cannot endure cold or frost, which can be detrimental to its growth and productivity. Hence, it's crucial to cultivate cowpea in environments that align with its warm and semi-arid preferences to ensure a successful harvest.

6. Soil Type & Field Preparation

Well-drained loam or slightly heavy soils are best suited. In colder climates, somewhat sandy soil is preferred, as crops mature earlier in them. It can grow successfully in acidic soil but not in saline or alkaline soil. In hard soil, one deep ploughing followed by two or three harrowings and plankings is sufficient. In normal soil, only two harrowings are enough. For the summer season crop, give irrigation immediately after harvesting the Rabi crop.

7. Sowing Time

Cowpea can be grown in spring-summer, rainy seasons, rainy autumn and early autumn.
In place with moderate temperature crop can be grown throughout the year. For seed production, rainy autumn and early autumn sowing is the best because the pods are matured in dry conditions. For green manure crop can be sown during mid-June to ist week of July.

8. Varieties

Cowpeas varieties can be group according to its end uses like used for vegetables or *daal* purpose, fodder or green manure type's etc. Within the vegetable type there are different cultivated forms like bush types and pole type. Table 1 list out some of the recent varieties in vegetable cowpeas while Table 2 represents the grin and fodder type varieties.

Table1: Vegetable cowpeas varieties along with their characters

Variety	Characters
Bush type cultivars	
Arka Samrudhi	Plants are erect, bushy and photo-insensitive. Pods are green, medium thick, medium long round, tender, fleshy without parchment with good cooking qualities. Pod Yield: 19 t/ha in 70-75 days.

Arka Suman	Plants are erect, bushy and photo-insensitive. Pods medium long, tender, fleshy, crisp, without parchment with good cooking qualities. Pod Yield: 18 t/ha in 70-75 days.
Pusa Sukomal	Plants are bushy that flowers in 45 days. Pods are light green, 25-30 cm long. Resistant to bacterial blight. Yield 10 t/ha
Kashi Kanchan	This is dwarf and bush type (height 50-60 cm), photo-insensitive, early flowering (40-45 days after sowing) and early picking (50-55 days after sowing) variety suitable for growing in both spring-summer and rainy seasons. Pods are about 30-35 cm long, dark green, soft, fleshy and free from parchment. The cultivar gives green pod yield of about 150-175 q/ ha and is resistant to golden mosaic virus.
Kashi Unnati	This is a photo-insensitive variety. Plants of this variety are dwarf and bushy, height 40-50 cm, branches 4-5 per plant, early flowering (30-35 days after sowing), first harvesting at 40-45 days after sowing, produces 40-45 pods per plant. Pods are 30-35 cm long, light green, soft, fleshy and free from parchment. The cultivar is resistant to golden mosaic virus and *Pseudocercospora cruenta*, and gives green pod yield of about 125-150 q/ ha.
Kashi Nidhi	Plants are dwarf, erect and bushy, with 20-25 peduncle per plant. Fruits are green, 25-30 cm long. Seed colour is reddish brown. Golden mosaic virus and Pseudocercospora cruenta tolerant with an average pod yield of 140-150 q/ha. Better yield and keeping quality suitable for distant marketing.
Pusa Dofasli	IARI, it is cross between Pusa Phalguni X Philipine selections. Photo insensitive, bushy cultivar and suitable for both summer and rainy seasons. The crop comes to harvest in 55-60 days and yields about 7.5-8t/ha.
Pusa Komal:	It is selected through pure line selection. Photo insensitive, indeterminate, bushy cultivars. Pods are light green, 25-30cm long. It flowers in 40-45 days. Resistant to bacterial blight, comes to harvest in 60 days and produces 10t/ha of green pods
Pusa Rituraj	The variety can be grown in summer as well as kharif due to it's highly photo thermo insensitive nature, bushy type. Pods are 22-24cm long, thin and palatable. Dual purpose variety. Seeds brown. The harvest starts from 45-50 days. Average yield is 8-9t/ha green pods.
Pusa Dharni	This variety is early in maturity, bears long green pods (20-25 cm) in 2-4 clusters, sweet in taste and highly suitable for growing during *Kharif* and spring-summer season both. The variety has been developed as pure line selection from local market of Bhabua district Kaimur, Bihar. Resistant to Golden mosaic virus.
Pusa Phalguni	The plants are dwarf, bushy and mature in 60 days. Suitable for February-March sowing, yields 5-10t/ha.
Cowpea 263	It is a selection from the material collected from Bangalore. It is photo-insensitive and is suitable for cultivation both in spring and rainy seasons. Its pods are green, thick, tender and medium long (20 cm). Average yield is 100 quintals per hectare. It is resistant to cowpea mosaic virus.

Tall type	
Arka Garima	Plants are tall, photo-insensitive. Pods are light green, long, thick, round, fleshy and stringless. Suitable for vegetable purpose. Tolerant to heat and low moisture stress. Pod Yield: 18 t/ha in 70-75 days.
Arka Mangala	Plants are tall (3-4 m), pods are very long (80 cm), light green, stringless, round, tender with crisp texture and matures in 60 days . Suitable for *kharif* and *Rabi*. Pod yield: 25 t/ha in 100 days.
Vyjayanthi	Trailing growth habit, long wine red coloured pods, brown seeds, Av. Length of pod50.62 cm. Average fruit weight 16.17 g. No. of seeds/pod 20-22.Productivity 12.6 t/ha
Pusa Barasati	Suitable for kharif season, viny plant habit and comes to harvest in 45 days after sowing, yield about 9-9.5t/ha.

.

Table 2: List of pulse type cowpea varieties

State-wise Recommended Varieties (Pulse Type)	
M.P.	Gujarat Cowpea-3, V-240, Gujarat Cowpea-4, UPC-622
M.H.	PhuleVithai
Gujarat	Pant Lobia - 4, Pant Lobia - 3
T.N.	Vamban-1, Co-6, UPC-628
Karnataka	KBC-2, IT-38956-1, PKB-4, PKB-6
Rajasthan	RC-101, RCP-27 (FTC-27), Pant Lobia-4 Pant Lobia-3
Punjab	CL-367, UPC-622, VRCP-4 (Kashichand)
C.G.	Khalleshwari
U.P.	UPC-622, Swarna Harita (IC285143), Kashi Chandan, UPC -628, Pant Lobia-1
Jharkhand	UPC-628
Haryana	Hisar Cowpea 46 (HC 98-46)
Uttrakhand	Pant Lobia-5, Pant Lobia-4, Pant Lobia-3, Pant Lobia-2

Source: *Seednet GOI, Min. of Agri. & FW, & ICAR-IIPR, Kanpur*

Fodder type varieties

Kharif: GFC1, GFC2, GFC3: **Summer Season:** GFC4, Bundel Lobia-1, UPC-287 and UP5286, Russian Giant, K-395, IGFRI-5450 (Khinnoor), C-88, UPC5287, UPC-4200, UPC618, UPC-62, UPC622, UPC-625, UPC628.

10. Isolation distance: It is importantadjacent cultivars should be at least 25 m apart with distance increased to at least 50 m for nucleus and stock seed production. For certified / quality seed production leave a distance of 5 m all around the field from the same and other varieties of cowpea.

11. SeedRate and treatment

Vegetable type Bush type	18-20kg/ha
Vegetable Pole type	12-15kg/ha
For pure crop (grain)	20-25 kg ha
For fodder and Green Manure	30-35

Like all other legumes, cowpea forms a symbiotic relationship with the soil occurring bacteria viz. *Rhizobium*strain @10g/kg of seed. In soils where cowpea is being sown the first time,

inoculation of seed with *Rhizobium* Frank culture facilitates quick nodulation on roots and helps in the fixation of atmospheric nitrogen. The culture should not be exposed to heat or direct sunlight.

12. Spacing

- Intermediate viny types as sole crop: 75×60cm
- Bushy and vigour cultivars: 50-60 × 50-60cm
- Busy and semi-vigorous cultivars: 45-50cm × 25-30cm
- Bush type: 60 × 15cm

13. Fertilizer applications: Apply FYM/compost 15-20t/ha as basal with last ploughing.15-30kg N/ha as starter dose in poor soils (organic carbon<0.5%),50-60kg/ha P_2O_5,and50-60kgK_2O/ha. Phosphorus and potassic fertilizer should be given according to soil test value. Cowpea is sensitive to zinc deficiency. In zinc deficient soils, application of Zinc Sulphate @ 10-15 kg per hectare is beneficial to the crop.

14. Water Management

Cowpea is shallow rooted crop and requires comparatively less moisture for its growth and development. For the summer crop, irrigation is the most critical of all inputs, followed by weeding and fertilizer. Generally, crops require 5–6 days of irrigation, depending on soil, prevailing weather conditions, etc., at an interval of 10–15 days. The response to irrigation is in the order of flowering>pod filling>vegetative. Crops can tolerate flooding for up to 2 days at flowering and pod setting thereafter, resulting in a marked decrease in yield and its attributes.

15. Weed Control & Intercultural operation

For higher yield crop should be free from weed upto 25 to 30 day crop stage. Application of pendimethaline 30% EC@ 0.75- 1kg a.i./ha combined with one hand weeding at 35 days after sowing is beneficial.

- Pinch the tendrils off for promotion of flower production.
- Spray NAA 40 ppm (40 mg in 1 litre) to reduce the flower drop.
- Spray DAP 2% at flower initiation and at peak flowering stage to promote pod setting.
- Pull out and destroy the plants exhibiting severe symptoms of mosaic in the early stages of growth.

15. Roguing

Careful and rigorous roguing on a plant basis is essential, particularly for the production of foundation seed. Roguing of the seed crop should begin with uprooting of the off types based on growth and leaf characters before anthesis which should continue up to mature fruit stage. Roguing at flowering and after pod formation needs to be done.Off types and plant affected by blight and pea mosaic must be removed as soon as observed. Rouging should be done atthree differences stages.

- **Before opening the first flower**: At this stage, roguing should be done considering the growth habit and foliage characters typical of the cultivar.
- **Early flowering stage:** Roguing is done on the basis of the observable characters of inflorescence and flower.
- **Fruits Setting Stage**: Off-types are rogued out considering the satisfactory level of productivity, and fruit characters including size, nature, shape, and colour are approaching the fruit stage.

18. Harvesting, Threshing, Yield and Storage

Green pods for use as vegetables can be harvested 45–90 days after sowing, depending on the variety. For grains, the crop can be harvested in about 90–125 days after sowing, when pods are fully mature and the moisture content of seeds will be about 18 per cent.Harvest the pods as they turn light straw in colour and the seeds turn brown or mottled in colour. Harvest the pods as picking (4–5 No) at 10 days interval.Air dries the pods for 1-2 days and then sundry until they become brittle. Beat the pods with pliable bamboo stick or pulse thresher by adjusting the cylinder speed to avoid splitting and cracking of seeds. The crop should then be dried and threshed; the threshed grain should be dried in the sun before storage.For fodder, the cutting of the crop depends upon the need and the stage of growth of the component crop sown with it. Generally, it should be done 40–45 days after sowing.

Drying

- The broken and immature seeds should not be selected for seed purpose.
- Dry the seeds to 8-10% moisture content.

Yield: Dependingupon the variety and the agro-climatic conditions, pod yield of cowpea varies from 80-180quintals per hectare.A good seed crop of cowpea yields about 12–15 q of grain and 50–60 q of straw per hectare. If the crop is raised for fodder purposes, 250–350 q of green fodder are obtained per hectare.

Seed treatment before storage

- Slurry treat with carbendazim @ 2g kg-1 of seed along with carbaryl @ 200 mg kg-1 of seed (or)
- Slurry treat seeds with halogen mixture (CaOCl2 + CaCO3 + arappu (*Albizziaamara*) leaf powder mixed in the ratio of 5:4:1) @ 3g kg-1 as eco-friendly treatment.

Storage

- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with seed moisture content of 8 - 9%.
- Store the seeds in polylined gunny bag for medium term storage (12- 15 months) with seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than15 months) with seed moisture content of less than 8%.

16. Plant protection measures

1. Bacterial Blight: Bacterial blight is caused by the bacterium *Xanthomonas axonopodis*pv. *vignicola*, which occurs in humid and moderate subtropical climates where cowpea is produced.The germinating seedling turns brown-red and dies. Irregular to round spots brown in colure with chlorotic halos appear on leaves and later spread to stems. Stems may break, and pods are also infected, leading to shrivelled seeds. Depending on the cultivar and the plant growth stage during which infection occurs, bacterial blight can reduce yield by up to 92% and emergence in infected seeds by 67%. Secondary infection can increase plant mortality by 81%.This aggressive pathogen is carried on the seeds and can survive in soil, crop residue, and seed, as well as on alternative hosts such as lablab bean, common bean and sunhemp. Seed and crop residue are the main source of infection, but it is also spread by insects and wind-driven rain.

Control Measures

i) Grow resistant varieties; ii) Use healthy and disease free seeds; iii) In case of severe infection, crop may be sprayed with 0.2 % (2g/liter) copper oxychloride (Blitox).

2. Cowpea Mosaic virus

It is caused by a virus transmitted by aphids. The affected leaves become pale yellow and exhibit mosaic, vein banding symptoms. The affected leaves become reduced in size and show puckering. Pods are also reduced and become twisted.

Control Measures: i) Use healthy seed from healthy crop; ii) Roguing out of cowpea mosaic virus diseased plants in the early stage of growth up to 30 days and spraying twice at fortnightly intervals with any registered insecticide. Spray 1 litre Dimethoate (Roger) 30 EC or 1.5 lit Metasystox 25 EC or Phormethion 25 EC in 600 liter of water/ha.

3. Powdery Mildew

Powdery mildew is visible on all the aerial parts of the affected plants. Symptoms first start with leaves and then spread to stems, branches, and pods. This white growth consists of the fungus and its spores. Affected leaves become twisted and smaller in size.

Control Measures: After harvest, collect the plants left in the field and burn them. The disease can be controlled by spray Sulphur 80%WP @1 kg in 300-400 L/acre or spray hexaconazole 5% SC @2 ml /L.

3. *Cercospora leaf spot: Cercospora cruenta and Cercospora canescens*

Rough circular, cherry red to dark red spots of variable sizes are formed by *Cercospora cruenta*. Black mats due to moldy growth of fungus are formed on leaves by *C. canescans*. Defoliation occurs in both the cases. At maturity infected pods show black sporulation of fungus.

Control measure: Spray the crop with Indofil M-45 @ 2 g per litre of water. If required, repeat the spray at 7-10 day intervals.

4. Rust (*Uromyces phaseolivignae*)

The disease mostly attacks leaves and rarely stem and petioles. Rust pustules appear in the form of minute, slightly raised spots which enlarge to form reddish brown sori. These soriin advanced stage turn dark brown to black with formation of teliospores. Severely affected leaves turn yellow and may fall off.

Control measure: All the affected plant debris should be destroyed after harvest. Suitable crop rotation with non-leguminous crops must be followed. Immediately after first symptom noticed, foliar spray of wet table sulphur 80%WP (0.3%) for three times at 10 days interval from initiation of disease is advisable or spray Tabuconazole 25.9 % EC @1 ml /L.

5. **Ashy stem blight (*Macrophomina phaseolina*)**

The disease is caused by seed-transmitted fungus *Macrophomin aphaseolina*. Initially, brown lesions appear on the collar region. These lesions later on spread rapidly covering the whole stem and killing the growing point. The vascular tissues turn brown and rootlets rot resulting in plant death.

Control measure: Fertilize the crop to promote vigorous growth.

- Irrigate to keep soil moisture high.
- Fumigate or flood the soil before planting to reduce primary inoculum.
- Use fungicides to treat seeds and transplants before planting.

6. ***Bacterial blight (Xanthomonas vignicola)***

Bacterial blight is a seed borne disease. The affected leaves show light yellow, irregular to circular spots with necrotic brown centre which later on changes to straw colour. Dark green water soaked lesions of variable shapes and sizes appear on pods, which later on turn, yellow and dry.

Control measure: Practicing crop rotation with non-leguminous can help reduce the buildup of the pathogen in the soil.Use of disease free seed, deep ploughing, long term crop rotation and destruction of diseased plant debris helps to reduce the disease. Treating bean seeds with hot water or chemical treatments can help reduce the chances of introducing the bacterium through infected seeds.

Insect-pest management:

1. Cowpea Pod Borer: Many species of beans are hosts, including French bean, cowpeas, pigeon peas and yard long beans.The caterpillar rolls the leaves and webs them with the top shoot. Caterpillars bore into the pods and feed on the seeds; if flowers and pods are not available larvae feed on foliage.

Control Measures: i) Collect and destroy the eggs and young larvae; ii) The young caterpillar can be killed by dusting 2% Methyl parathion at 25–30 kg per hectare or spraying Quinalphos at 2 ml/litre of water; iii) Fix a 3-foot stick in the field at 0/ha bird parches to attract predatory birds.

2. Hairy Caterpillar: It is a major insect of cowpea. It is used to cut juvenile plants and eat away all the green matter on the leaves.

Control Measures: I) Collect and bum the eggs and larva of the insect; ii) The young caterpillar can be controlled by spraying Quinolphos at 2 ml/liter of water.

3. **Aphids and Jassids**: The adults and nymphs of these pests suck the juice from the leaves, and the damage is more severe when the plants are young. As a result of sucking sap, the leaves turned brown and crumbled, and the plant looked sick.

Control Measures: i) Spray of Oxydemeton Methyl 25 EC (Metasystox) @ 1 ml/litre or Dimethoate 30 EC at 1 ml/liter of water

4. Bean Fly/Stem Fly: The bean fly causes the characteristic swelling swelling stem at ground level, where the maggots burrow onto the stem. The maggots are at the base of the plant, and as the stem grows, it often cracks. The petiole often shows dark streaks where the maggots have moved through damaged tissue.

Control Measures: I) Keeping the field clean from legume debris; ii) Application of Phorate (Thimet) 10 G @ 10 kg per hectare in furrows at the time of sowing is effective for avoiding infestation.

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Post-Harvest Management for Seed Quality Assurance in Pulse Crops

Dr. S. K. Goyal
Assistant Professor (S-3)
Deptt. of Agricultural Engineering, Institute of Agricultural Sciences, RGSC,
Banaras Hindu University, Barkachha, Mirzapur – 231 001 (U.P.)

Abstract

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

Introduction

Pulses are one of the most important food crops globally due to its high protein content. India, in Pulses as well, accounts for the largest producer in the world. It is pertinent to note that, India exported 2,96,169.83 MT of pulses to the world worth Rs 2,116.69 Crores during the year 2020-2021.Seed is a basic input in agriculture and it plays a crucial role in boosting up the productivity and economy of the country. Without the use of good quality seed, the investments, incurred on fertilizers, pesticides and water will not play dividend which must to be realized. Therefore, the pace and progress in food production of a country, will greatly depend on the availability of required quantities of seeds of superior genotype and hybrids.

Quality seeds are inevitable to meet the challenges of ever-increasing population and food security. Being the carrier of technology, seed over the period of time evolved as the trade commodity. India being the 5th largest player in global seed market and a wide range of crop seed being produced under varied agro-climatic condition, there is a scope for up-scaling revenues through seed export. Seed quality assurance in India comes under the jurisdiction of the Seeds Act 1966, wherein quality seed must satisfy the requirements of Indian Minimum Seed Certification Standards (IMSCS), but under global scenario seed quality assurance system for seed export comes under the scope of Organization for Economic Cooperation and Development (OECD) standards and International Seed Testing Association (ISTA) methodology of seed testing.

Achieving self-sufficiency in pulses

With the view to enhance the production of pulses, the government has put in place – National Food Security Mission (NFSM). Under this mission, assistance is extended by the State Governments to farmers for interventions like cluster demonstrations on improved package of practices, demonstrations on cropping system, seed production and distribution of High Yielding Varieties/Hybrids, improved farm machineries/resource conservation machineries/tools, efficient water application tools, plant protection measures, nutrient management/soil ameliorates, cropping system-based trainings to the farmers etc. Additionally, the mission also extended support to Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs)/Krishi Vigyan Kendras (KVKs) for transfer

of technology to the farmer under supervision of Subject Matter Specialists/Scientists. Besides, Rashtriya Krishi Vikas Yojana RAFTAAR (RKVY-RAFTAAR) provides provision for crop production related activities on pulses.

There has been a significant rise in the production of pulses in the country, due to government interventions and policies. In 2019-2020, production of pulses remained 23.03 million tonnes. For the year 2020-21, production of pulses increased 25.46 million tonnes.

Seed quality control

Quality control is an important component of the seed programme. A seed programme without the provision of regulating the seed quality control measures may affect badly. There are two aspects of quality control. Firstly, the genetic purity of the seed maintained during the production and marketing. Secondly, it should have adequate qualities like high germination and physical purity, free from weed seeds, disease and have optimum moisture content. Many parameters of the quality seed production are managed with good post-harvest management during seed processing.

Pulses in India

India grows such a variety of grain legumes which none of the countries in the world grows. There are nine major grain legumes (chickpea, pigeon pea, urd bean, mung bean, horse gram, moth bean, lathyrus, lentil and peas) which together account for more than 95% of the total area under pulses. There are 11 minor grain legumes viz. cowpea, broad bean, dry bean, rice bean, winged bean, adzuki bean, hyacinth bean, lima bean, jack bean, zombie pea and pilli pesera, which are grown sporadically in isolated pockets. Grain legumes are an important source of dietary protein for many people in developing world with a protein content meanly twice as high as that in cereals. They are the cheap source of quality protein that complements the protein in cereals and thus enhances the nutritional value of cereal dominated diets. Green pods of many legumes, tender shoots and leaves and roots in few legumes are consumed as vegetables. The green stalks and dry straw form nutritious animal feed. Through symbiotic nitrogen fixation, legumes play significant role in low-input agriculture by reducing the dependence on nitrogen fertilizers. Thus, contribution of pulses to soil fertility is a key factor in sustaining the production of cereals in the rain-fed dry areas in the developing world.

Constraints in quality seed production of pulses

Among major production constraints, availability of quality seed of improved varieties has been a major constraint in enhancing production and productivity of pulses in India. Despite a target of 10% of seed replacement rate we could not achieve even more than 7% at country level. This is primarily due to lack of organized seed production programme for pulses. Still, we do not have a proper medium term (4-5 years) seed rolling plan for major pulses producing states. The indent for breeder seed is quite low in many cases and that too is for old varieties. There is poor conversion of breeder seed to foundation and certified seed. Even true picture of conversion of breeder seed to foundation and certified seed is not available for most the states. To insure timely availability of quality seed, capabilities of seed production must be enhanced with introduction of contractual obligation component by involving seed societies, farmers, private sectors, FPOs and NGO's besides SAU's, Seed hubs of Pulses (at KVKs), IIPR and State Seed Corporations. Participation of growers in seed production should be encouraged by way of simplifying the registration and seed certification procedures.

Chickpea: Chickpea is grown on about 8.75 million ha covering almost all agro-ecological zones of the country and the maturity period varies (95-170 days) among zones. Therefore, it is imperative to produce the seed of a particular variety in its area of recommendation or in nearly states. The production levels and quality of seed produced is usually better in central and northern India than the coastal areas of the country. The fields free from weeds, diseases,

salinity and water logging ensure better quality of nucleus and breeder seed of high yielding varieties.

Mung bean: Since, mung bean can mature just in 60-70 days in most of the seasons and area, area is increasing in northern India as summer/ spring season crop between wheat and rice or after potato and rapeseed-mustard. The Overall demand for breeder seed of mung bean has increased considerably. For example, mung bean has tremendous potential for cultivation in Rajasthan and it has shown impressive area coverage from 3.66 lakh ha in 1991-95 to more than 9.80 lakh ha in 2009-10. Uttar Pradesh has shown positive growth rate for area under spring/summer whereas Maharashtra has also shown a significant increase in area in kharif season in during last 10 years.

Urd bean: Urd bean is the third most important pulse crop of India cultivated over a wide range of agro climatic situations. The major urd bean growing states of the country are Maharashtra, Andhra Pradesh, Madhya Pradesh and Tamil Nadu. Development of short duration, photo-thermo-insensitive and disease resistant varieties has led to its cultivation as a sole or intercrop during spring season in north India and as a sole relay crop during rabi season in the rice fallows of the coastal peninsular India. Uttar Pradesh has shown progressive increase both in area and production. This occurred mainly due to the popularization of high yielding varieties and improved production technology. The demand for quality is increasing in most of the states.

Pigeon pea: Pigeon pea is a hardy, widely adapted and drought tolerant crop with a large temporal variation (90–300 days) for maturity. These traits allow its cultivation in a wide range of environments and cropping systems. In India, pigeon pea area and production have increased about 70% and 75%, respectively since 1950-51. However, productivity (~ 8 q ha^{-1}) has remained almost the same. During the period, traditional long-duration types (mostly grown in north-eastern plains) have been continually replaced by short- (northwest plains, central and southern India) and medium duration (mostly central and southern India) varieties. These varieties although improved in per day productivity are low yielder compared to long-duration types. This is one of the reasons why no breakthrough has been realized in the productivity of pigeon pea. The indirect impact of these improved early and medium varieties has been on enhancement of overall crop intensity. Bihar ranks first in productivity (12-12.5 q/ha). South and central zones which account for nearly 2/3rd of the total area have productivity even lower than the national average yield. Since, pigeonpea crop is often cross pollinated (6-35% cross pollination), it becomes difficult or almost impossible to maintain genetic purity of seed at farm level. Therefore, systematic seed production programme for high yielding varieties involving farmers and other stakeholders is of paramount importance for this crop because it may not be possible for government agencies to produce and supply quality seeds every year for huge area.

Best practices to ensure quality seed production

Production of high-quality seed is fundamental to modern agriculture. Most annual crops are established each season from seeds, and seed quality can have a major impact on potential crop yield. Seeds can serve as the delivery system not only for improved genetics but also for new planting and production methods and crop protection strategies that improve the overall efficiency of agriculture and reduce its environmental impact. The purity of any commercial product propagated by seed begins with the genetic purity of the seed planted. Genetic purity standards have been established by state seed laws and seed certification agencies to assure growers that the seed they buy is accurately labelled with the correct crop and variety. Seed purity standards also specify the percentage of contamination by seeds or genetic material of other varieties or species. The physical purity of seed refers to the presence and identity of weed seeds, and the percentage of other materials such as dirt or plant residues. In addition, the germination capacity of the seed in a standard test must be shown on

the label. In some cases, seeds must also be tested for the presence of seed-borne diseases, and hybridity tests are conducted to confirm parentage in hybrid seed. Production of high-quality seed is an exacting task. Seed producers take many steps to protect genetic integrity, including ensuring the integrity of their planting seed, properly identifying and labelling plants and fields, planting seeds on clean land which has not been used to grow the same crop in the recent past, removing rogue plants, or plants which are not true to the variety's characteristics, and employing physical isolation – via net houses, distance isolation, time isolation or hand pollination – to ensure that pollination only occurs among plants of the desired variety. To maintain the quality of seeds following points should be keep in mind:

1. Maintaining genetic purity
2. Maintaining proper isolation distance
3. Hybridity and varietal purity tests

4. Seed enhancement

Seed quality or seed enhancement refers to various technologies used to increase the consistency in performance of the seed with respect to its vigour, leading to improved crop yield and quality of produce. In recent times with the availability of scientific information of various physiological aspects of the seeds and seed enhancement technologies in ensuring better protection against diseases and insect pests at seed or seeding stage, improve seed vigour and modify seed emergence capabilities, it has become easier to enhance seed quality before its sowing to ensure higher yield with better quality produce. We all are aware of the pulses seed treatment with recommended fungicides and insecticides besides inoculation with rhizobium or PSB culture. Some of the other technologies becoming popular are listed below.

***(a). Seed coating*:** The application of materials on the seed surface to minimize diseases and insect pest incidence is mainly related to seed coating. The chemicals or bio-agents such as fungicides, insecticides, *Trichoderma* etc. are normally used for seeds coating of seeds of pulse crops. In developed countries film coating, in which the active ingredient is applied in a quick-drying polymer film around the seed, has gained popularity. A major advantage of film coating of the seed is that it ensures reduced loss of active material from the seed during seed transport and handling. This can be of value for rajmash and soybean seed in India, where losses in germination has been observed during transportation.

(b). Seed pelleting: The technology is used to alter the seed surface properties to enable more precise seed singulation during sowing through seed drills and placement in the soil through other means. This helps in ensuring proper plant populations and avoids clustering of seedlings. Seed pelleting can also be used to deliver a range of beneficial additives like micro-organisms, micronutrients and plant protection agents e.g., trichoderma for pulses seeds. This technology can be of immense value for the crops like mung bean, urd bean, moth bean, cluster bean, cowpea, lentil, etc.

(c). Seed priming: Seed priming is being used to enhance germination at fast rate and overcome seed dormancy. In seed priming, seeds are hydrated in a controlled manner to provide enough water to initiate the physiological processes of germination (imbibitions), but not enough to allow germination. After soaking of the seeds in desired or recommended solution these are allowed to dry and sowing is done in usual way. These primed seed ensure rapid and uniform germination from the soil compared to non-primed seed of the same seed lot. These differences are greatest under receding soil moisture or poor moisture retentive soils. Seed priming can be of utmost importance in lentil or chickpea when sowing is to be done as utera/paira or under late sown conditions as zero tillage. Even under late sown condition, primed seeds of chickpea and lentil help in good growth and development of biomass.

5. Proper storage conditions for quality seeds

The storage of seeds in coastal or high humid area is a difficult task. For most of pulses, high quantity of seed is required for sowing in unit area; it becomes further difficult to store seeds in humid areas. Therefore, government should take initiative to develop infrastructure for safe storage of seeds and also maintains minimum stock for regular as well as contingent plan.

Post-harvest operations for quality seeds

In order to preserve pulse crops with high yield, seeds must be stored. Numerous biological and non-biological processes cause significant losses of these seeds during storage. Careful post-harvest handling practises can help preserve the quality of seeds. In order to minimise loss and maintain the quality and safety of these crops, it is necessary to design the most appropriate procedures for assessing losses that occur during the process. The goal is to produce high-quality seeds that fulfil both national and international standards and might satisfy the supplier's needs. The post-harvest practises and factors that are employed to preserve seed quality are highlighted here.

Objectives of PHM of pulses seed processing

Seed processing is done to improve the seed quality by removing foreign objects, inert materials, small seeds, weed seeds, deteriorated and damaged seeds and by providing chemical protectants to the seed to improve its planting circumstances. As a result, seed processing is crucial to:

- Enable uniform planting through correct size and the removal of seed appendages that obstruct planting.
- Boost seed marketing by enhancing product quality and preserving dependable seed-planting standards.
- Remove weed seed from crop seed to stop the spread of weeds.
- By eliminating contaminated seed from clean seed, you can improve crop quality.
- Use chemical treatments to protect crops from pests and illnesses.
- Reduce seed losses by drying seeds and reducing moisture content.
- By providing storage from the time of harvest until the seed is required for planting, you can promote uniform marketing.

Table-1: Post-harvest techniques for pulses seed production (Thooyavathy *et al.*, 2013)

S. No.	Crop	Harvesting	Threshing	Drying	Processing/Grading/ Storage	Seed standards
1	Green gram and Black gram(*Vigna radiata* and *Vigna mungo*)	Harvest is done soon after the maturation of the seeds. Seeds attain physiological maturity 30 days after 50% flowering. The mature pods turns brown. At this stage the	Harvested pods along with plants are dried to a moisture content of 12 – 13% and then threshed using sticks. Threshed grains are cleaned and dried to m. c. of 8 – 9%.	Processed and graded grains are further dried to attain 9% of moisture content.	Then seeds should be mixed with 3% neem seed kernel power to preserve the seeds from storage pests especially infestations of the bruchid beetle.	Physical purity of foundation and certified seeds should be 98%, minimum of 75% germination and 9% of moisture content.

		moisture content of the pods will be 17 – 18%.	The seeds are graded using BSS 7 x 7 wire mesh sieve.			Presence of other distinguishable varieties should be 10/kg for foundation seed and for certified seed 20/kg.
2	Cowpea and Soya bean (*Vigna unguiculata* and *Glycine max*)	Harvest is done soon after the maturation of the pods. In cowpea the matured pods will be straw yellow in colour and harvested by hand picking. Since flowering is continuous in cowpea, pod setting is also continuous. Harvesting is done periodically as and when the pods get mature. In soya bean, seeds attain physiological maturation 23 – 25 days after anthesis. Maturation can be confirmed by yellowing of	Harvested pods of cowpea and whole plants of soya bean are dried under the sun light. Dried pods are beaten with bamboo stick to remove the seeds. Seeds be cleaned by winnowing. The seeds of soya bean and cowpea are graded using 14/64" and 10/64" round perforated metal sieves, respectively.	Processed and graded grains are further dried to attain 9% and 12% of moisture content for cowpea and soya bean, respectively.	Seeds can be stored for a year under open storage conditions. The seeds should be mixed with 3% neem seed kernel power to preserve it from storage pests especially infestations of the bruchid beetle. Seeds can also be treated with activated clay @ 1 kg/100 kg of seeds.	Physical purity of certified and foundation seeds of cowpea and soya bean should be 98% with maximum germination capacity of 75% for cowpea and 70% for soybean seeds of both certified and foundation. M.C. should be 9% for cowpea and 12% for soybean and the presence of other crop seeds

		the plant and browning of the pods. This crop should be harvested at once, pods intact along with the plant.				for foundation seeds should be 5/kg and certified seeds of cowpea should be 10/kg, whereas for soya bean it should be 10/kg and 40/kg.
3	Red gram (*Cajanus cajan*)	The crop reaches the physiological maturity in 32 – 38 days after anthesis in winter and summer, respectively. Harvesting takes place soon after the maturation of seeds. Matured pods should be harvested in 2-3 pickings. Harvest should not coincide with rains, because it will result in off coloured and dimpled seeds.	Harvested pods are dried under the sun for a week. The dried pods are beaten with bamboo stick to separate the seeds. Seeds be cleaned by winnowing and graded using 10/64" (BSS 5x5) round perforated metal sieves.	Seeds of different colour and sizes should be removed . Processed and graded seeds are further dried for safe storage.	Seeds can be stored for up to one year under open storage conditions and for 15 months in 700 gauge polyethylene bags. The seeds should be mixed with a powder of neem and vitex and rinds of the fruits of Sapindus laurifolius (Punthi kottai) and Acacia concinna (soap nut) in 1:100 ratio. Seeds can also be treated with activated clay @ 1kg/100 kg of seeds to control bruchid infestation.	Physical purity of certified and foundation seeds should be 98% with minimum germination capacity of 75%. The maximum moisture content should be 9%. The presence of other crop variety should be 10/kg for foundation and that of certified seed should be 20/kg of seed.
4	Horse	The crop	Harvested	Seeds are	Seeds with this	Minimum

	gram (*Macrotyloma uniflorum*)	reaches the physiological maturity in 25 - 30 days after flowering. The maturation can be visually identified by colour change of the pods and the crop from green to straw yellow colour. The pods are harvested intact with plants and dried in the threshing yard.	plants are dried under the sun and threshed by beating with a pliable bamboo stick to separate the seeds. The seeds should then be cleaned by winnowing.	graded using 8/64" or 3.1 mm round perforated metal sieve. Seeds of different colour and sizes and broken ones should be removed. Processed and graded seeds are further dried for safe storage. The seeds should have the maximum M.C. of 8%.	moisture content can be stored for up to one year under open storage conditions.	physical purity of the certified and foundation seeds should be 98% with minimum germination capacity of 80%. The maximum moisture content should be 9%. The presence of inert material should not exceed 2% and other crop seeds should be 5/kg for foundation and 10/kg for certified seeds.

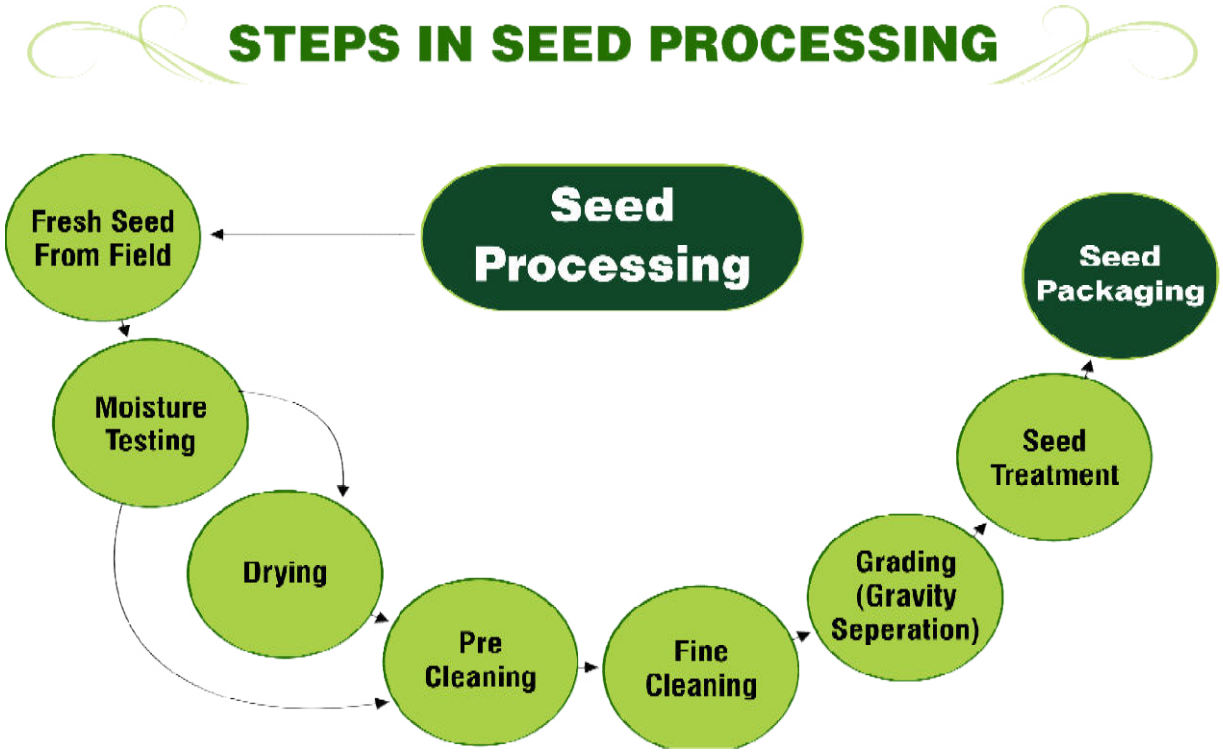

Fig-1.: Steps involved in pulses seeds processing

Quality assurance

Quality assurance means different things to different people. For people working with seed certification programs, it means being sure that the seed is inspected for genetic variability in the field, in the laboratory, and, after certification is complete, through grow-out tests. For seed analysts it means conducting tests to assure trueness-to-type, freedom from contamination, and the ability to produce normal, healthy plants in the field. Several state seed certification agencies have set up specialized programs for quality assurance and are providing this service to the seed producers.

Most quality assurance programs begin during seed production in the field. The use of high-quality, genetically pure planting seed, proper isolation distances, and weed and crop-free soil are all beginning steps in a quality-assurance program. Using the proper seeding rates, row spacing, fertility levels, and irrigation scheduling is essential in producing high quality seed.

A seed has its highest quality when it is physiologically mature. This stage of development usually is defined as that point during development when the seed has attained maximum dry weight. The quality of the seed at physiological maturity depends on the environment prevailing during seed development. The seed producer can control some of the environmental factors that affect quality, such as soil moisture, fertility, disease and insect stresses, and uniformity of stand.

Once the seed has been separated from the mother plant by the formation of an abscission layer, its quality is influenced by the environment, and deterioration begins. Pulses crops can be damaged easily during harvesting, threshing, dying, processing and handling. Factors such as moisture content during harvesting, mechanical damage during combining, and improper drying techniques all can lead to poor-quality seed. This damage can cause loss of vigour and/or viability, making the seed unusable for planting purposes. To prevent quality

losses, measures have developed for quality assurance to evaluate, monitor, and minimize the loss of quality.

Quality assurance measures require systematic sampling and testing of the seed during production, conditioning, and storage. During seed production, a seed sample should be taken when the crop has reached physiological maturity. This sample is used to establish the level of quality and the seed moisture content before harvesting and conditioning. Once the proper moisture content has been reached for harvesting, another seed sample should be taken. This sample will indicate if seed quality has been lost. During harvesting, the seed should be checked for cracked or broken seeds to determine that the harvest equipment is properly adjusted. There are several quick tests that can be used in the field to check seed damage. Once the harvesting equipment has been adjusted properly, a sample should be taken to assess the quality after harvesting and to check seed moisture again. If the seed moisture content is not acceptable for temporary storage the seed must be dried before seed conditioning, preferably at low temperature to avoid loss of viability and vigour. After drying, a seed sample should be taken to determine if seed has been damaged during drying. Often seed is not conditioned immediately and is put into temporary bulk storage. Movement into bulk storage usually requires the use of an elevator, which can damage the seed, therefore, a seed sample should be taken to determine if quality is lowered.

Seed conditioning is an essential step in making seed of genetically superior cultivars available to crop producers. Some objectives of seed-conditioning are to remove contaminants, upgrade quality, improve plant ability, apply seed treatment, and package the seed (Fig.2). Each of the steps in this flow diagram requires specialized equipment that performs specific conditioning functions. However, as the seed passes through each piece equipment man can be damaged. Consequently, a seed sample should be taken at each point along the way to assure that a piece of equipment is not reducing quality.

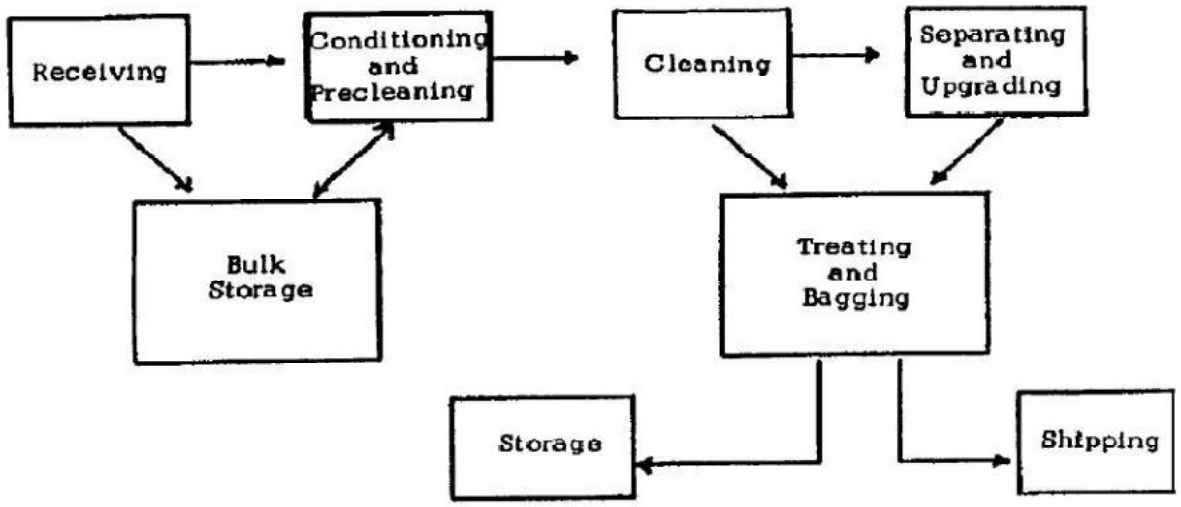

Fig-2. Basic diagram showing essential steps in seed conditioning (Vaughan et al., 1968)

Vigour tests

Several vigour tests have been developed over the years to measure seed performance under a wide range of field conditions. These tests also may be applicable to predict seed storage (Roos, 1989). The basis for vigour testing is the assumption that seeds undergo a sequential loss of cell function, which culminates in the loss of germinability (Fig. 3). While this scheme provides a simplistic illustration of what is thought to occur, the exact sequence

of events is not known. Exact procedures for conducting most of these tests have been summarized in the Seed *Vigour Testing Handbook,* published by AOSA (1983).

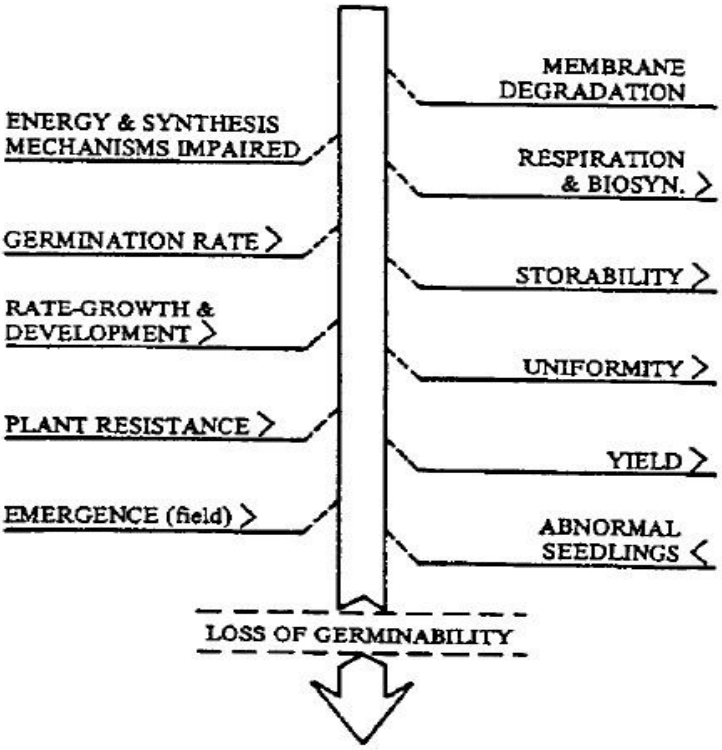

Fig-3. Probable sequence of changes in seed during deterioration (Delouche and Baskin, 1973)

The work of a quality-assurance program is not completed when the seed is put into storage. If seed remains in storage more than a few months, it should be sampled and checked to determine if its vigour or viability has changed. It is also important that all storage areas be kept free of insects and rodents. The quality-assurance program, as outlined, creates a large amount of data that can be helpful in determining where and why seed quality has been lost. When samples are evaluated using the various tests outlined above, a seed producer can make the necessary modifications in their production practices, conditioning procedures, and storage facilities to produce and maintain a high-quality seed.

Conclusion

Post-harvest management and seed quality preservation are the two viewpoints in seed industry that require the most focus. Though, significant progress has been made in recent years in the development of processing techniques, novel packaging, storage, and transport systems, pest control, and seed-borne disease management for market access. Researchers have to make an effort to develop integrated strategies for seed post-harvest management to obtain quality seed to meet national and international standards. To preserve seeds for extended periods of time without affecting their genetic makeup, seed biologists should attempt to further their research. For higher-quality harvests, seed quality needs to be preserved. These days, the main issue in developing nations is seed maintenance. Better postharvest handling and seed storage techniques must be developed in order to be more cost-effective, practical, and effective.

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National Seed Research & Training Centre
Central Seed Testing Laboratory
G. T. Road, Collectry Farm,
Varanasi- 221106 (U.P.)
Tel: 0542 2370222
E-mail: *dir-nsrtc-up@nic.in*
Website: www.nsrtc.nic.in