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TRAINING MANUAL ON GOOD POSTHARVEST MANAGEMENT PRACTICES FOR FIELD CROPS OF WEST COASTAL ECOSYSTEM

ICAR-Central Coastal Agricultural Research Institute
भाकृअनुप - केंद्रीय तटीय कृषि अनुसंधान संस्थान
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Foreword

Goa Regional Office

Post-harvest lossescover all losses from the stage of harvesting to the stage of consumption both in terms of quality and quantity. The awareness level regarding the post-harvest losses and the measures to minimize it are negligible at the ground level. For instance, it is estimated that post harvest losses in paddy account of about 23%. Sensitizing farmers on preventing post-harvest losses at different stages would help farmers to plug income leakages and enhance productivity. Towards this objective, NABARD Goa Regional Office has sanctioned the project 'Popularizing Good Post Harvest Management Practices for Field Crops of Goa' to ICAR-Central Coastal Research Institute under 'Farm Sector Promotion Fund (FSPF)' with particular focus on paddy which is the main food crop of the state.

Under the project, ICAR-CCARI has conducted extensive awareness and training programmes to sensitize farmers to minimize post-harvest losses.More than 400farmers have been trained in various aspects of good post-harvest managementpractices such as proper stacking, drying, parboiling / pre-treatment, fumigation, storage hygiene, structures, milling, etc.Hands on training on construction ofpusa bins, alow cost storage structure has also been imparted to farmers. Demonstration bins have been constructed under the project at Khandola and Cotigao.

I congratulate ICAR, CCARI Goa for their dedicated approach and sincere efforts towards publication of this manual. I am sure, this manual will guideGoan farmers in adopting modern management practices to reducepost-harvest losses.

Ms. Kamakshi S. Pai
Chief General Manager / Officer-in-Charge
NABARD, Goa RO, Panaji
29 July 2020

Director's Message

Coastal Regions of India have diverse field crops like Paddy, legumes, minor millets etc. which contribute to the livelihood security of the farmers. Postharvest losses from harvest to consumption range from 10-20 % in cereal crops and up to 50 % in fruits and vegetables, thus reducing their profit margins drastically. ICAR-Central Coastal Agricultural Research Institute has assessed the causes for postharvest losses in Paddy and Cowpea and estimated the extent of the same through an institute funded research project and based on the results formulated good postharvest management practices to mitigate the same. The sensitization of the farmers, stakeholders, and policy makers about the losses and training them about good postharvest management of crops was pertinent towards dissemination of these research findings.

This training manual is a step in that direction, and it contains especially useful inputs for proper variety selection, agronomic practices, soil-based nutrition management, pest, and disease management for reducing postharvest losses. It has been successfully used for various trainings and demonstrations conducted across the state to sensitize the farmers through NABARD funded project on "Popularizing Good Post Harvest Management Practices for Field Crops of Goa."I would like to register my sincere appreciation to NABARD for the funding of this project

I hope this manual will be useful to agricultural officers, field extension personnel and farmers across the coast and India.

Dr. E.B.Chakurkar
Director (A)
ICAR-Central Coastal Agricultural Research Institute

Preface

Postharvest losses during various unit operations of field crops like Paddy, legumes from harvest till they reach the consumer erode into the already dwindling farm incomes. Various studies at national and state level have been conducted to assess the post-harvest losses, their causes and develop suitable good management practices to mitigate the same. Sensitizing the farmers to the extent and causes for postharvest losses and popularising the good postharvest management practices amongst stakeholders viz. farmers, agricultural department, and policy makers is paramount to reduce postharvest losses at farm, market, and national level. For achieving this objective, ICAR-Central Coastal Agricultural Research Institute has undertaken a NABARD sponsored project on "Popularizing Good Post Harvest Management Practices for Field Crops of Goa" in the state of Goa and conducted series of training across the state at various villages at various stages viz, harvest, drying, parboiling, milling and storage. We have also constructed two Pusa Bins at farm level for training farmers.

This technical bulletin is compilation of the various lectures given during the four sensitization training conducted and it includes valuable inputs on choosing proper varieties, agronomic practices, nutrition management, adoption of suitable machinery, pest and disease management to reduce postharvest losses. Glimpses of the various trainings given also have been included. The work was done using the state extension agencies like Krishi Vigyan Kendras -North and South Goa, ATMA- north and South Goa, various Self-Help Groups and Farmers' clubs in the villages chosen for the training. This project has successfully sensitized more than 400 farmers of Goa, KVKs and ATMA extension workers and the state agricultural department about postharvest losses, their causes and good postharvest management practices to overcome the same.

We gratefully acknowledge the financial support of NABARD Regional Office, Panaji for the implementation of the project. We appreciate the help and cooperation of Directorate of Agriculture, KVK s and ATMA of North and South Goa, various SHGs and Farmers' clubs to successfully conduct the various training and demonstrations. We thank our director for his support and guidance during the project. We also thank all the project staff for their technical assistance during the project.

Dr. (Mrs.) Mathala Juliet Gupta

Dr. Maruthadurai R

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Choosing Varieties Suitable for West Coast Ecosystem to reduce post-harvest losses in Field Crops

Manohara, K. K.
Senior Scientist (Plant Breeding)
ICAR-CCARI, Goa

Goa, is a tiny state located on west coast of India, spread over in an area of 3702 sq. km. The State is flanked on the east by Sahyadri Mountains and on the West with Arabian Sea. Important field crops for the state include Paddy, Ragi, Sugarcane, Groundnut, Cowpea, Moong etc.

Rice is the most important food crop of Goa state. Rice area in Goa is to the tune of 40,000 to 45,000 ha being grown on different ecologies like rainfed shallow lowland (medium land), irrigated, rainfed upland and low lying coastal saline area. The rice based cropping systems include rice-pulse (local cowpea), rice-groundnut under residual soil moisture situation in rice-fallows from early December to March and rice-vegetables, rice- sweet potato in areas where lifesaving irrigation can be provided by traditionally developed sunken wells mostly in kher lands. These constitute the predominant cropping pattern which dominates nearly 42 - 45 per cent of the agrarian scenario in the state.

Jaya and Jyothi are still the ruling rice varieties in the state with few landraces or farmers' varieties grown in small pockets. Variety preference of people of Goa is medium duration varieties with coarse grains suitable for local traditional mills and for parboiled rice. Rice is a main crop in kharif season, and in rabi season it is cultivated wherever irrigation source is available.

Jyothi is the most predominantly grown rice variety in the state occupying nearly 50% of the total rice growing area. Jaya is second to Jyothi in terms of the area coverage. Other varieties are mainly local varieties or landraces. Korgut, Asgo and Shidde are the few predominant landraces grown in the low-lying salt-affected coastal saline soils (locally called as Khazan lands) due to their inherent tolerance to salinity and water logging.

As the rice is cultivated in three distinct ecologies during the rainy season namely upland, lowland, and saline soils, research and developmental interventions specific to the ecology will aid improving the production and productivity. For the upland's short duration high yielding rice varieties coupled with drought tolerance will help in mitigating the short duration breaks in the monsoon period with higher productivity. In the lowlands, availability of medium duration rice varieties with lodging resistance will help in increasing the productivity. Similarly, in the saline lands, availability of high-yielding salt-tolerant rice varieties will help in enhancing the total production from the ecosystem. Further, following an integrated nutrient management including profitable cropping systems will further accelerate the rice production in different ecologies.

Institute has released four salt-tolerant rice varieties for the salt-affected coastal saline soils. Goa Dhan 1 and Goa Dhan 2, were released in the year 2017, are the product of pure-line selection from the local salinity tolerant landrace Korgut. Goa Dhan 1 is a white-kernelled selection from Korgut having semi-tall plant type with yield potential of 2.4 - 2.7 t/ha under saline condition. Goa Dhan 2 is a red-kernelled selection from Korgut, is tall with yield potential of 2.6 - 2.8 t/ha under saline condition.

White kernelled rice variety Goa Dhan 1

Red kernelled rice variety Goa Dhan 2

Goa Dhan 3 is an advanced breeding line / culture received from International Rice Research Institute (IRRI), Philippines, found to be very promising under coastal salinity conditions of Goa, with yield potential of 3.0 - 3.5 t/ha. The variety can give yield up to 6.0 t/ha under normal condition. Goa Dhan 4 is a red-kernelled rice variety with long-slender grain type. It has a yield potential of 3.0 - 3.5 t/ha under saline condition and in normal condition it yields up to 6.0 t/ha. Due to its superior performance over Jyothi under normal condition, the variety is a probable replacement for Jyothi in the coastal state of Goa.

White kernelled rice variety Goa Dhan 3

Red kernelled rice variety Goa Dhan 4

Among the pulses, cowpea is a major pulse crop for the state. It is cultivated during rabi season in rice-fallow areas under residual moisture condition. Locally known by Alsando (red bold varieties) used in many of the culinary preparations owing to its unique taste, bold size seeds and better cooking quality. Institute has released one cowpea variety Goa Cowpea 3, for the state of Goa in 2015 for cultivation in the rice-fallow areas. Farmers in Goa has a liking for this variety due to its bold seed size and unique taste. Each kilogram of seeds of variety is fetching rupees 160 - 180. This is a semi-spreading variety with yield potential of 1.4 - 1.6 t/ha. As this variety can produce huge biomass, can be used as dual-purpose variety in the state.

Moong is one another pulse crop in Goa, has sizable area under cultivation. Institute has recommended two varieties IPM 2-14 and TM 96-2 for cultivation in the Goa state. Since, crop is short-duration and ready for harvest in 65-70 days, has huge scope for including in crop rotation thereby enriching the soil fertility.

Cowpea var Goa Cowpea 3

Moong var TM 96-2

Moong var IPM 2-14

Good Agronomic Practices for Field Crops of West Coast Ecosystem to reduce Post-harvest losses

Dr. Paramesha, V,
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System of rice intensification

Developed in Madagascar early – 1980s by Father Henri de Laulanié. Formal experimentation started in India by 2002-2003. One of the best Resource conserving technology.

Concept:

- The System of Rice Intensification is not a new method or technology. It is just altering the management practices to make more productive phenotype from the same genotype of rice plant.
- Artificial environment is created for growth and development of rice plant for exploitation of its full genetic potential, land, and water resources
- The System of Rice Intensification (SRI) is a methodology aimed at increasing the yield of rice produced in farming.
- It is a low water, labor-intensive, method that uses younger seedlings singly spaced and typically hand weeded with special tools.

SRI encourages rice plant to grow healthy with:

- Large root volume
- Profuse and strong tillers - Maximum tillering (30 tillers/plant can be easily achieved; 50 tillers per plant are quite attainable) occurs concurrently with panicle initiation. Under excellent management even 100 fertile tillers per plant or even more can be achieved due to early transplanting and absence of die back of roots.
- Non lodging
- Big panicles
- More and well filled grain panicles and higher grain weight
- Resists insects because it allows rice to absorb soil nutrients naturally

SRI Benefits:

SRI methods increase the productivity of:

- Water - since yields can double or more with only half as much water, the productivity of water is greatly increased – this is especially important in countries or places where water is becoming scarcer.
- Land– yields as indicated above can average about 8 t/ha once the methods are used correctly and can be twice that or more when they are used with precision and skill.
- Labor– SRI can require more labor– about 26% in one Madagascar evaluation, 11% in a Sri Lankan survey – but depending on the cost of labor, the value of increased production increases the returns to labor by at least 50% and often several hundred percent. Once the methods have been mastered, the labor requirements for SRI decline.

Also, implements are being developed that save labor. Due to smaller seedlings and fewer seedlings to transplant the drudgery of women's work is dramatically reduced.

Other benefits of SRI:

- Higher yields – Both grain and straw
- Reduced duration (by 10 days)
- Lesser chemical inputs
- Less water requirement
- Less chaffy grain %
- Grain weight increased without change in grain size
- Higher head rice recovery
- Withstand cyclonic gales
- Cold tolerance
- Soil health improves through biological activity

Core principles of SRI:

8-10 Days (2 leaf stage) nursery | Wider spacing (25X25cm) | Weeding with weeder | Use of Organics

Principles:

SRI method is based on the following principles:

- Early, quick and healthy plant establishment
- Reduced plant density
- Improved soil conditions through enrichment with organic matter
- Reduced and controlled water application
- Young seedlings between 8-12 days old (2-3 leaf stage) are transplanted to preserve potential for tilleringand rooting ability.
- Careful planting of single seedlings rather than in clumps that are often plunged in the soil; ϖ Wider spacing at 25 cm x 25 cm. in square planting rather than in rows.
- Use of cono-weeder/ rotary hoe/power weeder to aerate the soil as well as controlling weeds.
- Alternate wetting and dry method rather than continuous flooding in the field.

Methods

The System of Rice Intensification is not a new method or technology. It is just altering the management practices to make more productive phenotype from the same genotype of rice plant. Artificial environment is created for growth and development of rice plant for exploitation of its full genetic potential, land, and water resources. It can be accomplished by the following methods:

1. Raising nursery:

(a) Selection of site:

- In SRI method, utmost care should be taken in the preparation of nursery bed, as 8-12 days old seedlings and in some places 14-15 days old seedlings (2-3 leaf stage) are transplanted.
- The nursery bed should be preferably prepared in the centre / corner of the plot for quick / efficient transplanting.

(b) Size of bed:

- For one-acre transplantation, the nursery bed can be raised in 48 square yard (40 sq meter) plot.
- Depending upon the situation, two beds can be raised each measuring 24 sq. yards (20 sq meters) per 1 kg seed.
- A bed with a width of 125 cm or 4 feet is ideal.

(c) Bed preparation:

- Nursery bed is prepared with application of farmyard manures (FYM) and soil in four alternating layers.
- 1st layer: 1 inch (2.54 cm) thick well decomposed FYM,
- 2nd layer: 1 .5-inch (3.75 cm) soil,
- 3rdlayer :1 inch (2.54 cm) thick well decomposed FYM,
- 4th layer: 2.5-inch (6.3 cm) soil.
- All these layers should be mixed well as it will helps in easy penetration of roots.
- Besides compost or even compost can also be used and spread it over all the bed in 3-5 cm layer.

(d) Seed rate:

- 2 kg of seeds (5 kg / ha) is required to transplant in one acre of land.
- Seed should be thinly spread to avoid crowding of seedlings.
- Care should be taken that no two seeds should touch each other.

(e) Seed Treatment:

- Healthy and pure seeds are used.
- Soak the seeds for 12 hours in water.
- Drain the water and treat the seed with bavistin (2 gm / kg seed) or Trychoderma (3 gm / kg seed) or streptocyclin (1gm / kg of seeds).
- There after transfer the treated seeds to a water-soaked gunny bag.
- Leave it for 24 hours.
- Sprouted seeds are taken to the nursery for sowing.
- To ensure uniform broadcasting, divide the seed into four part and broadcast thinly over the bed.
- It is better to broadcast seeds in the evening.

(f) Mulching:

- Cover the bed with paddy straw, to cover from direct exposure to the sun and to ensure protection from birds.
- Depending upon requirement, apply water with rose cans twice daily.
- Care should be taken to see that the seeds do not come out while watering. Remove the straw once seeds germinate.



2. Nursery bed preparation



4. Cover with a layer of manure

6. seedlings ready for transplanting

Main field preparation:

- Land preparation is not different from regular irrigated rice cultivation.
- Leveling should be done carefully so that water can be applied very evenly.
- Provide a canal at every 3m distance to facilitate drainage.
- Draw lines both ways at 25x25cm apart with the help of a marker and transplant at the intersection.
- The main field is prepared and leveled with little standing water a day before planting for grid marking. Provision should be made for 30 cm wide channels at 2 meters interval.
- Perfect leveling is the pre-requisite for proper water management and good crop stand.
- 8-12 days old seedlings are transplanted


The field should be well drained and leveled. After leveling the field, a marker can be used to lay out the plot into wider spacing i.e., 25 cm x 25 cm row to row and plant to plant. This can also be done with the help of rope by marking.

Nutrient Management:

- Organic manures / vermicompost are recommended in SRI cultivation as they give better response and improve soil health.
- Application of FYM / compost (10-12 t/ha) before ploughing and incorporation of in situ grown 45-60 days old green manures crops are beneficial.
- Though complete organic manuring is recommended for SRI, in case of short supply of organics, fertilizer supplementation may be adopted for better yields.
- Apply and incorporate 50 % of recommended fertilizers (NPK) through in-organics i.e., 50: 30: 20 kg NPK in kharif and 60:30 : 20 kg NPK in rabi depending on soil test values at the time of preparation of the field.
- Apply second dose (25 per cent) of N at the time of 2nd weeding (20 DAT) and final dose of 25 per cent N and remaining 25 per cent K a week before panicle initiation stage.
- Need based N can be applied with the use of Leaf Colour Chart to enhance the N use efficiency.

Water management

- SRI method does not require continuous flooding.
- Irrigation is given to maintain soil moisture near saturation initially and water is let in when surface soil develops hairline cracks.
- Soils having low water holding capacity require frequent irrigation.
- This method also helps in better growth and spread of roots.
- The field should be irrigated again when the soil develops hair line cracks.
- Depending upon the soil and the environment conditions, the frequency of irrigation should be decided.
- At the time of weeding operation to avoid shoulder pain, the field should be irrigated to have 2-3 cm of water.
- After completion of weeding the water should not be let out of the field.
- After the panicle initiation stage until maturity, one inch of water should be maintained in the field until maturity.
- The water can be drained after 70 per cent of the grains in the panicle get hardened.

Weed Management:

- Absence of standing water leads to more weed growth in SRI.
- In SRI, the weeds are incorporated by operating conoweeder between rows at the right time, which also supply nutrients to the crop as green manures.
- Use the weeder on the 10th and 20th day after transplanting
- For smoother and easy operation of conoweeder, it is advisable to coincide the weeding with irrigation.
- Further weeding may be undertaken depending on the necessity at 10-15 days interval until crop reaches panicle stage.
- Weeds close to the hills/tillers must be removed by hand.
- The first advantage of using the weeder is the control of weeds and adding organic matter to the soil.
- This gives the benefits of cultivating a green manure crop.
- Further, the soil gets aerated and the roots are exposed to air.
- This results in profuse growth of diverse soil microorganisms which make nutrients available to the plant.

Pest and Disease Management:

- The uniqueness of SRI method lies in not using the chemical pesticides and herbicides.
- Wider spacing and use of organic manures results in healthy growth of the plants and incidence of the pests and diseases is naturally low.
- The pests can be easily managed by using some organic concoctions either as a preventive measure or as and when needed. AmritJalam is one such concoction.

Harvesting:

- The grain matures even while the crop is green in color.
- Hence farmers should be ready to undertake timely harvesting.
- The grain continued to mature up to 120 DAT.
- Harvest the crop around 20-25% moisture in the grain.
- The plot is then drained 10-15 days before harvest

Threshing:

- Avoid delays in threshing after harvesting
- Use proper machine settings when using a threshing machine
- Clean the grains properly after threshing
- Dry the grains immediately after threshing

The thresher separates the grains from the stalks

Aerobic rice:

Aerobic rice is a production system in which especially developed “aerobic rice” varieties are grown in well-drained, non-puddled, and nonsaturated soils. With a good management, the system aims for yields of at least 4-6 tons per hectare.

Origin:

- International Rice Research Institute (IRRI) developed the -aerobic rice technology to address the water crisis in tropical agriculture.
- Aerobic rice cultivation in Karnataka State in India was first conceptualized at UAS Bangalore by DrShivashankar G and DrShailajaHittalmani (1980-1985].
- This visionary work was initiated by the teacher-student duo in form of a doctoral thesis to explore growing rice under sub-optimal water and soil conditions with improved upland base varieties that are responsive under non- submerged aerobic situation.
- It was essentially to upgrade the existing farmers’ practice of direct seeding of rice in rain fed situation with minimum tillage with local varieties that fetched extremely low yields.

- Thus, growing rice in unpuddled condition was later nomenclatured as "Aerobic Rice Cultivation' (Venkataravana and ShailajaHittalmani 1989-91).
- Aerobic rice cultivation system is the method of cultivation, where the rice crop is established by direct seeding (dry or water-soaked seed) in non-puddle field and un-flooded field condition.
- The usual way of planting aerobic rice is the same as we would plant the other cereal crops like wheat or maize-by direct seeding.
- It is the most promising approaches for saving water and labour

Targeted areas:

Aerobic rice can be found, or can be a suitable technology, in the following areas:

- "Favorable uplands": these are areas where the land is flat, and where rainfall with or without supplemental irrigation is sufficient to frequently bring the soil water content close to field capacity, and where farmers have access to external inputs such as fertilizers.
- Fields on upper slopes or terraces in undulating, rainfed lowlands: quite often, soils in these areas are relatively coarse-textured and well-drained, so that ponding of water occurs only briefly or not at all during the growing season.
- Water-short irrigated lowlands: these are areas where farmers do not have access to sufficient water anymore to keep rice fields flooded for a substantial period.

A dry seeded Aerobic rice field

Dibbling Aerobic rice seeds

Advantages of aerobic cultivation:

- Puddling and submergence is not required
- Nursery and transplanting are not required
- Saving of seeds up to 80%
- Less labour requirement
- Saving of water up to 60%
- Efficient fertilizer utilization
- Less pest/ disease incidence
- Reduced methane emission leading to lower environment pollution
- Porfuse rotting and high tilling, less lodging and high grain and fodder yield
- Retention of soil structure and quality

Principles:

Direct seeding of treated seed in non-puddle and non-flooded field

- It can be rain fed or fully irrigated or supplementary irrigated
- Maintain water at just soil saturation level (aerobic i.e. with oxygen)
- Effective and timely weed control is crucial for success of this system
- Row to row spacing should be adopted at 20 or 25cm with continuous sowing
- Use of best nutrient management practices along with use of FYM/compost/ vermicompost etc.

Concept:

- The new concept of aerobic rice may be an alternate strategy, which combines the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs.
- Aerobic rice cultivation is an approach in rice cultivation is to grow the croplike an irrigated upland crop, such as wheator maize. Unlike lowland rice, it is grown inunpuddled, non-saturated (i.e., aerobic) soil without flooded water.
- It is a new concept of reducing water requirement for rice in which rice is grown like an upland crop with high inputs and supplementary irrigations whenrainfall is insufficient.
- It is responsive to high inputs, can be rainfed or irrigated and can tolerate occasional flooding also.

Crop establishment:

- **Time of Sowing:**
  Sowing of aerobic rice may be taken up as kharif (June-July) and summer (February) crop.
- **Seed Rate:**
  Seed rate of 5-6 kg per hectare is used for this method of cultivation.
- **Spacing:**
  Wider spacing of 25 cm. x 25 cm. or 30 cm. x 30 cm. is followed. This type of square method helps to carry out intercultural operations in both directions.
- **Method of Sowing:**
  Dibbling method of sowing is practiced by dibbling two seeds per hill at five-centimeter depth. Sowing can be done either by using manual seeding or drum seeder.

1. **Main field preparation and transplanting:**
   - Proper land preparation and leveling should be followed for ensuring adequate crop stand and finally achieving higher yield.
   - Ploughing 2-3 times followed by 2-3 harrowing and planking are necessary for this crop.
   - Minimum Tillage is enough for aerobic rice cultivation.
   - Dry direct seeding ensures that fields are well harrowed and leveled.
   - Field should be thoroughly prepared by using disc plough, cultivator and rotavator
   - Transplant seedlings into wet soil that is kept around saturation for a few days to ease transplanting shock.
   - Let the field dry out to field capacity.
2. **Direct dry seeding:**
   - Prepare the land by plowing and harrowing to obtain a smooth seed bed before

seeding.

- Sow seeds at a depth of 1-2 cm in heavy soil (clay) and a 2-3 cm depth in light-textured soil (loam).
- Sowing may be done manually by dibbling seeds into slits opened by a stick or tooth harrow or mechanically using direct seeding machines.
- The optimum seeding rate is 70-90 kg/ha. Maintain 25-35 cm row spacing

Inter cultivation:

- Inter-cultivation should be done once in 15 days by using hoes till panicle initiation.
- Inter-cultivation could be done in two directions which are facilitated by square method of sowing.
- Inter-cultivation helps not only in controlling weeds, but also aerates the soil and increases infiltration of water.

Transplanting method of aerobic rice

Irrigation management:

- Aerobic rice system can be rain fed or fully irrigated or supplementary irrigated.
- Irrigation is applied by flash flooding, furrow irrigation or sprinkle
- It can be also grown entirely on rainfall in wet season with a well distributed rain.
- Some visible signs that the soil moisture is below field capacity are hair-line cracks in the soil and rolling of the tips of leaves.
- Water management is done to keep soil moist alternate wetting and drying.
- Aerobic rice cultivation can reduce the irrigation by about 40-50 percent when compared to transplanted rice.
- Irrigation should be apply according to critical physiological growth stages of rice crop, viz. 1 DAS (or pre sowing), tillering, panicle initiation (PI), flowering and grain filling stages, respectively for obtaining good grain yield particularly during rabi season/boro as reported by Jana

'Aerobic' rice cultivation reduces water usage

Nutrient management:

- Incorporate 10 tons of well decomposed farmyard manure or compost 2-3 weeks in advance helps for better availability of nutrients.
- In addition, crop demands 100 kg of nitrogen, 50 kg each of phosphorus and potassium per hectare.

- Apply 50 per cent of nitrogen and potash and full dose of phosphorus at the time of sowing.
- Top dressing of 25 per cent nitrogen and 50 per cent potash should be given at 30 days after sowing and remaining 25 per cent nitrogen at 60 days after sowing.
- 120:50:50 kg ha-1 NPK to obtain a yield of 4-6 t ha-1
- First split can best be given at 10-12 days after emergence, second split at active tillering (AT) and third split fertilizer application at panicle initiation (PI) stage.

Weed management:

- Weed population is extremely high in aerobic rice culture due to non-flooded condition as compared to conventional method of rice cultivation (flooded condition).
- That is why weed poses a bigger threat in aerobic direct seeded rice system
- Preemergence application of pendimethalin (PE) @1.0kgha-1 at 1-2 days after sowing should be done.
- 2, 4-D Na salt @ 0.80kgha-1 at 25-30 days after sowing is applied.
- Two mechanical weeding or two hand weeding is done at 40 and 60 days after sowing (DAS).
- At 55 DAS, with or with-out preemergence application of pendimethalin, 2 mechanical weedings controlled weed population and reduced weed biomass.
- Higher weed biomass was observed with higher nitrogen application at 55 DAS.

Yield:

By following recommended practices, grain yield of 4.5-5.0 t/ha and straw yield of 5.0-5.5 t/ha may be obtained from aerobic rice cultivation.

Direct seeded rice:

Direct seeded crops require less labour and tend to mature faster than transplanted crops.

In this method, plants are not subjected to stresses such as being pulled from the soil and re-establishing fine rootlets. However, they have more competition from weeds.

Benefits of Direct Seeded Rice:

- Avoids repeated puddling, preventing soil degradation and plow-pan formation
- Facilitates timely establishment of rice and succeeding crops as crop matures 10-15 days earlier
- Saves water by 35-40%, reduces production cost by Rs 3000/ha, and increases yields by 10%
- Saves energy: labour, fuel, and seed
- Solves labour scarcity problem and reduces drudgery of labours

Principles:

- Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery.
- There are three principal methods of direct seeding of rice (DSR):
  a. dry seeding (sowing dry seeds into drysoil),
  b. wet seeding (sowing pre-germinated seeds on wet puddledsoils) and
  c. Water seeding (seeds sown into standing water).

Land preparation:

- Land preparation is important to ensure that the rice field is ready for planting. A well-prepared field controls weeds, recycles plant nutrients, and provides a soft soil mass for transplanting and a suitable soil surface for direct seeding.
- Land preparation covers a wide range of practices from zero-tillage or minimum tillage which minimizes soil disturbance through to a totally 'puddled' soil which destroys soil structure.
- It typically involves
  a. ploughing to "till" or dig-up, mix, and overturn the soil.
  b. harrowing to break the soil clods into smaller mass and incorporate plant residue, and
  c. Levelling the field.
- Initial land preparation begins after your last harvest or during fallow period. This is important for effective weed control and for enriching the soil. Generally, it will take 3−4 weeks to prepare the field before planting.

(1) Clear the field:

- At dry field condition, apply glyphosate to kill weeds and for better field hygiene.
- Irrigate the field 2−3 days after glyphosate application.
- Maintain standing water at 2−3 cm level for about 3−7 days or until it is soft enough and suitable for an equipment to be used.
- Plow or rotovate the field to incorporate stubbles and hasten decomposition.
- Implements: Power tiller with attached mouldboardplough, Hydro tiller, Rotovator
- Flood the field. Keep it submerged for at least two weeks. Let the water drain naturally to allow volunteer seeds and weed seeds to germinate.
- Depending on weed population and soil condition, another tillage operation can be done.

(2) Create compost from rice residue:

Composting converts crop residues into better organic fertilizers. To create a compost:

- Ensure that the field is level, well drained, and under shade.
- Chop compost materials into small pieces (3−5 cm).
- If possible, build compost heaps in layers consisting of rice crop material, combined with legume or manure wastes, on a 2:1 ratio.
- Keep compost heaps moist—not to wet and

not too dry. Make sure that no water drains from the compost pile. If rice straw cracks when bent, then the compost must be too dry.

- Sprinkle compost heap with decaying material (e.g., cow urine), a dilute solution of N fertilizer such as urea, and/or with a micro-organism solution (e.g., tricho). This will decompose the materials faster.
- Mix and turn the heaps every two weeks.
- Compost should be ready within 4−8 weeks if moisture and temperature conditions are good.

(3) Plant cover crop:

- Growing cover crops help suppress weeds and enrich the soil.
- Crops that can be planted after harvest include nitrogen fixing crops like Sesbania, Azolla, and other legumes such as mung bean and cow pea.

Depending on the land preparation method used, direct seeding can be done in two ways:

1.Dry direct seeding:

This method is usually practiced for rainfed and deep-water ecosystems. Farmers sow onto dry soil surface, then incorporates the seed either by plowing or harrowing.

- **Broadcasting:**
- Broadcast 60−80 kg of seeds uniformly by hand or in furrows in 1 ha of field.
- Make shallow furrows by passing a furrower along the prepared field.
- After broadcasting, cover the seeds using a spike-tooth harrow.

- **Drilling:**
- Precision equipment, such as the Turbo Happy Seeder, can be used to drill seeds.
- Drill 80−100 kg of seeds per ha.
- Seeds are placed by the machine into both dry and moist soil, and then irrigated. A smooth, level seedbed is necessary to ensure that seeds are not planted at depths greater than 10−15 mm.
- In this technique, fertilizers can be applied at the same time as the seed. Manual weeding also is easier in machine-drilled crops than in broadcast crops.
- **Dibbling:**

Dibbling or hill planting is usually practiced along mountain slopes or where plowing and harrowing are difficult.

- Use a long wood or bamboo pole with a metal scoop attached at the end for digging holes.
- Drop the seeds into the holes and cover them with soil.

2. Wet direct seeding:

In wet fields, direct seeding can be done either through broadcasting or drilling seeds into the mud with a drum seeder.

- Broadcasting:
- Broadcast 80−100 kg per ha of pre-germinated seeds to recently drained, well-puddled seedbeds or into shallow standing water.
- If water in the field is muddy, allow 1−2 days for it to dry before broadcasting.
- If water is drained from the fields after broadcasting, seeds are re-introduced 10−15 days after first seeding.

- **Drum seeding:**
- Drum seeders are used for fast planting. It operates best on a well-leveled, smooth, and wet seedbed. However, seeders may be clogged if the soil is sticky or if the machine is poorly designed.
- Prepare 80 kg of pre-germinated seeds per ha.

Weed management:

- The choice of herbicide depends on the type of weeds. No single herbicide can control all weeds in the rice crop.
- For effective weed control, apply a pre-emergence herbicide, 1–3 DAS. While post-emergence application should be at 15–25 DAS.
- Weeds are practically impossible to control by manual weeding by hand.
- However, one or two spot hand weeding can be done to
  a. Remove weeds that escape herbicide application,
  b. Prevent weed seed production and the accumulation of weed seeds in the soil.
- In mechanical weeding, motorized cono and other hand weeders can be used.

Water management:

- Rice is typically grown in bunded fields that are continuously flooded up to 7−10 days before harvest.
- Continuous flooding helps ensure sufficient water and control weeds.
- Lowland rice requires a lot of water.
- Continuous flooding of water generally provides the best growth environment for rice.
- After transplanting, water levels should be

around 3 cm initially, and gradually increase to 5−10 cm (with increasing plant height) and remain there until the field is drained 7−10 days before harvest.

- For direct wet seeded rice, field should be flooded only once the plants are large enough to withstand shallow flooding (3-4 leaf stage).

Nutrient management:

- Applying nutrients to the crop is essential in managing soil fertility so the plants grow and develop normally. A few crop problems can be related to inefficient management of nutrients and nutrient imbalances in the field.

Disease and pest management:

Crop problems can be caused by other living organisms, like rats and fungus, or by non-living factors, such as wind, water, temperature, radiation, and soil acidity.

- The best control for pests and disease problems is prevention.
- To limit pest and disease damage:
- Practice good cleaning of equipment and field between seasons
- Use clean seeds and resistant varieties
- Do not over apply fertilizer
- Encourage natural pest enemies
- Do not apply pesticides within 40 days of planting
- Properly store grain

Harvesting

- **Harvesting:**
  Harvesting is the process of collecting the mature rice crop from the field. Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling. These can be done individually, or a combine harvester can be used to perform the operations simultaneously.
- It is important to apply good harvesting methods to be able to maximize grain yield and minimize grain damage and quality deterioration.

Harvesting processes:

- Harvesting rice consists of the basic operations which can be done in individual steps or in combination using a combine harvester. These include:

- Reaping - cutting the mature panicles and straw above ground
- Threshing - separating the paddy grain from the rest of cut crop
- Cleaning - removing immature, unfilled, non-grain materials
- Hauling - moving the cut crop to the threshing location

When to harvest:

Depending on the growth duration of the variety, harvesting time should be around 110–120 DAS for direct seeded rice, and 100–110 DAT for transplanted rice.

To properly harvest your crops, make sure to:

- Harvest at the right time with the right moisture content.
- Avoid delays in threshing after harvesting.

Threshing should be done as soon as possible after cutting to avoid rewetting and to reduce grain breakage.

- Use proper machine settings when using a threshing machine.
- Clean the grains properly after threshing.
- Dry the grains immediately after threshing.

Seed treatment:

- Treat the seeds in Carbendazim or Pyroquilon or Tricyclozole solution at 2 g/l of water for 1 kg of seeds. Soak the seeds in water for 10 hrs. and drain excess water.
- This wet seed treatment gives protection to the seedlings up to 40 days from seedling disease such as blast and this method is better than dry seed treatment.
- If the seeds are required for sowing immediately, keep the soaked seed in gunny in dark and cover with extra gunnies and leave for 24hrs for sprouting.
- **Seed treatment with Pseudomonas fluorescens:**
    - o Treat the seeds with talc-based formulation of Pseudomonas fluorescens 10g/kg of seed and soak in 1lit of water overnight.
    - o Decant the excess water and allow the seeds to sprout for 24hrs and then sow.

- **Seed treatment with biofertilizers:**
    - o Five packets (1kg/ha) each of Azospirillum and Phosphobacteria or five packets (1kg/ha) of Azophos bioinoculants are mixed with sufficient water wherein the seeds are soaked overnight before sowing in the nursery bed (The bacterial suspension after decanting may be poured over the nursery area itself).
    - o Biocontrol agents are compatible with biofertilizers.
    - o Biofertilizers and biocontrol agents can be mixed for seed soaking.
    - o Fungicides and biocontrol agents are incompatible.

Nutrient management:

- Apply 1 tonne of fully decomposed FYM or compost to 20 cents nursery and spread the manure uniformly on dry soil.

- Basal application of DAP is recommended when the seedlings are to be pulled out in 20-25 days after sowing in less fertile nursery soils.
- For that situation, before the last puddling, apply 40 kg of DAP and if not readily available, apply straight fertilizers 16 kg of urea and 120 kg of super phosphate.
- If seedlings are to be pulled out after 25 days, application of DAP is to be done 10 days prior to pulling out.
- For clayey soils where root snapping is a problem, 4 kg of gypsum and 1 kg of DAP/cent can be applied at 10 days after sowing.

Main field:

Nutrient management:

Application of organic manures:

- Apply 12.5 t of FYM or compost or green leaf manure @ 6.25 t/ha.
- If green manure is raised @ 50 kg seeds/ha in situ, incorporate it to a depth of 15 cm using a green manure trampler or tractor.
- In the place of green manure, press-mud / composted coir-pith can also be used.

Stubble incorporation

Stubble incorporation:

- Apply 10 kg N/ha (22 kg urea) at the time of first puddling while incorporating the stubbles of previous crop to compensate immobilization of N by the stubbles.
- This may be done at least 10 days prior to planting of subsequent crop. This recommendation is more suitable for double crop wetlands, wherein, the second crop is transplanted in succession with short turn around period.

Biofertilizer application:

- Broadcast 10 kg of soil based powdered BGA flakes at 10 DAT for the dry season crop. Maintain a thin film of water for multiplication.
- Raise Azolla as a dual crop by inoculating 250 kg/ha 3 to 5 DAT and then incorporate during weeding for the wet season crop.
- Mix 10 packets (2 kg/ha) each of Azospirillum and Phosphobacteria or 10 packets (2 kg/ha) of Azophos inoculants with 25 kg FYM and 25 kg of soil and broadcast the mixture uniformly in the main field before transplanting and
- Pseudomonas fluorescens (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil andbroadcast the mixture uniformly before transplanting.

System of Rice Intensification:

Mat nursery preparation

- **Preparation of soil mixture:**
    - o Four (4) m3of soil mix is needed for each 100 m2of nursery. Mix70% soil + 20% well-decomposed pressmud / bio-gas slurry / FYM + 10% rice hull.
    - o Incorporate 1.5 kg of powdered DAP or 2 kg 17-17-17 NPK fertilizer in the soil mixture.

- **Seed Treatment with biofertilizers:**
    - o Five packets (1 kg/ha) of Azospirillum and five packets (1kg/ha) of Phosphobacteria or five packets (1 kg/ha) of Azophos.
    - o Biofertilizers are mixed with water used for soaking and kept for 4 hrs. The bacterial suspension after draining may be sprinkled in the nursery before sowing the treated seeds
- **Pre-germinating the seeds 2 days before sowing:**
    - o Soak the seeds for 24 hr, drain and incubate the soaked seeds for 24 hr, sow when the seeds sprout and radical (seed root) grows to 2-3 mm long.
- **Soil application of biofertilizers:**
    - o Application of Azospirillum @ 2 kg and Arbuscular mycorrhizal fungi @ 5 kg for 100 m2 nursery area

Spraying fertilizer solution(optional): If seedling growth is slow, sprinkle 0.5% urea + 0.5%zinc sulphate solution at 8-10 DAS.

Spraying fertilizer solution (Sprinkle 0.5% urea + 0.5% zinc sulphate solution at 8-10 DAS)

Azolla's incorporation of nitrogen into soil:

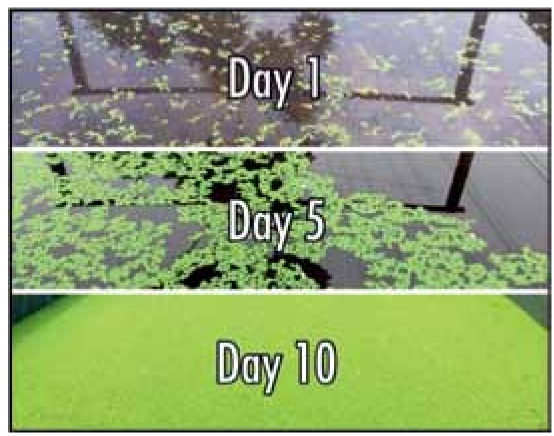
- Incorporation of Azolla into the soil improves the release of nitrogen.
- If Azolla is grown as a monocrop and the field should be drained several days in advance of incorporation.

Pre-transplanting incorporation

- Grow Azolla for about a month before incorporating at transplanting.
- Fertilize Azolla with 2.2 kg Phosphorus (P)/ha every 5 d, 4 kg K/ha every 10 d, and/or 500−1000 kg/ha farmyard manure every 5−10 d.
- If chemical fertilizers are unavailable, ash is substituted.

Azolla's use as an intercrop:

- Introduce azolla into the rice field when permanent standing water is available.
- Intercropped azolla is usually not fertilized (but if super phosphate is available one application of 4.5 kg P/ha per crop is recommended).
- Azolla incorporated 78 days after transplanting rice was shown to contribute a greater amount of nitrogen to rice grain than was contributed by earlier incorporation (30-53 days after transplanting).
- Under both systems, azolla can be incorporated several times during the crop cycle.
- Since it has been found that the optimal stocking density for Azolla, with respect to area-specific nitrogenase activity, is approximately 50 to 100 g dry weight m-2, nitrogen inputs may be best maximized by frequent but partial incorporations of Azolla.



Other benefits of incorporating Azolla in rice cultivation:

As well as its nitrogen biofertilization, Azolla provides a variety of benefits for rice production and grows in a way that is complementary to rice cultivation:

- **The thick Azolla mat in rice fields suppresses weeds.**
- Since Azolla floats at the water surface, it does compete with rice for light and space.
- In most climates, Azolla grows best under a partial shade of vegetation which is provided by the rice canopy during early and intermediate stages of growth
- When the rice approaches maturity, Azolla begins to die and decompose due to low light intensities under the canopy and a depletion of nutrients, thus releasing its nutrients into the water.
- Because Azolla decomposes rapidly, its

nitrogen, phosphorus and other nutrients are rapidly released into the water and made available for uptake by rice during grain development.

- Azolla has a greater ability than rice to accumulate potassium in its tissues in low-potassium environments, providing rice with potassium after Azolla's decomposition
- In contrast with chemical nitrogenous fertilizers, Azolla has various positive long-term effects, including the improvement of soil fertility by increasing total nitrogen, organic carbon, plus phosphorus, potassium, other nutrients and organic matter.
- If chemical nitrogenous fertilizers are applied, the presence of an Azolla mat reduces ammonia volatilization that would normally occur.
- When grown in a rice field, Azolla reduces the ammonia volatilization that occurs following the application of inorganic nitrogen fertilizers by 20% to 50%.

Limitations:

- Azolla cannot withstand any drying – so standing water is always required.
- Because Azolla grows from vegetative multiplication, inoculum must be maintained in nurseries all year and multiplied for distribution before field inoculation and multiplication.
- High temperatures cause greater disease and insect attack on azolla. Cool weather is a key to successful Azolla utilization.
- Among nutrients, P is most important for azolla. Since Azolla floats, it is not able to extract P from soil, thus its growth is often constrained by insufficiency of P if P is not applied into the flood water.
- The economics of Azolla use is especially important. The technology is labor intensive.
- Often farmers have little or no economic advantage in choosing azolla over chemical fertilizer because the additional costs of labor, land opportunity irrigation, seed/inoculum, phosphate, and pesticides make the use of Azolla uneconomical.

Incorporation of green manure

Management of sesbania in rice:

- The organic matter and nitrogen produced by Sesbania help improve the soil and subsequent crop growth.
- Sesbania can produce up to 80−100 kg N/ha (equivalent to 4−5 t dry biomass of Sesbania per ha) in around 40 days during the long-day season and in 50−60 days during the short-day season.
- Sesbania is planted before or after rice crop when the land is vacant.
- Sesbania is highly photoperiod sensitive,

flowering in about 35 days during the long-day season and in 125 days during short-day season.

Incorporation:

- After about 45−60 days, and before it becomes woody, incorporate the sesbania in one of several ways: e.g., chop the crop for easier ploughing.
- A faster and more efficient way is to knock over the standing crop of sesbania using for example an animal-drawn wooden plank, and then plough along the direction of the lodged crop.
- A hydrotiller used for tillage in deep mud, incorporates bulky biomass effectively.
- The high-speed cage wheel, with short triangular teeth, cuts the biomass into pieces before burying it into the puddled soil.
- If using the hydro tiller, the field should be water soaked for at least 48 h before the biomass is incorporated.
- For large-scale production, a four-wheel tractor fitted with a rototiller is the most efficient method.

Limitations

Constraints of sesbania as a green manure include:

- Low seed production.
- Increased labor-requirements (e.g., for ploughing and incorporation of bulky biomass into the soil).
- Sesbania's sensitivity to photoperiod.
- Insect problems.
- Competition with cash crops for land and water.

Nutrient Management in Field Crops in west Coastal Ecosystem for reducing Post harvest losses

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The soils of the west coastal region of India are having multi-nutrient deficiency. Thus understanding it and managing the nutrients accordingly becomes important so as to successfully grow crops for improved productivity and income.

Like human beings plants also need essential nutrient elements for proper growth and developement. Deficiency of one even after all the other are sufficient can lead seroius crop yield losses.

There are total seventeen (17) essential nutrient elements to plants:

Nutrient category	Nutrient element	Source	Content in plant (% of dry matter)	Need of soil testing
Structural	Carbon(C), Hydrogen (H), Oxygen (O),	Water and air	About96%	No
Macronutrients-Primary	Nitrogen (N), Phosphrous(P), Potassium (K)	Soil and fertilizers	About 3%	Yes
Macronutrients-Secondary	Calcium(Ca), Magensium (Mg), Sulphur(S)	Soil and fertilizers	About 1%	Yes
Micronutrients	Iron(Fe), Manganese(Mn), Copper(Cu), Zinc(Zn), Molybdenum(Mo), Boron(B), Chlorine(Cl), Nickel (Ni)	Soil and fertilizers		Yes

Deficiency of any one of the seventeen elements can not be substituted any of the rest of sixteen. Balanced application of nutrient elements is very important. So, based on soil fertility status and crop demand the nutrient element should be applied through organic manures and fertilizers to the soil.

Soil testing:

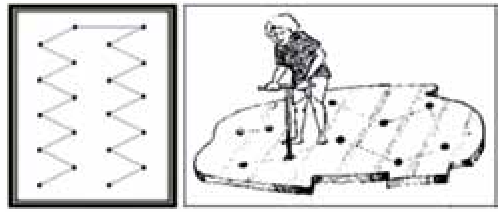
Soil testing means testing of the representative soil sample of the field for its physical, chemical and biological properties. Through soil testing the soil pH, electrical conductivity, soil organic carbon and availability of the different essential nutrient elements can be known.

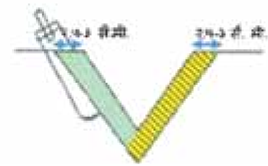
Importance of soil testing:

The availability of the essential nutrients *i.e.* soil fertility status can be known.

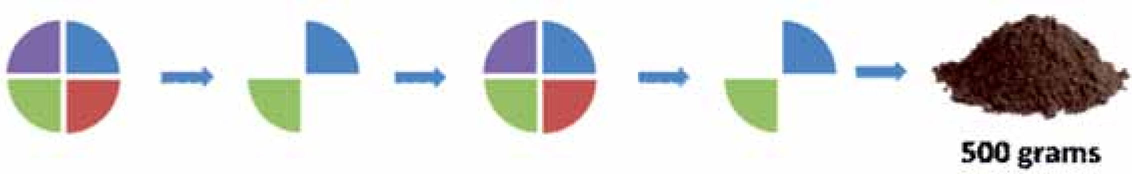
- ✓ The soil fertility and productivity can be known.
- ✓ It enables balanced use of organic and chemical fertilizers. It saves the unnecessary expenditure on the fertilizers. It results in good crop and yield.
- ✓ Knowing the soil acidity, alkalinity, salinity or any other degradation problems can be solved by possibble use of the ammendments.

How to take the soil sample:





1. (See the figure) The places for soil sampling should be chosen in a zig-zag fashion. The waste material like grasses, leaves, etc. should be removed from the surface.
2. (See the figure) Dig a V shaped 15 cm deep pit (Depth of soil sample should be based on the type of crop)
3. Scrap the sides of the pit a 2.3-3.0 cm layer and collect the scrapped soil.
4. This way, soils from 8-10 places depending on the area should be collected and mixed uniformly.
5. Material other than soil like stones, sticks, roots, leaves, etc. should be removed.
6. (See the figure) Spread the soil on a plastic or cloth in a circular fashion and divide it into four equal parts. Remove the two opposite parts. Again mix the soil and spread in the circular fashion. And repeat the same process till you get 500 grams of soil sample.



7. The soil sample should be kept in a clean and dry plastic bag and closed. The labeling with the following details should be done on the plastic bag.
8. The depth of soil sampling for the field crops like rice, cowpea, etc. is 0-15 cm.

Criteria for various soil fertility parameters and their inferences

Soil organic carbon and macronutrients

Category	Soil organic carbon	Soil available nutrients (kg/ha)		
		Nitrogen	Phosphorus	Potassium
Very low	Below 0.25	Below 140	Below 5	Below 60
Low	0.25-0.50	140-280	5-10	60-120
Medium	0.50-0.75	280-560	10-18	120-180
High	0.75-1.00	560-720	18-25	280-560
Very high	Above 1.00%	Above 720	Above 25	Above 560

Micronutrients

Micronutrients	Deficient	Sufficient
Iron (Fe)	Below 4.5	Above 4.5
Zinc (Zn)	Below0.6	Above0.6
Manganese (Mn)	Below2.00	Above2.00

Copper (Cu)	Below0.50	Above0.50
Boron (B)	Below0.50	Above0.50
Molybdenum (Mo)	Below0.05	Above 0.05

Based on the recommendations given in the soil test report, apply the exact amount of fertilizers manures and amendments in a given area at a given time.

The organic manures or fertilizers that can be used in agriculture

Farmyard manure, vermicompost, Dhaicha, glyricidia, compost, well decomposed organic matter, etc. can used for application in the field. The waste generated in the field should not be thrown or burnt. It should be decomposed through composting and applied again in the field. This makes the land fertile by adding the organic matter and by increasing the beneficial microbial activity in the soil and it also improves the water holding capacity of the soil.

Chemical fertilizers (e.g. 15:15:15 N:P:K means 15% N, 15% P2O5 and 15% K2O)

Nitrogen, phosphorus and potassium fertilizers		
Urea (46% N)	**Single super phosphate (16% P2O5)**	**Muriate of potash (60% K2O)**
DAP (18:46:00)	MOP (11:52:00)	Ammonium sulphate nitrate (20:20:00)
28:28:00	15:15:15	16:16:16
17:17:17	19:19:19	20:20:00
24:24:00	10:26:26	12:36:16
13:33:00	14:35:14	14:28:14
16:20:16		

Micronutrients	**Micronutrient fertilizers**		
Iron(Fe)	**Iron sulphate (19% Fe)**	**Iron sulphate (17% Fe)**	**Iron chloride (5-18% Fe)**
Manganese(Mn)	Manganese sulphate (26-28% Mn)	Manganese sulphate (30-32% M	
Zinc (Zn)	Zinc suplhate (21% Zn)	Zinc sulphate (33% Zn)	
Copper(Cu)	Copper sulphate (24% Cu)	Copper sulphate (33% Cu)	
Boron (B)	Borax (10.5% B)	Boric acid (17.5% B)	Solubor (19% B)
Molybdenum(Mo)	Sodium molybdate (37-39% Mo)	Ammonium molybdate (54% Mo)	
Chlorine(Cl)	Potassium chloride (48% Cl)		

To keep your soils living and fertile…!

Due to the continuous and intensive farming over the years, our soils have depleted to the worst extent. The backbone of agriculture i.e. soil is experiencing fatigue to produce even after we have good seeds, agrochemicals, advanced technologies of crop production. Thus, our efforts should be intended towards making our soil more fertile and productive and for this no rocket science, no advanced technologies or no extra expenditure is required

1. Necessary steps should first be taken to arrest the soil going with the rain water. The necessary steps should be taken before onset of monsoon. The need is to implement very simple things by farmers. It takes hundreds and thousands of years to develop the soil particle, but few minutes to go away with the runoff water.
2. The waste material from the field such as – grasses, sticks, straw, etc. should not be thrown. Rather it should be decomposed there in the field or at a particular place. Burning the crop residue kills the useful soil microorganisms. Thus, results into lower decomposition of crop residues and lower soil available nutrients to the plants.
3. Never forget the combination of improved seed + balanced chemical fertilizers + well decomposed farmyard manure/compost/vermicompost + green manuring crops + biofertilizers for harvesting good yields and improved soil health.

Be a curious farmer and visit the field regularly for weeds, insect, pest, diseases infestation etc. take necessary steps to control it in early stages only. Once the infestation crosses the economic threshold level, the yield losses are serious. Always test your soil for knowing its soil fertility status. Based on the soil testing report decide what crop, manures and fertilizers to be applied. For maintaining and improving your soil health, visit the Agricultural Deparments, Krishi Vigyan Kendras, Agricultural Institutes, etc. Regularly read the agricultural newspapers. Try to implement the things which you think possible for improving your soils.

Fertilizer recommendations for the important field crops of west coast region

Crops	**Recommended dose of fertilizer nutrient (kg/ha)**					**When and how much to apply?**
	N	**P**	**K**	**Zn**	**B**	
Rice	100	50	50	5	2	Dose 1 - Basal/before transplanting: 1/3rd N and full P, K and micronutrients; Dose 2 - At tillering: 1/3rd N; Dose 3 -Panicle initiation: 1/3rd N
Maize	120	60	60	5	2	Dose 1: Basal/before sowing - 1/3rd N and full P, K and micronutrients; Dose 2:20-30 days after sowing - 1/3rd N; Dose 3: flag leaf emergence -1/3rd N
Sweet corn	150	60	40	5	2	Dose 1: Basal/before sowing - 1/3rd N and full P, K and micronutrients; Dose 2:20-25 days after sowing - 1/3rd N; Dose 3: 40-45 days after sowing -1/3rd N
Sugarcane	250	125	150	10	5	Dose 1, 2 and 3: Three equal splits of all nutrients at 30, 60 and 90 days after planting
Cowpea	25	50	30	5	2	Dose 1: All the fertilizer nutrients should be applied before sowing
Black gram	25	50	30	5	2	Dose 1: All the fertilizer nutrients should be applied before sowing
Green gram	25	50	30	5	2	Dose 1: All the fertilizer nutrients should be applied before sowing
Groundnut	25	50	25	5	2	Dose 1: All the fertilizer nutrients should be applied before sowing
Ragi	60	30	30	5	2	Dose 1 - Basal/Before sowing: Half dose of N and full dose of P, K and micronutrients; Dose 2- At tillering- Half dose of N

Some important nutrient deficiency symptoms in rice and their corrective measures

Nitrogen deficiency symptoms

- Yellowing of older leaves first in V shape
- Whole plants yellowish green
- In case of severe deficiency leaves become light green and chlorotic at the tip
- leaves die under severe N stress
- N deficiency often occurs at critical growth stages such as tillering and panicle initiation when the demand for N is large.

Correction measures

- Divide N fertilizer recommendations larger than 60 kg N/ha into 2-3 (wet-season crop) or 3-4 (dry-season crop) split applications.
- Use more splits, especially with long-duration varieties and in the dry season when crop yield potential is greater.
- Apply top dressing of nitrogen when values of SPAD and leaf color chart goes below 35 and 4, respectively.

Phosphorus deficiency symptoms

- Deficiency symptoms first appear on older leaves, they show characteristic reddish purple color and bluish green color.
- Premature leaf fall.
- Deficiency of phosphorus reduces tillering in rice
- Develops necrotic area on the leaf petiole.

Remedial measures

- Before transplanting 60 kg P2O5 is advocated as a basal dose.
- For immediate management of P deficiency in rice water soluble fertilizers like single superphosphate should be applied based on severity of deficiency.
- Growing of green manures or application of FYM @ 15-20 t/ha repeatedly for several years may meet out the phosphorus requirement In case of acute P deficiency as in hills, application of Rock Phosphate @ 5q/ha once in three years may take care of phosphorus nutrition of the organic rice in addition to application of FYM.

Potassium deficiency symptoms

- Deficiency symptoms of potassium deficiency first occurs on older leaves as dark green plants with yellowish brown leaf margin
- Deficiency symptoms appear in inverted V shape
- Necrotic spots appear on the tip of older leaves


Correction measures

- To avoid potassium deficiency, apply 60 kg K2O before transplanting or direct seeding of rice and mix it well. Soil application of 25 % excess of recommended dose of potassium.
- Foliar spray of 1 % KCl (Potassium chloride) solution.

Machinery and Technologies for reducing Post harvest losses in Field crops of West Coastal Ecosystem

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Paddy is a major field crop of the India grown over 43.79 Mha with a production of 112.91 Mt and productivity of 2.576 t/ha (Directorate of Economics and Statistics, 2019). The climate and topography of its cultivation with undulating fragmented or waterlogged landholdings, leading to high harvest and post-harvest losses. Researchers have found -10 to 37 percent losses in paddy from harvest to storage (FAO, 2011). These losses eat into the already dwindling profit margins of the paddy farmers. Hence sensitization about these losses and training them for use of good post-harvest management practices and improved technologies is of utmost importance.

A research project conducted in Goa from 2011 to 2015 showed that the harvest and post-harvest losses for two years was as summarized in table 1(Gupta et al. 2020).

Table 1. Operation wise losses by observation (%)

Harvesting	Threshing	Winnowing	Parboiling	Storage	Milling
2.04±3.56	2.88±5.16	2.16±7.25	0.62±0.20	3.51±1.80	0.20±0.17

*** Average±S.D**

The study showed that the farmers need to be sensitized about the various reasons for post-harvest losses, trained on improved methodologies, technologies and management practices to ensure that their produce reaches the end user with minimum losses.

Harvest

The losses on field ranged from 0.44±0.40% to 2.04±3.56 %. (Gupta, 2020) The study showed that the main reasons for losses during harvest were due to use of manual harvesting and delayed harvest leading to lot of shatter losses, broadcast method of sowing due to which lot of losses occurred during combine harvesting.

- Harvesting timing and method (mechanical vs. manual) - two critical factors dictating the losses during the harvesting operations
- Losses occur at harvesting operations, if it is not performed at adequate crop maturity and moisture content
- Too early harvesting of crop - high moisture content -high drying cost, susceptible to mold growth, insect infestation, and resulting in a high amount of broken grains and low milling yields
- matured crop if left un-harvested - high shattering losses, exposure to birds and rodents attack, and losses due to natural calamities
- The optimum moisture content for harvest of Paddy is 22-28%(W.B.) and Pulses 30–40%(W.B.)

Measures that can be adopted to reduce harvest losses

1) Transplanting or line sowing using tramsplanters or drum seeders

Transplanters & Drum Seeders

2) Proper intercultural operations such as weeding to assure reduction of harvest losses by facilitating easy harvest.

Cono weeder

Power weeder

3) Timely harvest using suitable harvesters and avoiding stacking on field by using suitable threshers if not using a combine harvester

Threshing and Winnowing

- Manual threshing - Grain spillage, incomplete separation of the grain from chaff, grain breakage due of excessive striking
- Delay in threshing after harvesting of crop - significant quantity and quality loss- crop is exposed to atmosphere, and is susceptible to rodents, birds, and insect attack
- Internal breaking and milling losses
- Winnowing -Inadequate cleaned grains –increases insect infestation and mold growth during storage, add unwanted taste and color, large % grains lost as spillage

Drying

Coastal states have very high rainfall due to monsoons, which usually are extending even upto the time of harvest. Hence the sun dependent drying of field crops leads to a lot of losses. Introduction of agricultural waste fired mechanical dryers and greenhouse-type solar dryers will enable faster drying of most of the crops and reduce spoilage due to fungus etc which is common due to the high humidity of the region.

- Paddy should be dried to safe storage M.C. -13%, even for short storage period of six months <15%
- Post-harvest losses are 3.5-4.5 % during sun drying due to birds, insects and rodents

Table 2. Weight of common Paddy varieties of Goa (1000 grains) at safe moisture content

S.NO	Variety	1000 grain weight , g for safe storage
1	Jaya	30
2	Jothi	35
3	Karzat	24
4	Shiddi	38

Adopting mechanical, solar or waste fired dryers could assure better quality of dried paddy and assured drying even in unfavourable weather conditions.

	Agricultural waste fired crop dryer can be used for drying most crops in the bin and thus reduce spoilage, uses agricultural waste for firing and production of hot air, cost is Rs. 1,50,000/-, cost of operation Rs. 20/ hr. The capacity is 1 tonne/day.
	ICAR-NRRI Mechanical Rice Dryer : It is a variable capacity batch dryer of 125-500 kg capacity. Both raw andparboiled paddy can be dried in this dryer. Drying is accomplished on thin layer principle. The air temperature can be maintained at 40±2OC throughout the dryingperiod. Paddy at moisture content of 20% was dried to 14% in 6-7 hrs using 10 kg of coal in the furnace.
	Greenhouse-type solar dryer can be used for drying of most field crops even under monsoon conditions. Greenhouse-type solar dryer with ventilating fans and M.S. racks and trays. Cost around Rs. 1 lakh for a 20 sq.m. dryer.

Parboiling

Parboiling increases nutritive value of rice and if done properly reduces milling losses. Losses during parboiling and subsequent milling can be reduced by the use of modern parboiling units provided by CPCRI, Mysore and TNAU Coimbatore.

Traditional Method:	
	
TNAU Model:	
	Household parboiling unit can provide uniform parboiling and improved head rice recovery. It has a capacity of 125 kg/batch and The first batch takes around 45 minutes and subsequent operations take 25 minutes. The cost of the unit is ì 2,500/- and the cost of operation is ì7/h. It can be used as a storage bin when not in operation.
ICAR-NRRI Cuttack model	
	Cost: ì 7000/- Capacity 70 kg/batch, cost of parboiling : <`30/ per quintal (less than traditional practice by `10/-) Payback period of this unit is less than a year or equivalent to processing 10 tonnes of Paddy

Storage

Traditional storage practices and reuse of woven plastic sacks or gunny bags results in on-farm storage losses due to high infestation of insects. Lack of hygiene in the storage area and exposure to harsh weather conditions also leads to high storage losses.

Traditional on-farm storage structures in use

To reduce storage losses, the following practices need to be adopted:

- Clean the storage areas by sweeping the floor, removing cobwebs and dust, collecting and disposing grain spills.
- Post-storage cleaning should include spraying walls, crevices etc. with an insecticide /fumigant before using them again (plastering cow dung mixed with mud is a good traditi0nal practice which could be followed too).
- Rat proofingof storage areas (Figure 1)is also very important. Cats could be used to help control rats and mice.
- Periodic inspection of storage area to keep it vermin proof is very important.
- The stored paddy or rice should be inspected once a week for signs of insect infestation. In-bag sampling devices (Figure 2) should be used to draw samples.

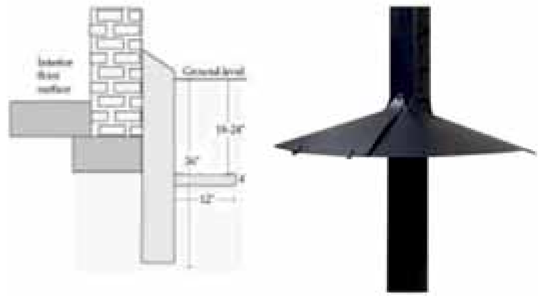
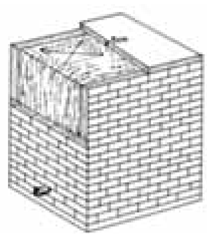


Figure 1 Rat proofing devices

Figure 2 TNAU Insect probe trap (agritech.tnau.ac.in)

It is better to store Paddy as paddy than rice to have lesser pest infestation, though rice needs 20% less storage space.

Pusa Bin	
	Pusa bin (Figure 3) is like other traditional storage structures made of mud , but for the high rainfall coastal area, we have replaced the kucha mud bricks with laterite stones or baked bricks to improve stability of structure, so the modified Pusa bin was basically a double brick wall bin with a plastic film in between to make it moisture proof and a slant pipe to remove stored paddy/rice.
NRRI RCC Ring Bin	
	A permanent bulk storage structure (mini silo), constructed using pre-cast RCC rings, with a capacity of 5 quintals. It is airtight and suitable for fumigation and also completely rat-proof. Paddy/ rice can be safely stored in it for 6-8 months. The cost of the bin is ì3,000/-

Hermetic Storage	An airtight barrier between the grain and the outside atmosphere is created and the stored grain moisture content is maintained the same as when the storage was sealed. Insects, if any inside the storage will exhaust the oxygen trapped inside by biological activity and as a result most insects will die. Thus in a nutshell Hermetic storage provides both moisture and insect control without pesticides. It can be a Galvanised Iron (G.I.) Bin or a hermetic storage bag.
G.I. Bins	
 	
Hermetic grain storage bags	
	

Milling

Milling losses can be reduced by eliminating practices like stacking harvested crop on field for long intervals and delayed threshing. Also overcooking during parboiling could be eliminated by using modern methods of parboiling where steam is used (given in section on parboiling) . Use of modern mills with rubber roll shelters in the place of huller type mills also can reduce the qualitative losses during milling.

Conclusions

An attempt has been made to sensitize the farmers and stakeholders about the various causes for postharvest losses at different stages from harvest to storage and milling through trainings and demonstration under NABARD funded project on "Popularizing Good Post Harvest Management Practices for Field Crops of Goa" (NB.Goa/906/FSDD/2017-18/FSPF). Also the machineries, technologies, and good management practices needed to reduce postharvest losses on field and farm have been described in detail in this chapter and could serve as an handy aid for extension workers and farmers. It is based on experiences gained during a five year research project on “Estimation of post-harvest losses in field crops of Goa” conducted by Dr. Mathala Juliet Gupta, at ICAR-CCARI, Goa.

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Good management practices to reduce fungi/pathogen related losses in field crops of West Coastal Ecosystem

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Cereal grains are the basis of staple food in most of the developing nations and account for the maximum post harvest losses on a calorific basis among all agricultural commodities. In developing countries post harvest loses are relatively high in the early stages of the post-harvest system i.e. at farm level. And as much as 50%–60% cereal grains can be lost during the storage stage due only to the lack of technical inefficiency. Also, the use of scientific storage methods can reduce these losses to as low as 1%–2%.In rice, most of the losses (85.28%–87.77% of the total) happen in the farm level operations. Storage losses (33.92%–40.99% of farm level losses) are being the main contributor of total loss.

Severe fungal infection and disease incidence in the field will lead to:

- Unfilled/ chaffy grains
- Reduction of quantity
- Reduction of quality- colour change, fungal structures, mycotoxin contamination produced by storage fungi makes the food unsuitable for human consumption or animal feed.
- fungi can be a major reason for spoilage at high relative humidity storage
- Moulds and mycotoxins cause dry matter as well as quality loss, and are a hazard in the food value chain
- Mould during storage damages the grains as well as reduce grain germination, deteriorates the grain quality due to the musty odour, increased fatty acid content, and reduced starch and sugar contents.
- Lipid peroxidation is another phenomenon that causes food deterioration and alters the taste and aroma, and may cause undesirable effects on human health.

How to minimize the post-harvest losses?

Spurgeon says, "the post-harvest system should be thought of as encompassing the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and maximum return for all involved"

Losses can be minimized by physically avoiding the entry of insects and rodents, and maintaining the environmental conditions that avoid growth of microorganisms.

The knowledge of control points during harvesting and drying before storage can help in reducing losses during the storage of cereals.

Minimize the temperature difference of inside and outside the storage structure.

Taking the timely preventive actions for biotic and abiotic factors can be very effective in reducing the losses during storage.

Follow Hermetic storage (HS), also known called as “sealed storage” or “airtight storage”, as a storage method for cereal and pulses due to its effectiveness and avoidance of the use of chemicals and pesticides.The method creates an automatic modified atmosphere of high carbon dioxide concentration using sealed waterproof bags or structures.

A metal silo is a strong hermetically sealed structure (mostly cylindrical), built using a galvanized steel sheet, and has been found to be very effective for storing grains for long periods of time.

The fungal infection and disease management in major cereal crop like rice and cowpea in the field level are discussed below. These field level interventions reduce the post-harvest fungal infection during storage.

Management practices for rice diseases

Blast

- Remove and destroy affected straw, stubbles and weed hosts to contain spread.
- Treat the seeds with Captan/ Thiram/ Carbendazim/ Carboxin/ Tricyclazole @ 2.0 g/kg.
- Treat the seeds with biocontrol agents like Trichoderma @ 4g/kg or other bacterial biocontrol agent @10 g/kg.
- Avoid closer spacing of seedlings in the field.
- Spray the crops with Ediphenphos (1ml/litre)/ Carbendazin(1g/litre)/ Tricyclazole (2g/litre)/ Iprobenphos (2ml/litre)/ Thiophanate methyl.
- Four to five sprays at 10 days interval may be needed for complete control. One at nursery, two during tillering stage and one to two during panicle emergence stage.

Brown spot (Sesame leaf spot)

- As the disease is seed borne, avoid seeds obtained from an infected crop for sowing.
- Treat the seeds with Thiram/ Captan @ 4g/kg or Trichoderma @ 4g/kg or other bacterial biocontrol agent @10 g/kg.
- Spray the crop with Mancozeb (2g/litre)/ Ediphenphos (1ml/litre) as 500 ml/ Captafol (625g/litre).

Sheath Rot

- Apply recommended dose of fertilizers and adapt optimum spacing.
- Spray Carbendazin/ Ediphenphos/ Mancozeb/ Chlorothalanil at boot leaf stage and 15 days later.

False smut

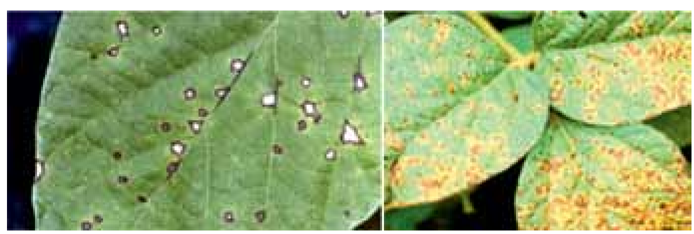
- Grow resistant varieties.
- Use disease-free seeds that are selected from healthy crop.
- Seed treatment with carbendazim 2.0g/kg of seeds.
- Remove infected plant debris.
- Spray copper oxychloride at 2.5 g/litre or Propiconazole at 1.0 ml/litre at boot leaf and milky stages.

Management practices for cowpea diseases

Seedling diseases and root rot

- Crop rotation with non-host crops for 2-3 years
- Seed treatment with Carbendazim or Thirum @2g/kg of seeds
- Seed treatment with Trichoderma or other bacterial biocontrol agent @10g/ kg of seeds and soil application of biocontrol agents along with organic manure.
- Use pathogen free certified seeds

Foliar diseases



- Destroy diseased debris
- Use pathogen free seeds from healthy plants
- Seed treatment with Carbendazim or Thirum @2g/ kg of seeds
- Spray mancozeb (0.2%) or carbendazim (0.2%) at fortnight interval

Viral diseases

- Use plant resistant varieties wherever available
- Use disease free healthy seeds
- Crop rotation with non-legumes for 4-5 seasons
- Remove the infected plants at the first instance, weeds and alternate hosts
- Management of vectors through insecticide spray to prevent secondary infection
- Spray any one of the systemic insecticides like Chlorpyriphos @0.1% or Metasystox @ 0.1% to control the vector.

Pest Management for reducing Post-harvest losses in Field Crops of the West-coastal Ecosystem

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Introduction

Pest infestation is one of major constraint in grain storage. Insects play a major role in the deterioration of food grains and seeds causing both quantitative and qualitative losses. The stored grains are damaged by a number of insect pests. The climatic conditions of India is highly suitable for continuous occurrence of storage insect pests throughout the year. In India, post-harvest losses caused by unscientific storage, insects, rodents, microorganisms etc., account for about 10 per cent of total food grains. Insect pests gain access to the grain storage from the standing crop in the field to various stages of grain processing and storage.The major sources of infestations are fields, old cunny bags, agricultural machineries, storage structure, old containers, and cross over infestation. In Goa, periodical sampling revealed the occurrence of three storage insect pests of paddy viz., Rice weevil *Sitophilus oryzae* (Curculionidae: Coleoptera), lesser grain borer *Rhyzopertha dominica* (Bostrychidae: Coleoptera) and rice moth *Corcyra cephalonica* (Pyralidae: Lepidoptera. The percentage of infestation varied from 2-13 %.

Classification of storage insect pests

Storage insect pests are categorized into two types

Primary storage insect pests: Insects that damages healthy and sound grains are primary storage pests.

Internal feeders: Insects spend most of their life feeding within the kernel of grain

External feeders: Insects spend their life feeding on the surface of grains or on the finished products of grains.

Secondary storage insect pest: Insect pests that cause further damage to the grains or stored products that are already damaged by other insects are called secondary pests.

1) **Rice weevil *Sitophilus oryzaeLinn.* (Curculionidae: Coleoptera)**

It is one of the most destructive insect pests of paddy, wheat, millet, barley, maize, sorghum and other cereal crops causing considerable qualitative and quantitative loss during the storage.

Damage symptoms

- Both grubs and adults causes damage. Grubs feed inside the grains are hollowed out.
- Presence of irregular holes on the grains
- Grain with emergence hole becomes quite hollow and can float in water.

Damaged grains

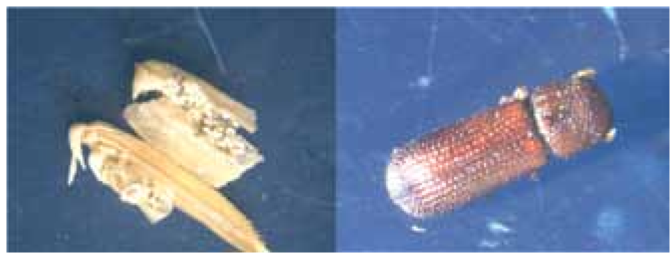
Adult weevil

Identification

- The adult weevil is dark brown in colour and has four light reddish or yellowish spots on elytra.
- Grubs are white, curved, translucent, with yellow or brown head and biting jaws.
- The grub feeds inside the grain, pupates there itself and emerges through an irregular hole made on the grain.

2) **Lesser grain borer: *Rhyzopertha dominica*** (Bostrychidae: Coleoptera)

It is regarded as second most important pest of the stored grains. Mostly occurs in tropical and subtropical regions of the world and damages wheat, barley, maize, paddy, sorghum and other products.



Damaged grains Adult beetle

Damage symptoms

- Both adults and grubs cause serious damage.
- The adults and grubs bore into the grains and feed inside. It reduce the grains to mere shells with many irregular holes.
- The main characteristic of its damage is profuse powdery substance

Identification

- The adult is a small cylindrical dark brown coloured beetle
- Larva is dirty white with pale brown head and curved abdomen covered with tiny hairs.

3) **Rice moth: *Corcyra cephalonica* (Pyralidae: Lepidoptera)**

It is a serious pest of stored paddy, milled rice, sorghum, maize and other millets in storage. Infestation results in loss of quality of stored grains.

Adult moth

Damage symptoms

- Larva is mainly responsible for the damage. It web the grains together and feed from inside the silken web.
- Presence of webbed mass is the main characteristic symptoms
- Characteristic foul odour develops and the grains are rendered unfit for human consumption.

Identification

- The adult moth is greyish brown in colour.
- The larvae are dirty white in colour and they web the grains together and feed from inside. They pupate in silken cocoons.

4) **Saw toothed grain beetle: *Oryzaephilus surinamensis* (Cucujidae: Coleoptera)**

This is a cosmopolitan pest of stored grain and grain products and reported to occurs in flour mills, warehouses and generally associated with starchy food


Damaged grains


Adult

Damage symptoms

- Larvae feed on endosperm of broken grains or starchy food by scarving of grain surface or burrowing holes in them.
- It also attacks rice, wheat, maize, cereal products, oil seeds and dry fruits.

Identification

- Adult is dark brown flattened beetle having a row of saw like sharp teeth on each side of the prothorax.
- The larva is slender, pale cream in colour with to slightly darken patches on each segment.

5) **Pulse beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae)**

It is a very important pest of grain legumes both in storage and field. It attacks peas, chickpea, pigeon pea, black gram, horse gram, cowpea etc and distributed throughout India.


Green gram damaged by pulse beetle

Damage symptoms

- Infested grains having emergence holes of beetles
- Presence of minute white eggs adhering to the seed coat.

Identification

- The adult beetle is small, oval, dark brown in colour having elevated ivory like spots near the middle of the body
- Larva is white or creamy yellow in colour and remains inside the seed in curved position.

6) **Red flour beetle: *Triboliumcastaneum* (Tenebrionidae: Coleoptera)**

It is a major and destructive insect pest of flour mills. It feeds on cereals, flour, starchy material, groundnuts, nuts, spices, coffee, cocoa and dried fruits.


Flour damaged by red flour beetles

Damage symptoms

- Both adults and grubs cause damage.
- It feed on broken grains and results in dust formation. Infested flour emits sour and pungent smell.

Identification

- Adult beetles are reddish brown in colour.
- Grub is yellowish white in colour. Pupation takes place in the flour

7) Sweet potato weevil *Cylas formicarius Fb.* (Curculionidae: Coleoptera)

Damage symptoms

- The grubs and adults bore into the tender vines, stems and tubers making them unfit for use.
- The damage is characterized by small feeding and ovipositional punctures on the surface and larval tunnels filled with frass in the tissues.
- Damage occurs both in the field and storage

Damaged tubers with adult

Identification

- The adult weevil is long, slender, smooth and hard-bodied ant-like insect with a distinct snout, metallic blue head and legs being red
- The grubs are white in colour and eat into the tissue leaving only the hole of entry.

Integrated pest management strategies for stored grain insect pests

Preventive measures

Sanitation and exclusion

- Thoroughly clean the godowns, storage room, structures before storing the newly harvested grains
- Clean the grains and dry well in the sun to remove excess moisture in the grain and to bring it down below the optimum level (less than 10- 12%).
- Cracks, crevices and corners of the godown/ structure should be properly sealed
- Machines like harvester and thresher need to be cleaned before their use.
- Threshing floor/yard should be cleaned prior to use.
- The new grains should not be stored along with old grains and infested stocks
- Spilled grain should be removed from the storage structure
- Store the food grains in moisture and rat proof storage structures.

Curative measures

- Periodical monitoring and inspection of grains for insect pest infestation.
- Traps viz., probe trap, pit fall trap and light trap can be used for monitoring the infestation
- Remove all the broken grains through proper sieving
- Store the food grains in air tight sealed structures to prevent the infestation by insects. Accumulation of carbon dioxide and depletion of oxygen levels adversely affects the insect growth.
- Pulses could be stored in the form of split to escape from the attack by pulse beetle
- Provide proper aeration/ ventilation in the storage structure to reduces the humidity

- Use improved storage structures viz., Pusa bin, Pusakothar, Pusa cubicle and improved bamboo basket.
- Pulses for seed purpose can be coated with clay (1 kg activated kaolin for every 100 kg of grain). Vegetable oils can also be used to prevent pulse beetles damage.
- Use seed protectants like pyrethrum dust and spinosad dust to mix with grains meant for seed purposes only.
- Disinfect old gunny bags by dipping them in hot water oruse new gunny bags to store the grains.
- Use fumigants like aluminium phosphide and available in the market under trade name Celphos of 3 gram tablets. Recommended dose is @ 3 tablets/tonne of food grains.

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Glimpses of Trainings

Glimpses of Trainings

PUBLICATIONS UNDER THIS PROJECTS

Extension Leaflet No. - 5/2020

IMPROVED PARBOILING TECHNOLOGY

Parboiling is partial boiling of the paddy done before milling to increase its nutritional value, texture of cooked rice, and reduce the breakage in milling.

Parboiling involves three steps: Soaking, steaming and drying.

Parboiling results in gelatinization of the starch during the boiling and re-association of amalyase molecules during cooling which forms a tightly packed structure. Finally, the kernels obtained are harder and appear glassy after the parboiling process. Another important use of parboiling is that the micro nutrients present in the bran (usually removed in the whitening process in the rice mill) are transferred to the endosperm. Thus in a nutshell **"Parboiled rice is more nutritious than white rice".**

The process also improves head rice recovery during milling by cementing little cracks that develop in the endosperm during postharvest processing.

Parboiled rice takes less time to cook and is firmer and less sticky when cooked.

Traditional Parboiling[2]	Improved Parboiling Technology (CFTRI/NRRI)[2]
Paddy	Paddy
↓ Cleaning	↓ Cleaning
↓ Soaking in water (8 h)	↓ Soaking in hot water for 3 h (70°C)
↓ Draining	↓ Draining the water
↓ Steaming (20 minutes)	↓ Steaming
↓ Aerating (3h) and heaping (3h)	↓ Shade drying (2-4 h)
↓ Tempering (1h)	↓ Dried paddy (15% moisture)
↓ Sun drying (2-4 h)	
↓ Dried paddy (14% moisture)	

Advantages of parboiling[2]

1. The process imparts a hard texture and a smooth surface finish to the grain as a result of which the brokens in the milled rice is minimized. While 90 % of the parboiled grains may remain unbroken; the brokens in raw rice could be as high as 50 %. The reduction in broken rice results in an increase of 3-5 per cent in the total yield of rice.
2. Insects find it more difficult to bite and eat their way through the hard and smooth surface of parboiled rice.
3. The loss of solids in the gruel during cooking is also less in parboiled than in raw rice.
4. Milled parboiled rice contains more of B-vitamins than milled raw rice.
5. Loss of B-vitamins is less in parboiled rice, during washing and cooking, compared to that in raw rice.
6. The cooking quality is different from that of raw rice. Parboiled rice is non-sticky and non-glutinous.
7. The parboiled paddy on milling produces a bran higher in oil content (about 25-30 % oil) compared to raw rice bran (about 10-20 % oil).
8. Parboiled rice bran is relatively stabilized compared to raw rice.

Disadvantages[2]

1. It develops a relatively darker colour compared to raw rice.
2. The traditional parboiled process produces and undesirable smell.
3. Parboiled rice takes more time to cook to the same degree of softness than raw rice.
4. Because of long soaking in traditional process, mycotoxins may develop in parboiled rice and cause health hazards.
5. Heat treatment during parboiling destroys some natural antioxidants and hence parboiled rice develops more rancidity than raw rice during storage.
6. Shelled parboiled rice requires more power for polishing.
7. Parboiled paddy may choke the polisher because of the higher oil content of the bran.
8. Parboiling process requires an additional investment of capital.

Cost-Economics

Cost of CRRI mini parboiling unit is ` 7000 per unit and the cost of using the mini parboiling unit is less than ` 30/ per quintal which is less than traditional practice by ` 10/-. Payback period of this unit is less than a year or equivalent to processing 10 tonnes of Paddy2.

1 URL http://agritech.tnau.ac.in/postharvest/pht_cereal_rice_processing.html

2 Mishra, P, and Das, F.C. 2004. CRRI Mini Modern Paddy Parboiling Unit , Technical Bulletin.

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Extension Leaflet No. - 6/2020

सुदारीत अर्द शिजोवणेचें तंत्रगिन्यान

अर्द शिजोवणी म्हळ्यार भाताचें पोशक मोल, शिजयल्ल्या तांदळाचो टॅक्सचर वाडोवंक आनी गाळपा वेळार तुटपाचो प्रकार उणो करपा खातीर गाळचे पयलीं भात अर्दवट शिजोवप.

अर्द शिजोवणेंत तीन पांवडे आसात : फुगत घालप, वाफ दिवप आनी सुकोवप.

अर्द शिजोवणेक लागून उकडपा वेळार स्टार्चाचें जिलेटिनीकरण जाता आनी थंड जावपा वेळार एमिलेज मॉलिक्युल्साचें परत एकीकरण जाता जाका लागून घट बशिल्ली बांदावळ निर्माण जाता. निमणें म्हणल्यार, अर्द शिजोवणेच्या प्रक्रियेउपरांत घट आनी पारदर्शक आशिल्ले वरी भाताचो दाणो तयार जाता. अर्द शिजोवणेचो आनीक एक म्हत्वाचो उपेग म्हणल्यार कुंड्यांत (चड करून तांदळाच्या भिरगेंत सफेदीकरणाच्या प्रक्रियेंत काडटात) आशिल्लें सुक्ष्म पोशक द्रव्यां अंतर्बिजांत वतात. संक्षिप्तपणान सांगपाचें म्हणल्यार उकडें तांदूळ धव्या तांदळा परस चड पोशक आसा.

ही प्रक्रिया, तांदळांत लुंवणी उपरांतचे प्रक्रिये वेळार अंतर्बिजांत येवपी ल्हान वेरो, गाळपा वेळार घट्ट करतात आनी ते खातीर तुटूंक नाशिल्लें तांदूळ मेळप सुदारता.

उकडें तांदूळ शिजपाक उणो वेळ घेता आनी शिजल्या उपरांत ते घट आनी उणें चिकट आसता.

पारंपारीक अर्द शिजोवणी[1]	सुदारीत अर्द शिजोवणेचें तंत्रगिन्यान (सीएफटीआरआय/एनआरआरआय)[1]
भात	भात
↓ नितळ करप	↓ नितळ करप
↓ उदकांत फुगत घालप (8 वरां)	↓ 3 वरां खातीर गरम उदकांत फुगत घालप (70°C)
↓ सुकें करप	↓ उदक सुकोवप
↓ वाफ दिवप (20 मिणटां)	↓ वाफ दिवप
↓ वारें भरप (3 वरां) आनी रास घालप (3 वरां)	↓ सावळेंत सुकोवप (2-4 वरां)
↓ उदक मारप (1 वर)	↓ सुकिल्लें भात (15% वलसाण)
↓ वतांत सुकोवप (2-4 वरां)	
↓ सुकिल्लें भात (14% वलसाण)	

अर्द शिजोवणेचे फायदे[2]

1. प्रक्रिया तांदळाच्या दाण्याक घट टॅक्चर आनी सपाटळ दिता जाका लागून गाळिल्ल्या तांदळांत तुटपाचें प्रमाण उणें जाता. 90 % उकडें तांदूळ तुटनासतना उरपाक शकतात; जाल्यार कच्च्या तांदळांत तुटपाचें प्रमाण 50 % इतलें चड आसपाक शकता. तांदूळ तुटपाचें प्रमाण उणें जाल्ल्यान तांदळाचें पुराय उत्पन्न 3-5 टक्क्यांनी वाडटां.
2. कीड वा किड्यांक उकड्या तांदळाच्या घट आनी सपाट तळाक घांस मारप आनी खावप कठीण जाता.
3. पेज रांदतना उकड्या तांदळांत कच्च्या तांदळा परस घट्ट पदार्थाचें प्रमाण उणें आसता.
4. गाळिल्ल्या उकड्या तांदळांत विटामीन बी गाळिल्ल्या कच्च्या तांदळा परस चड आसता.
5. धुंवपा आनी रांदपा वेळार कच्च्या तांदळा परस उकड्या तांदळांतल्यान विटामीन बी वचपाचें प्रमाण उणें आसता.
6. रांदपाचो दर्जो कच्च्या तांदळा परस वेगळो आसता. उकडें तांदूळ चिकट नासता आनी ग्लुटीन मुक्त आसता.
7. गाळपाचे प्रक्रिये उपरांत कच्च्या तांदळाच्या कुंड्याचे (सुमार 10-20% तेल) तुलनेंत अर्द शिजोवणेचें भात चड प्रमाणांत तेल आशिल्लो कुंडो (सुमार 25-30% तेल) तयार करता.
8. उकड्या तांदळाचो कुंडो कच्च्या तांदळाचे तुलनेंत घट आसता.

लुकसाण[2]

1. कच्च्या तांदळा परस ह्या तांदळाचो रंग मातसो गडद आसता.
2. पारंपारीक उर्द शिजोवणेची प्रक्रिया नाका आशिल्लो वास तयार करता.
3. उकडें तांदूळ कच्च्या तांदळाचे मोवसाणी वरी शिजपाक चड वेळ घेता.
4. पारंपारीक प्रक्रियेंत खूब वेळ फुगत घातिल्ल्यान उकड्या तांदळांत मायकोटॉक्सिन्स तयार जावपाक शकता आनी भलायकेचेर परिणाम करपाक शकता.
5. अर्द शिजोवणे वेळार गरम करपाची प्रक्रिया कांय नैसर्गीक एण्टीऑक्सिडण्ट्स नश्ट करतात आनी सांठवणी वेळार कच्च्या तांदळा परस उकड्या तांदळांत चड खवटपण येता.
6. उकड्या तांदळाच्या दाण्याक पॉलिशींग करपाक चड शक्त जाय.
7. अर्द शिजयल्ल्या भाताच्या कुंड्यांत चड प्रमाणांत तेल आशिल्ल्यान भात पॉलिशरांत आडकूंक शकता.
8. अर्द शिजोवणेचे प्रक्रियेंत अतिरिक्त भांडवली गुंतवणूक लागता.

मोलाचें-अर्थशास्त्र

सीआरआरआय मिनी पारबॉयलिंग युनिटाचें मोल रु. 7000 प्रती युनिट आसा आनी मिनी पारबॉयलिंग युनिट वापरपाचें मोल रु. 30/- परस उणें प्रती युनिट आसा जें पारंपारीक पद्धतीच्या रु. 10/- उणें आसा. ह्या युनिटाची परत फारीकणी करपाचो काळ एका वर्सा परस उणो वा भाताचीं2 10 टन प्रक्रिया करपाच्या सारकें आसा.

1 युआरएल http://agritech.tnau.ac.in/postharvest/pht_cereal_rice_processing.html

2 मिश्रा, पी, आनी दास, एफ. सी. 2004. सीआरआरआय मिनी मॉडर्न पॅडी पारबॉयलिंग युनिट, टॅकनिकल बुलेटीन.

उपकार

गोंयांतल्या शेती पिकां खातीर उपरांतचे बऱ्या लुंवणी वेवस्थापन पद्दतींचो प्रसार ह्या प्रकल्पा खातीर नाबार्ड संस्थेन दिल्लें अर्थीक सहाय्या खातीर (NB.Goa/906/FSDD/2017-18/FSPF) तांचे उपकारी आसात.

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Extension Leaflet No. - 7/2020

Modified Pusa Bin for use in High Rainfall Coastal Regions

Pusa bin is just like other traditional storage structure and is usually made of mud. To suit high rainfall conditions we have replaced mud bricks with baked bricks or locally available stones like laterite. To make this storage structure moisture proof, a plastic film is used on inner side of the bin.Following is the step by step procedure to make a modified Pusa Bin:

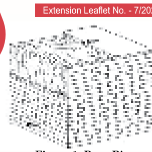
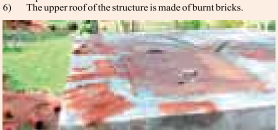


Figure 1: Pusa Bin

1) A platform of bricks/ uniformly cut laterite stones is made.

2) On this platform, a sheet of 700 gauge plastic is spread in such a way that it overlaps the platform on all sides by atleast 6 cm.
3) On the plastic sheet, a layer of 7 cm thick bricks / cut stones is then laid.
4) Walls are made of bricks/ stones and these are sealed with mud or cement plaster.

5) Now the walls are raised to proper height and a wooden frame is placed on it.
6) The upper roof of the structure is made of burnt bricks.



1) For unloading of grains, an inclined wooden or steel pipe is fixed in such a way that grains may come out of structure by gravity.
2) The mouth of pipe is closed by a cover.
3) The inside of all the four walls and roof are covered with a plastic sheet.
4) On the top, an open space of about 50 cm x 50 cm is left for loading of grains.
5) Leaving this open space, the roof is sealed by mud/plaster.
6) After the bin is filled with grains, the top open space is well covered by a plastic sheet so that air may not enter the bin.

A typical Pusa bin is shown in Figure 1. The cross section view is given in figure 2. To improve stability of structure under high rainfall conditions of the coastal regains, the mud bricks have been replaced by laterite stones or baked bricks with a cement plaster on outside and inside wall. If the structure is built in an area safe from rain the inner and outer walls can be plastered with mud to cut cost.

Figure 2: Pusa Bin Cross sectional view
Capacity 0.5-4.0 tonnes LXBXH : 610-1720X610-1520X1360-1600 (mm)
Source : Buholt and Diop, 1987

Acknowledgement

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Extension Leaflet No. - 8/2020

खूब पावस पडपी दर्यादेग वाठारां खातीर सुदारीत पुसा बिन

हेर पारंपारीक सांठवण करपाच्या बांदकामां सारकेंच पुसा बिन आनी तें सादारणपणान मातयेचें बांदतात. खूब पावस पडपी दर्यादिग वाठारां खातीर आमी कच्च्या मातयेची वीट बदलून लेटरायट फातर वा भाजिल्लो वीट घाल्यात. वलसाण मुक्त करूंक ताच्या मदीं प्लास्टीक फिल्म आसता.

सकयल सुदारीत पुसा बिन तयार करपाची क्रमवार प्रक्रिया दिल्याः

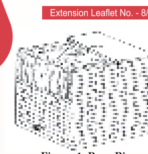


Figure 1: Pusa Bin

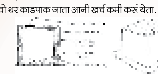
1) भाजिल्ली वीट वा समान तरेन कापिल्ल्या लेटरायट फातरांची एक माची तयार करतात.

2) ह्या माचयेर 700 प्रमाणाचे प्लास्टीक पुराय माचयेर 6 मिटर वाठारांत धांपून वतलें अशे तरेन एकार एक पातळयतात.
3) ह्या प्लास्टीक चादरीचेर 7 सॅण्टीमिटर दाट वीट वा कापिल्ल्या फातरांचो थर पातळायतात.
4) विटो वा फातर वापरून वणटी तयार करतात आनी त्यो माती वा शिमिटाचो प्लास्टर घालून घट्ट करतात.

5) आतां, वणटी फावो त्या उंचायेर उबारतात आनी ताचेर लांकडाची फास्की बसयतात.
6) ह्या बांदकामाचें वयलें पांखें भाजिल्ल्या विटां पसून करतात.

1) धान्य देंवोवपा खातीर, गुरुत्वमध्याकर्शणाक लागून त्या बांदकामांतल्यान धान्य भायर सरतलें अशे तरेन एक लांकडाचे वा स्टीलाचें पायप बसयतात.
2) पायपाचे तोंड धांपणे लावन बंद करतात.
3) चारूय वणटी तशेंच पांखें प्लास्टीक चादरान धांपतात.
4) वयल्या भागांत, 50 ् 50 सॅण्टीमिटराची उकती सुवात धान्य देंवोवपा खातीर सोडटात.
5) ही उकती सुवात सोडल्यार हेर भाग माती वा शिमिटान बंद करतात.
6) बिन धान्यान भरले उपरांत, वयली उकती सुवात बिनांत वारो वच्चो न्हय म्हणून प्लास्टीक चादरीन घट्ट धांपतात.

सर्वसादारण पणान पुसा बिन कशें दिसता तें चित्र 1 हातूंत दाखयलां. क्रोस विभागी देखाव चित्र 2 हातूंत दाखयला. खूब पावस पडपी दर्यादिग वाठारांत घटसाण मेळचे खातीर कच्च्या मातयेची वीट बदलून लेटरायट फातर वा भाजिल्लो वीट घाल्यात आनी ताच्या भायल्या आनी भितरल्या वणटींचेर शिमिटाचो थर मारला. पावसा पसून सुरक्षीत आशिल्ल्या भागांत बांदकाम केलें जाल्यार भायल्या आनी भितरल्या वणटींचेर मातयेचो थर काडपाक जाता आनी खर्च कमी करूं येता.



चित्र 2: पुसा बिनाचो क्रोस विभागी देखाव
आकलन शक्त 0.5-4.0 टन LXBXH : 610-1720X610-1520X1360-1600 (mm)
संदर्भ : बुहोल्ट आनी दियोप, 1987

उपकार : गोंयांतल्या शेती पिकां खातीर उपरांतचे बर्या लुंवणी वेवस्थापन पद्दतींचो प्रसार ह्या प्रकल्पा खातीर नाबार्ड संस्थेन दिल्लें अर्थीक सहाय्या खातीर (NB.Goa/906/FSDD/2017-18/FSPF) तांचे उपकारी आसात.

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