Seed Production Techniques for Oilseeds and Pulses

The Revitalizing Rainfed Agriculture Network (RRAN) is a growing network of civil society organizations, research institutions, policy makers, donors and individuals engaged in evolving a differentiated agricultural policy with enhanced public investments and support system for rainfed areas in India. The Comprehensive Pilots (CPs) are part of the RRA Network's action research programme that seeks to establish evidence and experience on the ground, in support of the various propositions that the Network has developed. In order to offer support for CPs a set of organizations have been identified as Nodes on specific identified themes such as – seeds, soils, water, millets, fisheries, livestock, credit, markets and institutions.

The Centre for Indian Knowledge Systems (CIKS) has been identified and functioning as the nodal anchor for the theme of seeds. A series of booklets is being published on various technical and institutional aspects of seed systems to build the capacity of the CPs as well as various field groups who are involved in the efforts to build community managed seed systems.

This publication on seed production for oilseeds and pulses describes the procedures and technologies involved in the production of quality seeds of oilseeds and pulses. Next to cereals, oilseeds and pulses are the major crops in India. The technologies involved in the certified and foundation stages of seed production from seed selection to storage including the quality standards for the seeds and appropriate storage methods are explained in detail in this publication.






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PREFACE

The Revitalizing Rainfed Agriculture Network (RRAN) is a growing network of civil society organizations, research institutions, policy makers, donors and individuals engaged in evolving a differentiated agricultural policy with enhanced public investments and support system for rainfed areas in India. Based on the vast experience on the ground and analysis of issues, RRA Network is evolving specific propositions on various aspects of rainfed agriculture such as seeds, soils, water, crop systems, millets, livestock, fisheries, credit, markets and institutions. The Comprehensive Pilots (CPs) are part of the RRA Network's action research programme that seeks to establish evidence and experience on the ground, in support of the various propositions that the Network has developed. In order to offer support for CPs a set of organizations have been identified as Nodes on specific identified themes such as – seeds, soils, water, millets, fisheries, livestock, credit, markets and institutions.

The Centre for Indian Knowledge Systems (CIKS) has been identified and functioning as the nodal anchor for the theme of seeds. The CPs started functioning in the year 2012 and in June 2012 the seed node convened a meeting of representatives of CPs for an inception workshop in Chennai. During this workshop the CPs shared their proposals and plans of work as well as their thinking about the work that they plan to undertake in the area of seeds. Presentations were made during the workshop on how to undertake a situation analysis with respect to seeds, the elements of designing a robust seed system for rainfed areas and also about undertaking a planning exercise through which each CP can proceed towards the establishment of a robust community managed seed system in its area of work. A part of the workshop was to identify the specific needs expressed by each of the CPs in terms of the support and help they would need in the area of seeds. A beginning was made in terms of the capacity building exercise through a series of presentations.

Beginning from the early part of the year 2012 Dr. G. Venkat Raman of the Seed node had started making a series of visits to various CPs. During the visits he provided help and assistance to the CPs for performing situation analysis, evolving a plan for a robust seed system for the area undertaking capacity building exercises and also trying to create linkages between the groups and scientists and institutions who could provide technical support. During this process he also identified various needs in the form of topics on which training and capacity building was required.

Subsequently, on two different occasions when the seed node team met the CPs – in Bagli in Madhya Pradesh in November 2012 and in Tiptur in Karnataka in December 2012 there were opportunities to review the progress of each CP as well as provide technical inputs and training. Earlier this year, towards the end of July 2013 a workshop was held by the seed node in the CIKS Technology Resource Centre in the Kancheepuram district of Tamil Nadu. In this workshop a series of technical trainings were provided on various aspects of seeds. The training was not only in the

form of lectures and presentations but also included field work, experiments, visits to government and private seed farms and seed production centres as well as meetings with the officials of the Directorate of Agriculture and Seed Certification departments. During these meetings drafts of some of the technical training modules that were prepared were circulated and comments and suggestions were sought from the CPs. Based on these efforts and also building upon discussions that took place during the visits to CPs a set of topics had been identified to produce training modules. We expect this process to be dynamic and interactive so that changes can be made based on the suggestions received from the various user groups. A series of reports and books that have been circulated and discussed as drafts and presentations are now being brought out as publications.

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Chennai, December 2013

About this Book

This publication on seed production for oilseeds and pulses describes the procedures and technologies involved in the production of quality seeds of oilseeds and pulses. Next to cereals, oilseeds and pulses are the major crops in India. The technologies involved in the certified and foundation stages of seed production from seed selection to storage including the quality standards for the seeds and appropriate storage methods are explained in detail in this publication.

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SEED PRODUCTION IN OILSEEDS

India is one of the largest vegetable oil economies in the World, next only to USA and China. Next to food grains in terms of hectarage, production and value, oilseeds play a vital role. India accounts for about 13% of world's oilseed area, 7% of world's oilseeds output and 10% of world's edible oils consumption. The country's diverse agroecological conditions favour the cultivation of all nine annual oilseeds which include edible and non-edible oilseeds. The country ranks first in the global production of castor, sesame and niger, second in groundnut and mustard, third in linseed and fifth in soya bean and sunflower. 13% of the gross cropped area is occupied by oilseeds which accounts for 10% of the value of all the agricultural commodities.

The oilseeds scenario in the country is presenting a dismal picture currently. India changed from net importer in 80s to a net exporters status during the early 90s. However, it is back to net importer status, necessitating import of more than 40% of its annual edible oils.

To achieve good production of oilseeds good quality seeds are of great importance. The first section of this book provides the seed production technologies for four important oilseed crops i.e., groundnut, gingelly, sunflower and mustard. While the standards mentioned here are for certified seed production farmers are also advised to follow these procedures in general for seed production. This will ensure good quality seeds which will in turn lead to good crop yields.

GROUNDNUT *(Arachis hypogaea)*

Groundnut *(Arachis hypogaea)* is one of the important oilseed crops belonging to the family Fabaceae. The optimum season for seed production is December – January for the irrigated crop and June – July for the rainfed crop. The maturation and harvesting period should not coincide with the rainy season. If it coincides with the rains *in-situ* germination of the pods, will take place.

Method of seed production

Groundnut is a self pollinated crop with 0 – 5% of cross pollination. The crop should be raised in isolation and seeds should be produced by self pollination. The isolation distance maintained between the varieties is 3 metres for both certified and foundation seed production.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed.

Land selection

The land selected should not be cultivated with groundnut in the previous season. The soil should be fertile and porous with good drainage facility.

Seed selection and sowing

Certified seeds should be obtained from an authorised source. Healthy kernals free from disease and pest infection should be used for sowing. Remove the decoated, tip broken, coloured kernals and use uniformly graded seeds. Seed rate is 45 kg/acre (110 kg/ ha) for spreading type and 50 kg/acre (120 kg/ha) for bunch type.

Selected seeds should be treated with asafoetida solution (1.5 kg in 12 litres of water is sufficient for120 kg of seeds) to prevent the crop from blight disease. Soak the selected seeds in this solution for 12 hours and then shade dry for 30 minutes before sowing. Biofertilizers like *Rhizobium* (600 gms for 120 kg of seeds) and Bio-control agents like *Trichoderma viride* (480 gms for 120 kg of seeds) can also be used for the seed treatment. Mix *Rhizobium* (or) *Trichoderma* with 500 ml of cooled rice gruel and mix the solution with seeds. Shade dry the seeds for 30 minutes before sowing.

Treated seeds are dibbled either manually or mechanically (using seed drill) at a depth of 7.5 – 10 cm. The spacing for bunch type is 30 x 10 cm and 45 x 20 cm for spreading type.

Nutrient management

Groundnut is a deep rooted plant and hence uses both moisture and nutrients in the deeper layers of the soil. Nitrogen requirement in rainfed crop is 4 kg/acre (10 kg/ha) and in irrigated crop it is 7 kg/acre (17 kg/ha). Phosphorus requirement for rainfed crop is 4 kg/acre (10 kg/ha) and in irrigated crop it is 14 kg/acre (35 kg/ha). Although Indian soils are rich in potassium, the recommended dose is 18 kg/acre (45 kg/ha) in rainfed and 22 kg/acre (54 kg/ha) in irrigated crop. Based on this quantity, nitrogen rich vemicompost and compost need to be applied before and after 20 days of sowing.

Before sowing, apply 4 tonnes of FYM, 16 kg of neem cake and 80 kg of gypsum per acre (10 tonnes of farmyard manure, 40 kg of neem cake and 200 kg of gypsum per hectare) as basal manure and incorporate into the soil with the help of a country plough or a blade harrow. FYM improves the porosity and structure of the soil and

supplies the crop with the required micronutrients. An alternative to FYM is to practice green manuring with crops like *Sunhemp*, *Daincha* and other legumes. After 15 - 20 DAS first weeding is done and 16 kg/acre (40 kg/ha) of neem cake and 8 kg/acre (20 kg/ha) of gypsum is applied. Following this, 2 - 3 weeks after flowering 8 kg/acre (20 kg/ha) of neem cake and 0.8 tonnes/acre (2 tonnes/ha) of vermicompost is applied.

Spraying 3% panchagavya (300 ml panchagavya per tank of water) on 30th day and 10% buttermilk (1litre curd in 9litres of water) on the 45th day after sowing helps in crop growth.

Weed management

Weeds reduce the yield upto 20 – 45% in groundnut. Based on the soil type and the extent of weed infestation two hand hoeing and weeding should be done. The first hoeing should be done three weeks after sowing. This should be repeated before the onset of flowering. Weeding should not be done after 45 days as it may interrupt peg elongation and pod formation.

Pest and disease management

Groundnut is affected by pests like root and pod feeders (white grubs), red hairy caterpillar, leaf miner and tobacco caterpillar and diseases like leaf spot or tikka disease, rust, *Alternaria* leaf spot and stem rot at different growth stages. Detailed management measures for these pests and diseases are provided in Appendix – I.

Interculture and Earthing up

Inter cultivation operations have to be started as soon as the rows of groundnut seedlings are visible and repeated at regular intervals till 45 days. Shallow inter cultivation is adequate. Earthing up should be done simultaneously with intercultural operations (40 days). It facilitates

maximum penetration of pegs and provides a larger spreading area. Apply gypsum @ 80 kg/acre (200 kg/ha) during earthing up to facilitate peg penetration and to obtain good oil content.

Irrigation

Depending on soil texture, the frequency of irrigation varies. However, irrigation should be given during the critical stages of growth like flowering, peg formation and pod development / seed filling. The crop should be irrigated once in 10 – 15 days. Irrigation before harvesting will make the operation easier.

Roguing

Roguing should be done from vegetative phase upto harvest. Off-types are removed based on the colour, growth pattern, flowering etc. Maximum percentage of off-types permitted at final inspection is 0.10% for Foundation seed production and 0.20% for Certified seed production.

Field inspection

A minimum of two inspections will be done, one at flowering and second at pod maturity stage (15 days prior to harvesting) by the Seed Certification Officer.

Field standard

	Foundation seed	**Certified seed**
Isolation distance	3 m	3 m
Off-types	0.10%	0.20%

Harvesting

When the crop matures, the older leaves will dry and fall off, top leaves will start yellowing and the inner side of the pod will turn black and the seeds inside will move freely. Soil moisture level is very critical during harvesting. The bunchy varieties are harvested by hand whereas the spreading varieties by digging, ploughing or with the help of a blade-harrow. Groundnut should be harvested in bright sunshine.

Stripping and drying

After harvesting the groundnut pods are removed from the plants. This is called stripping. The pods are removed by picking or flailing (beating) on the ground. The pods should be dried under the sun to have less than 9% moisture content.

Seed storage

Groundnut pods are stored as such till next sowing. The seeds can be stored viable up to 18 months. Pods should be stored in gunny bags lined with polythene. Few pieces of camphor should be added in the bag to preserve the seeds. Pods can also be mixed with neem leaves (@ 2 kg/400 kg seeds) to act as a repellent for storage pests.

Seed standards

	Foundation seed	Certified seed
Physical purity (min)	96%	96%
Germination (min)	70%	70%
Moisture (max)	9%	9%

GINGELLY *(Sesamum orientale)*

Gingelly *(Sesamum orientale)* belonging to the family Pedaliaceae is one of the oldest oil seed crops cultivated for culinary and medicinal needs. Seed production can be done in all the three seasons - rabi (October - November), kharif (June - July) and summer (February - March).

Method of seed production

Gingelly is a cross pollinated crop and seeds are allowed to set by open pollination and then multiplied. The seed crop should be raised in isolation and the isolation distance maintained between varieties is 50 metres for certified and 100 metres for foundation seed production.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should not be cultivated with the same crop in the previous season. The land should be fertile with proper drainage facility.

Seed selection and sowing

Good quality certified seeds should be sourced from an authorised dealer. Seeds should be healthy with a good germination percentage. Seed rate is 2 kg/acre (5 kg/ha). Selected seeds should be treated with bio-control agents like *Trichoderma viride* @ 4 g/kg of seeds. Mix *Trichoderma viride* in rice gruel and mix the solution with seeds. Shade dry the seeds for 30 minutes before sowing. Soaking the seeds in hot water at 52^{o}C for 30 minutes before sowing will control the bacterial leaf spot disease.

Treated seeds should be mixed with ash or fine sand to increase the volume for easy sowing. Seeds can be sown in beds and channels or in ridges and furrows. The spacing maintained is 60 x 30 cm (11 plants / m^2).

Nutrient management

FYM or compost @ 4 tonnes/acre (10 tonnes/ha) is thoroughly incorporated into the soil before the last plough. This will improve the texture as well as the nutrient content of the soil. To improve the nitrogen content of the soil green manuring with subabul @ 2 tonnes/acre (5 tonnes/ha) should be done or castor cake or neem cake @ 400 kg/acre (1 tonne/ha) should be applied.

Trichoderma viride @ 1.5 kg/acre mixed with 300 kg compost and kept as such for one week is applied to the field as top dressing. It will protect the crop from root rot and pathogens like *Pythium* and *Phytophthora.* In prolonged dry condition top dressing can be done using vermiwash. Rainfed sesame requires 17 kg of nitrogen, 13 kg of Phosphorous and 13 kg of Potassium, whereas the irrigated crop requires 21, 23 and 23 kg respectively. Appropriate biofertilisers can be used to meet the nutritional need of the crop.

Weed management

Sesame is very sensitive to weed competition during the first 25 days after sowing. The first weeding is done 20 days after sowing followed by the second one in 15 days interval. Another weeding may be done in 15 days gap. Apart from hand weeding, implements such as hand hoe, bullock drawn blade harrow, rotary or finger weeders are used for weeding.

Pest and disease management

Gingelly is commonly affected by pest and diseases like leaf and pod caterpillar, gall fly, sphinx or hawk moth, wilt, phyllody, stem and

root rot and bacterial leaf spot at different growth stages. The management measures for these pests and diseases are provided in Appendix -I.

Interculture practices

Earthing up should be done at the stage of fruit setting to avoid lodging of the crop.

Irrigation

Irrigation should be done once in 15 days. It is critical during flowering and pot filling stage.

Roguing

Roguing should be done from vegetative phase to harvesting phase. Off-types are removed based on the branching type, capsule size and colour of the seeds. Maximum percentage of off-types permitted is 0.10% and 0.20% and permitted percentage of plants affected by seed borne diseases is 0.50% and 1.0% for foundation and certified seed production respectively.

Field inspection

A minimum of three field inspections should be done from pre flowering stage to harvesting stage by the Seed Certification Officer. First inspection is done before flowering followed by the second inspection during flowering stage. The third inspection is scheduled between fruit maturity and harvest.

Field standards

	Foundation seed	Certified seed
Isolation distance	100 m	100 m
Off-types	0.10%	0.20%
Plants affected by seed borne diseases	0.50%	1.00%

Harvesting

Harvesting should be done when 75 – 80% of the pods become brown in colour and few at the bottom have dehisced (burst open). At this stage the moisture content of the pods and seeds will be 50 – 60% and 25 – 30%, respectively. For black

seeded variety, check the colour of the seeds in the 10th capsule from the bottom of the crop. If the seeds are black in colour then harvest should be done. Delaying harvest may result in yield loss.

Stacking and drying

The harvested plants are stacked upright in the threshing yard for a period of three days. This will help the immature pods in the terminal edge to mature and also help in drying of the pods. The moisture content of the pods will reduce to 9%.

Threshing and processing

Threshing is carried out manually by beating the capsules with pliable bamboo sticks. The seeds removed from the pods are graded using round perforated metal sieves of 5/64” size.

Seed storage

Seeds are dried under the sun for 3-4 days to reduce the moisture content to 5.0% before storage. After proper drying the seeds should be mixed with activated clay @ 1 kg/100 kg of seeds. Seeds are then stored in gunny bags or bins. Seeds can be stored upto one year under open storage conditions.

Seed standards

The percentage of physical purity of foundation and certified seeds should be 97% with 80% of germination capacity and 9% of moisture content. The maximum presence of seeds of other crops and weeds should be 10/kg for foundation and 20/kg for certified seeds.

SUNFLOWER *(Helianthus annuus)*

Sunflower *(Helianthus annuus)* belonging to the family Asteraceae was introduced in India in 1969 and became one of the important oilseed crops. The oil is used for culinary purpose, preparation of cosmetics etc. Seed production can be taken up in all the three seasons like kharif, rabi and summer. For rainfed conditions June – July and October – November and for irrigated conditions April – May and December – January is suitable for seed production.

Method of seed production

Sunflower is a cross pollinated crop. Anthesis takes place between 5 – 8 am and the pollen grains are viable for 12 hours. Honey bees are the pollinating agents. During pollination if the insect activity is low, it will result in poor seed setting and poorly filled seeds. The isolation distance maintained between varieties is 200 metres for certified and 400 metres for foundation seed production. The potential of the seed storage depends on the oil content of the seeds. Sowing in September - October result in seeds with low oil content. Hence the storage potential of the seed is very high. If sowing took place in March – April, the resulting seeds will be high in oil content with less storage potential.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should not be cultivated with sunflower in the previous season. The soil should be fertile with neutral pH and good drainage facility.

Seed selection and sowing

Seeds should be obtained from the appropriate source approved by the seed certification agency. Fresh seeds possess 45 – 60 days of dormancy. To break the dormancy, the selected seeds should be soaked in water for 12 – 16 hours and seeds can also be leached in running water. Seed rate is 3 – 4 kg/acre (8 - 10 kg/ha). Treated seeds are sown in the field with a spacing of 45 x 30 cm.

Nutrient management

FYM or compost @ 4 tonnes/acre (10 tonnes/ ha) is thoroughly incorporated into the soil before the last plough. This will improve the texture as well as the nutrient content of the soil. NPK @ 16:8:8 kg/acre (40:20:20 kg/ha) is recommended for better seed yield. Nitrogen supply can be split into two halves and applied as basal dose at the time of sowing and as top dressing after 30 – 35 DAS just after weeding.

Weed management

Maintaining the seed field free from weeds and unwanted plants is very important for successful seed production. A total of two hand hoeing and a weeding should be done. First weeding is done 30 – 35 days after sowing.

Pest and disease management

Sunflower crop is affected by pest and diseases like white fly, jassids, capitulam borer and root rot at different growth stages. The management measures for these pests and disease are provided in Appendix -I.

Irrigation

First irrigation is done soon after the seed sowing. On the third day after sowing field should be again irrigated. After this depending on the nature of the soil field should be irrigated once a week. Irrigation is very critical during flowering and seed maturation stages. Water scarcity at these stages will result in ill filled seeds. Proper irrigation will result in high yield of seeds.

Roguing

Roguing should be done from vegetative phase up to harvest. Off-types are removed based on the plant height, head size, branching habit, number of

heads and colour of seeds. Maximum percentage of off-types permitted at and after flowering stage is 0.10% for foundation seed production and 0.20% for certified seed production. The percentage of plants affected by downy mildew allowed in foundation stage of seed production is 0.05% and 0.50% for certified stage of seed production.

Field inspection

A minimum of three inspections will be done from vegetative to harvesting stage by the Seed Certification Officer. Normally first inspection is done at the stage when 6 – 7 pairs of leaves are present to check the isolation, presence of volunteer plants and designated diseases. Second inspection will be made during flowering stage to check isolation, off-types and other factors. Sometimes third inspection will be scheduled prior to harvest to verify the designated disease, true nature of plant, flower head and seed and also to estimate the yield of seed crop.

Field standard

	Foundation seed	Certified seed
Isolation distance	400 m	200 m
Off-types	0.10%	0.20%
Plants affected by downy mildew diseases	0.05%	0.50%

Supplementary pollination

Supplementary pollination is done when the insect activity is low. Palm covered with muslin cloth is used to rub the flower heads to make sure all the flowers are fertilized and increase seed setting.

Harvesting

Sunflowers should be harvested when the backside of the flower heads turns lemon yellow from green. After anthesis in about 40 – 45 days the heads will mature. Heads are harvested in one picking.

Threshing and drying

The harvested heads are dried under the sun for a couple of days to reduce the moisture content to 15 – 18%. After this the seeds are removed from the heads by hand threshing or mechanically using sunflower thresher. After threshing seeds are dried under the sun to obtain the moisture content of 10 – 12%.

Processing

Seeds dried to an optimum moisture content are graded using 9/64" round perforated sieve as middle sieve using OSAW cleaner cum grader.

Seed storage

Seeds can be stored in gunny bags for up to 10 months and in 700 gauge polyethylene bags for about 15 – 18 months.

Seed standards

The percentage of physical purity of foundation and certified seeds should be 98% with 70% of germination capacity and 9% of moisture content.

MUSTARD *(Brassica sp.)*

Mustard *(Brassica sp.)* is a well known condiment and an important oil seed crop of the family Cruciferae. The plant is also used as a vegetable, fodder and medicine. Seed production can be done in rabi (from September and October) in plains and in hills during kharif (June - July).

Method of seed production

Mustard is a cross pollinated crop and seeds are allowed to set by open pollination and then multiplied. The crop should be raised in isolation to maintain varietal purity. The isolation distance maintained between the varieties is 50 metres for self compatible and 100 metres for self incompatible types for foundation seed production and for certified seed production it is 25 metres for self compatible and 50 metres for self incompatible types. The isolation distance maintained between the varieties not conforming to the varietal purity requirements for certification is 200 metres for self compatible and 100 metres for self incompatible types for foundation seed production. In Certified seed production, it is 50 metres for both self compatible and self incompatible types.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should be fertile and free from volunteer plants. It should not be cultivated with the same crop in the previous season. The land should be tilled twice to make the soil smooth.

Seed selection and sowing

Good quality certified seeds should be sourced from an authorised dealer. Seeds should be healthy with a good germination percentage. Seed rate is 4 – 5 kg/acre (10 - 13 kg/ha). Selected seeds should be treated with bio-control agents like *Trichoderma viride* @ 4 g/kg of seeds. Mix *Trichoderma* in rice gruel and mix the solution with seeds. Shade dry the seeds for 30 minutes before sowing. This will help in the control of root rot and *Fusarial* wilt disease.

Treated seeds should be sown in ridges and furrows at 4 – 5 cm depth. The spacing maintained is 45 x 15 cm. After sowing planking is done to cover the seeds.

Nutrient management

FYM or compost @ 4 tonnes/acre (10 tonnes/ha) or vermicompost @ 1.6 – 2 tonnes/acre (4 - 5 tonnes/ha) should be applied and thoroughly incorporated into the soil before the last tilling. This will help to improve the texture as well as the nutrient content of the soil. Green manure crops like *Sunhemp* or *Sesbania* are grown in the field and ploughed into the soil after 40 – 50 days of sowing. This enhances the nitrogen, phosphorous and other nutrients in the soil.

Trichoderma viride @ 1.5 kg/acre is mixed with 300 kg compost and kept as such for a week and then applied to the field as top dressing. It will protect the crop from root rot and pathogens like *Pythium* and *Phytophthora*.

Weed management

In kharif crop harrowing is done 25 – 30 days after sowing. The first weeding is done 45 – 50 days after sowing. Weeding is repeated before budding stage followed by harrowing with hand harrow.

Pest and disease management

Mustard aphid, painted bug, sawfly, *Alternaria* blight and white rust are some of the common pests and diseases affecting mustard crop. The management techniques for these pests are provided in Appendix – I.

Irrigation

Irrigation should be done once in 15 days. It is critical during flowering and pot filling stage.

Roguing

Roguing should be done from the vegetative phase to the harvesting phase. Off-types are removed based on the branching type, capsule size and colour and colour of the seeds. Maximum percentage of off-types permitted is 0.10% for foundation seed production and 0.50% for certified seed production.

Field inspection

A minimum of three field inspections should be done from pre flowering stage to maturity stage by the Seed Certification Officer. First inspection is done before flowering followed by second inspection during flowering. The third inspection is scheduled at maturity stage prior to harvesting.

Field standard

	Foundation seed	Certified seed
Isolation distance	200 m	100 m
Offtypes	0.10 %	0.50 %
Objectionable weed seed	0.05 %	0.10 %

Harvesting

Harvesting should be done when 75% of the pods become golden yellow in colour. The moisture content of the seeds will be 25% in this stage. Delaying harvest may result in yield loss. The crop is harvested at the level of lowest pods.

Threshing and drying

The harvested plants are heaped and dried under the sun for 4 – 5 days to attain 12 – 13% of moisture level for uniform maturation of seeds. This is called swathing. During swathing the immature pods with green seeds mature. Threshing is done after 10 – 12 days by hand using stick. Threshed seeds are cleaned by winnowing and sieving using suitable size of sieve.

Seed storage

Seeds are dried under the sun to attain 8% of moisture content. This is safe for mustard seeds and can be stored in gunny or cotton bags upto one year under open storage conditions.

Seed standards

The minimum percentage of purity of foundation and certified seeds should be 97% with 85% of minimum germination capacity and 8% of maximum moisture content. Presence of other distinguishable variety in foundation seed should be 0.10% and that of certified seed should be 0.50%.

SEED PRODUCTION IN PULSES

Pulses are an important source of dietary protein. They also have a unique property of maintaining and restoring soil fertility by fixing the biological nitrogen. Besides this, they also conserve and improve physical properties of the soil because of the deep root system and leaf fall. Pulse crops add nitrogen to the soil @ nearly 30 kgs/ha. According to the Food and Agricultural Organisation (FAO) the individual protein requirement per day is 80 gms. However, the availability today is less than 40 gms/day.

India grows nearly 23 million hectare of pulse crops and the production of pulse grains is nearly 14.4 million tonnes. However, for the last 40 years the yield of pulses is rather stagnant. It is important to increase the yields to twice the rate at the earliest.

The most important factor in increasing the yields of pulses is to get access to good quality seeds. The second section of this book deals with seed production techniques of important pulses like greengram, blackgram, cowpea, soya bean, redgram and horsegram. While the techniques described here are for certified seed production farmers are advised to follow these procedures for seed production in general to get good quality seeds.

GREENGRAM AND BLACKGRAM
(Vigna radiata and *Vigna mungo)*

Greengram and blackgram *(Vigna radiata* and *Vigna mungo)* belong to the family Leguminosae are widely cultivated pulse crops. The optimum season for seed production is June – August, September – November and February – March for both blackgram and greengram. Though it can be grown in all the three seasons, June – July is the best season.

Method of seed production

Greengram and blackgram are highly self pollinated crops with cross pollination to the extent of 5 – 10%. The crop should be raised in isolation and seeds are allowed to set by self pollination. To maintain the varietal purity an isolation distance of 5 metres for certified and 10 metres for foundation seed production is maintained between varieties and of the same variety not conforming to varietal purity requirements of certification.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should be free from volunteer plants. The soil should be fertile with neutral pH and proper drainage facility. It should be prepared to fine tilth. Ridges are formed with a gap of 60 – 90 cm.

Seed selection and sowing

Good quality certified seeds should be obtained from an authorised dealer. Seeds should be healthy with a good germination percentage. Only graded seeds should be used. Remove the off colour and out sized seeds. Seed rate is 8 kg/ acre (20 kg/ha). Selected seeds should be treated with *Trichoderma viride* @ 4 gm/kg of seeds or *Pseudomonas* @ 10 gm/kg of seeds. Mix *Trichoderma* or *Pseudomonas* in rice gruel and mix the solution with seeds. Shade dry the seeds for 30 minutes before sowing. Treating the seeds with *Trichoderma* or *Pseudomonas* protects the crops from disease causing microorganisms. Seeds should be treated with *Rhizobium* @ 250 gm/acre (600 gms / ha) to facilitate natural nitrogen fixation by plants.

Treated seeds should be dibbled at 3-4 cm depth at the side of the ridges. Sowing should be planned in such a way that the maturation of seeds does not coincide with rains. It will increase the percentage of off coloured seeds. The spacing maintained is 25 x 10cm for rainfed and 30 x 10cm for irrigated crop.

Nutrient management

During land preparation, farmyard manure @ 10 truck loads/acre (25 truck loads/ha) should be added and incorporated into the soil by ploughing. To meet the nutritional need of the crop Panchakavyam @ 300 ml/tank should be sprayed.NPK @ 10:20:10 kg/acre (25:50:25 kg/ ha) is recommended for irrigated crop, whereas for rainfed crop it is 5:10:5 kg/acre (12.5:25:12.5 kg/ha) for good seed yield. This will increase the number flowers and improve the seed setting and quality of the seeds.

Weed management

Hand weeding is done on 15th and 30th day after sowing.

Pest and disease management

Aphids, army worms, pod borer, white fly, yellow mosaic, leaf curl and leaf crinkle (Virus), root rot and powdery mildew are the common pests and diseases that affects the greengram and blackgram crop. The management measures for these pest and diseases are provided in Appendix – I.

Irrigation

The first irrigation is done soon after the sowing and life irrigation is done on the third day. After this, irrigation should be done once in 10 – 15 days depending upon the soil and climatic

conditions. Water stagnation should be avoided at all growth stages. Irrigation during flowering and pod formation stages are very critical.

Roguing

Roguing should be done from vegetative phase to reproductive phase. Offtypes are removed based on the leaf colour, plant stature, leaf shape, pod colour, flower colour and seed colour. Maximum percentage of offtypes permitted at final inspection is 0.10% for foundation seed production and 0.20% for certified seed production. In case of greengram the permitted limits of seed borne disease like halo blight affected plants is 0.10% for foundation and 0.20% for certified seed production.

Field inspection

A minimum of two inspections will be done from flowering to maturity stage by the Seed Certification Officer. The first inspection is done during flowering followed by second in flowering and maturity stage to check the isolation, off-types, volunteer plants, diseased plants and estimated yield.

Field standard

	Foundation seed	Certified seed
Isolation distance	10 m	5 m
Off-types	0.10%	0.20%
Greengram seed borne disease affected seed	0.10%	0.20%

Harvesting

Harvest is done soon after the maturation of the seeds. Seeds attain physiological maturity

30 days after 50% flowering. The mature pods of blackgram turns black and greengram pods turns brown. At this stage the moisture content of the pods will be 17 – 18%.

Threshing and processing

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 attain a moisture content of 8 – 9%. The seeds are graded using BSS 7 x 7 wire mesh sieve.

Drying and storage

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.

Seed standards

The percentage of maximum physical purity of foundation and certified seeds should be 98% with minimum of 75% of germination capacity and 9% of moisture content. Presence of other distinguishable varieties should be 10/kg for foundation seed and that of certified seed is 20/kg of seed.

COWPEA AND SOYA BEAN
(Vigna unguiculata and *Glycine max)*

Cowpea and Soya bean *(Vigna unguiculata* and *Glycine max)* belongs to the family Leguminosae. The suitable season for seed production is June – July and September – October for both cowpea and soya bean. There should not be rain or high humidity at the time of harvest as this will hamper the germination.

Method of seed production

Cowpea and Soya bean are self pollinated crops. In cowpea cross pollination occurs to the extent of 15 – 20% and mainly through insects. The crop should be raised in isolation. To maintain the varietal purity an isolation distance of 5 metres for certified and 10 metres for foundation seed production is maintained between varieties in cowpea and in soybean an isolation distance of 3 metres is maintained between varieties for certified and foundation seed production.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should not be cultivated with the same crop in the previous season. The land should be fertile with a pH range of 6 – 7.5 and proper drainage facility. Land should be ploughed for 3 – 4 times. During last plough apply FYM @ 10 truckloads per acre (25 truckloads per hectare).

Seed selection and sowing

Certified seeds of good quality should be obtained from authenticated source. Seeds should be healthy with good germination percentage. Remove the off colour and out sized seeds. Seed rate is 16 kg/acre (40 kg/ha) for soybean and for cowpea 8 kg/acre (20 kg/ha). Selected seeds should be treated with *Trichoderma viride* @ 10gm/kg of seeds to control seed borne diseases like root rot and wilt. Shade dry the seeds for 30 minutes before sowing. Seeds can also be treated with cow's urine, cow pat pit, panchagavyam etc. Seeds should be treated with *Rhizobium* @ 250 gms/acre to facilitate natural nitrogen fixation by plants. Soybean seeds are treated by wet sand method for uniform germination. Take equal quantity of seeds and sand. Mix water with sand @ 50 ml/kg and take a broad vessel and add seeds and sand in alternate layers and cover the vessel with a cloth. Remove the seeds after 16 hrs using a sieve. This seed treatment improves the germination capacity of the seeds.

Treated seeds should be dibbled at 2 - 4 cm depth in seed beds. Sowing should be planned in such a way that the harvest does not coincide with rains. It will reduce the seed quality. The spacing maintained is 45 x 15cm for cowpea and 30 x 10 cm for soya bean.

Nutrient management

The nitrogen, phosphorous and potassium requirement of soya bean is 8:32:16 kg/acre (20 : 80 : 40 kg/ha) and for cowpea is 10:20:10 kg/acre (25:50:25 kg/ha). Seed treatment with *Rhizobium* meets the nitrogen requirement to the extent of 8 kg/acre (20 kg/ha). Farmyard manure @ 5.5 tonnes/acre (14 tonnes/ha) or compost or biogas slurry @ 5 tonnes/acre (12.5 tonnes/ha) is applied.

Weed management

Hand weeding is done 25 – 30 days after sowing. This will control the weeds at the initial stage itself.

Pest and disease management

Soya bean is affected by pests and diseases like stem fly, girdle beetle, bacterial blight, yellow mosaic virus whereas cowpea is affected by aphids, pod borer, yellow mosaic virus and root rot. The management measures for these pests and disease are provided in Appendix -I.

Irrigation

The first irrigation is done soon after the sowing and the life irrigation is given on the third day of sowing. After this, the field is irrigated once in 7 – 10 days. Irrigation during flowering and pod filling stages are very critical.

Important operations

In cowpea the tendrils of the crops should be nipped off. This will aid in good seed setting.

Rouging

Roguing should be done from vegetative stage to harvesting stage. During this time off-types and volunteer plants are removed as and when they occur. Rouging is done based on the colour of leaves and stem, growth pattern, flower colour, pod colour and seed colour etc. Maximum percentage of off-types permitted at final inspection is 0.10% for foundation seed production and 0.50% for certified seed production.

Field inspection

A minimum of two inspections will be done by the Seed Certification Officer for both cowpea and soybean. In cowpea first inspection is done before flowering stage followed by the second one in maturity stage.

Field standard

	Foundation seed	Certified seed
Isolation distance	10 m	5 m
Off-types - Cow pea	0.10%	0.20%
Soya bean	0.10%	0.50%
Plants affected by seed borne diseases (for cow pea)	0.10%	0.20%

Harvesting

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 the plant and browning of the pods. This crop should be harvested at once, pods intact along with the plant.

Threshing and processing

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. The seeds should then be cleaned by winnowing. The seeds of soya bean and cowpea are graded using 14/64" and 10/64" round perforated metal sieves respectively.

Drying and storage

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.

Seed standards

The percentage of minimum 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 stage. Moisture content should be 9% for cowpea and 12% for soybean and the presence of other crop seeds 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 respectively.

REDGRAM *(Cajanus cajan)*

Redgram or pigeonpea *(Cajanus cajan)* belonging to the family Leguminosae is commercially known as toor dal. It is one of the widely used pulse varieties. The seed production of this crop can be taken up in all the three seasons June – August, September – November and February – March.

Method of seed production

Redgram is a cross pollinated crop. Cross pollination occurs mainly by bees and thrips. Seeds are allowed to set by open pollination under isolation. To maintain the varietal purity an isolation distance of 100 metres for certified and 200 metres for foundation seed production is necessary from fields of other varieties and of the same variety not conforming to the varietal purity requirements of certification.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should not be cultivated with the same crop in the previous season and should be free of volunteer plants. The land should be fertile with neutral pH. The soil should be light with proper drainage facility. A deep tilling up to 1.5 feet and a shallow tilling should be done before sowing.

Seed selection and sowing

Certified seeds of good quality should be obtained from authenticated source. Seeds should be healthy with good germination percentage. Remove the off colour and out sized seeds. Seed rate is 10 kg/acre (25 kg/ha) for short duration varieties and 4 kg/acre (10 kg/ha) for long duration varieties.

Treat the seeds with powder form of *Trichoderma viride* @ 4 gm/kg of seeds or *Pseudomonas* @ 10 gm/kg of seeds. Treating the seeds with *Trichoderma* or *Pseudomonas* protect the crops from disease causing microorganisms. Seeds can be soaked in diluted panchagavyam for 20 minutes and dried before treating with *Trichoderma* or *Pseudomonas*. After treating the seeds with these biocontrol agents treat them with biofertilizer *Rhizobium* @ 250 gms/acre seeds to facilitate natural nitrogen fixation by plants. Mix *Rhizobium* in rice gruel and then mix it with seeds. Shade dry the seeds for 15 minutes before sowing.

Treated seeds are sown in 4 – 6 cm deep by drilling when the soil is wet. The spacing maintained is 45 x 30 cm and 90 x 30 cm for short and long duration varieties, respectively.

Nutrient management

The nitrogen, phosphorous and potassium requirement of redgram is 10:20:10 kg/ acre (25:50:25 kg/ha). Seed treatment with Rhizobium meets the nitrogen requirement to the extent of 8 kg/acre (20 kg/ha). Farmyard manure @ 5.6 tonnes/acre (14 tonnes/ha) or compost or

biogas slurry @ 5 tonnes/acre (12.5 tonnes/ha) is applied.

Weed management

The first weeding / hoeing is done 20 – 25 days after sowing. The second weeding is done on 50 – 60 days after sowing. Weeding is not required after 60 days of sowing. If needed, then manual weeding should be done.

Pest and disease management

Redgram is affected by aphids, pod borer, yellow mosaic virus and root rot at different growth stages from vegetative stage to fruiting. The management measures for these pest and diseases are provided in Appendix – I.

Irrigation

The first irrigation is done immediately after sowing and the second irrigation is done 2 – 3 days after sowing. After this, the field is irrigated once in 8 – 10 days. Irrigation during flowering and pod filling stages are very critical.

Important operations

- To supplement pollination 5 – 8 beehives may be placed per hectare.
- To ensure pollen availability for longer duration and to induce continuous flowering, immature pods set in the plants should be removed from time to time.

Roguing

Roguing should be done at a 7 – 10 days interval till the completion of the flowering stage. Off-types and diseased plants affected by leaf spot, stem canker, wilt, yellow mosaic and sterility virus are removed from the seed field to maintain healthy crops. Plants of early and late flowering types should also be removed.

Field inspection

A minimum of three inspections should be done from vegetative to maturity stage by the Seed Certification Officer. The first inspection is done before flowering followed by the second during flowering and maturity stage to determine isolation, off-types, volunteer plants, presence of designated diseased plants and also to estimate the yield.

Field standard

	Foundation seed	Certified seed
Isolation distance	200 m	100 m
Off-types	0.10%	0.20%

Harvesting

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 two to three pickings. Harvest should not coincide with rains, because it will result in off coloured and dimpled seeds.

Threshing and processing

Harvested pods are dried under the sun light for a week. The dried pods are beaten with bamboo stick to separate the seeds. The seeds should then be cleaned by winnowing. Seeds are graded using 10/64" (B.S.S 5 x 5) round perforated metal sieves. Seeds of different colour and sizes should be removed.

Drying and storage

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 (Punthikottai)* 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.

Seed standards

The percentage of maximum 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.

HORSEGRAM *(Macrotyloma uniflorum)*

Horsegram *(Macrotyloma uniflorum)* belonging to the family Leguminosae is a lesser known bean variety and commonly known as poor man's pulse. The seed production of this crop should be taken up in November. Though the crop is extremely drought resistant the growth, flowering and fruit setting will be better during the winter season.

Method of seed production

Horsegram is a cross pollinated crop and the seeds are allowed to set by open pollination under isolation. To maintain the varietal purity an isolation distance of 5 metres for certified and 10 metres for foundation seed production is necessary from the fields of other varieties and of the same variety not conforming to the varietal purity requirements of certification.

Seed production stages

Breeder seed ➔ Foundation seed ➔ Certified seed

Land selection

The land selected should not be cultivated with the same crop in the previous season and should be free of volunteer plants. The land should be fertile with neutral pH. The soil should be light with proper drainage facility. One or two ploughings followed by harrowing is enough to prepare the land for cultivation.

Seed selection and sowing

Certified seeds of good quality should be obtained from authenticated source. Seeds should be healthy with good germination percentage. Remove the off coloured and out sized seeds. Seed rate is 20 kg/ha.

Treat the seeds with powder form of *Trichoderma viride* @ 4 gm/kg of seeds or *Pseudomonas* @ 10 gm/kg of seeds. Treating the seeds with *Trichoderma* or *Pseudomonas* will protect the crops from disease causing microorganisms. After treating the seeds with these biocontrol agents treat them with biofertilizer *Rhizobium* @ 250 gm/acre (600 gms/ha) of seeds to facilitate natural nitrogen fixation by plants. Mix *Rhizobium* in 500 ml of cooled rice gruel and then mix it with the seeds. Shade dry the seeds for 3 – 4 hours before sowing.

Treated seeds are sown in lines at 2 cm depth in the wet soil. The spacing maintained is 30 x 10 cm.

Nutrient management

Farmyard manure @ 6 tonnes/acre (14 tonnes/ha) or compost or biogas slurry @ 5 tonnes/acre (12.5 tonnes/ha) is applied before last ploughing and incorporated into the soil. A basal dose of 4 kg/acre (10 kg/ha) nitrogen and 10 kg/acre (25 kg/ha) phosphorus promotes good crop growth and increases the yield of grain and fodder. The nitrogen, phosphorous and potassium requirement of horsegram is 10:20:0 kg/acre (25:50:0 kg/ha). Seed treatment with Rhizobium meets the nitrogen requirement to the extent of 8 kg/acre (20 kg/ha).

Weed management

The first weeding is done within 10 days after sowing and repeated after 15 days. Hand weeding is most preferred. Weeding should be repeated as and when needed.

Pest and disease management

Horsegram is commonly affected by the pests and diseases like aphids, pod borer, leaf eating caterpillar, yellow mosaic virus and root rot at different stages of its growth. The management techniques for these pests and diseases are provided in Appendix – I.

Irrigation

The first irrigation is done immediately after sowing and the second irrigation is done 2 – 3 days after sowing. After this, the field is irrigated

as needed. Irrigation during flowering and pod filling stages are very critical.

Roguing

Roguing should be done from the vegetative stage to the harvesting stage. Off-types and diseased plants are removed from the seed field to maintain healthy crops. Roguing is done based on the height, colour and shape of the plant, flower colour, size, shape and colour of the pod etc. Maximum percentage of off-types permitted at the final inspection is 0.10% for foundation seed production and 0.20% for certified seed production.

Field inspection

A minimum of two inspections will be done from flowering to fruiting stage by the Seed Certification Officer. The first inspection is done during peak flowering stage followed by the second during fruiting stage to determine isolation, off-types, volunteer plants and to estimate the yield.

Field standard

	Foundation seed	Certified seed
Isolation distance	10 m	5 m
Off-types	0.10%	0.20%

Harvesting

The crop 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. Harvest should not coincide with rains, because it will result in off coloured and dimpled seeds.

Threshing and processing

Harvested 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. Seeds are graded using 8/64" or 3.1 mm round perforated metal sieve. Seeds of different colour and sizes and broken ones should be removed.

Drying and storage

Processed and graded seeds are further dried for safe storage. The seeds should have the maximum moisture content of 8%. Seeds with this moisture content can be stored for up to one year under open storage conditions.

Seed standards

The percentage of minimum 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.

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APPENDIX – I PEST AND DISEASE MANAGEMENT IN OILSEEDS AND PULSES

Sl. No.	Crop	Common Pests and Diseases	Management measures
1.	Groundnut	Root and pod feeders, *White grubs* - (affects at the time of pod formation)	Summer ploughing, good drainage facility, early sowing, using light traps, manual picking and destroying of affected parts.
		Tobacco caterpillar *(Spodoptera litura)* - (affects at the vegetative stage)	Use light trap or pheromone trap @ 5/acre (12/ha) and collect and destroy the egg masses manually.
		Red hairy caterpillar *(Amsacta albistriga)* - (affects at the vegetative stage)	Use egg parasitoids – *Telenomous manolus* for destroying the eggs and fungal parasitoids – *Aspergillus flavus* for the control of larvae.
		Groundnut Leaf miner – *Aproaerema modicella* - (affects at the vegetative stage)	Early sowing in rain fed cultivation, use light traps or pheromone traps, mulch in dry lands and spray neem seed kernel extract 6 litres/acre (15 litres/ha) or neem oil 6 litres/ acre (15 litres/ha) or neem leaf extract 10 kg/acre (25 kg/ha).
		Leaf spot or Tikka disease Rust *(Puccinia arachidis)* Alternaria leaf spot *(Alternaria helianthi)* Stem rot *(Sclerotium rolfsii)*	Destroy the diseased plant parts, proper weed management and seed treatment using asafoetida solution (250 gms in 2 litre of water for 20 kg of seeds).

2.	Gingelly	Leaf and pod caterpillar *(Antigastra catalaunalis dup.)*- (affects at early vegetative stage) Sesame sphinx or hawk moth *(Acherontia styx) – (affects from vegetative to maturity stage)*	Summer ploughing, good drainage facility, early sowing, using light traps @ 6-9 per acre (15 – 22 per ha) once in fortnight, manual picking and destroying of affected parts.
		Sesame gall fly *(Asphondylia sesami)* - (affects at the flowering stage)	Remove and destroy infested buds, using light traps and spraying neem seed kernel extract (100 gm in 10 litres of water).
		Phyllody (virus)	Remove and destroy the affected plants and delaying the sowing three weeks after onset of the monsoon.
		Wilt *(Fusarium oxysporum)*	Destroy the diseased plants, spray *Trichoderma viride* (10 gms in 1 litre of water) or 5% cow's urine.
		Stem and root rot *(Macrophomina phaseolina)*	Proper aeration and drainage, soil application of *Pseudomonas fluorescens* (@ 1 kg/ acre or 2.5 kg/ha mixed with 20 kg / 50 kg of farmyard manure) on 30 days after sowing or soil application of neem cake @ 60 kg/acre (150 kg/ha) combined with seed treatment with *Trichoderma viride* @ 1.5 kg/acre (4 kg/ha).
		Bacterial leaf spot *(Pseudomonas syringae, P. sesami)*	Seed treatment with hot water (at 52^{o}C for 10 minutes) is best to prevent the disease.

3.	Sunflower	Captiulum borer *(Helicoverpa armigera)* - (affects from vegetative to maturity stage)	Collect and destroy the caterpillars and use pheromone traps to attract adult moths.
		White fly *(Bemisia tabaci)* - (attacks at all stages of the crop)	Spray 5% neem seed kernel extract or neem oil extract
		Jassids *(Amrasca biguttula biguttula)* - (attacks at early vegetative stage)	Spray the following solution - cow's urine 15 litres, cow dung 2 kg and crushed neem leaves 15 kg mixed with 100 litres of water and fermented for 3 - 5 days. Filter the solution and use as foliar spray.
		Leaf spot, Rust *(Puccinia helianthi)* and Root rot *(Sclerotium rolfsii)*	Seed treatment with *Trichoderma viride* @ 4gm/kg of seed or *Pseudomonas* @ 2g/kg seeds, spray 10% cow's urine thrice at 10 days interval and apply 60 – 100 kg of neem cake as basal manure.
4.	Mustard	Alternaria blight *(Alternaria brassicae)*	Seed treatment using cow's urine and spraying of *Trichoderma viride* (10 gms/ litre of water) or cow's urine @ 5% concentration.
		Mustard aphid - *(Lipaphis erysimi)* - (attacks at all stages of the crop)	Sprinkle ash @ 500 – 600 kg/acre (1250 – 1500 kg/ha) on the crop in initial stage, irrigate 45 days before sowing to control the pest and use light traps.
		Painted bug *(Bargrada hilaris)* – (attacks young plants) Mustard sawfly *(Athalia lugens proxima)* - (attacks at early vegetative stage)	Remove and destroy infested plants and bugs, spray 10% neem seed solution, use light traps and sprinkling *Jeevamrut* at the initial stage for resistance.
		White rust *(Albugo candida)*	Seed treatment using *Trichoderma viride* @ 4gm / kg, vermiwash mixed with water @ 1:13.5 ratio protects the crop from fungal infections.

PULSES			
5.	Greengram and Blackgram	White fly *(Bemisia tabaci)* - (attacks at early vegetative stage)	Spray neem seed kernel extract or neem oil extract @ 5% concentration.
		Powdery mildew *(Erysiphe poygoni)*	Spray butter milk extract (one part of curd in two parts of water) @ 1 litre/tank or spray *Eucalyptus* leaf extract @ 10% at the initial stage of disease infestation and repeat after 10 days.
6.	Soybean	Stem fly *(Melanagromyza sojae)* – (attacks from vegetative to reproductive stage)	Deep summer ploughing, remove and destroy leaves with the eggs, spray cow's urine or ash and cow's urine at seedling stage with 2-3 leaves.
		Girdle beetle *(Oberea brevis)* - (attacks from vegetative to reproductive stage)	Use healthy seeds, light traps and spray cow's urine and cow dung solution.
		Bacterial blight *(Pseudomonas glycinea)*	Mix *Trichoderma viride* @ 3.2 kg with 25 kg of farmyard manure and apply it to the field after one week before sowing or seed treatment using *Trichoderma* @ 10 gm/kg of seeds.
		Yellow mosaic virus	Pull out and destroy the infected plants.
7.	Greengram Blackgram Cowpea Redgram Horsegram	Aphids *(Aphis craccivora)* – *(attacks at all stages of the crop)*	Spray neem seed extract or neem cake extract @ 1 litre/tank and maintain proper spacing between the crops.
		Army worm *(Spodoptera litura)* – (attacks at early vegetative stage) Pod borer *(Helicoverpa armigera)*- (attacks from vegetative stage to maturity stage)	Use light traps, erect bird perches @ 4 – 5 per acre (10 – 12 per hectare), releasing *Chrysoperla* @ 2025 eggs/acre (5000 eggs/ha) at 15 days after sowing and *Trichogramma* @ 50,000 eggs (2-3 cards) at 30 days after sowing or spray five leaf extract or ginger, garlic and chilli extract @ 1 litre/tank.

8.	Greengram Blackgram Cowpea Redgram Horsegram	Leaf eating caterpillar *(Azazia rubricans)* – (attacks at vegetative stage)	Collect and destroy eggs and larvae and pull out and destroy infected plants.
		Yellow mosaic virus Leaf curl and leaf crinkle (Virus)	Pull out and destroy infected plants
		Root rot *(Pellicularia filamentosa),* Rust *(Uromyces appendiculatum)* and Anthracnose *(Colletotrichum lindemuthianum)*	Use healthy seeds, seed treatment with talc formulation of *Trichoderma viride* @ 4 gm/kg of seed or *Pseudomonas fluoroscences* @ 10 gm/kg seed and application of neem cake @ 60 kg/acre (150 kg/ha) as basal manure to reduce the root rot and cyst nematode.

APPENDIX – II PREPARATION PROCEDURES

1. Cow dung extract

Mix one kilogram of cow dung with 10 litres of water and filter using a gunny cloth. Dilute the solution with 5 litres of water and filter again. This can be used for spraying.

2. *Panchagavyam*

Panchagavyam is a growth regulator produced with the combination of five products obtained from the cow along with a few other bioproducts. Collect fresh cow dung (5 kg), mix it with ghee (1 litre) and keep it in a plastic barrel separately for 3 days. On the same day, mix the other ingredients namely cow's urine (3 litres), cow's milk (2 litres), curd (2 litres), yellow banana (400 g, without skin), coconut water (3 litres), Jaggery (one kilogram dissolved in 3 litres water) in a plastic barrel separately. Filter the jaggery solution before adding it to the other ingredients. On the 3rd day, mix the contents of both the barrels and leave it aside for 7 days. Stir the contents with a wooden stick twice a day. After 7 days, filter the product with a khada cloth / Terracot (TC) cloth and store it in closed containers. (Pierce small holes in the cap of the containers to prevent bursting). This is diluted @ 300ml / 10 litres water and sprayed.

3. *Amirthakaraisal*

Take fresh cow dung (10 kg), cow's urine (10 litres), country jaggery (1 kg) and water (100 litres) in a cement tank and mix well. This can be used the next day. Add this extract to the irrigation channel or spray directly. This improves the soil fertility and gives good yield.

4. *Bija Amrut*

Ingredients : Cow dung – 5kg, cow's urine – 5 lit, cow's milk – 1 lit, lime – 250 gms and water – 100 lit. Mix all the ingredients and keep it overnight, sprinkle this formulation on seeds to be sown, dry in shade before sowing.

5. *Jiwa Amrut*

Ingredients: Cow dung – 10 kg, cow's urine – 10 lit, jiggery (old) – 2kg, flour of gram, pigeon pea, moong dal or cowpea or urad dal – 2 kg, live soil – 1 kg and water – 200 lit

Take 100 litres of water in barrel and add 10 kg cow dung + 10 lit cow's urine. Mix well with the help of wooden stick, add 2 kg old jaggery and 2 kg flour. Mix this solution well with wooden stick. Keep this solution for fermentation for 2 to 7 days. Shake the solution regularly three times a day.

6. *Amritpani*

Mix 10 kg of cow dung with 500 gm honey and mix thoroughly to form a creamy paste. Add 250 gm of ghee and mix at high speed. Dilute with 200 litres of water. Sprinkle this suspension in one acre over soil or with irrigation water. After 30 days, apply second dose in between the row of plants or through irrigation water.

7. Ginger, Garlic, Chilli Extract

This extract is made from three plants. For preparing the extract required for one acre, 1 kg of garlic, ½ kg of ginger and ½ kg of green chillies are required. Take all the three separately and make them into a fine paste. Dissolve all the three pastes in 7 litres of water and mix them well. On filtering this, 6 litres of extract can be obtained. The concentration of the extract can be increased or decreased from 500-1000 ml/tank (10 litre capacity) depending on the intensity of the pest attack. This extract should be used immediately after preparation. This extract can be stored for a maximum of 3 days.

8. Five Leaf Extract

This extract is prepared using leaves of five different plants. Leaves with five different characteristics are used for this purpose

- Plants with milky latex - *Calotropis, Nerium, Cactus* and *Jatropha.*
- Plants which are bitter - Neem, *Andrographis, Tinospora* and *Leucas.*
- Plants that are generally avoided by cattle - *Adathoda, Ipomeafistulosa*
- Aromatic plants – *Vitex, Ocimum, Papaya*
- Plants that are not affected by pests and diseases – *Morinda, Ipomeafistulosa*

One plant in each category should be taken in equal quantities (1 kg in each) and pound well. Take them in a mud pot and add twice the quantity of water. To this, add 1 litre of cow's urine and 100 g of Asafoetida. Tie the mouth of the pot tightly with a cloth. This extract should be mixed well daily in the evening.

This extract should be used after a period of one week. If this extract is to be used for prophylatic as a precautionary measure, 500 ml of the extract should be added for a tank of 10 litre capacity. This should be diluted with 9½ litres of water and used. If the pest infestation is severe 1000 ml of extract should be used per tank and diluted with 9 litres of water. This extract can be stored and used for a period of 25-30 days.

Note : Cow's urine is used for disease control and Asafoetida prevents flower dropping and enhances the yield.

9. Neem Kernel Extract

About 3–5 kg of neem kernel is required for an acre. If the seeds are fresh, 3 kg of kernel is sufficient. If the seeds are old, 5 kg is required. Remove the outer seed coat and use only the kernel. Pound the kernel gently and place it in an earthen pot. To this, add 6-10 litres of water. Tie the mouth of the pot securely with a khada cloth. Leave it as such and filter after 3 days. On filtering, 5-9 litres of extract can be obtained. When the pest incidence is more, 1000 ml of this extract should be used for one tank (a tank of 10 litre capacity). If the pest population is less, it is enough to use just 500 ml of the extract for one tank. 500-1000 ml of extract should be diluted with 9 ½ or 9 litres of water before spraying. Khadi soap solution @ 10ml/litre (100 ml/tank) should be added to help the extract stick well to the leaf surface. For one acre of the crop, 6-7 tanks of the diluted extract should be used.

Note : The seeds used for preparing this extract should be at least 3 months old. When they are less than 3 months or more than 8 months old, the azadirachtin content in the seeds will be less and hence the pest control property in these seeds will also be poor. The extract prepared should be milky white in colour. If they are prepared from aged seeds, the extract will be brownish in colour.

Preparation of Khadi Soap Solution

Khadi soap solution should be added with all botanicals before spraying. This is a neem based soap without any detergent. Khadi soap solution helps the extract to stick well to the plant surface. It should be soaked overnight in water and used. The soap solution should be sticky and thick in nature. Before spraying the botanicals, for every one litre of the extract, 10 ml of khadi soap solution should be added.

10. Neem Cake Extract

5 kg of Neem cake is required for an acre of land. Powder the neem cake well and place it in a khada cloth and tie it. Soak it in a vessel containing 10 litres of water for 3 days. After 3 days squeeze the pouch well into the water. About 7–8 litres of extract can be obtained. About 500–1000 ml of this extract is used for one tank (a tank of 10 litre capacity). 500-1000 ml of the extract should be diluted with 9½ or 9 litres of water before spraying. Khadi soap solution @ 10 ml / litre (100 ml/ tank) should be added to help the extract stick well to the leaf surface. For one acre 6-7 tanks of the extract should be used.

11. Neem Oil Extract

About 1200–1800 ml of neem oil is required for one acre. 200–300 ml of oil is required for one tank (a tank of 10 litre capacity). Take the required neem oil and the soap solution and mix it well. Khadi soap solution @ 10ml/litre (100 ml/tank) should be added. Once the soap solution is mixed well with the extract, it should be diluted and used for spraying.

Note: This spray should be used immediately after preparation. Otherwise oil droplets will start floating on the surface. Power sprayers should be used for spraying this extract. The oil which has been prepared within a year's time should only be used.

12. Preparation of Kashayam

The plants selected for kashayam preparation should be collected without the roots. The plants should be cut into small pieces and used. For one acre of crop, 2 kg of the cut plants should be mixed with 8 litres of water. This has to be taken in a wide mouthed vessel and boiled until the extract reduces to 2 litres. This has to be cooled and filtered. 300 ml of this extract should be diluted with 100 ml of soap solution and 9.4 litres of water to obtain one tank capacity of the extract.

Plants used in kashayam preparation	Pests and diseases controlled
1. Andrographis paniculata	All kinds of larvae
2. Sida spinosa	Aphids and Sap feeders
3. Adathoda zeylanica	Fungal diseases
*4. Panchathiktha kashayam**	All kinds of pests

* Panchathikthakashayam is prepared by using equal quantities of five types of bitter leaves.

Note:

1. The extracts that are kept closed should be stirred well daily.
2. Power sprayers should be used for controlling winged pests such as green plant hoppers, ear head bugs and white flies.
3. For one tank of the extract 100 ml of khadi soap solution should be added.
4. The extracts should always be sprayed in the morning (between 7.00 a.m.–10.00 a.m.).
5. Use 500 - 1000 ml of extract per tank depending upon the intensity of the pests.
6. Use 6 - 7 tanks of extract per acre (15 - 17 tanks/ha

APPENDIX – III

COMMON AND SCIENTIFIC NAMES OF PLANTS

Sl. No.	English Name	Scientific Name
1.	Adhatoda	*Justicia adhatoda*
2.	Andrographis	*Andrographis paniculata*
3.	Blackgram	*Vigna mungo*
4.	Chillies	*Capsicum annuum*
5.	Cowpea	*Vigna unguiculata*
6.	Daincha	*Sesbania bispinosa*
7.	Garlic	*Allium sativum*
8.	Gingelly	*Sesamum indicum*
9.	Ginger	*Zingiber officinale*
10.	Greengram	*Vigna radiata*
11.	Groundnut	*Arachis hypogea*
12.	Guduchi	*Tinospora cordifolia*
13.	Holy basil	*Ocimum tenuiflorum*
14.	Horsegram	*Macrotyloma uniflorum*
15.	Horseshoe vitex	*Vitex negundo*
16.	Indian mulberry	*Morinda citrifolia*
17.	Ipomoea	*Ipomoea sp.*
18.	Milk weed	*Calotropis procera*
19.	Mustard	*Brassica sp.*
20.	Neem	*Azadirachta indica*
21.	Nerium	*Nerium oleander*
22.	Papaya	*Carica papaya*
23.	Prickly fan plant	*Sida spinosa*
24.	Prosopis	*Prosopis juliflora*
25.	Purging nut	*Jatropha curcas*
26.	Redgram	*Cajanus cajan*
27.	Soyabean	*Glycinia max*
28.	Sunflower	*Helianthus annus*
29.	Sunhemp	*Crotolaria juncea*
30.	Thumbai	*Leucas aspera*

APPENDIX – IV

COMMON AND SCIENTIFIC NAMES OF INSECTS

Sl. No.	English Name	Scientific Name
1.	Aphids	*Aphis craccivora*
2.	Army worm	*Spodoptera litura*
3.	Capitulum borer / pod borer	*Helicoverpa armigera*
4.	Girdle beetle	*Oberea brevis*
5.	Groundnut leaf miner	*Aproaerema modicella*
6.	Jassids	*Amrasca biguttula biguttula*
7.	Leaf eating caterpillar	*Azazia rubricans*
8.	Leaf and pod caterpillar	*Antigastra catalaunalis*
9.	Mustard aphid	*Lipaphis erysimi*
10.	Mustard sawfly	*Athalia lugens proxima*
11.	Painted bug	*Bargrada hilaris*
12.	Red hairy caterpillar	*Amsacta albistriga, A. Moorie*
13.	Sesame sphinx or hawk moth	*Acherontia styx*
14.	Sesame gall fly	*Asphondylia sesame*
15.	Stem fly of Soyabean	*Melanagromyza sojae*
16.	Tobacco caterpillar	*Spodoptera litura*
17.	White fly	*Bemisia tabaci*
18.	White grub of groundnut	*Holotrichia consanguinea*

APPENDIX – V GLOSSARY OF TECHNICAL TERMS

ANTHESIS: The process of dehiscence of anthers and the period of pollen distribution - See also Dehiscence.

BREEDER SEED - The seed of a new variety with highest purity, produced, developed, controlled and distributed directly by the breeders or their institution for further multiplication.

CERTIFIED SEED - The progeny of the foundation seed, registered or certified seeds, handled to maintain sufficient varietal identity and purity, grown by selected farmers under prescribed conditions of culture and isolation and subjected to field and seed inspections prior to the approval by the certifying agency.

CROSS POLLINATION: When the pollen of one flower gets deposited on the stigma of another flower either on the same plant or on a different plant of the same kind.

CULTURAL PRACTICE: Practices that have been followed by farmers for several generations and found effective. Practices like, deep ploughing and burning of crop residues, synchronous planting of crop fields, planting trap crops, intercropping, crop rotation, tillage and use of pest-free seeds and planting material are examples of cultural practices.

DAMPING OFF: An infection of the basal portion of the nursery seedlings and young plants caused by fungus, resulting in decomposition of the plants.

DEHISCENCE: Act of anthers becoming ripe and bursting to discharge the dry pollens. The time when this takes place is called anthesis.

DESICCATE: Process of drying seeds completely in order to preserve it.

EXOTIC SPECIES: A species that has been introduced from another geographic region to an area outside its natural range.

FOUNDATION SEED - The progeny of the breeder seed produced by the trained officers of an agricultural station in conformity with regulated national standards and handled to maintain genetic purity and identity of the variety.

FUMIGATION: The application of smoke, vapour or gas for the purpose of disinfecting or destroying pests or microorganisms.

GENETIC UNIFORMITY / PURITY: A variety that has all the unique characteristics of its mother. It can be maintained by isolation of a crop by a specified distance from other varieties (or) contaminants. See varietal purity.

GREEN MANURE CROPS: Plants that can absorb atmospheric nitrogen with the help of certain microorganisms found in their root nodules and convert it into a form, which can be used by the soil. Eg. Most of the *Leguminosae* members.

INFLORESCENCE: An inflorescence is a group or cluster of flowers arranged on a stem that is composed of a main branch or a complicated arrangement of branches.

MONECIOUS: Plants with separate male flowers and female flowers on the same plant.

OFF TYPES: Plants that are differ in morphological and agronomical characteristics from the majority or the representative plants of a variety. Ex: Admixtures and obvious contaminants in a field.

OPEN POLLINATION: Pollination occuring by insects, birds, wind, or other natural mechanisms. The seeds of open-pollinated plants will produce new generations of those plants.

PLANKING: In some crops soon after the seed sowing, the seeds are covered with a layer top soil using a wooden plank to protect them from insects, birds etc. Ex: Mustard.

PUBESCENCE: The hairy growth on the surface of the plant body.

ROUGING: The act of removing undesirable plants. The removal of individual plants, which deviate in a significant manner from the normal or average type of a variety. A step in the maintenance of purity in an established variety or in the attainment of purity in a new variety.

SEED DORMANCY: A period in the seed life history where development is temporarily suspended.

SEED DRILL: An agricultural implement that makes furrows into which it drops seeds.

SEED VIABILITY: The capacity of a seed to germinate.

THINNING: The process of removing additional seedlings from a pit / plot after germination to improve the growth rate or health of other seedlings.

TIME ISOLATION: Separation of varieties / species / contaminants by adjusting the sowing date in such a way that both crops do not come to flowering at the same time. The crossing is prevented and genetic purity is maintained.

VARIETAL PURITY: Maintenance of true to type nature of the plant / seed. The plant / seed resembles its mother in all features (i.e.) from seed to plant to seed.

VIGOUR: Seed vigour is a measure of the quality of seed, and involves the viability of the seed, the germination percentage, germination rate and the strength of the seedlings produced.

VOLUNTEER PLANTS: Unwanted plants growing from the seeds that remain in the field from a previous crop.

WINNOWING: A method by which the chaff is wafted away from the seeds after tossing into the air. By this method the calyxes, stems, old petals, husks and dead reproductive organs of the flowers and fruits etc. could be separated from the seeds.