

# Seed Production Techniques for Cereals and Millets

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 techniques for cereals and millets describes the procedures and technologies involved in the production of quality seeds of cereals and millets. Cereals and Millets 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 Techniques for Cereals and Millets**

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**December 2013**

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Editorial Assistance	R. Abarna Thooyavathy & K. Parimala
Editor	K. Vijayalakshmi
Publication	December 2013
Cover Photograph	Centre for Indian Knowledge Systems
Cover Design & Typesetting	S. Ramesh
Design Consultant	Pavithra Sankaran
Published by	Centre for Indian Knowledge Systems (CIKS) Seed Node of the Revitalising Rainfed Agriculture Network
Financial Support	Revitalising Rainfed Agriculture Network
Copies can be had from	Centre for Indian Knowledge Systems, No.30,Gandhi Mandapam Road, Kotturpuram, Chennai – 600 085 Ph: (044) 24471087, 24475862 Email: info@ciks.org /ciksorg@gmail.com Website: www.ciks.org  The RRA Network, Secretariat WASSAN, House No. 12-13-450 Street No. 1, Tarnaka Secunderabad - 500 017, Andhra Pradesh. Email : secretariat@rainfedindia.org Website : www.rainfedindia.org
Printed by	PM Digital Products 'Konar Maligai', 25, Peters Road Chennai - 600 014.

## 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 techniques for cereals and millets describes the procedures and technologies involved in the production of quality seeds of cereals and millets. 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 TECHNIQUES FOR CEREALS

The land under cereal production in India was last reported as 9,26,10,000 hectares in 2010 according to a World Bank report published in 2012. Cereals have throughout history been unquestionably the most important sources of plant food for humans and livestock. The development of all the major cereals occurred long before the recorded history for all the oldest civilizations.

All cereals are members of the grass family, Gramineae. Wheat, Rye, Rice, Oats and maize are some of the important cereals in the world today. Cereals are important because one or more of them are available in each of the different world

climates. They also have a wide range of soil and moisture requirements. They can be cultivated with minimum effort and can give a high yield. The grains are relatively easy to handle and store because of their low water content. The food value of cereals is very high and they contain a high percentage of carbohydrates than any other food.

It is becoming very important to increase the yields of cereals to feed the growing population. Good quality cereal seeds play a very important role in increasing yields. This section deals with the seed production techniques for two important cereals namely paddy and wheat.





## PADDY (*Oryza sativa*)

**P**addy (*Oryza sativa*) is a well known cereal belonging to the family Gramineae. It is the second important cereal next to wheat in Asia. It is a staple food for more than 60% of the population. Paddy seed production can be taken up in all the seasons like December - January, April - May, May - June, June - July, July - August and September - October.

### Method of seed production

Paddy is a self-pollinated crop with cross-pollination to the extent of 0 - 4%. The crop should be raised in isolation and seeds are allowed to set by open-pollination. To maintain the varietal purity an isolation distance of 3 metres is maintained in both certified and foundation stage of seed production. If isolation by space is not possible then the time isolation of 21 days can be given. Barrier isolation with polythene sheets of 2 metres height or barrier crops like sesbania, sugarcane and maize covering a distance of 3 metres would also serve the purpose.

### 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. This standard requirement is applicable for both nursery and main field. Land should be free of volunteer plants. Land should be fertile with good irrigation and drainage facilities and with good sunlight and aeration.

### Seed selection and sowing

Seeds used for the seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with good germination percentage. Seed rate is 60 kg/acre (150 kg/ha). Quality seeds can be separated from unviable seeds by soaking in water. The unviable and damaged seeds that float on the water surface

should be removed and the good quality seeds that sink should be used for cultivation. If there is excess of chaffy seeds in the selected seed lot, take some water in a vessel and drop an egg in it and keep adding salt till the egg reaches surface. Then add seeds to the water and remove the chaffy unviable seeds that float on the surface of the water. Then wash the selected seeds in good water for 2 - 3 times to remove the salt completely. Otherwise it will interfere with germination.

Selected seeds should be treated in order to improve the germination potential, vigour and resistance to pest and diseases.

- Selected seeds should be treated with cow dung and cow's urine solution (0.5 kg fresh cow dung + 2 litres of cow's urine + 5 litres of water). Soak the seeds in water for 10 - 12 hours and then in the cow dung solution for 5 - 6 hours. Shade dry the seeds before sowing.
- Selected seeds should be tied in small cloth bags and soaked in cow's urine solution (500 ml cow's urine in 2.5 litres of water) for 30 minutes and shade dried before sowing.
- Soak the seeds required for 1 hectare in sweet flag extract (1.25 kg of sweet flag rhizome powder in 6 litres of water) for 30 minutes and shade dry before sowing.
- Biofertilizers like *Azospirillum* / *Azotobacter* / *Pseudomonas* @ 10 gms / kg of seeds mixed with 20 ml cooled rice gruel can be used. Mix this with the sprouted paddy seeds. Shade dry the seeds for 30 minutes before sowing.

### Nursery preparation

To raise seedlings for one hectare of land 800 m<sup>2</sup> of nursery bed is required. The nursery bed should be ploughed for four times and then spread with neem leaves. Neem leaves should be allowed to decay in the water for 6 - 7 days. After that the land should again be ploughed for four times and leveled. Neem leaves can be substituted



with neem cake (8 - 10 kg) or vermicompost (10 – 15 kg). It has to be added and incorporated into the soil during the last plough. Then seeds are sown on a leveled nursery bed. Leaves of *Adhatoda vasica* can be incorporated into the soil while preparing the nursery. This will increase the soil fertility, act as an insecticide and render the easy uprooting of the seedlings.

### Nursery level pest and disease management

Seedlings in the nursery are generally attacked by green leaf hopper, green horned caterpillar and diseases like brown leaf spot and blast. These attacks can be prevented at the appearance of the first symptom by spraying 10% cow's urine solution in two doses at 7 days interval. This should be immediately followed by pest management techniques.

Before plucking the seedlings the nursery should be irrigated and applied with 15 – 20 kgs of gypsum to prevent damage to the rootlets. Biofertiliser *Azospirillum* @ 1 kg/acre (2.5 kg/ha) is mixed with 25 kg of farmyard manure and applied to the nursery 30 minutes before plucking. The seedlings are kept submerged in the nursery for 30 minutes and then transplanted.

### Preparation of main field

The main field should be ploughed and irrigated many times and the bunds are plastered to prevent water leakage. Groundnut or neem cake @ 6 quintals/acre (15 quintals/ha) should be applied as basal manure during final plough. Then the field should be leveled before transplanting. At the time of final ploughing dried cow dung and ash mixture can be spread uniformly to facilitate aeration and to activate microbes in the soil.

### Seedling treatment and transplantation

Before transplanting the seedlings are treated against pest and disease attack.

- Treat seedlings with ash and neem seed mixture. Paddy seedling bundles should be kept in small plots of standing water mixed with ash and neem seed powder mixture (1 kg ash and 500 gms of neem seed powder for 50 bundles of seedlings) for 30 minutes to an hour. Seedlings treated with this mixture produce a crop free from pests and diseases.
- Soak the seedlings in groundnut cake and neem cake solution before transplanting to make the seedlings less vulnerable to pest attack.
- Paddy seedlings can also be dipped in a solution of *Amirthakaraisal* (*Amrutpani*) / *Panchagavyam* / *Jeevamrut*.

The optimum age of seedlings for transplanting is 18 – 22 days for short, 25 – 30 days for medium and 35 – 40 days for long duration varieties. 2-3 seedlings per hill are transplanted at a depth of 3 cm. The spacing between the seedlings will vary according to the variety cultivated (Short duration – 15 x 10 cm, Medium duration – 20 x 10 cm and Long duration – 20 x 15 cm). Before transplanting clip off the tips of the seedlings to facilitate uniform growth.

### Nutrient management

During final ploughing cow dung 5 – 6 tonnes/acre (12 – 15 tonnes/ha) / goat dung 5 tonnes/acre (12.5 tonnes/ha) / poultry waste 2 tonnes/acre (5 tonnes/ha) / pig dung 1 tonne/acre (2.5 tonnes/ha) can be applied and incorporated into the soil. To meet the nitrogen need





biofertilizers like *Azospirillum* / *Azotobacter* / *Phosphobacteria* are also used.

Growth regulators like *Panchagavyam* @ 3% can be applied at the tillering and bootling stages for coarse varieties and at the bootling stage alone for fine varieties. *Amithakaraisal* @ 500 litres/acre (1250 litres/ha) should be mixed with irrigation water.

Green manure crops like sunhemp, daincha, Indian indigo etc., should be raised in the main field and incorporated into the soil 45 – 50 days after sowing. The plants should be allowed to decay in the water for ten days and then ploughed. The decomposed plants convert the unavailable forms of calcium, phosphorus and micronutrients present in the soil into an easily available form.

Application and ploughing of green leaves into the soil will also increase the nitrogen content of the soil. Leaves of *Neem*, *Pongamia*, *Gliricidia* etc., are used as green leaf manure.

Oil seed cakes like neem cake and groundnut cake can also be applied to meet the nitrogen needs of the crop. In paddy neem cake is applied as basal manure @ 60 kg/acre (150 kg/ha) and as top dressing @ 25 kg/acre (60 kg/ha) or groundnut cake is applied as basal manure @ 40 kg/acre (100 kg/ha) and as top dressing @ 10 kg/acre (25 kg/ha).

### Weed management

Weeding should be done manually and the weeds removed should be trampled into the field for the conservation of nutrients and for organic matter as mulch. The first weeding should be done at 15 – 20 days after transplanting. After weeding 50 kg of neem cake should be applied

to the field. Weeding should be done as and when it is required. Weeds can be controlled by the following methods,

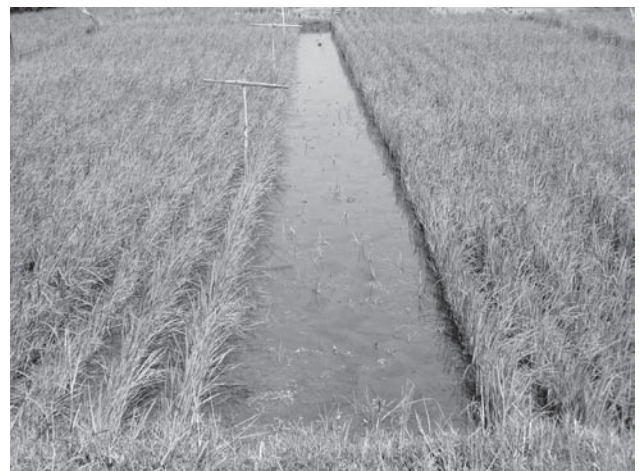
- Weeds can be controlled by flooding the field to a height of 5 – 8 cm at an early vegetative stage.
- *Calotropis* (*Calotropis gigantea*) can be used as green manure to control the weeds.
- During land preparation leaves and twigs of poison nut (*Strychnos nux-vomica*) can be added and incorporated into the soil. This will suppress the weed growth.

### Irrigation

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

### Pest and disease management

Paddy is commonly affected by pests and diseases like leaf eating caterpillars, leaf folders, case worm, green leaf hopper, yellow stem borer, blast, brown leaf spot, sheath blight, stem rot, bacterial leaf blight, tungro virus etc., at different growth stages. The management techniques for these pests and diseases are provided in Appendix – I.





## **Roguing**

Roguing should be done from vegetative phase to harvesting phase. The seed production field should be checked and off-types and diseased plants should be removed. Major roguing is done before flowering stage to assure the genetic purity of the seeds. Off-types are identified by plant type, plant height, days taken for flowering, leaf colour, flag leaf shape, panicle shape and colour of glumes etc. Maximum percentage of off-types permitted at the final inspection is 0.050% for foundation seed production and 0.20% for certified seed production.

## **Field inspection**

A minimum of two field inspections should be done from flowering to harvesting stage by the Seed Certification Officer. During inspection parameters such as isolation requirement, off-types, volunteer plants, diseased plants etc., are checked.

## **Harvesting**

Harvest is done soon after the maturation of the seeds that turns from green to straw yellow colour. Earheads should be harvested when the seeds have attained their maximum physiological maturity i.e., 90% of the seeds are straw yellow in colour. Irrigation to the seed plot should be withheld at this point as it delays the drying of the plants/seeds. Plants should be harvested with their panicles intact.

## **Threshing and processing**

Harvested plants should be stacked on a clean floor of the threshing yard free from other varieties. Harvested plants with a moisture content of 15 – 18% should be threshed by hand beating or by using machineries in bulk quantities. This level of moisture content is safe for threshing without any mechanical injury to the seeds. Threshed grains are winnowed and cleaned. Cleaned seeds are dried to attain a safe moisture content of 10 – 13% and graded using the preferable size of sieve to remove chaffy, ill filled, under and over sized seeds.

## **Drying and storage**

The cleaned and graded seeds are dried to attain 10 - 13% of moisture content. Normally paddy seeds can be stored for 1 – 2 years under ambient storage conditions without losing much of germination potential. Seeds can be stored for more than 3 years in moisture vapour proof containers with an initial moisture below 8%.

## **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 98% with a minimum of 80% of germination capacity and 8 - 13% of moisture content. The presence of inert and huskless seeds should not exceed 2.0% and other crop seeds, other distinguishable varieties and weed seeds should not be more than 10 Nos/kg for foundation and 20 Nos/kg for certified seeds.





# WHEAT (*Triticum aestivum*)

**W**heat (*Triticum aestivum*) is one of the important food grain crops of India belonging to the family Gramineae. Wheat is a primary important cereal in Asia. Seed production can be taken up during October – February in rainfed areas and in mid November – March / April in irrigated areas.

## Method of seed production

Wheat is a self-pollinated crop with cross-pollination to the extent of 0 – 4%. The crop should be raised in isolation and seeds are allowed to set by open-pollination. To maintain the varietal purity an isolation distance of 3 metres is maintained in both certified and foundation stages of 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. Land should be free of volunteer plants. Land should be fertile with good irrigation and drainage facilities and with neutral pH.

## Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy, uniform in size and free from the insect or disease attack and with good germination percentage. Seed rate is 35 – 40 kg/acre (85 - 100 kg/ha).

Selected seeds should be treated in order to improve the germination potential, vigour and resistance to pest and diseases. Seeds are treated with a mixture of *beejamrut* (150 ml) and *Trichoderma viride* (8 gms) for one kilogram of seeds and dried in shade. Again treat the seeds with a mixture of *Azotobacter* and PSB (Phosphate Solubilizing Biofertilizers) biofertilizer like *Pseudomonas* / *Bacillus* / *Aspergillus* @ 20 gms of each for one

kilogram of seeds. Shade dry the seeds and sow within 6 - 8 hours of treatment.

Treated seeds should be sown in the well ploughed, softened wet soil at a depth of 5 – 7.5 cm by drilling method or behind the plough. Spacing between the rows should be 22.5 cm

## Nutrient management

During final ploughing farmyard manure @ 5 – 6 tonnes/acre (12 – 15 tonnes/ha) should be applied and incorporated into the soil. Mix 800 gms/acre (2 kg/ha) of *Pseudomonas* or *Aspergillus* with farmyard manure or compost @ 325 – 400 kgs/acre (800 – 1000 kg/ha) or vermicompost @ 200 – 400 kg/acre (500 – 1000 kg/ha) and apply to the soil before sowing. Apply neem cake / pongam cake / castor cake / groundnut cake @ 60 – 80 kg/acre (150 – 200 kg/ha) for increased production. Apply *Jeevamrut* @ 200 litres/acre (500 litres/ha) along with irrigation water during first four irrigations for good crop growth.

## Weed management

Weeding is important during early stages of cultivation. Manual weeding is most preferred under organic management. For rainfed crops two manual weeding is enough. For irrigated crops, a minimum of three weeding during 20 - 25 days, 40 – 45 days and 60 – 65 days after sowing is essential.

## Irrigation

First irrigation is done before sowing since the seeds should be sown in irrigated wet soil. Crop should be irrigated at 10 - 20 days interval. Irrigation during tillering to flowering and panicle initiation stage to heading are very critical. This determines the quality of the seeds.

## Pest and disease management

Wheat is commonly affected by pests and diseases like termites, army worms, brown wheat

mite, aphids, jassids, rust, smut, kernel bunt etc., at different growth stages. The management measures for these pests and diseases are provided in Appendix – I.

### **Roguing**

Roguing should be done from vegetative phase to harvesting phase. The seed production field should be checked for off-types and diseased plants and rogued off. Major roguing is done before flowering stage to assure the genetic purity of the seeds. Off-types are identified by plant type, plant height, days for flowering, leaf colour, panicle shape and colour of glumes etc. Maximum percentage of off-types permitted at the final inspection is 0.050% for foundation seed production and 0.20% for certified seed production.

### **Field inspection**

A minimum of two field inspections should be done between flowering and harvesting stages by the Seed Certification Officer. During inspection parameters such as isolation requirement, off-types, volunteer plants, diseased plants etc., are checked.

### **Harvesting**

Harvest is done soon after the maturation of the seeds that turns from green to straw yellow in colour. Earheads should be harvested when the seeds attain maximum physiological maturity.

Irrigation to the seed plot should be withheld at this point to facilitate the drying of the crop/seeds. Crop should be harvested with their panicles intact.

### **Threshing and processing**

Harvested plants should be stacked on a clean floor of the threshing yard free from other varieties. Harvested plants with a moisture content of 15% should be threshed by hand beating or threshers. This level of moisture content is safe for threshing without any mechanical injury to the seeds. Threshed grains are winnowed and cleaned. Cleaned seeds are dried to attain a safe moisture content of 12 – 13 % and graded using a suitable sieve to remove chaffy, under and over sized seeds.

### **Drying and storage**

The cleaned and graded seeds are dried to attain 12 - 13% of moisture content. Normally the seeds can be stored for one year under ambient storage conditions without losing much of the germination potential.

### **Seed standards**

The percentage of minimum physical purity of the certified and foundation seeds should be 98% with a minimum of 80% of germination capacity and 8 - 13% of moisture content. The presence of inert and huskless seeds should not exceed 2.0%.



## SEED PRODUCTION TECHNIQUES FOR MILLETS

**M**illets are small seeded annuals belonging to the family Poaceae. They were the first crops to be cultivated prior to plough age. Millets are classified as major and minor based on the size of seeds and the extent of cultivation. Realizing the excellent nutritional composition of these grains they are now called as nutritious grains or nutri cereals.

Millets as a group figure prominently among the rainfed crops. India is the one of the major producers of millets in the World. They are often grown in diverse soils, climates and harsh environments. They have been important food and feed crops producing more reliable harvest than many other crops. The annual planting area under all millets in India put together is

23 – 24 million hectares producing around 20 – 22 million tonnes. However, there has been a gradual reduction in the cultivated area of millets in the last five decades and also reduction in yields because of the attention that is given to these crops.

Millets are often cultivated in diverse soils, climates and harsh environments. The cultivation is also done with minimum inputs. By making minimum interventions it is possible to increase the yields substantially. One of the important interventions in millet cultivation is to provide good quality seeds. This section of the book provides seed production techniques for nine millet crops.





## MAIZE (*Zea mays*)

**M**aize (*Zea mays*) is one of the well known major millet belonging to the family Gramineae. The best season for seed production is November – December. Seed setting should not coincide with rains for quality and effective seed setting. The temperature of 37°C is favourable for seed setting.

### Method of seed production

Maize is a highly cross-pollinated crop. Seeds are allowed to set by open pollination in isolation. The isolation distance maintained between the varieties is 200 metres for certified and 400 metres for foundation seed production. The spacing between the plants should be 45 x 10 cm.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season. Land should be fertile with good drainage facility.

### Seed selection and sowing

Good quality certified seeds should be obtained from an authentic source. Seeds should be healthy with good germination percentage. Seed rate is 4 kg/acre (10 kg/ha). Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds.

The seeds are sown in ridges and furrows at a depth of 4 cm as one seed per hole along the sides of the ridges. The spacing between the plants should be 45 x 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost

per hectare) should be applied as basal manure. After first weeding at 20 – 25 days after sowing first top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha) followed by the second top dressing at 40 – 45 days after sowing using 25 kg neem cake and 250 kg vermicompost per acre (60 kg neem cake and 600 kg vermicompost per hectare). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed.

For rainfed crop, 50 kg pungam cake and 250 kg vermicompost should be applied as basal manure just before sowing. First top dressing should be done at 20 – 25 days after sowing using 250 kg/acre of enriched vermicompost. At 40 – 45 days after sowing apply 25 kg pungam cake and 250 kg vermicompost per acre (60 kg pungam cake and 600 kg vermicompost per hectare) as second top dressing. Spray 10% tender coconut water at the time of flower initiation. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### Weed management

Hoeing and hand weeding should be done on the 17<sup>th</sup> or 18<sup>th</sup> day after sowing.







### **Irrigation**

The irrigation should be done once a week after life irrigation on the third day of sowing. Irrigation during silk formation stage and milky stage of cob are very critical.

### **Pest and disease management**

Maize is affected by pests like stem borer, aphids, corn worm and diseases like leaf spot, charcoal stalk rot and stem blight at different growth stages. Detailed management measures for these pests and diseases are provided in Appendix – I.

### **Roguing**

Roguing should be done to remove the unwanted plants, off-types and diseased plants from the seed production field. Roguing is done based on the leaf waveriness, tassel colour, cob shape, stem and silk colour, number of leaves, presence and absence of auricle etc. To avoid genetic contamination detasselling should be done perfectly without shedding tassel. Detasselling should be done when the tassel is well out of the boot leaf but before the anthers shed their pollen. It should be done daily upto 14 days from anthesis. Maximum percentage of off-types permitted at the final inspection is 0.01% for foundation seed production and 0.05% for certified seed production.



### **Field inspection**

In maize a minimum of four field inspections should be conducted between vegetative and harvesting stages by the Seed Certification Officer. First inspection is done during the vegetative stage before flowering to check the parameters like isolation requirement, off-types, volunteer plants and diseased plants. Second to fourth inspection is scheduled between flowering to maturation stage to check off-types, isolation distance and other relevant factors.

### **Harvesting**

Seeds attain physiological maturation 45 days after flowering. The physiological maturation can be visually identified by darkening of the silk and the drying up of the husk to yellow. The cobs of the male plant should be harvested first and removed from the field before the harvesting of the female cobs.

### **Threshing and processing**

Harvested cobs are threshed by removing the husk either manually or mechanically using maize dehusker. The dehusked cobs are sorted out carefully to protect the genetic purity of the seeds. The sorting is based on the number of rows, kernel colour and size, pith colour and arrangement of seeds in the cob. The sorted cobs are dried further to attain a safe moisture level of 15 – 18%. At this stage the kernels are removed from the cob by manually or mechanically using maize sheller. Care should be taken to avoid mechanical injury to the kernels. Separated kernels are graded using round perforated metal sieve of 18/64” size as middle sieve in OSAW cleaner cum grader.

### **Drying and storage**

The shelled and graded seeds are dried to attain 12% of moisture content for safe storage. Seeds can be stored upto 12 months in gunny bags or cloth bags.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 98% with a minimum of 80% of germination capacity and 8 - 12% of moisture content. The presence of inert matter should not exceed 2.0%.

## SORGHUM (*Sorghum bicolor*)

**S**orghum (*Sorghum bicolor*) is one of the important major millet belonging to the family Gramineae. The best season for seed production is November – December. The pollination should not coincide with rains. Rains prevent quality and effective seed setting. The temperature of 37°C is favourable for seed setting.

### Method of seed production

Sorghum is often a cross-pollinated crop and seeds are allowed to set by open-pollination in isolation. The crop should be raised in isolation of 200 metres for foundation and 100 metres for certified seed production to maintain the varietal purity. Time isolation is not permitted. The spacing between the plants should be 45 x 15 cm.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

The land selected should be free from volunteer plants and wild grass varieties like Johnson grass, sudan grass and other forage types. The land should not be cultivated with the same crop in the previous season. Land should be fertile with good drainage facility.

### Seed selection and sowing

Seeds used for the seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with good germination percentage. Seed rate is 3 kg/acre (7.5 kg/ha) for irrigated crop (transplanted) and for direct sown rainfed and irrigated are 6 kg/acre (15 kg/ha) and 4 kg/acre (10 kg/ha), respectively. In cultivation through transplantation, the duration of the crop is reduced by 10 days and the seed rate is also reduced by 1 kg/acre (2.5 kg/ha).

For dryland or summer sowing, selected seeds should be hardened by soaking them in 1:0.6 volume of 1% *Prosopis* and *Pongamia* leaf extract and further pelleted with *Pongamia* leaf powder using 10% maida as the adhesive material. The seeds are sown in ridges and furrows at a depth of 2 - 4 cm along the sides of the ridges. The spacing between the plants should be 45 x 15 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. After first weeding at 20 – 25 days after sowing first top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha) followed by the second top dressing at 40 – 45 days after sowing using 25 kg neem cake and 250 kg vermicompost per acre (60 kg neem cake and 600 kg vermicompost per hectare). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed.

For rainfed crop, 50 kg pungam cake and 250 kg vermicompost should be applied as basal manure just before sowing. First top dressing should be done at 20 – 25 days after sowing using 250 kg/acre of enriched vermicompost. At 40 – 45 days after sowing apply 25 kg pungam cake and 250 kg vermicompost per acre (60 kg pungam cake and 600 kg vermicompost per hectare) as second top dressing. Spray 10% tender coconut water at the time of flower initiation. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

## **Weed management**

Sorghum is slow growing in the early stages and is adversely affected by weeds. Hence, the field should be maintained weed free upto 45 days. Hoe or hand weeding on the 10<sup>th</sup> day of transplanting is a must. Hoe or hand weeding between 30 – 35 days after transplanting and between 35 – 40 days for a direct sown crop is necessary.

## **Irrigation**

The crop should be irrigated once a week to increase the percentage of seed setting. Irrigation during primordial initiation, vegetative, milky and maturity stages are very critical. When irrigation during critical stages are withheld that will result in poor seed setting and reduced size of the seeds.

## **Pest and disease management**

Sorghum is affected by pests like shoot fly, stem borer, sorghum midge, ear head bug and diseases like kernel smut, head smut, downy mildew, rust and grain mold at different growth stages of the crop. Detailed management measures for these pests and diseases are provided in Appendix – I.

## **Roguing**

Roguing should be done in the vegetative phase. Off-types and volunteer plants should be uprooted and removed before they start shedding pollen. Off-types are identified based on the plant height, leaf shape, leaf colour, stem pigmentation, days for flowering etc. Rogue other plants like Johnson grass, sudan grass, forage plants and diseased plants of kernel smut and head smut. Maximum percentage of off-types permitted at the final inspection is 0.01% for foundation seed production and 0.05% for certified seed production.



## **Field inspection**

A minimum of three field inspections should be done between vegetative and harvesting stages by the Seed Certification Officer. First inspection is done during the vegetative stage to check isolation requirement, off-types, volunteer plants and diseased plants. Second inspection is done during the flowering stage to check off-types, isolation and other relevant factors. The third inspection should be scheduled at the time of maturity prior to harvest to check for designated diseases, true nature of plants, head and seed.

## **Harvesting**

Seeds attain physiological maturity 40 – 45 days after 50% flowering. A black layer formed over the seeds is a sign to confirm the physiological maturation of the seeds. After confirming the maturity the earheads should be harvested. At this time the moisture content would be around 20 – 25%.

## **Threshing and processing**

Harvested earheads should be dried further for a safe moisture level of 15 – 18% before threshing. After drying, the earheads are beaten with bamboo stick to separate the seeds. In case of mechanical thresher care should be taken to prevent the seeds from mechanical damage. Threshed grains are winnowed and cleaned. Cleaned seeds are further dried to attain a safe moisture content of 8% and graded using round perforated metal sieve of 9/64” size as middle sieve.

## **Drying and storage**

The cleaned and graded seeds are dried to attain 8% of moisture content under the sun. Seeds can be stored upto 12 months under open storage conditions and upto 18 months in moisture vapour proof containers.

## **Seed standards**

The percentage of maximum physical purity of certified and foundation seeds should be 98% with a minimum of 75% of germination capacity and 8 - 13% of moisture content. The presence of inert matter and huskless seeds should not exceed 2.0% and other distinguishable varieties and weed seeds should not be more than 10/kg for foundation and 20/kg for certified seeds.



## PEARL MILLET (*Pennisetum glaucum*)

Pearl millet (*Pennisetum glaucum*) is widely grown millet variety belonging to the family Gramineae. The best season for seed production is October - December. The temperature favourable for seed setting is 37°C. The pollination should not coincide with rains. Rain affect effective seed setting and production of quality seeds.

### Method of seed production

Bajra is a highly cross-pollinated crop with 80% of cross-pollination. The crop should be raised in isolation and seeds should be allowed to set by open-pollination. The isolation distance maintained between the varieties is 400 metres for foundation seed and 200 metres for certified seed production.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

The selected land should be fertile and free from volunteer plants. The land should not be cultivated with the same crop in the previous season. If cultivated, it should be of same variety and duly certified by the seed certification agency.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with good germination percentage. Use only graded seeds. Remove the seeds affected with *Ergot* and *Sclerotia* to prevent primary infection. Seed rate is 3 kg/acre (8 kg/ha).

Add the selected seeds to the salt water (1 kg salt in 10 litres of water) and remove the floating seeds affected by *Ergot* and *Sclerotia*. Wash the seeds in fresh water for 2 – 3 times to remove the salt and shade dry. Selected seeds should be treated with *Azospirillum* @ 250 gms / 3 kg of seeds (600 gms / 8 kg of seeds). Seeds can

be sown directly in the main field in ridges and furrows or seedlings can be raised in the nursery and transplanted to the main field.

### Nursery preparation and sowing

Seeds are sown in the nursery and then the seedlings are transferred to the main field. Select an area of 7.5 cents for raising nursery for one hectare (3 cents for one acre). Plough the plot thoroughly and add farmyard manure or compost @ 750 kg / 7.5 cents (300 kg / 3 cents) and incorporate it into the soil by ploughing. Seeds are sown in raised bed nursery in lines. Cover the seeds with farmyard manure @ 500 kg / 7.5 cents (200 kg / 3 cents). 20 – 25 days old seedlings are then transplanted to the main field. The spacing between the plants should be 45 x 20 cm.

### Main field preparation

The main field is prepared with series ploughing to make it a fine tilth (Tilth is the physical condition of the soil that is soft, friable and properly aerated) and formed into ridges and furrows. Apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha). Seedlings can be transplanted from the nursery or from the directly sown hill. The extra seedlings from each hill should be pulled out at 20 – 25 days after sowing and transplanted.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. After first weeding at 20 – 25 days after sowing first top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/



acre (600 kg/ha) followed by the second top dressing at 40 – 45 days after sowing using 25 kg neem cake and 250 kg vermicompost per acre (60 kg neem cake and 600 kg vermicompost per hectare). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed.

For rainfed crop, 50 kg pungam cake and 250 kg vermicompost should be applied as basal manure just before sowing. First top dressing should be done at 20 – 25 days after sowing using 250 kg/acre of enriched vermicompost. At 40 – 45 days after sowing apply 25 kg pungam cake and 250 kg vermicompost per acre (60 kg pungam cake and 600 kg vermicompost per hectare) as second top dressing. Spray 10% tender coconut water at the time of flower initiation. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### **Weed management**

The seed production field should be maintained weed free from the initial stage. The first weeding should be done at 30 – 35 days after sowing. Subsequent weeding can be done depending upon the intensity of the weeds.

### **Jerking**

Jerking is a process of removing the early formed earheads of the first formed tillers to facilitate uniform flowering in all the tillers. It is done at 20 – 25 days after transplanting or 30 – 40 days after sowing.

### **Irrigation**

The field should be irrigated soon after sowing and life irrigation is done on the third day of sowing. Irrigation should be done once in 10 days. Irrigation during tillering, milky stage and maturation stage are very critical. Proper irrigation during critical stages increases the seed setting and quality of the seeds.

### **Pest and disease management**

Pearl millet is affected by pests like shoot fly, root grub and diseases like downy mildew and ergot at different growth stages. Detailed management measures for these pests and disease are provided in Appendix – I.

### **Roguing**

Intensive roguing should be done at three growth stages like seedling, tillering and seed setting. To maintain genetic purity of the crop, off-types and diseased plants are rogued out periodically based on the colour and waviness of leaves, plant height, shape and size of the earhead and colour of the grains etc. The rogues should be either pulled out as a whole plant or cut off at the base. Plants affected by green ear, ergot and grain smut diseases should be removed and discarded from time to time.

### **Field inspection**

A minimum of three field inspections should be conducted between pre flowering and harvesting stages by the Seed Certification Officer. First inspection is done before flowering to check isolation, volunteer plants, off-types, downy mildew etc. The second inspection would be made during 50% flowering to determine relevant factors. The final inspection would be made at the maturity stage before harvesting to determine the true nature of the crop and other relevant factors. Maximum percentage of off-types permitted at the final inspection is 0.050% for foundation seed production and 0.10% for certified seed production.

### **Harvesting**

Seeds attain physiological maturation 30 - 35 days after 50% flowering. The physiological maturation can be identified by change in the colour of the seeds from green to straw yellow. A dunken layer also forms at the point of attachment to the panicle. The moisture content of the seeds at this stage is 30 – 35%. Harvesting is done in two pickings since, the maturation of the earheads are not uniform because of the tillering habit of the crop.

### **Threshing and processing**

Harvested earheads should be dried for two to three days to attain a safe moisture content of 15 - 18% for threshing. Threshing is carried out either manually or mechanically. Normally the dried earheads are threshed by beating with a bamboo stick. Threshed grains are cleaned by winnowing. Threshed and cleaned grains are

graded using round perforated metal sieve of 4/64" size OSAW cleaner cum grader.

### **Drying and storage**

The cleaned and graded seeds can be stored upto 12 months with proper pre-storage treatment.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 98% with a minimum of 80% of germination capacity and 5 - 12% of moisture content. The presence of inert matter should not exceed 2.0%.



## FINGER MILLET (*Eleusine coracana*)

**F**inger millet or Ragi (*Eleusine coracana*) is one of the important minor millets belonging to the family Gramineae. This is widely grown in hilly and rainfed areas. It is a tropical crop can be grown to an altitude of 2100 metres. The best season for seed production is December – January. Pollination should not coincide with rains for quality and effective seed setting. The temperature of 37°C is favourable for seed setting.

### Method of seed production

Ragi is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

Ragi can be grown in poor to fertile soil. The crop can tolerate salinity better than any other crops. The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season. Land should be ploughed 2 - 3 times to get fine tilth and levelled.



### Seed selection and sowing

Ragi is a season bound crop and the best season to take up sowing is December - January and June - July. Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with required germination percentage. Recommended seed rate is 2 kg/acre (5 kg/ha). Selected seeds should be treated with *Azospirillum* @ 125gms/kg of seeds.

### Nursery preparation

Nursery should be raised in an area of 500m<sup>2</sup> to plant one hectare of main field (200m<sup>2</sup> per acre). Selected nursery plot should be ploughed for two to three times to have fine tilth of soil. Raised beds should be formed and shallow rills are formed over the beds by passing the fingers vertically. Seed should be broadcasted and covered with a thin layer of farmyard manure @ 500 kg/ha (200 kg/acre).

### Main field preparation

The main field is prepared with 2 – 3 ploughing to make it a fine tilth and formed into ridges and furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. 20 - 25 days old seedlings transplanted to the main field. Two seedlings per hill should be planted. Follow a spacing of 15× 15 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. After first weeding at 20 – 25 days after sowing first top dressing should be done using enriched vermicompost (2 kg *Azospirillum*,



2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha) followed by the second top dressing at 40 – 45 days after sowing using 25 kg neem cake and 250 kg vermicompost per acre (60 kg neem cake and 600 kg vermicompost per hectare). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed.

For rainfed crop, 50 kg pungam cake and 250 kg vermicompost should be applied as basal manure just before sowing. First top dressing should be done at 20 – 25 days after sowing using 250 kg/acre of enriched vermicompost. At 40 – 45 days after sowing apply 25 kg pungam cake and 250 kg vermicompost per acre (60 kg pungam cake and 600 kg vermicompost per hectare) as second top dressing. Spray 10% tender coconut water at the time of flower initiation. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### **Weed management**

The seed production field should be maintained weed free from the initial stage. The first weeding should be done on 15<sup>th</sup> day after planting and followed by the second one on 30<sup>th</sup> day. After hand weeding allow the weeds to dry for 2 – 3 days.

### **Irrigation**

The irrigation should be done once a week after life irrigation on the third day of sowing. Irrigation during flowering and grain setting stages are very critical.

### **Pest and disease management**

Ragi is affected by pests and diseases like pink stem borer, aphids, root aphids, earhead caterpillars, blast, brown spot, mottle streak virus etc., at different growth stages. Detailed management measures for these pests and diseases are provided in Appendix- I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from the seed production field to avoid the genetic

contamination. Roguing should be done upto the flowering stage. Maximum percentage of off-type permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Physiologically mature earheads will turn from brown to green colour. Harvesting is done in two pickings since, the maturation of the earheads are not uniform because of the tillering habit of the crop. Second harvesting should be done seven days after the first one. Mature earheads should be harvested and threshed with bamboo sticks. Threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Care should be taken while drying to avoid mechanical injury to the seeds and contamination. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.



## KODO MILLET (*Paspalum scrobiculatum*)

**K**odo millet (*Varagu*) (*Paspalum scrobiculatum*) is a well known minor millet belonging to the family Gramineae. This coarse millet is highly resistant to drought and can also be cultivated in the areas with 400 - 500 mm annual rainfall. It is grown in gravelly and stony upland poor soils to loamy soils. Seed production can be done in June – July and February – March. The pollination should not coincide with rains for quality and effective seed setting.

### Method of seed production

Kodo millet is a self-pollinated crop. The crop should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

The selected land should be free from volunteer plants. The land should not be cultivated with the same crop in the previous season. Land should be fertile with good drainage facility.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic



source. Seeds should be healthy with required germination percentage. In North India, sowing should be done in mid June to mid July and in South India during September – December. Recommended seed rate is 4 kg/acre (10 kg/ha).

Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds should be sown at the depth of 3 – 4 cm.

### Main field preparation

The main field should be ploughed before the onset of monsoon to enable the soil to hold the moisture. At the onset of monsoon field should be ploughed for 2 – 3 times to make it a fine tilth and formed into ridges and furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. Seeds can be sown in the ridges with a spacing of 30 × 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. For rainfed crop, apply 50 kg/acre (125 kg/hectare) of pungam cake and 250 kg per acre (600kg/hectare) of vermicompost as basal manure just before sowing. After first weeding at 20 – 25 days after sowing top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### **Weed management**

The seed production field should be maintained weed free from the initial stage. It is essential to control the weeds in the initial stages of plant growth especially upto 35 – 40 days after sowing. Generally two weedings at an interval of 15 days is sufficient. Weeding can be done with hand hoe or wheel hoe in line sown crop.

### **Irrigation**

*Kharif* season crop does not require any irrigation, it is mostly grown as a rainfed crop. In the absence of rains one or two irrigation can be done. During heavy rains the excess water from the field should be drained out.

### **Pest and disease management**

Kodo millet is affected by shoot fly pest and head smut disease at different growth stages. Detailed management measures for this pest and disease are provided in Appendix- I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from the seed production field to avoid the genetic contamination. Roguing should be done upto the flowering stage. Maximum percentage of off-type permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 100 days. Physiologically mature earheads will turn from brown to green colour. Plants are cut close to the ground level, bundled and stacked for a week before threshing. The earheads are threshed by trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Care should be taken while drying to avoid mechanical injury to the seeds and contamination. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.





# FOXTAIL MILLET / ITALIAN MILLET

## (*Setaria italica*)

**F**oxtail millet (*Setaria italica*) is a well known minor millet variety belonging to the family Gramineae. It is cultivated in both tropical and temperate regions. The crop can be grown upto an altitude of 200 meters. The crop can be grown successfully in areas receiving 750 mm of annual rainfall. Best season for seed production is June - July and February – March. The pollination should not coincide with rains for quality and effective seed setting.

### Method of seed production

Foxtail millet is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

Foxtail millet needs moderately fertile soil for good yield. The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season. Land should be ploughed 2 - 3 times to get a fine tilth and levelled.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with required germination percentage. Recommended seed rate is 2 kg/acre (5 kg/ha).

Selected seeds should be treated with *Azospirillum* @ 125 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm at a depth of 3 – 4 cm.

### Main field preparation

The main field should be ploughed for 2 – 3 times to make it a fine tilth and formed into ridges and

furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. Seeds can be sown in the ridges at a depth 3 - 4 cm with a spacing of 30 × 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. For rainfed crop, apply 50 kg/acre (125 kg/hectare) of pungam cake and 250 kg/acre (600 kg/hectare) of vermicompost as basal manure just before sowing. After first weeding at 20 – 25 days after sowing top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### Weed management

The seed production field should be maintained weed free. Weeding can be done with a tyne-harrow when the crop is 30 days old. Allow the weeds to dry for 2 - 3 days after hand weeding.

### Irrigation

*Kharif* season crop does not require any irrigation. It is mostly grown as a rainfed crop. However, if the dry spell prevails for longer period, then 1 - 2 irrigations should be given to boost the yield. Summer crop requires 2 - 5 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

### **Pest and disease management**

Foxtail millet is affected by pests like army worm, cut worm, leaf scrapping beetle and shoot fly and diseases like blast and rust at different growth stages. Detailed management measures for these pests and diseases are provided in Appendix- I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from the seed production field to avoid the genetic contamination. Roguing should be done upto the flowering stage. Maximum percentage of off-types permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second inspection is done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 80 - 100 days after sowing. Physiologically mature earheads will start to dry. Plants are either harvested intact with earheads or earheads alone. The earheads are dried before threshing. The earheads are threshed by stone roller or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be dried under the sun to attain a safe moisture level of 12%. Care should be taken while drying to avoid mechanical injury to the seeds and contamination. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.





## PROSO MILLET (*Panicum miliaceum*)

**P**roso millet (*Pani varagu*) (*Panicum miliaceum*) is a common and important minor millet belonging to the family Gramineae. This short duration millet variety is widely grown in India. The crop is able to evade drought by its quick maturity. Best season for seed production is June - July and February – March. The pollination should not coincide with rain for quality and effective seed setting.

### Method of seed production

Proso millet is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

Proso millet can be cultivated in both rich and poor soils. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with required germination percentage. Recommended seed rate is 4 kg/acre (10 kg/ha).

Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds should be sown in June – July onset of monsoon rains. Summer crop should be sown in the month of February – March. Seeds are broadcast manually or by seed driller in furrows at a depth of 3 – 4 cm.

### Main field preparation

The main field should be harrowed for 2 – 3 times to make it a fine tilth and levelled. The levelled field is formed into ridges and furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. Seeds can be sown in the ridges at a depth 3 - 4 cm with a spacing of 30× 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. For rainfed crop, apply 50 kg/acre (125 kg/hectare) of pungam cake and 250 kg/acre (600 kg/hectare) of vermicompost as basal manure just before sowing. After first weeding at 20 – 25 days after sowing top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.





### **Weed management**

The seed production field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and nutrients. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with a handhoe or wheel hoe.

### **Irrigation**

*Kharif* season crop does not require any irrigation. However, if the dry spell prevails for longer period 1 - 2 irrigations should be given at the tillering stage to boost the yield. First irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 - 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

### **Pest and disease management**

Proso millet is commonly affected by shoot fly and there is no other remarkable disease incidence. The management measures for this pest are provided in Appendix- I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from the seed production field to avoid the genetic contamination. Roguing should be done upto the flowering stage. Maximum percentage of off-types permitted at the final inspection is 0.05%

for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second inspection is done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 65 - 75 days after sowing. The crop should be harvested when two thirds of the seeds are ripe. The harvested earheads are threshed by hand or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.



## LITTLE MILLET (*Panicum sumatrense*)

Little millet (*Samai*) (*Panicum sumatrense*) belongs to the family Gramineae. The crop can grow well in drought conditions and considered as a good famine food as it can produce some grain even under severe drought conditions when all the other crops fail to produce. It is a typical dryland crop suitable for the areas with low rainfall and poor soils. Seed production can be done during June – July and February – March. The pollination should not coincide with rains for quality and effective seed setting.

### Method of seed production

Little millet is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

Little millet can be cultivated in both rich and poor soils. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with required germination percentage. Recommended seed rate is 4 kg/acre (10 kg/ha).

Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds should be sown in June – July at the onset of monsoon rains. Summer crop should be sown in the

month of February – March. Seeds are broadcast manually or by seed driller in furrows at a depth of 3 – 4 cm.

### Main field preparation

The main field should be harrowed for 2 – 3 times to make it a fine tilth and levelled. The levelled field is formed into ridges and furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. Seeds can be sown in the ridges at a depth 3 - 4 cm with a spacing of 30 × 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. For rainfed crop, apply 50 kg/acre (125 kg/hectare) of pungam cake and 250 kg/acre (600 kg/hectare) of vermicompost as basal manure just before sowing. After first weeding at 20 – 25 days after sowing top dressing should be done using enriched vermicompost (2 kg *Azospirillum*, 2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha). During flower initiation stage 10% tender coconut solution (1 litre tender coconut





water + 9 litres of water) should be sprayed. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### **Weed management**

The seed production field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and nutrients. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with handhoe or wheel hoe.

### **Irrigation**

*Kharif* season crop does not require any irrigation. However, if the dry spell prevails for longer period at least one irrigation should be given at the tillering stage to boost the yield. First irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 - 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

### **Pest and disease management**

Little millet is commonly affected by shoot fly and there is no other remarkable disease incidence. The management measures for this pest are provided in Appendix- I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from the seed production field to avoid the genetic contamination. Roguing should be done upto the

flowering stage. Maximum percentage of off-types permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second inspection is done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 80 - 85 days after sowing. The crop should be harvested when two thirds of the seeds are ripe. The harvested earheads are threshed by hand or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.





## BARNYARD MILLET (*Echinochloa frumentacea*)

**B**arnyard millet (*Echinochloa frumentacea*) is an important minor millet grown in India. This millet crop belongs to the family Gramineae. The crop is able to evade drought by its quick maturity. Best season for seed production is September – October and February – March. The pollination should not coincide with rains for quality and effective seed setting.

### Method of seed production

Barnyard millet is a self-pollinated crop and should be raised in isolation. The isolation distance maintained between the varieties is 3 metres for both foundation and certified seed production to maintain the varietal purity.

### Seed production stages

Breeder seed → Foundation seed → Certified seed

### Land selection

Barnyard millet can be cultivated in both rich and poor soils with variable texture. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. The selected land should be free from volunteer plants. The land should not be cultivated with same crop in the previous season.

### Seed selection and sowing

Seeds used for seed production should be of good quality certified seeds from an authentic source. Seeds should be healthy with required germination percentage. Recommended seed rate is 4 kg/acre (10 kg/ha).

Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds should be sown in September - October at the onset of monsoon rains. Summer crop should be sown in the month of February – March. Seeds are broadcast manually or by seed driller in furrows at a depth of 3 – 4 cm.

### Main field preparation

The main field should be harrowed for 2 – 3 times to make it a fine tilth and levelled. The levelled field is formed into ridges and furrows. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. Seeds can be sown in the ridges at a depth 3 - 4 cm with a spacing of 30× 10 cm.

### Nutrient management

Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. Instead of this cattle penning can also be practiced. 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. For rainfed crop, apply 50 kg/acre (125 kg/hectare) of pungam cake and 250 kg/acre (600 kg/hectare) of vermicompost as basal manure just before sowing. After first weeding at 20 – 25 days after sowing top dressing should be done using enriched vermicompost (2 kg *Azospirillum*,



2 kg *Phosphobacterium* and 2 litres *Panchagavya* mixed with 250 kg vermicompost and kept covered for a week and then used) @ 250 kg/acre (600 kg/ha). During flower initiation stage 10% tender coconut solution (1 litre tender coconut water + 9 litres of water) should be sprayed. All the above mentioned inputs should be applied to the rainfed crop only when the soil is wet.

### **Weed management**

The seed production field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and to get high yields. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with a handhoe or wheel hoe.

### **Irrigation**

*Kharif* season crop does not require any irrigation. However, if the dry spell prevails for longer period at least one irrigation should be given at the tillering stage to boost the yield. First irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 - 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

### **Pest and disease management**

Barnyard millet is commonly affected by shoot fly and three types of smut diseases at different growth stages. The management measures for these pest and diseases are provided in Appendix-I.

### **Roguing**

Roguing should be done often to remove the off-types, volunteer plants and diseased plants from

the seed production field to avoid the genetic contamination. Roguing should be completed within the flowering stage of the crop. Maximum percentage of off-types permitted at the final inspection is 0.05% for foundation and 0.10% for certified seed production.

### **Field inspection**

A minimum of two inspections should be done between flowering and maturity stages by the Seed Certification Officer. The first inspection is done at the time of flowering to check the isolation and off-types and the second inspection is done during the maturity stage prior to harvest to check the off-types and to estimate the yield.

### **Harvesting and processing**

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 75 - 90 days after sowing. The crop should be harvested when two thirds of the seeds are ripe. The harvested earheads are threshed by hand or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

### **Drying and storage**

The cleaned seeds should be sun dried to attain a safe moisture level of 12%. Seeds can be stored upto 13 months under proper storage conditions.

### **Seed standards**

The percentage of minimum physical purity of certified and foundation seeds should be 97% with a minimum of 75% of germination capacity and 12% of moisture content. The presence of inert matter should not exceed 2.0%.



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## APPENDIX – I PEST AND DISEASE MANAGEMENT IN CEREALS AND MILLETS

Sl. No.	Crop	Common Pests and Diseases	Management measures
1.	Paddy	<p>Leaf folder (<i>Cnaphalocrocis medinalis</i>) – (attacks at the vegetative phase)</p> <p>Rice case worm (<i>Nymphula depunctalis</i>) - (attacks at the vegetative phase)</p> <p>Green leaf hopper (<i>Nephotettix virescens</i>) - (attacks at the vegetative phase)</p> <p>Yellow stem borer (<i>Scirpophaga incertulas</i>) - (attacks at the vegetative phase)</p> <p>Sheath blight (<i>Rhizoctonia solani</i>), stem rot (<i>Leptosphaeria salvinii</i>), bacterial leaf blight (<i>Xanthomonas campestris</i> pv. <i>Oryzae</i>) - (attacks at the vegetative phase)</p>	<p>Spray 3-5% of <i>Andrographis paniculata kashayam</i> or 5% neem kernel extract, release ducks in the field to feed on the pests, erect bird perches and before transplanting apply two cartloads of well decomposed farmyard manure.</p> <p>Rope method for the control of larvae, spread chopped pieces of <i>Colacasia (taro or chembu)</i> and <i>Citrus grandis (Pomelo or Pambalimasu)</i> in the field to repel the pest, use light traps, flood and drain water from the field for 3-4 days or apply raw cow dung to the stagnated water to suffocate the larvae.</p> <p>Treat the seedlings in neem seed kernel extract for 24 hours before transplanting, spray a mixture of neem oil and pongam oil @ 1:4 ratio and the common egg laying spots of the pests like wild grasses and weeds should be removed from the field and bunds.</p> <p>Land should be ploughed as soon as the harvest is completed to destroy the eggs and pupae, apply neem cake @ 42 – 50 kg as basal manure, place neem cake bags in the irrigation channel, use <i>Trichogramma</i> cards, pheromone traps and light traps.</p> <p>Spray a solution of cow dung slurry 20 kg mixed in 200 litres of water, filtered and diluted with 50 litres of water.</p>

2.	Paddy and Finger millet	Rice blast ( <i>Pyricularia oryzae</i> ), Ragi blast ( <i>Pyricularia grisea</i> ) Foxtail millet blast - (attacks at the early vegetative phase)  Rice tungro virus, Mottle streak virus of ragi – (attacks at all the growth stages of the crop)	Crush and apply the bark of <i>Careya arborea</i> @ 2-3 kg, boil 1 kg wild Tulsi leaves in 2 litres of water and spray this solution @ 2 ml/litre of water for twice at 15 days interval.  Spray the fermented cow's urine (fermented for one week) over the crops to control bacterial and fungal diseases, spray a solution of cow's urine (1 litre) and buttermilk (1 litre) diluted with 8 litres of water and spray 300 ml of sweet flag extract mixed with 1 litre of cow's urine and 8.7 litres of water to control the disease spread.
3.	Paddy, Finger millet and Maize	Brown leaf spot ( <i>Helminthosporium oryzae</i> ), Ragi ( <i>H.nodulosum</i> ), maize leaf spot ( <i>Curvularia lunata</i> ) - (attacks at the early vegetative phase)	Treat the seeds with 20% mint leaf extract for 24 hours, spread the leaves of <i>Cleistanthus collinus</i> @ 25 quintals/ha the field and allow them to decay and irrigate after three days.
4.	Wheat	Termites- (attacks the field throughout the cropping period)  Brown wheat mite ( <i>Petrobia latens</i> ) - (attacks at all the growth stages of the crop)	Apply neem leaf manure @ 500 kg/ha or neem seed manure @ 100 kg/ha at the time of sowing.  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.
5.	Wheat and Foxtail millet	Army worms of wheat and foxtail millet / corn worm of Maize ( <i>Spodoptera frugiperda</i> ) – Infestation is more in lushy vegetative growth phase)	Spraying of neem leaf extract (5 kg neem leaves grounded in boiled water and diluted to 100 litres) can reduce the worms attack.
6.	Wheat, Sorghum and Ragi	Brown rust ( <i>Puccinia recondite tritici</i> ), yellow rust ( <i>Puccinia striformis</i> ) and black rust ( <i>Puccinia graminis tritici</i> ), Rust of sorghum/foxtail millet – (attacks the crop in the later vegetative phase)	Use rust resistant varieties, spray sour butter milk solution (5 litres in 200 litres of water) or spray dry leaf power extract of mint ( <i>Pudhina</i> ) or <i>Amaranth</i> green @ 25 – 30 gms per litre of water.

7.	Wheat and Barnyard millet	Loose smut ( <i>Ustiloto tritici</i> ), grain smut of barnyard millet ( <i>Ustilago panici frumentacei</i> ) – (attacks at the time of grain formation)	Treat the seeds with 5% vermiwash, pull out and destroy infected plants and soak the seeds in water for 4 hours and dry under the hot sun to kill the dormant fungus in the seeds.
8.	Wheat, Sorghum and Barnyard millet	Kernel bunt ( <i>Neovossia indica</i> ), kernel smut of barnyard millet ( <i>Ustilago paradoxia</i> ), kernel smut of sorghum ( <i>Sphaecelotheca sorghi</i> ) – (attacks at the time of grain formation)	Seed treatment with 5% vermiwash, foliar spray of the mixture of 1 kg mustard powder, 5 litres of milk and 100 litres of water, summer ploughing and avoiding excessive irrigation during earhead formation stage.
9.	Maize and Finger millet	Stem borer of Maize ( <i>Chilo partellus</i> ), Pink stem borer of Ragi ( <i>Sesamia inferens</i> ) – (attacks in the later vegetative phase)	Plough deeply soon after harvest to destroy the eggs and pupae, apply neem cake @ 42 – 50 kg/ha as basal manure, using pheromone traps to attract and destroy male adult moths and using <i>Trichogramma</i> cards.
10.	Sorghum, Maize, Bajra	Aphids of maize and ragi ( <i>Rhopalosiphum Maidis</i> ), root aphid of ragi ( <i>Tetaneura nigriabdominalis</i> ) – (attacks in the vegetative phase)	Spray garlic extract (100 gms crushed and mixed with 50 litres of water) or apply manure prepared using <i>Adhatoda vasica</i> .
11.	Sorghum and Maize	Downy mildew- sorghum/maize ( <i>Perenosclerospora sorghi</i> ), cumbu ( <i>Sclerospora graminicola</i> ) - (attacks in the vegetative phase)	Management measures are removing the infected seedlings at the time transplanting and scouting the field upto 45 das to remove the infected plants.
		Charcoal stalk rot of sorghum/maize ( <i>Macrophomina phaseolina</i> ), Grain mould of sorghum (all types of fungus) – (attacks in later vegetative stage and during grain formation stage)	Seed treatment with <i>trichoderma viride</i> @ 4 gm / kg of seeds prevents the charcoal rot disease.



12.	Maize	Leaf blight of Maize ( <i>Exserohilum turcicum</i> )- (attacks in early vegetative stage).	Managed by growing disease resistant varieties.
13.	Sorghum, Pearl millet, Kodo millet, Foxtail millet, Proso millet, Little millet, Barnyard millet	Shoot fly ( <i>Atherigona varia soccata</i> )- (attacks from early vegetative to maturation stage)	Managed effectively by keeping fish meal traps @ 12 numbers / ha.
14.	Sorghum and Finger millet	Ear head bug of sorghum ( <i>Calocoris angustatus</i> ) Ear head caterpillar of ragi- (Damage is severe after earhead formation)	Managed by planting the crops in early kharif season.
15.	Sorghum, Kodo millet, Branyard millet	Head smut of sorghum ( <i>Sphace lotheca reiliana</i> ), Kodo millet ( <i>Sorosporium paspali-thunbergii</i> ), Barnyard millet ( <i>Ustilago crus-galli</i> ) – (attack at grain formation stage)	Use seeds treated with 5% vermiwash, remove the infected plants and destroy them. seed treatment by soaking the seeds in water for four hours and then drying under the hot sun kills the dormant fungus in the seeds activated by water.
16.	Sorghum	Sorghum midge ( <i>Contarinia sorghicola</i> )- (attacks at the early vegetative stage)	Managed by integration of cultural practices that affects the outbreak of insect population. Field sanitation and early planting in kharif also found effective.
17.	Bajra	Ergot disease of Cumbu ( <i>Claviceps fusiformis</i> ) - (attacks at flowering stage)	Selection of disease free seed material and selection of optimum cropping period.

## APPENDIX – II PREPARATION PROCEDURES OF BOTANICALS AND ANIMAL PRODUCTS

### 1. Sweet flag rhizome extract

**P**ound 10 gms of sweet flag rhizome to a coarse powder and add 50 ml of water. Leave the solution undisturbed for one hour and filter the Sweet flag rhizome extract. For seed treatment, boil one litre of water and add 50 ml each of cow's urine and sweet flag rhizome extract the next day. Soak the seeds in water for six hours and then in the above solution for about 30 minutes. Filter the seeds, shade dry and sow. This gives protection against a number of bacterial and fungal diseases.

### 2. 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.

### 3. 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 gms, 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 3<sup>rd</sup> 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.

### 4. 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.

### 5. 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.

### 6. Jiwa Amrut

**Ingredients:** Cow dung – 10 kg, cow's urine – 10 lit, jiggery (old) – 2 kg, 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.

### 7. Amrit Pani

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.

### 8. 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.

### 9. 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*, *Ipomea fistulosa*
- Aromatic plants – *Vitex*, *Ocimum*, *Papaya*
- Plants that are not affected by pests and diseases – *Morinda*, *Ipomea fistulosa*

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 prophylactic 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.

### 10. 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 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 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.

### 11. 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.



## 12. 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.

## 13. 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. <i>Andrographis paniculata</i>	All kinds of larvae
2. <i>Sida spinosa</i>	Aphids and Sap feeders
3. <i>Adathoda zeylanica</i>	Fungal diseases
4. <i>Panchathiktha kashayam*</i>	All kinds of pests

\* Panchathiktha kashayam 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 per hectare).

## APPENDIX – III

### COMMON AND SCIENTIFIC NAMES OF PLANTS

Sl. No.	English Name	Scientific Name
1.	Amaranth	<i>Amaranthus sp.</i>
2.	Andrographis	<i>Andrographis paniculata</i>
3.	Barnyard millet/kudiraivali	<i>Echinochloa frumentacea</i>
4.	Calotropis	<i>Calotropis gigantea</i>
5.	Castor	<i>Ricinus communis</i>
6.	Colocasia (taro/chembu)	<i>Colocasia exculenta</i>
7.	Dhaincha	<i>Sesbania cannabina</i>
8.	Finger millet/Ragi	<i>Eleusine coracana</i>
9.	Foxtail millet/Italian millet/Tenai	<i>Setaria italica</i>
10.	Garari	<i>Cleistanthus collinus</i>
11.	Glyricidia	<i>Gliricidia sepium</i>
12.	Groundnut	<i>Arachis hypogaea</i>
13.	Indian Indigo	<i>Indigofera tinctoria</i>
14.	Johnson grass	<i>Sorghum halepense</i>
15.	Kodo millet/Varagu	<i>Paspalum scrobiculatum</i>
16.	Little millet/Samai	<i>Panicum sumatrense</i>
17.	Maize	<i>Zea mays</i>
18.	Malabur nut	<i>Adhatoda vasica</i>
19.	Mint/pudhina	<i>Mentha piperita</i>
20.	Mustard	<i>Brassica juncea</i>
21.	Neem	<i>Azadirachta indica</i>
22.	Paddy	<i>Oryza sativa</i>
23.	Pearl millet	<i>Pennisetum glaucum</i>
24.	Pongamia	<i>Millettia pinnata</i>
25.	Poison nut	<i>Strychnos nux vomica</i>
26.	Pomelo/Pambalimasu	<i>Citrus maxima</i>
27.	Prosopis	<i>Prosopis juliflora</i>
28.	Proso millet/PaniVaragu	<i>Panicum miliaceum</i>
29.	Sorghum	<i>Sorghum bicolor</i>
30.	Sesbania	<i>Sesbania grandiflora</i>

31.	Sudan grass	<i>Sorghum bicolor sub sp.drummondii</i>
32.	Sugarcane	<i>Saccharum officinarum</i>
33.	Sunhemp	<i>Crotalaria juncea</i>
34.	Sweet flag	<i>Acorus calamus</i>
35.	Wheat	<i>Triticum aestivum</i>
36.	Wild Guava	<i>Careya arborea</i>
37.	Wild tulsi	<i>Ocimum tenuiflorum</i>



## APPENDIX – IV

### COMMON AND SCIENTIFIC NAMES OF INSECTS

Sl. No.	English Name	Scientific Name
1.	Aphids (Corn aphid)	<i>Rhopalosiphum maidis</i>
2.	Armyworm	<i>Spodoptera frugiperda</i>
3.	Brown wheat mite	<i>Petrobia latens</i>
4.	Green leaf hopper	<i>Nephotettix virescens</i>
5.	Jassids	<i>Pyrilla perpusilla</i>
6.	Leaf folder of paddy	<i>Cnaphalocrocis mainsails</i>
7.	Pink stem borer of ragi	<i>Sesamia inferens</i>
8.	Rice case worm	<i>Nymphula depunctalis</i>
9.	Root aphids of ragi	<i>Tetraneura nigriabdominalis</i>
10.	Shoot fly of sorghum	<i>Atherigona varia soccata</i>
11.	Shoot fly of little millet	<i>Atherigona pulla wiedemann</i>
12.	Sorghum midge	<i>Contarinia sorghicola</i>
13.	Stem borer of sorghum/maize	<i>Chilo partellus</i>
14.	Yellow stem borer of paddy	<i>Scirpophaga incertulas</i>

## APPENDIX-V GLOSSARY OF TECHNICAL TERMS

**ALIEN SPECIES:** Species that do not naturally occur within an area and that have usually arrived in the area as a result of human intervention. Alien species often have adverse effects on native species as a result of competition.

**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:** The oldest and effective method of pest suppression. 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.

**DOUGH GRAIN STAGE:** In paddy crop, the stage in which the milky portion of the grains turns into soft dough and later into hard dough. The grains in the panicle will turn from green to yellow colour.

**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.

**GINNING:** It is the process of removing the fibres around the seeds of cotton in an authorised seed processing units under close supervision of the concerned authorities.

**GLUME:** The two chaffy basal bracts of a paddy spikelet.

**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.

**HAULMS:** The vegetative shoot portion of the potato crop is called as haulm.

**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.

**OFFTYPES:** Plants that 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 occurring by insects, birds, wind, or other natural mechanisms. The seeds of open-pollinated plants will produce new generations of those plants.

**PANICLE:** When axis of raceme branches and the flowers are borne not directly on the axis but on its branches then the inflorescence is called a panicle.

**PSB (PHOSPHATE SOLUBILIZING BIOFERTILIZERS):** Bio – fertilizers containing the phosphate solubilizing microbes like Pseudomonas, Agrobacterium, Rhizobium etc., are known as phosphate solubilizing biofertilizers.

**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.

**STOLON:** A prostrate stem, at or just below the surface of the ground that produces new plants from buds at its tips or nodes. Eg: Potato

**TASSEL:** Tassel is the male flower of the corn plant. The tassel is a group of male flowers that grow at the apex or top of the corn stalk. Tassels are in the shades of yellow, green and purple.

**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.

**UNISEXUAL:** Flowers having either stamens (Androecium) or stigma (gynoecium) are said to be unisexual. If they have only the androecium, they are male flowers. If the flowers have only the gynoecium, they are said to be female flowers. Eg. Cucurbit, Castor.

**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.

**WINNOWER:** 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.