# Entrepreneurship Development Program
on

# Technologies Developed by ICAR-NRRI to Strengthen Rice Production

## 11-16 January, 2021







*Editors*
Sai Krishna Repalli
Rakesh Kumar Nayak
Trusha Das
G.A.K. Kumar

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*Organized by:* Agribusiness Incubation Centre
ICAR-National Rice Research Institute, Cuttack - 753006, Odisha

# Compendium
# on
# ‘Technologies developed by ICAR-NRRI to strengthen rice production’

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भाकृअनुप-राष्ट्रीय चावल अनुसंधान संस्थान, कटक-७५३००६, ओड़िशा

# PREFACE

ICAR-National Rice Research Institute (NRRI) is working with a mission to develop and disseminate eco-friendly technologies to enhance productivity, profitability and sustainability of rice cultivation. In this sequence, the institute have developed commercial technologies to strengthen rice production system.

In this context, Entrepreneurship Development Program on 'Technologies developed by ICAR-NRRI to strengthen rice production' holds significance. One of the technologies, biofertilizers can replace chemical fertilizers as they are renewable source of plant nutrients and relatively less expensive. Biofertlizers are selected strains of microorganisms which are beneficial to the growth of the plants. Phosphorus is one of the vital nutrients required for optimum growth of plant. Pseudomonas, Bacillus, Aspergillus, are examples of Phosphate solubilizing bacteria (PSB). Role of PSB in enhancing rice yield are dealt in detail.

Similarly, Integrated Farming System (IFS) technologies has immense potential for improvement of rural economy due to intensification and integration of crop and allied enterprises. Adoption of modern rice based farming system approach helps the farmers to understand the interaction and linkage of different farm resources which helps in resource recycling and ultimately leads to reduction of input cost and enhancement of productivity and profitability of the system. Benefits of adopting IFS by the farmers are explained during this training.

Genetically pure seed is the basic and important input for crop establishment and production. Good quality seed can contribute up to 15% increase in productivity. With increasing awareness on role of quality seed, the Seed Replacement Rate (SRR) has gradually increased in the country. Hence there is a huge demand for quality seed. In this scenario, knowledge of rice seed production will help to gain benefits. Economics of seed production over grain production are clearly elucidated during this training program.

Application of synthetic pesticides leads to environmental hazards along with many health ailments. An ecofriendly approach is to use bio pesticides in which pathogenic fungi kills the insect pests without causing harmful effects to the crop. Technical knowledge about this technology has entrepreneurial opportunity in synthesis of bio-pesticides.

A simplified and farmer friendly version of tensiometer tube for real time soil water potential based irrigation management was developed by ICAR – National Rice Research Institute, Cuttack. The benefits of water management in the rice field through this novel colour coded tensiometer are explained during this training program.

Rice bran oil (RBO) is extracted from the outer bran or husk of rice grains. It is nutritious and also has health benefits. There is a gap of about 6 lakh tonnes between actual production and production potential of RBO in India which is providing entrepreneurial opportunities in this sector. Technical aspects of RBO production are covered in this program.

This course has been designed to skill the budding entrepreneurs to enhance their income by proper utilization of NRRI technologies. Course comprised of interaction with scientists, discussions and information/idea exchange with participants for the benefit of prospective entrepreneurs.

This compendium comprises of the lecture notes given by eminent scientists in the relevant fields. We had organized this course material for participants future needs and reference. Contact details of all the participants and faculty members were also furnished.

(G.A.K. Kumar)

डॉ. जी. ए. के. कुमार Dr. G. A. K. Kumar
प्रधान वैज्ञानिक Principal Scientist
सामाजिक विज्ञान प्रभाग Social Science Division
भाकृअनुप-केंद्रीय चावल अनुसंधान संस्थान, कटक-७५३००६ (ओडिशा)
ICAR-Central Rice Research Institute, Cuttack-753006 (Odisha)

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**Phosphate solubilizing bacteria a potential biofertilizer to enhance rice yield**

Upendra Kumar, Scientist, ICAR-NRRI, Cuttack

Biofertilizers can replace chemical fertilizers as they are renewable source of plant nutrients and relatively less expensive. Biofertlizers are selected strains of microorganisms which are beneficial to the growth of the plants. Soil microorganism plays an important role in regulating the levels of carbon, nitrogen, phosphorus and sulphur at the rhizosphere. Solubilization of macronutrient is an important aspect in plant growth and development. Phosphorus is one of the vital nutrient required for optimum growth of plant. *Pseudomonas*, *Bacillus*, *Aspergillus*, are examples of Phosphate solubilising bacteria (PSB).

### Recommended dose

It is recommended that 5-6 kg solid or 500 ml liquid inoculum of PSB is required for one hectare of rice crop, which can supply around 10-20% of phosphorus with increasing grain yield by 5-15%

### Economics of PSB

Liquid inoculum of PSB (500 ml) @ Rs.150/- is required to increase the availability of 20-30 Kg of phosphate per hectare.

### Salient features

- PSB provokes immediate plant growth by providing easily absorbable form of phosphorus and production of plant growth hormones such as auxins, and gibberellins.


- PSB supports plant growth and increases efficiency of nitrogen fixation.
- PSB results in faster sprouting of seeds resulting in faster growth.
- PSB acts as a biocontrol agent against plant pathogens through production of antibiotics.
- PSB represent potential substitutes for inorganic phosphate fertilizers to meet the phosphorus demands of plants, improving yield in sustainable agriculture.

**Arbuscular mycorrhizal fungi as a potential biofertilizer**

Upendra Kumar, Scientist, ICAR-NRRI, Cuttack

Arbuscular mycorrhizal fungi (AMF) form mutuality with roots of most agricultural crops, including rice. These mutualistic associations have shown the potential to increase crop productivity and playing a key role in the functioning and sustainability of agro ecosystems. AMF also facilitate host plants to grow vigorously under stressful conditions like drought, salinity and under disease conditions. Thereby, AMF can be used as a potential bio fertilizer.

## Recommended dose

It is recommended that 1 tons of soil based inoculum of AMF is required for one hectare of rice crop, which can supply around 30% phosphorus with increasing grain yield by 15-25%

## Entrepreneurial opportunity

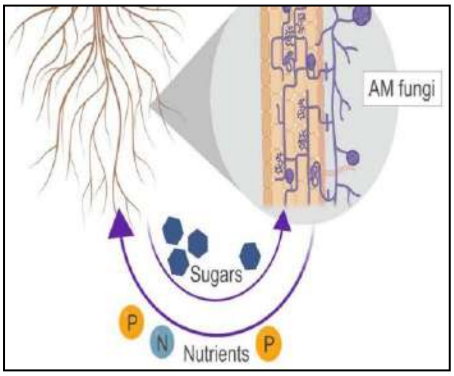
The total annual cost of production for 30 tons of AM fungi in prescribed area (Rs. 2 lakhs) with an additional operational cost (Rs. 5 lakhs) is 7 lakhs. If it can be sold @ Rs. 50 per / kg, one can reap a benefit of Rs.15 lakhs/ year.

## Economics of AMF

AMF can supply around 30% phosphorus with increase in grain yield by 15-25%

## Salient features

- AMF are soil microorganisms which represent a key link between plants and soil mineral nutrients.
- They provide the host plant with mineral nutrients and water, in exchange for photosynthetic products




- AM fungal hyphae exclusively colonize the root cortex and form highly branched structures inside the cells, i.e., arbuscules, which are considered the functional site of nutrient exchange.
- Transfer of nutrients such as organic carbon, in the form of sugars and lipids to the fungi by the plants, and the transfer P and N to the plants by the fungi
- The AMF mycelium that emerges from the root system can acquire nutrients from soil volumes that are inaccessible to roots
- AMF improve the quality of soil and plant health.

**Rice- Fish Integrated Farming system and Entrepreneurial opportunity involved**

Annie Poonam

Principal Scientist, ICAR- National Rice Research Institute, Cuttack-753006

India is predominantly an agrarian country and hence agriculture sector has a huge potential for promoting innovations as it has rich resources of traditional indigenous knowledge. Moreover, country is gradually shifting to demand driven and market led agricultural research. Government has introduced many schemes to upgrade the farming community and increase the income but due to the fragmented landholding and conventional practices, farm mechanization and new technologies are not able to implement. In today' India farming context a system or approach should suitable to the fragment holding, cut down the input cost and there should provision for the reuse of the waste as the input for the another to yield better productivity and output.

The marginal and small farmers constitute 78.2 per cent of the farming community in India. The unique Indian situation of small fragmented holdings and lack of capital investments is not suitable for single commodity farming being practiced in developed countries. Therefore, the integrated farming system appears to be a viable solution to the Indian agriculture for increasing productivity and income of the small and marginal farmers with constrained resources.

The concept of integrated farming can be adopted in any situational basis as it does not involve any particular pattern and it can be formulated as the facilities available and land type. Integrated farming system adoption can be better business opportunities for graduates as by better planning and provides employment for the rural population. it will be better enterprise option for women entrepreneur as it involves low cost and yield high income

***INTEGRATED FARMING SYSTEM***

The integrated farming system is a commonly used term to explain a more integrated approach to farming compared to monoculture approaches. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as integrated biosystems. In this system, an inter-related set of enterprises is used so that the "waste" from one component becomes an input for another part of the system. This reduces costs and improves production and/or income. Since it utilizes waste as a resource, farmers not only eliminate waste but they also ensure an overall increase in productivity for the whole farming system.

At present, farming and business are viewed as two individual units, which do not go hand in hand, and the farmers concentrate mainly on crop production, which is subjected to a high degree of uncertainty in income and employment to the farmers. In this contest, it is imperative to evolve suitable strategy for augmenting the income of a farm and to meet the challenges in agricultural practices and make it as business zone. Integrated farming system has revolutionized conventional farming of livestock, aquaculture, horticulture, agro-industry and allied activities. It could be crop-fish integration, livestock-fish integration, crop-fish-livestock integration or combinations of crop, livestock, fish and other enterprises. It is needed to make strong link between the crop production with its allied activities and to be better recycled for productive purposes in the integrated system to change in the farming techniques for maximum production in the cropping pattern and make better utilization of resources to make the farming as the business enterprise which gives steady profit and employment opportunity.

***FACTORS DETERMINING TYPES OF FARMING***

- Physical Factor: Climate soil and Topography
- Economic Factor:

    Marketing Cost

    Labour Availability

    Capital

    Land Value

    Consumer demand

    Prevalent abiotic and biotic stress

- Social Factor: Type of community, Transportation ease, Marketing facilities
- Objective: Maximize Income, Enhance Production, Minimizing cost etc.
- Environment: Availability of resources and components

Factors Determining Nature and Size of enterprises

- Farm size
- Marketing Facilities
- Climate
- Technologies available

- Soil Type and condition
- Income Level
- Credit Facility
- Skill/Knowledge

***COMPONENTS OF INTEGRATED FARMING SYSTEM***

- Crops, Fish, livestock, birds and trees are the major components of any IFS.
- Crop may have subsystem like monocarp, mixed/intercrop, multi-tier crops of cereals, legumes (pulses), oilseeds, forage etc.
- Livestock components may be milch cow, goat, sheep, Duckery/ poultry, bees, fish, and piggery.
- Tree components may include timer, fuel, fodder and fruit trees.

The integrated farming system is also a sustainable system which focuses on increasing farm productivity by increasing diversification, resource integration and creating market linkages. Thousands of small and marginal family farmers in resource-poor regions in Asia and Africa have converted their farming to this sustainable farming system to diversify farm production, increase cash income, improve the quality and quantity of food produced and the exploitation of unutilized resources. It usually takes three to four years to establish a well-integrated farm with market linkages to ensure nutrition and the livelihood of a family. Benefits provided by using an integrated farming system are:

- The integrated farming system approach introduces a change in farming techniques for maximum production in the cropping patterns and ensures the optimal utilization of resources
- The farm waste is recycled for productive purposes in the integrated system
- A judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers can bring prosperity to the farming operations.

It is imperative to focus attention overall farm approach by integrating various allied enterprises with cropping for better security, sustenance and productivity. Integration of various enterprises in a farm ensures recycling of residues, optimum resource use, and higher employment, minimization of risk and uncertainties and increased farm income. Integrated farming systems research in wet land; garden land and rain fed ecosystems have demonstrated the technical feasibility and economic viability through linking of different components as projected data.

**Table-1: Ecosystem wise comparative net return (Rs. ha-1)**

| **Ecosystem** | **Wet land** | **Garden land** | **Rain fed** |
|---|---|---|---|
| **Farming system model** | **Crop + Fish + Poultry + Mushroom** | **Crop + Milch cow+ Goat + Vermicompost** | **Crop +Goat + Agro forestry + Farm pond** |
| Integrated farming system | 1,76,774 | 1,56,177 | 67,015 |
| Conventional system | 37,153 | 65,833 | 22,670 |
| Increase over conventional system | 1,39,621 | 90,344 | 44,345 |

**Sources**: (**Uvaneswaran and Keerthana)**

The establishment of farming system will be able to help for the efficient allocation of available resources in the farm and reduce the use of external inputs. With the aid of the developed technology and the knowledge on the strength of farming system, it would be possible to disseminate the integrated farming system model for large-scale adoption.

***POSSIBLE ENTERPRISE LINKAGE IN IFS***

***Wetland Ecosystem***

Crop + Fish + Poultry

Crop + Fish + Duck

Crop + Fish + Pigeon

Crop + Fish + Poultry/pigeon + mushroom

Crop + Fish +Mushroom

Crop + Fish + Pig + Mushroom

Crop + Fish + Goat

***Dry Land Ecosystem***

Crop + Goat

Crop + Goat + Agroforestry

Crop + Goat + Agroforestry + Horticulture

Crop + Goat + Agroforestry + Horticulture + Farm pond

Crop + Goat + Buffalo + Agroforestry + Farm pond

Crop + Goat + Pigeon + Buffalo + Agroforestry + Farm pond

Crop + Goat + Rabbit

***Homestead Land Ecosystem***

Crop + Dairy + Biogas

Crop + Goat + Biogas + fishery

Crop + Dairy + Biogas + Fishery

Crop + Dairy + Biogas + Homestead garden + piggery

Crop + Dairy + Biogas + Homestead garden + Silviculture + Apiculture.

Crop + Dairy + Biogas + Spawn production + Mushroom

Crop + Dairy + Biogas + Spawn production + Mushroom + Silviculture.

The profit from fish culture is often increased 30-40 percent because of integration with rice over per unit of area per unit of time. Secondly, the overall income is increased by adding livestock lik duckery / or poultry rising, grain and vegetable farming, etc., which supplement the income from fish farming in the rice field. Thirdly, by producing grain, vegetables, fish and livestock products, the community becomes self-sufficient about food and this contributes to a high degree of self-reliance. Fourthly, the silt from the ponds, which is used to fertilize crops, increases the yield of crops at a lower cost and reduces the need to buy chemical fertilizer greatly by 75 %. The grain and cropping waste (straw) can be used as the feed for the dairy farming and in other hand; the dairy waste (dung) can be used as the manure for the crop production and for biogas production. The power produced from the biogas plant will be sufficient for the farm to carry its production activities. The sorghum seeds produced from the crop production can be used as the raw material for spawn production and paddy straw can be used for the bedding of mushrooms. The biogas slurry can be used for crop production and the fodder can be used as the feed for the dairy animals. Than from the integrated farming system the individual unit will provides its maximum output as the resources are better utilized to their maximum and cut down the input cost.

## CONCLUSION

The Entrepreneurs vision, therefore, is the first step of thinking about a farm business plan based on his own competence, skills and capacity and oriented towards the market and the way of life determining the company vision and strategy towards sustainable profitable farming. Integrated Farming is a sense of whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food. Integrated Farming makes a vital contribution to sustainable development by adding consideration of economic, ecological and social objectives to the essential business of agricultural food production.

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# QUALITY SEED PRODUCTION IN RICE

**R. K. Sahu**

**Nodal Officer Seed**

**ICAR - National Rice Research Institute, Cuttack**

**Seed, the starting material…**

For a good production in rice crop so many factors are responsible *viz;* fertile land, quality seed, timely sowing, timely transplanting, timely irrigation, timely weeding, timely fertilizer application, timely plant protection measure if required, timely harvesting, timely post-harvest processing, timely packaging and timely storage. Any discrepancies in any of these operations reflect itself in the yield loss. However, if we prioritize these factors as per their effect on production, then quality seed is a single factor that contributes the maximum towards yield in comparison to other factors responsible for higher yield. Increase in yield up to 5-20% is achieved by using quality (pure and healthy) seeds alone.

**Seed quality strongly affects crop success…**

Rice crop grows better if better seeds are sown (5-20% increase in yield). Fully mature, good quality and healthy seeds are more vigorous to overcome adverse conditions in early stages of plant growth (e.g., weed growth). Higher germination percentage (greater than 80%) of seeds gives a good crop stand.

**Good quality seed should be…**

Pure, full & uniform in size, free from weeds, insects, disease &other inert matter and viable (germination 95%).

**Seed multiplication… an integral part of the high yielding varieties program:**

Multiplication of the high yielding varieties immediately after they are notified and their distribution to farmers is very vital in a crop improvement program. For safeguarding quality, seeds of improved varieties are produced in several stages, each stage generating a particular class of seeds viz.; Nucleus seed, Breeder seed, Foundation seed and certified seed.

**Generation system of seed multiplication:**

Generation system of seed multiplication is the production of a particular class of seed from specific class of seed up to certified seed stage. The choice of a proper seed multiplication model is the key to further success of a seed program which basically depends upon the rate of genetic deterioration, seed multiplication ratio and total seed demand. Based on these factors different seed multiplication models are derived viz; three - Generation model with Breeder Seed to Foundation Seed Certified Seed, Four -

Generation model with Breeder Seed to Foundation Seed I to Foundation Seed II to Certified Seed and Five - Generation model with Breeder Seed to Foundation Seed I to Foundation Seed II to Certified Seed I to Certified Seed II.

Indian Seeds program largely adheres to the limited generation system i.e. Three Generation System for seed multiplication which recognizes three generations, namely, breeder, foundation and certified seed. It provides adequate safeguards for quality assurance in the seed multiplication chain to maintain the purity of variety as it flows from the breeders to the farmers.

**Nucleus Seed:**

Nucleus seed refers to the seed produced by the breeder who developed the particular variety or any other breeder of the Institution where the variety was developed. This is the initial seed of a particular variety used for the purpose of maintaining that variety by the originating breeder and its further multiplication under his own supervision or the supervision of a qualified plant breeder in the same Institute where the variety is developed. Nucleus seed has 100% genetic & physical purity and high standards of all other quality parameters. It is multiplied and maintained by selecting individual panicles and growing individual panicle progenies rows. This process is repeated continuously to keep a continuous production of Nucleus seed so that it can be used for Breeder seed production program.

**Production of Nucleus seed:**

To start a nucleus seed program of a variety, seeds of base source (seeds maintained by the breeder) are a prerequisite. The selection of base consists of two stages i.e. release and notification of variety &sufficient true-to-the-type panicles (at least 500) selected from the original source crop based on the morphological identity, uniformity and genetic purity.

The procedure for production of Nucleus seed follows the following pathway viz., sowing of true-to-the-type panicles with that of bulk nucleus seed, transplanting of panicle progeny rows (2 lines each)and 8 lines border all around the plot with seedlings from bulk nucleus seed**;** maintaining gap of 50cm between panicle progeny rows; critical inspection of these rows throughout the growing season particularly at early growth stage, panicle emergence, early dough stage and at maturity; rejection of the entire panicle progeny rows that show off-type(s)/deviations; rejection of rows on either side of the row showing off type when an off type is detected after flowering stage; selection of progeny rows which are true-to-the-type of the original variety for all externally observable characters, collection/harvesting of 400-600 panicles from these true to the type rows for the next cycle of nucleus seed production; separate harvesting of each panicle progeny rows; table-top examination of panicles for color, shape & size of seeds collected from panicle progeny rows; rejection of the panicle and the corresponding number panicle progeny row seeds if any deviations observed; bulking of the confirmed progeny lines seed as Nucleus Seed.

The nucleus seed plot should be maintained with all optimum conditions of agronomical practices. An isolation distance of 3 meters is to be maintained with the adjacent plots. It is always better if time-isolation is maintained.


**Panicle Progeny**

**Breeder Seed:**

Breeder seed is the progeny of nucleus seed. Production of breeder seed is the responsibility of the Research Station or Institutes, which has developed the variety. This should be strictly done under the supervision of, either the breeder who has developed the variety, or a qualified breeder who is well acquainted with the variety. The genetic purity of breeder seed is 100 per cent. Other attributes of seed quality must meet the specified norms. Quality norms for breeder seed are indicated in the label attached to the seed bag. Breeder seed tag is golden yellow in colour. Breeder seed is the source for initial and recurring increase of Foundation Seed.

The quality of Breeder seed is strictly controlled by periodical inspection by a joint monitoring team consisting of the concerned breeder, representative from the National Seed Corporation and State Seed

Certification Agency. NRRI being a seed production & seed technology centre, a Central Monitoring Team of NSP also monitors the seed production and seed technology facilities.

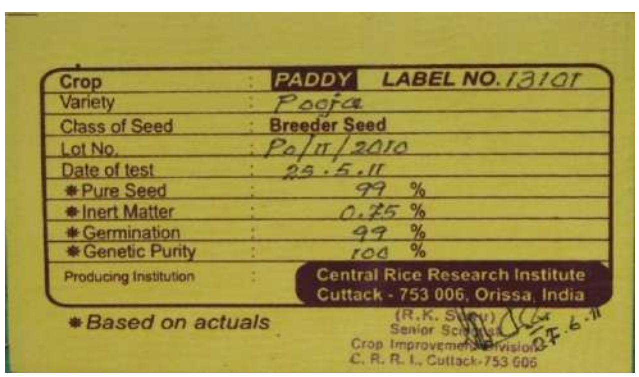
**Production of Breeder seed:**

The procedure for production of Breeder seed follows the following pathway viz.; Sowing of Nucleus seed; transplanting in time with single seedling per hill;8 lines border all around the plot with same seedlings;50cm. gap after every 8 rows for facilitating rouging; critical inspection of the breeder seed plot throughout the growing season particularly at early growth stage panicle emergence, early dough stage and at maturity for any off-types; removal of the off-type plants showing variation from the original identity of the variety (rouging);Harvesting of the plot discarding the border lines.

The breeder seed plot should be maintained with all optimum conditions of agronomical practices. An isolation distance of 3 meters is to be maintained with the adjacent plots. It is always better if time-isolation is maintained.

**Breeder Seed Tag must have the following information:**

1. Name of the crop
2. Tag No.
3. Name of the variety
4. Class of seed
5. Lot No.
6. Date of test
7. Pure seed
8. Inert matter
9. Germination (%)
10. Genetic purity (%)
11. Source
12. Signature of the Breeder
13. Seal




**Foundation Seed**

Foundation seed is the progeny of breeder seed or foundation seed itself. When foundation seed is the progeny of breeder seed, it is called foundation seed stage I and when foundation seed is the progeny of foundation seed, it is called foundation seed stage II. Only foundation seed stage I can be used for production of foundation seed stage II. Foundation seed stage II cannot be used to produce foundation seed. It can only be used to produce certified seeds. The minimum seed standard for Foundation seed stage I & stage II are similar. Production of Foundation seed stage II is undertaken only when it is expressed by the seed certifying agencies that breeder seed is in short supply and stage II foundation seed has to be produced to meet the seed demand.

Foundation seed tag is white in colour and carries all the relevant information about the foundation seed lot contained in the bag. The genetic purity of foundation seed should be maintained at 99.5 %.

The production of foundation seed shall be supervised and approved by the Certifying Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to confirm certification standards. This class of seed can be produced either by the State Farm Corporation of India, National Seed Corporation, State seed Corporation, State Farm Cooperatives, Government farms, Agricultural Universities, or the registered growers.

**Certified Seed:**

Certified seed is the progeny of foundation seed. Certified seed can also be the progeny of certified seed provided this reproduction does not exceed three generations beyond foundation seed stage I. Certified seed produced from foundation seed is called certified seed stage I, while Certified seed produced from certified seed is called certified seed stage II. Certified seed stage II cannot be used for further seed multiplication.

Certified seed tag is blue in colour and carries all the relevant information about the certified seed lot contained in the bag. The genetic purity of certified seed should be maintained at 99.0 %.

Production of certified seed is supervised and approved by certification agency. The seed of this class is normally produced by the State and National Seeds Corporation and Private Seed companies on the farms of progressive growers. This is the commercial seed which is available to the farmers.

**Seed Standards of Foundation & Certified seed:**

| | Pure seed %(min) | Inert matter % (max) | Other crop seeds /kg (max) | Total weed seeds/kg (max) | Objectionable weed seeds/ Kg (max) | Germination % (min.) | Moisture% (max.) | | ODV/ kg (max) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ordinary container | Vapour - proof container | |
| F | 98 | 2 | 10 | 10 | 2 | 80 | 13 | 8 | 10 |
| C | 98 | 2 | 20 | 10 | 5 | 80 | 13 | 8 | 20 |

**Maximum permissible frequencies of off-type plants, objectionable weed plants, and seed infected by designated diseases at any field inspection (as % of plants)**

| | Off type plants | Inseparable other crop plant | Objectionable weed plants | Diseased Plants |
|---|---|---|---|---|
| Certified seed | 0.2 | 0.05 | 0.02 | 0.5 |
| Foundation seed | 0.05 | 0.01 | 0.01 | 0.1 |

**Truthfully Labelled Seed:**

Truthfully Labelled Seed is a type of seed which can be produced by government institutions, universities and registered growers. This class of seed is not certified but the labeling is done to indicate its quality or standard in truthful manner. However, quality of any seed sale in the public domain can be checked by seed inspectors to safeguard the quality assurances.

| Certified seed | Truthfully labeled seed |
|---|---|
| Certification is voluntary | Truthful labeling is compulsory for notified kind of varieties |
| Applicable to notified kinds only | Applicable to both notified and released varieties |
| It should satisfy both minimum field and seed standards | Tested for physical purity and germination |
| Seed certification officer, seed inspectors can take samples for inspection | Seed inspectors alone can take samples for checking the seed quality. |

**Label Specification for Different Seed Categories:**

| Seed Category | Label colour | Size |
|---|---|---|
| Breeder seed | Golden yellow | 12 cm X 6 cm |
| Foundation seed | White | 15cm X 7.5 cm |
| Certified seed | Blue | 15cm X 7.5 cm |
| Truthfully Labelled seed | Opel green | 15cm X 10 cm |

**Seed Multiplication Ratio**

Seed Multiplication Ratio is the number of seeds to be produced from a single seed when it is sown and harvested. The seed multiplication ratio for rice varieties is 1:80.

**Quality Seed Production:**

**Isolation:**

The rice crop raised for seed production should be separated from other rice fields by a distance. This distance is known as isolation distance. Isolation is essential to prevent mechanical mixture and chance cross-pollination in rice. The minimum isolation distance is 3 meters.

**Cultivation Procedure**

Cultivation is done by direct seeding or transplanting which mainly depends on land type. Generally transplanting is preferred as it restricts mixtures. However, for upland direct seeding, medium land transplanting and for low land both the direct seeding/transplanting can be done.

**Arrangement of Good Quality Seed**

Source of seed must be from a registered seed grower. Healthy, clean and heavy seed of the variety is to be chosen with germination percentage more than 85%. For heavy seed selection…, put the seed in a solution of 100gm salt dissolved in 1 litre of water and select the seeds those settle at the base of the container.

**Seed Bed Preparation**

Select a field where no immediate rice crop was there. For dry seeding, sandy soil is good. Sow in time in1 metre width long seed bed with 30cm drain in between two beds. Sow the seeds 2cm deep in the soil, cover with soil and protect from bird damage. For wet seeding, puddle the field, leave it for 3-4 days, prepare leveled bed of 1.5 metre width and sow pre-germinated seed. Protect from bird damage. Seed rate for high yielding varieties is 30 kg per hectare

**Dry Seed bed**

**Seedling Uprooting:**

Use 3-4-week old seedling, remove diseased/ different looking seedling, Check root damage during uprooting.

**Transplanting:**

Line transplanting is always preferred. Transplant 2-3 seedling per hill, For early varieties maintain line to line 15cm and plant to plant 10 cm spacing. For medium and late varieties maintain line to line 20cm and plant to plant 15 cm spacing. Complete transplanting in time.

**Care after Transplanting**

The major care after transplanting are timely irrigation, timely weeding, timely fertilizer application and timely plant protection measures if required. Apply $1/4^{th}$of potash with nitrogen during flowering for a good quality of seed production.

**Rouging:**

Rouging is the removal of off-types which are phenotypically different from the plants of the variety under certification. The off-type plants are regularly removed from seed fields either by uprooting or by cutting at the ground level.

**Harvesting**

Harvesting is done when the grains become hard and yellow. Harvested crops kept for two to three days in the field for better drying.

**Threshing**

Threshing should be done in a clean threshing floor, preferably cemented floor. Only one variety at a time should be brought to the threshing floor to avoid mixing. Thresh by thresher or by hand.

**Seed Processing:**

**1. Cleaning:**

Threshing floor seed is mixed with pieces of straw, gravel, soil, weed seeds etc. Separation of this unwanted matter from the seed is cleaning. It can be done manually or by mechanical seed winnower.

**2. Drying:**

Seed must be dried to 13% moisture level to facilitate processing, to prevent losses in germination and to reduce the chances of insect attack

i) Natural drying process includes: Dry in a clean threshing floor in 3cm depth. Use of tarpaulin on the floor for drying is preferred. Alter the seed-spread every 15 to 20 minutes. Dry the seed from 9AM to 12

PM and 3 to 5 PM. In middle two hours make a heap of seed and cover it with tarpaulin for uniform and better drying. Dry the seed up to 13% seed moisture.

ii) Artificial drying process includes: Unheated air drying &heated air drying.


**Seed Winnower**

**3. Grading:**

Grading is the removal of smaller & shriveled seeds from the well filled healthy seeds. Air and screen machine is extensively used for cleaning and grading of seeds.

**4. Testing:**

For quality parameters it is required to test the seed lots for percentage of pure seed, weed seeds, seeds of other crops, inert matter and germination.

**5. Treating:**

Before bagging, seeds are treated with a suitable fungicide, often in combination with an insecticide.

**6. Bagging &labeling:**

After processing the seeds are distributed in bags of appropriate size (generally, 30 kg bags are used). Each bag should be labelled with an appropriate label which carries the information’s viz.; Crop name, Variety name, purity, Percentage of germination, date of test, percentage of weed seed percentage of inert matter, name & address of the seller etc. Seed laws require that accurate information be provided on the label.


**Seed grader**

**7. Seed Storage:**

Gunny bags or cloth bags (having pores for air circulation) are generally used for storage of seed. If seed moisture is as per requirement, polythene bags can be used which can protect from humidity. It's required to store the seed packets on a wooden rack above the soil level to avoid contact with floor-moisture.

**8. Seed Quality test:**

Seed tests are conducted on small samples generally drawn from the processed seed lots. It is essential that the samples used for seed tests are representative of the lot. Generally, 3 tests are conducted to determine the quality of seeds. They are: Cultivar Purity test, Germination or seed viability testand Moisture content test.

## Economics of paddy seed vs. grain production

**Biswajit Mondal**

*Pr. Scientist (Ag. Economics), NRRI, Cuttack*

Economic computation in agriculture has become imperative due to increased use of purchased inputs in the cultivation of crops/enterprises and changing policy environment. It is necessary to convince farmers to adopt the emerging technologies. The economics of a farm or a part of the farm business is computed through budgeting techniques. Budgeting is a process of estimating costs, returns and net profit of a farm, a particular enterprise or a particular activity of an enterprise. There are three budgeting techniques used in economic analysis, i. e. Partial budgeting, Enterprise budgeting and Complete farm budgeting; the first two types are most frequently used.

### Partial Budgeting

Partial budgeting is the method of making a comparative study of a part of the farm business. It is simple, quick and easy. The partial budgeting technique helps in the decision making process, whenever small changes in the existing farm planning are anticipated as to which methods to adopt, which practice to follow, or which activity to substitute for the other to reduce the unit cost and make higher profits. The technique is commonly used to estimate the effects or outcomes of possible adjustments in the farm business before such adjustments are actually made. The following points are followed in setting up a partial budget.

- The increase in costs due to the new inputs or practice suggested in the change.
- The decrease in the return that might occur due to reduction in yield or loss of production from the activity which has been replaced in the change.
- The decrease in the costs which will not have to be incurred after the change or on the new inputs suggested in the change or reduced level of an input item.
- Additional returns that would accrue from the change i. e. from the increased production of the same activity or from the production of the new activity to be introduced.

After arranging the above four items in a format, a partial budget table will look like the following.

| Debit | Credit |
|---|---|
| a) Increase in costs per ha | a) Decrease in costs per ha |
| b) Decrease in returns per ha | b) Increase in returns per ha |
| Total of debit column | Total of credit column |

Net gain = Total of Credit column – Total of Debit column

After using partial budget analysis, the farmer would know the total net benefit from the change, the complete details of what he should do at what cost and what he should not do after the change and come out with higher profits

Examples: a) Purchasing a new implement

b) Trying a new agro-chemical

c) Deciding about the dose of a fertilizer

d) Deciding about the method of use of a fertilizer

e) Deciding about inter-cropping etc.

**Enterprise Budgeting**

Enterprise budgeting depicts the input-output relationship of a particular production activity. It provides information like the inputs required, cost involved, cash expenses required, and expected returns from a particular enterprise. The purpose of budgeting an enterprise is to aid in selection of inputs and enterprises consistent with the resources available and to find out the combination that will increase income from the farm business. Examples of enterprise budget with respect to rice cultivation are computing cost of cultivation of rice, computing cost of cultivation of other crops or enterprises which competes with rice on the same piece of land etc. The data requirements for enterprise budget are physical input data (seed, fertilizer, pesticides, labour etc.), output data like quantity of grain and straw, prices data for inputs and outputs. The format for computing enterprise budget is given below.

**Whole Farm Budget:**

A whole farm budget is a summary of available resources and the planned type and volume of farm production that are under the management of the farm owner. The whole farm budget is constructed to include the expected costs, revenues, and profitability of each enterprise that compose the overall farm business. The purpose of this budget is to analyze a major change that has the potential to affect several enterprises. A simple whole farm budget may include minimal information (e.g., list enterprises and production level) or include detailed data for each enterprise (e.g., seed and fertilizer prices and volumes, custom harvest costs, pre- and post-production labor hours, application rates, etc.).

**Advantages of Farm Budgeting**

- It evaluates the old plan and guides the farmers to adopt a new farm plan with advantage.
- It makes the farmer conscious of the waste (leakage) in the farm business.
- It gives comparative study of receipts, expenses and net earnings on different farms in the same locality and in different localities for formulating national agricultural policies.
- It guides and encourages the most efficient and economical use of resources.
- It serves as valuable basis for improvements in farm management practices.

**Cost of Cultivation of Crops**

To calculate the cost of cultivation, value of total produce and profit or loss, the following concepts are used. The definitions of the concepts and the measures followed in the analysis of data are explained briefly as follows:

**Definitions of the Concepts**

1. **Human labor**

(a) ***Hired Labor***: This included the hired/ casual labor employed in the crop production. The mode of payment is either cash or kind in nature.

(b) ***Family Labor***: It is the actual work done by the family members for the crop production. The value of the wages for family labour was calculated on the basis of existing wages paid to the hired labor.

2. **Bullock Labor**: Both owned and hired bullock labor comes under this category. The value or charges of the crop production can be considered on the basis of existing charges paid to the hired bullock labor in that area.

3. **Tractor Power Charges:** This also included both owned and hired tractor power charges. The cost of the crop production are accounted on the basis of market prices paid towards the hired tractor power charges.

4. **Seeds, Manure, Fertilizers and Pesticides**: There are two types of seeds and manure are available in the crop production. One is home produced seeds and manure and second one is purchased seeds and manures. The value of home produced seeds and manure used in the crop production used to be calculated at the prevalent village prices. The value of all inputs like purchased seeds, manures, fertilizers and pesticides have to be considered paid at the actual prices in the area.

5. **Irrigation Charges:** Value of electricity power charges comes under irrigation charges for the use of well in that area. Depreciation on pump sets also calculated under irrigation charges. For getting irrigation from well/pumps of other farmers, actual amount paid as rents/charges used to be considered.

**Format for acquisition of data for cost of cultivation calculation**

| Operation/Item | Labour requirement (*man-days per ha*) | Costs involved (*Rs/ha*) |
|---|---|---|
| 1. Land preparation & leveling | | |
| 2. Seeds | | |
| 3. Sowing | | |
| 4. Interculture & weeding | | |
| 5. FYM, Fertilizers & application | | |
| 6. Plant protection | | |
| 7. Harvesting & transportation | | |
| 8. Threshing, cleaning & bagging | | |
| 9. Interest on working capital | | |
| 10. Total cost | | |

**Gross returns** = Yield of grain in quintals per ha x Price of grain per quintal+ Yield of straw in quintal x Price of straw per quintal

**Net returns =** Gross returns – Total cost

**Benefit cost ratio** = Gross returns per ha / Cost of cultivation per ha

**Recent Cost Concepts:**

There are different cost concepts used in economic analysis as detailed below:

- Cost A1 = All operational expenses + Depreciation+ Interest on WC
  Operational expenses include the items such as (I) charges of hired human labor, (2) charges of bullock labor, (3) charges of tractor power, (4) charges of seeds, (5) charges of manure, (6) charges of fertilizers, (7) charges of pesticides, (8) Irrigation charges.
- Cost A2= Cost A1 + Rent for leased in land
- Cost B1 = Cost A1+Int. on FC
- Cost B2= Cost B1+ Rent for [owned + leased in] land
- Cost C1 = Cost B1 + imputed value of family labour
- Cost C2 = Cost B2 + imputed value of family labour

**Gross Income:**

Values of both main product and by product are valued at the existing post harvested prices in the area. Profits at different cost concepts used above provide different estimates of returns to the cultivators and have been worked out on per acre.

**Sensitivity Analysis:**

Markets, inflation and policies are often unpredictable for which the input and product prices are subject to change. Farmer/ Manager need some way of deciding which prices to use in a partial budget when making decisions. The best way to test a decision for its ability to withstand price changes is through sensitivity analysis. Sensitivity analysis simply implies redoing a partial budget analysis or marginal analysis with alternative prices. For instance, a fertilizer recommendation is made using current fertilizer prices, but there are indications that those prices may increase. Therefore, a reasonable estimate of the new prices may be substituted in the analysis.

**Break-even Analysis**

The important management decision as to when to leave one practice and adopt another i. e. effect of a change in the system, is answered by the break-even point. The break-even point refers to that volume of business at which the farmer is indifferent between two alternatives i. e. neither he / she is better off nor worse-off irrespective of the choice he makes. He / she neither gets higher returns nor incurs higher costs. Thus, whereas partial budgeting analysis can be used to know whether a particular alternative with given parameters as yields, prices, costs etc. is profitable or not, the break-even budgeting can be used to know the critical values of one or more of the parameters at which the farmer is neither better nor worse-off.

**Economics of seed vs. grain production**

Seed is a crucial, vital, basic and important input for attaining sustained growth in agriculture production and productivity. A sustained increase in agriculture production and productivity has dependent on the development of new improved variety, timely and adequate supply of quality seed to the farmers. It is estimated that the direct contribution of quality seed alone to the total production is about 15-20% depending upon the crop and it can be further raised up to 40% with effective management of other inputs. A superior quality seed not only increases productivity per unit area, but it also helps in producing uniform crops without any admixtures which is important for obtaining high prices on the market.

Quality seed production is a specialized activity. The general farm produce retained for seed cannot be substituted for quality seed; farm saved seed generally lacks genetic vigour and has poor germination. Seed of paddy has significant share in its cost of cultivation; therefore the economics of paddy seed production has impacted both seed producers as well as its users.

**Comparison in Paddy Grain and Certified Seed Production**

In a study, Pal et al. (2020) calculated total cost of cultivation in paddy certified seed production which was 11.36 per cent higher than grain production while, gross return was 18.92 per cent higher in seed production (Rs.80388 /ha) than grain production (Rs. 67600/ha). Further, net return from seed production of paddy was 35.66 per cent (Rs. 28506/ha) higher than grain production (Rs. 21012/ha). Therefore, production of certified seed has resulted in win-win situation for the farmers with higher yield and better quality of output. Because of seed production, seed producer fetched higher price than the grain in the marketing of produce.

Economics of certified seed production in Eastern Uttar Pradesh

| Sl. | Particulars | Amount (Rs.) | Per cent |
|---|---|---|---|
| 1 | Human labour | 21900 | 42.21 |
| 2 | Bullock & Machine labour | 6120 | 11.80 |
| 3 | Seed | 1030 | 1.99 |
| 4 | Irrigation | 1650 | 3.18 |
| 5 | Manures & Fertilizers | 6150 | 11.85 |
| 6 | Plant protection chemicals | 2350 | 4.53 |
| 7 | Seed certification charges | 590 | 1.14 |
| 8 | Interest on working capital | 1592 | 3.07 |
| 9 | Total variable cost | 41382 | 79.77 |
| 10 | Total fixed cost | 10500 | 20.23 |
| 11 | Total cost | 51882 | 100.00 |
| 12 | Yield | | |
| a | Seed (q) | 36.00 | |
| b | Rejected seed (q) | 6.00 | |
| c | By-product (q) | 25.00 | |
| 13 | Gross return (Rs.) | 80388 | |
| 14 | Net return (Rs.) | 28506 | |
| 15 | BC ratio | 1.55 | |

Source: Pal et al., 2020

**Partial Budgeting**

Pal et al. (2020) calculated the additional costs and returns incurred in the certified seed production of paddy over grain production showed that the increment in profit realized in paddy certified seed production which was Rs.7494.00/ha. In case of certified seed production, the main factors responsible for cost increase are irrigation, human labour and seed certification charges etc. On the other hand, added returns pertinent to paddy certified seed production is mainly due to higher productivity of certified seed production and realization of higher price for certified seed over grain. Thus, the partial budgeting analysis implies that the adoption of certified seed production technology could add additional profit to the farmers.

**Partial budgeting of certified seed production in Eastern Uttar Pradesh**

| Debit | | Amount (Rs.) | Credit | Amount (Rs.) |
|---|---|---|---|---|
| A | Increase in cost | | Decrease in cost | |
| i | Human labour cost | 3900 | Bullock/Machine labour | 2070 |
| ii | Seed | 470 | | |
| iii | Irrigation | 1650 | | |
| iv | Manures & Fertilizers | 370 | | |
| v | Plant protection chemicals | 180 | | |
| vi | Seed certification charges | 590 | | |
| vii | Others | 204 | | |
| | Total | 7364 | | 2070 |
| B | Decrease in return | 0 | Increase in return | 12788 |
| | Total Debit | 7364 | Total credit | 14858 |
| | | Profit | 7494 | |

Source: Pal et al., 2020

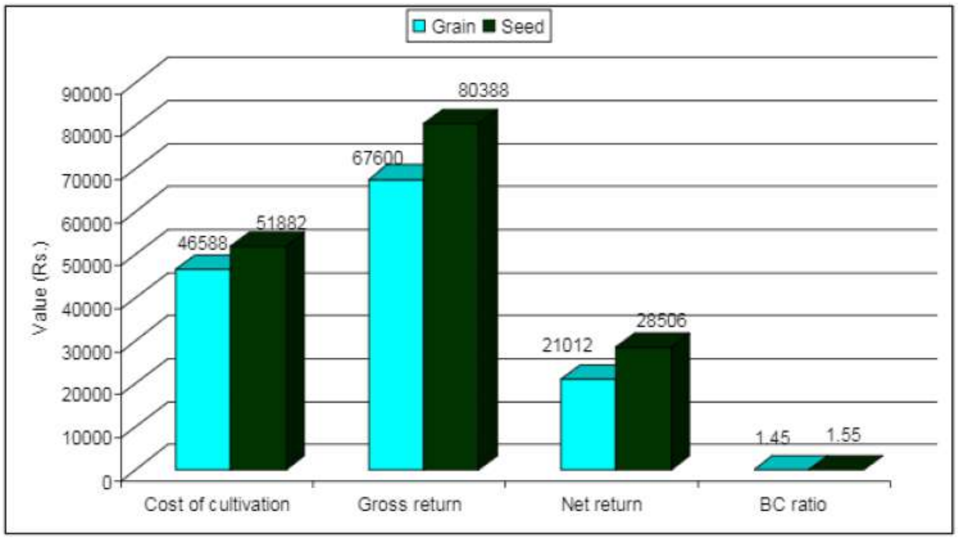
**Cost of Production and Return over Cost**

Pal et al. (2020) also calculated the cost of cultivation / production according to other cost concepts - cost A2 & FL (Family Labour) and C2. According to cost C2 concept, cost of production of paddy grain and seed estimated to Rs. 1096 and Rs. 1231 per quintal. The return to the farmers on cost C2 was 45.07 and 55.0 per cent above cost of production for paddy grain and seed respectively. Similarly, cost of production according to cost A2 & FL concept of paddy grain and seed estimated to Rs. 863 and Rs. 996 per quintal. The return to the farmers on cost A2 & FL was 84.24 and 91.57 per cent above cost of production for paddy grain and seed respectively.

**Cost and returns comparison**

| Crop | Cost of cultivation (Rs./ha) | Cost of production (Rs./q) | Output price (Rs./q) | Percentage return over cost |
|---|---|---|---|---|
| **Cost of cultivation / production (according to cost $C_2$)** | | | | |
| Paddy grain | 46588 | 1096 | 1590 | 45.07 |
| Paddy seed | 51882 | 1231 | 1908 | 55.00 |
| **Cost of cultivation / production (according to cost $A_2$ and family labour)** | | | | |
| Paddy grain | 36688 | 863 | 1590 | 84.24 |
| Paddy seed | 41982 | 996 | 1908 | 91.57 |

Source: Pal et al., 2020




Source: Pal et al., 2020

**Conclusion**

Production of paddy seed has resulted in higher profitability situation for the farmers. The net return from paddy seed production was encouraging, therefore the entrepreneurial farmer can take up seed production activities to get higher profitability over grain production.

**Reference:**

Pal, G., Sripathy, K. V., Kamble, U. R., Kumar, S. P. J., Kumari, K., & Agarwal, D. K. (2020). An Economic Analysis of Paddy Seed Production in Mau District of Eastern Uttar Pradesh. *Journal of Economics, Management and Trade*, *26*(4), 45-51. https://doi.org/10.9734/jemt/2020/v26i430247

# Climate smart irrigation with special reference to Customized Color Coded Tensiometer & entrepreneurial opportunities involved

Anjani Kumar
ICAR-National Rice Research Institute, Cuttack – 753006, Odisha

Rice crop is known to have high water requirement. In traditional rice cultivation, farmers generally keep the field continuously flooded from transplanting to physiological maturity of rice crop. However, it is well established that continuous flooding is not necessary for rice to achieve high yields. After seedling establishment phase, even in the absence of standing water in field, rice plant can extract soil water from the below surface soil around root zone. Over the past few decades, water scarcity has emerged as one of the biggest challenges for sustaining rice production. Development of novel water saving technologies is an important step to help rice farmers cope with water scarcity. It is well proved that soil water potential as measured by tensiometer can be used as an irrigation index for scheduling irrigation in rice.

The tensiometer consists of a rigid and sealed body tube and a porous ceramic cup filled with water. The body tube is transparent so that water within the tube can easily be seen. The tensiometer tube along with the ceramic cup is inserted in the soil preferably at the plant root zone depth to provide a direct measurement of soil water potential- the force by which the soil particles hold the water. The wetter the soil, the lower the soil water potential. The ceramic cup is porous so that water can move through it to equilibrate with the soil water. As the soil dries out, water is sucked out of the tensiometer through the porous ceramic tip. This creates a partial vacuum in the sealed tensiometer tube which is measured by the electronic gauge. When the soil is watered the converse happens. The core idea behind the use of tensiometer is the identification of threshold soil water potential for optimizing irrigation scheduling. Such irrigation scheduling can maximize water productivity by reducing irrigation water input, because farmer generally over irrigates the crop irrespective of its requirement.

A simplified and farmer friendly version of tensiometer tube for real time soil water potential based irrigation management was developed by ICAR – National Rice Research Institute, Cuttack. In this tensiometer, the usual measuring gauge has been replaced by the stripes of light blue, deep blue, orange and brown color. While the water level in tensiometer tube at light blue stripe signifies no need for irrigation, there is need to irrigate when the water level enters the deep blue stripe. The entry into the orange and brown stripe may adversely affect the crop yield and hence should be avoided.

## Installation and Use

### STEP 1

Before installation, fill the tensiometer tube with air free water and cap it. Place the unit into a container of clean water deep enough to cover the ceramic cup and leave overnight. The porous ceramic cup of the tensiometer must be kept dipped overnight to ensure that they get fully water saturated and do not leak.

## STEP 2

The instrument is now ready to be installed, but the ceramic cup must be protected from drying out. Cover the ceramic cup with wet paper towels or a plastic bag, while transporting to the site.

## STEP 3

- ❖ For field installation, make a hole in the soil, using a soil auger upto the desired depth (20 cm). Remove the auger and drop a handful of loose friable soil into the hole.
- ❖ Insert the tensiometer into the hole after removing the paper towel. Push the instrument by giving a firm twisting downward motion applied to the connecting tube and place the cup at the desired soil depth. This procedure will ensure the necessary intimate contact between the porous cup and the soil in the vicinity. However, care must be taken that the cup is not broken in this process.
- ❖ Backfill the hole with soil slurry so that the tensiometer is firmly held in the soil.

STEP 4

- Check the tensiometer tube for accumulated air. If air bubble is present beneath the service cap, the cap should be removed and the tube should be refilled with de-aerated water.
- Allow the tensiometer to equilibrate for about 24 hours before recording readings.

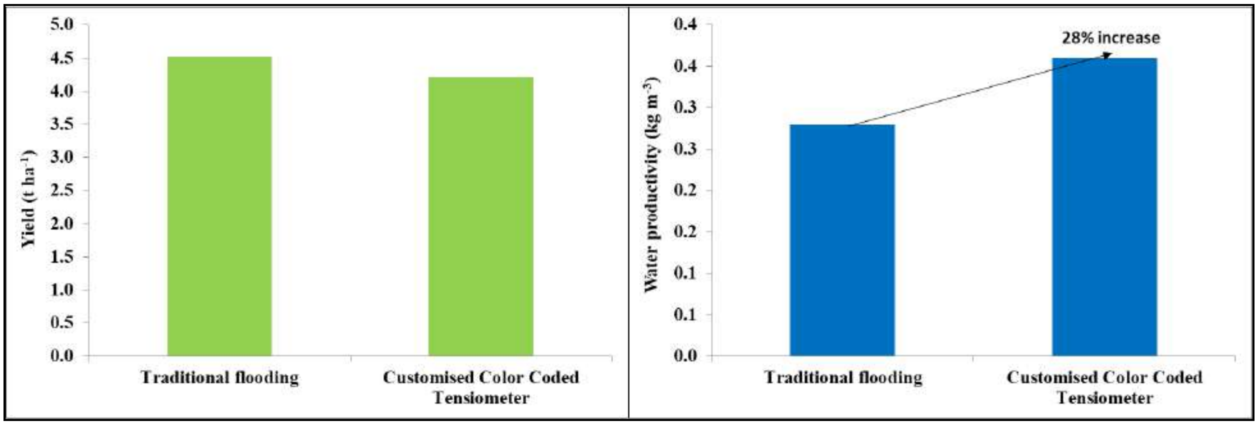
**Interpretation of the color stripes of Customized color coded tensiometer**

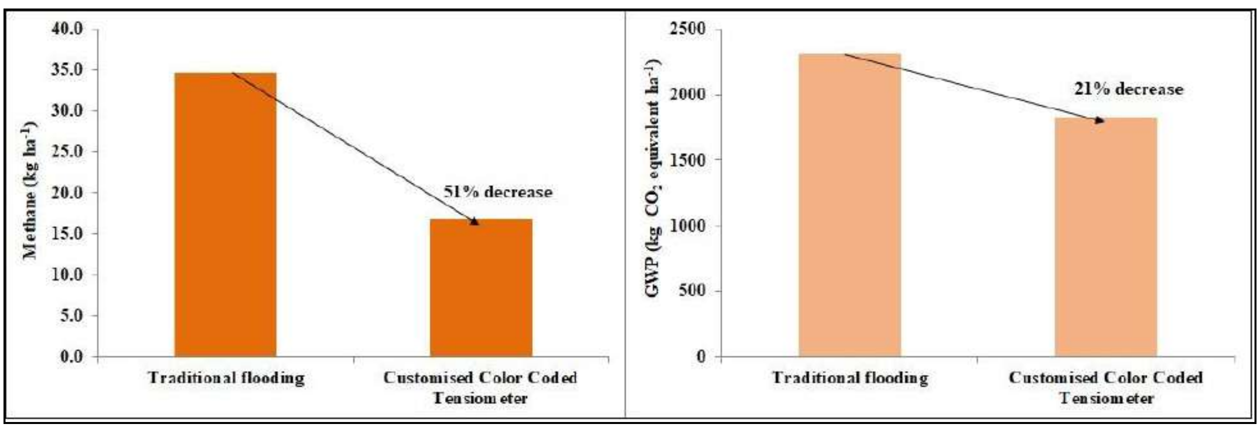
| Color Stripe | Interpretation |
|---|---|
| **Light Blue** | No need of Irrigation |
| **Deep Blue** | Irrigation should be applied |
| **Orange** | Immediate need of irrigation |
| **Brown** | Adverse effect on grain yield and hence should be avoided |

**Customized color coded tensiometer based irrigation scheduling: A strategy for eco-friendly rice cultivation**

Evaluation of Customized color coded tensiometer for irrigation scheduling in rice revealed that irrigation scheduling based on customized color coded tensiometer resulted in similar grain yield with significantly higher water productivity (28%)

and it also mitigates methane emission by 51% and global warming potential by 21%. Its cost-benefit ratio varies from 0.4 to 0.5.



# Nutritional composition of Rice bran Oil

**Dr.T.B.Bagchi**

Rice bran is the upper thin layers of white endosperm of rice grain. It can be obtained as a bi -product of rice milling and contains 14 to 15% crude oil. The extraction of the oil can be done simply by solvent extraction or pressing by a machine. Rice bran oil (RBO), one of the high-valued edible vegetable oils recommended by WHO, is widely consumed in the major parts of the Asian countries. It contains large amounts of unsaturated fatty acids (oleic acid and linoleic acid) and many dietary phytochemicals such as Vitamin-E, squalene, phytosterols, polyphenols, and γ-oryzanol. These bioactive compounds show excellent physiological activities and can be used as an antioxidant, anti-inflammatory agent, and for the treatment of cardiovascular disease. Oleic acid (C18:1) was found at the highest levels in the RBO, followed by linoleic acid (C18:2), and palmitic acid (C16:0). It also contains substantial amount of PUFA (Poly unsaturated fatty acids), which is beneficial for the health of heart. An imbalance of omega-6 and omega-3 PUFAs in the diet is associated with an increased risk of cardiovascular disease. The optimal dietary ratio of omega-6 to omega-3 PUFAs is between 1:1 and 4:1. As leafy vegetables and fish oil are rich in EPA eicosapentaenoic acid and DHA (docosahexaenoic acid), these are often prescribed for individuals with a history of cardiovascular disease. Acid value (AV) and peroxide value (PV) are also the most basic and important physicochemical parameters to assess the quality or edibility of oil. The AV of the rice bran oil is low after refining, which is within the permitted levels of Codex Stan 210–1999 Codex Standard for Named Vegetable Oils (≤0.6 mg KOH/g). In addition, it also exhibits the acceptable PV level (approx. 1.17 mmol /kg) after refining (prescribed level ≤10.0 mmol/kg). However, it is recommended that RBO mixing with other edible oil are better for health. Blending of RBO with sunflower oil (70:30 v/v) exhibits better antioxidant property than any single oil (Choudhary M et al., 2015).

*Table 4: Comparison of fatty acid and nutritional composition of rice bran oil with other commonly used oils*

| Sl. No. | Fatty acids | Chemical composition (%) | RBO | Mustard oil | Sunflower oil |
|---|---|---|---|---|---|
| **1** | 14:00 | Myristic acid | 0.1-0.3 | - | 0.1 |
| **2** | 16:00 | Palmitic acid | 12.8-21.6 | 10.24 | 6.0-7.1 |
| **3** | 18:00 | Stearic acid | 0.7-4.7 | 2.02 | 2.5-4.1 |
| **4** | 20:00 | Arachidic acid | 0.5-1.4 | 0.92 | - |
| **5** | 16:01 | Palmitoleic acid | 0.0-0.3 | - | - |
| **6** | 18:01 | Oleic acid | 32.4-43.4 | 36.65 | 23.1 |
| **7** | 18:02 | Linoleic acid | 28.0-53.4 | 22.06 | 65.1 |
| **8** | 18:03 | α-Linolenic acid (ω-3) | 0.2-1.6 | 8.06 | 0.2 |
| **9** | | Free Fatty acids | 0.29-0.55 | 0.43 | 0.04-0.08 |
| **10** | | Oryzanol | 0.55-1.39 | - | - |
| **11** | | Tocopherol(mg%) | 48.0-70.0 | 21 | 50.0-52.0 |
| **12** | | Total PUFA | 37 | 21 | 65.7 |
| **13** | | Total MUFA | 38 | 60 | 19.5 |

- *Source: Gopala Krishna A G et al., 2006.,*
- *PUFAs (Poly Unsaturated Fatty Acids) with a double bond between C-3 and C-4 (from methyl end of fatty acid chain) are called **omega-3 (ω-3) fatty acids**, and those with a double bond between C-6 and C-7 are **omega-6 (ω-6) fatty acids**.*

## Know Your Faculty

| S.N | Topic | Faculty | Contact details |
|---|---|---|---|
| 1 | Opening session | Dr. G.A. K. Kumar<br>I/c Head,<br>Social Science Division<br>ICAR-NRRI, Cuttack,753006 | 9437484576<br>gak.kumar26@gmail.com |
| 2 | Phosphate solubilizing bacteria a potential biofertilizer to enhance rice yield & entrepreneurial opportunities involved | Dr. Upendra Kumar<br>Scientist<br>ICAR-NRRI, Cuttack,753006 | 79782 18576<br>ukumarmb@gmail.com |
| 3 | Rice-Fish Integrated Farming System & entrepreneurial opportunities involved | Dr. Annie Poonam<br>Principal Scientist<br>ICAR-NRRI, Cuttack,753006 | 94370 71534<br>annie_poonam@rediffmail.com |
| 4 | Quality rice seed production & entrepreneurial opportunities involved | Dr. R.K.Sahu<br>Former Scientist<br>ICAR-NRRI, Cuttack,753006 | 94373 86275<br>rabinksahu@yahoo.com |
| 5 | Economic/entrepreneurial benefits of seed production over grain production in rice. | Dr. Biswajit Mondal<br>Principal Scientist<br>ICAR-NRRI, Cuttack,753006 | 79783 43012<br>bisumondal@rediffmail.com |
| 6 | Potential biocontrol agents for insect pests of rice & entrepreneurial opportunities involved | Dr. Arup K. Mukherjee<br>Principal Scientist<br>ICAR-NRRI, Cuttack,753006 | 72058 81784<br>titirtua@gmail.com |
| 7 | Climate smart irrigation with special reference to Customized Color Coded Tensiometer & entrepreneurial opportunities involved | Dr. Anjani Kumar<br>Scientist<br>ICAR-NRRI, Cuttack,753006 | 89843 06249<br>anjaniias@gmail.com |
| 8 | Rice bran oil & entrepreneurial opportunities involved | Dr. Torit Baran Bagchi<br>Scientist<br>ICAR-NRRI, Cuttack,753006 | 95563 72678<br>torit.crijaf09@gmail.com |

## CONTACTS OF PARTICIPANTS

| S.N | Name | Mobile | E-Mail |
|---|---|---|---|
| 1 | Achyuta Kumar Biswal | 9348950134 | biswalachyut@gmail.com |
| 2 | Ambuja Kumar Mohanty | 9437529314 | mohantyambuja@gmail.com |
| 3 | Anushka Maiti | 9404179254 | anushka.maiti22@gmail.com |
| 4 | Arindam Sen | 9609702923 | arindam.sen.panseeds@gmail.com |
| 5 | Bairi Ganjan Parida | 8018742551 | bgp.odisha@gmail.com |
| 6 | Bhaudip Rajhans Shahare | 9545232450 | bhaudipshahare@gmail.com |
| 7 | Bibhash Ranjan Sahu | 7377110358 | bibhashranjan20@gmail.com |
| 8 | Chaitanya Kumar Mallik | 9937686577 | chaitanyakumarmallik@gmail.com |
| 9 | Dr. Debasis Mahata | 9851538191 | dmahata1987@gmail.com |
| 10 | Harekrushna Swain | 7538928920 | harekrushnaswain21@gmailS.N123.com |
| 11 | Harihar Mohapatra | 8249385033 | mohapatraharihar8@gmail.com |
| 12 | Jogamaya Mohanty | 9337756440 | jogamayamohanty27@gmail.com |
| 13 | Jyoti Prakash Sahoo | 7978401259 | jyotiprakashsahoo2010@gmail.com |
| 14 | Kumari Priyanka | 7008341960 | priyankakumarinrri@gmail.com |
| 15 | Manoj Kumar Mahali | 7008924991 | manojmahali75@gmail.com |
| 16 | Partha Sarathi Pattanaik | 7894450363 | sarathi.partha0173@gmail.com |
| 17 | Priyanka Priyadarsani Giri | 7873517318 | mamagiri1158@gmail.com |
| 18 | Puja Kanungo | 9777566642 | kanungopuja42@gmail.com |
| 19 | Ritesh Kar | 7978681128 | riteshkar866@gmail.com |
| 20 | Rudra Narayan Nayak | 9937024926 | rudra789@gmail.com |
| 21 | Rudramadhab Behera | 9439107243 | rudramadhabbehera@gmail.com |
| 22 | Rupalin Jena | 7978405073 | rupalinjena2015@gmail.com |
| 23 | Sanjaya Kumar Patra | 9849991302 | p.sanjayakumar@gmail.com |
| 24 | Santosh Kumar Danta | 9937994729 | swarajboudh@rediffmail.com |
| 25 | Shamil Emonar Rahman Laskar | 7086228836 | shamilunk@gmail.com |
| 26 | Shovan Kumar Dash | 9437331443 | dashshovan@gmail.com |
| 27 | Shubhashree Mund | 9348997454 | mundshubhashree0820@gmail.com |
| 28 | Sk Safilluddin | 7008748806 | sksafilluddin@gmail.com |
| 29 | Soumya Ranjan Nayak | 9437230681 | nayak.soumyaa@gmail.com |

| | | | |
|---|---|---|---|
| 30 | Style Swain | 7098163588 | styleswain@gmail.com |
| 31 | Subhasmita Swain | 6372916177 | subhasmita.s2019bag@srisriuniversity.edu.in |
| 32 | Subrata Kumar Bohidar | 9437781513 | sbohidar6383@outlook.com |
| 33 | Sujit Kumar Sahu | 8895337636 | sujitchem12@gmail.com |
| 34 | Sumanta Biswal | 842577648 | bsumanta75@gmail.com |
| 35 | Susanta Kumar Padhiary | 7586935381 | padhiary2013@gmail.com |
| 36 | Suryakant Trimbakrao Pawar | 9763084130 | suryakantt.pawar@gmail.com |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