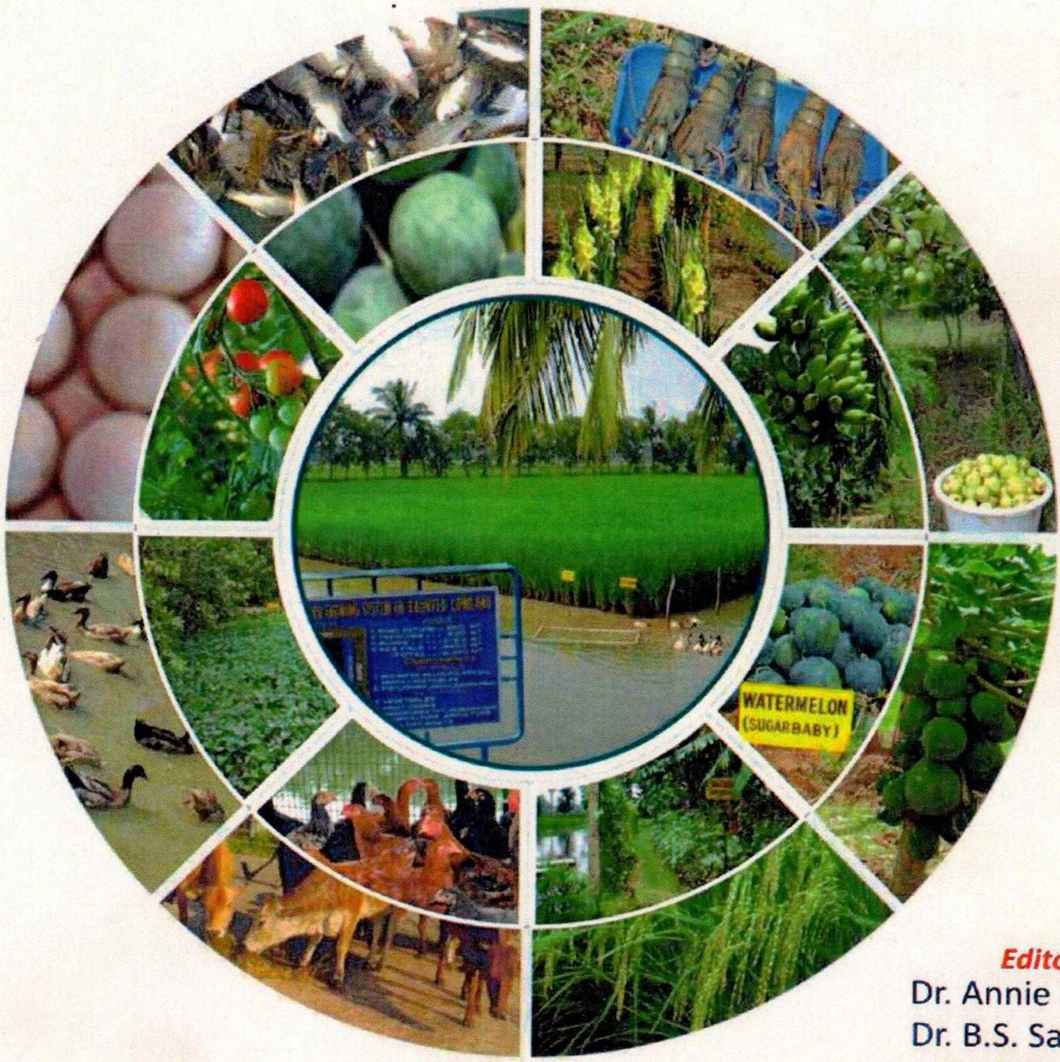
ICAR

Training Manual

SHORT COURSE ON RICE BASED INTEGRATED FARMING SYSTEM

09 - 12 November 2021



Editors
Dr. Annie Poonam
Dr. B.S. Satapathy
Dr. S.K. Lenka

150 YEARS OF CELEBRATING THE MAHATMA

Supported by:
RKVY, DEPARTMENT OF AGRICULTURE AND FARMERS EMPOWERMENT
GOVERNMENT OF ODISHA UNDER THE PROJECT E.A.P-252

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Published by: ICAR-National Rice Research Institute, Cuttack, Odisha 753006

Compendium
on
Rice Based Integrated Farming System

09-12 November 2021

Editors

Dr. Annie Poonam

Dr. B.S. Satapathy

Dr. S.K. Lenka

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

PREFACE

Changing to farming system from mono-cropping is one of the major thrust areas in agricultural research and development, especially in the fragile rice ecologies and also in the case of small farms. In this Endeavour rice-fish farming system is one of the- befitting options, particularly in the eastern India, as it matches with the resources and socio-economic conditions of the farmer.

ICAR National Rice Research Institute, Cuttack, being the premier institution for research on rice , has taken up the pioneering research on rice-fish farming system especially in rainfed lowland ecology, which occupies 42% of the total area including 82% in the eastern India itself The institute has developed a concept, design and production technology of rice-fish diversified farming system for improvement of farm productivity, income and employment in rainfed lowlands. This technology is in adoption stage in the eastern India.

The training programme was organized by ICAR National Rice Research Institute, Cuttack to impart knowledge about the Methodology, benefits and component selection at the farmer's field to increase the livelihood of the resource poor farmers with limited land and other resources. This training programme aims to expose the participants from line departments of state governments and farmers of Coastal Odisha where there is greater scope for development of Integrated Farming System models as the land is fertile and farmers are capable to bear risks upto some extent. We express our thanks to RKVY (Production Growth) to Department of Agriculture and Farmers' Empowerment, Government of Odisha for their financial support. The contributions from all the resource persons towards preparing and delivering the lectures are gratefully acknowledged.

The assistance rendered by staff of ABI Training Center in facilitating the course is heartily appreciated. Sincere thanks are also due to Administration and Finance & Accounts Sections of this Institute for providing timely support during the course.

S. Lenka	B.S. Satapathy	Annie Poonam
(Course Co-Director II)	(Course Co-Director I)	(Course Director)

Contents

Integrated Farming System: Concept and Principles

Dr. A. Poonam and Dr. B. S. Satapathy

Crop Production Division

ICAR-National Rice Research Institute

Introduction

Agriculture is still considered as backbone of Indian Economy. Under the changing scenario of climate and increase in human population, the role of farmers is more critical to sustain the economic development of our country. In India more than 86% of Indian farm families with holding size below 1.2 ha are living in risk prone diverse production conditions. No single farm enterprise is likely to support the small and marginal farmers for generation of adequate income and gainful employment year-round. Urbanization, industrial and infrastructural growth reduces the availability of arable land for agriculture thus there is a need for vertical growth rather than horizontal expansion as far as Indian agriculture is concerned. Integrated farming is the one of the viable option which can take care of increasing demand for food as well as environmental safety.

What is integrated farming system?

Farming system may be defined as a positive interaction of two or more components within the farm boundaries to increase productivity of the farm and to enhance the income of the far family in a sustainable way. An inter-related set of enterprises are integrated in such a manner that the "waste" from one component becomes an input for another part of the system, which reduces cost and improves production and income. With the adoption of resource-saving practices not only achieves high and sustained production levels but it also minimizes the negative effects of intensive farming and preserving the Environment. The goals of IFS are to sustain agricultural production, maintain farm incomes, safeguard the environment and respond to consumer concerns about food quality issues. Integrated farming is an ideal agricultural system with the principle of management and utilization of agriculture biomass and organic waste.

An appropriate combinations of available and adoptable different agricultural enterprises like crop, dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming.

Major features of integrated farming system are; i) by-product or waste recycling, a by-product of one component which otherwise may have been wasted become an input to other component, **ii)** efficient utilization of space by multiple cropping. The main benefits of the system are i) higher and stable farm productivity, ii) better diet for farm family, iii) more cash flow and income, iv) better employment v) less risk (biological and economic), vi) environment friendly and vii) optimum resource utilization. Integrated farming system thus can ensure food, nutritional and household security on sustainable way under the changing climate scenario.

Concept of farming system:

The Farming System, as a concept, takes into account the components of soil, water, crops, livestock, labour, capital, energy and other resources with the farm family at the centre managing agricultural and related activities. The farm family functions within the limitations of its capability and resources, the socio-cultural setting, and the interaction of these components with the physical, biological and economic factors. The term "farming system" refers to a particular arrangement of farming enterprises that are managed in response to physical, biological and socio-economic environment and in accordance with farmer’s goals, preferences and resources. “The household, its resources and the resource flows and interactions at the individual farm levels are together referred to as a farm system” (FAO, 2001).

Farming system focus on;

• The interdependencies between components under the control of household and,

•How these components interact with the physical, biological and socio-economic factors, which is not under the control of household.

•Farm household is the basic unit of farming system and interdependent farming enterprises carried out on the farm.

•Farmers are subjected to many socio-economic, bio-physical, institutional, administrative and technological constraints.

•The operator of the farming system is farmer or the farming family.

Types of farming system

(i) Indigenous farming systems (ii) Modern integrated farming systems

(i) Indigenous farming system

Traditional rice-based farming system is ecologically sound and based on need of the society. India is rich in traditional farming systems and practiced in different regions rich in biodiversity and managed on community basis for sustainable food security and environmental safety. Different location specific indigenous faring system practices in various parts of the country described below (Table 1).

Table 1: Major indigenous farming systems of India

Farming system	State /region
Shift/*Jhum* cultivation	North eastern states and other hill regions
Taungya system	Kerala, West Bengal, Uttar Pradesh, and to a limited extent in Tamil Nadu, Andhra Pradesh, Orissa, Karnataka
Rice-based farming system of Apatanis	Apatani plateau of Arunachal Pradesh
Panikheti system of rice cultivation	Nagaland, Sikim and Manipur
Zabo farming	Phek district of Nagaland
Rice field capture fishery system	Brahmaputra and Barak Valley of Assam
Wild aqua-cropping	Assam, Manipur and foot hills of other north eastern states of India
Kaipad rice farming	North and Central Kerala
Bhasabandha system	Sundarban of West Bengal
Xeng fishery	Assam and other north eastern states
Bamboo drip irrigation system	Meghalaya
Fish-cum-vegetable (bottle gourd) culture	Tripura, Assam, Manipur

(ii) Modern integrated farming systems

To meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability, researchers have developed the several integrated farming system models and recommended for different agro ecological regions of the country. The approach aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself (Singh *et al*., 2006). The IFS was found valid for resource-poor farm families with increasing land use efficiency, sustaining livelihood by strengthening the economic status and generating employment using the land and time judiciously. The recommended integrated farming systems for different regions of India and particularly for different agro climatic zones of Odisha were mentioned in Table 2 and 3. There are two major type of faming systems *i.e,* (i) crop based and ii) pond based and the farmers has to select the components based on resource available with him and need of the farm family.

Table 2 Major rice-based farming systems for different ecosystem of India

Integrated farming systems	Recommended for the Region/State
Rice-fish– poultry	Karnataka
Rice-fish-duck-goatery	Bihar
Rice-wheat+ poultry +goatery +mushroom	Patna, Bihar
Rice+Azolla+Fish	Tamil Nadu
Rice-vegetables+mushroom+poultry	Goa
Crop + diary +fish + Piggery	Punjab
Crop + diary +fish + Piggery	Punjab
Rice-fish-poultry	Tamil Nadu
Rice-fish-duck	Tripura
Rice-fish-fruits-plantation crop	Tripura
Rice + fish	Medium lowland of Odisha
Rice-fish-prawn-horticulture -agro forestry	Deep water rice ecosystem of Odisha
Rice-fish-horticulture-Duckery	Assam
Rice-vegetables-dairy	Telengana
Rice-vegetables-fodder-dairy	Telengana
Crop-dairy-fishery-horticulture-apiary	Uttar Pradesh

Table 3 Identified farming system models for different agro climatic zones Odisha

Agro climatic zone of Odisha	**Rice-based farming system**
North Western plateau (SunderGarh, Deogarh)	Rice – (Mustard / Green gram) + Dairy + Goatery + Poultry +Agro forestry
North Central plateau (Keonjhar, Mayurbhanja)	Rice – (pulse / mustard) + Dairy + Goatery +Poultry + Apiculture +Agro forestry
North Eastern Coastal Plain (Balasore, Jajpur, and Bhadrak	Rice-(Pulses/Oil seed)+Diary-Fish-Mushroom

East & South-Eastern Coastal Plain (Kendrapara,Jagatsinhpur, Khordha,Puri, Nayagarh, Cuttack)	Rice-(Pulses/Oilseed/Vegetables)+ Dairy+ Fish+ Mushroom
North East Ghat (Kandhamal, Rayagada Gajapati, Ganjam)	Rice-(Pulses/Oilseeds) + Goatery + Sheep + Poultry + Agroforestry
EasternGhatHighland (Nawarangpur, Part of Koraput)	Rice-(Niger/Pulses)+ Goatery + Sheep + Agrofoestry
South Eastern Ghat (Malkangiri, Part of Koraput	Rice - Vegetables + Poultry + Goatery +Sheep +Agro forestry
Western Undulating Zone (Kalahandi, Nuapada)	Rice – (Pulse / Oilseeds) + Dairy +Poultry+ Piggery +Goatery
Western Central Table Land(Baragarh, Bolangir, Boudh, Sonepur, Jharsuguda, Sambalpur)	Rice – (Pulse/Oilseed) + Dairy + Poultry + Piggery + Goatery
Mid-central Table Land (Angul, Dhenkanal)	Rice – (Pulse / Oilseeds) +Poultry +Dairy +Apiculture +Goatery +Mushroom

Source: Das et al., 2015

References:

- Das AK, Ananth PN, Singh S, Banja BK, Sahoo PR, Pati BK, and Jaysankar P 2015. Empirical proof on benefits of integrated farming system in small holders farms in Odisha. *Current Agricultural research Journal* 3(1):69-74.
- FAO, 2001. Farming Systems and Poverty: Improving Farmers' livelihoods in a changing World. Food and Agriculture organization of the United Nations, Rome pp 412.
- Singh, Kalyan, Bohra, J.S., Singh, Y. and Singh, J.P. 2006. Development of farming system models for the north-eastern plain zone of Uttar Pradesh. *Indian Farming* **56** (2): 5-11.
- Srivastava AP 2018. Selected Integrated farming system models for enhanced income. *Indian farming* 68(1):12-15.

Site selection, Design and field construction for integrated farming system

Annie Poonam and D P Sinhababu

ICAR-National Rice Research Institute, Cuttack-753006

Introduction

Rice being the staple food is grown in the country in around 44.5 million (m) ha under various ecologies of which about 50 % area is rainfed. More than 80% of the rice farmers belong to small and marginal groups and the average per capita land holding in India is only about 0.17 ha. In view of the population growth, competition of land with industrialization and urbanization, declining farm holding size and the dietary nutrition requirement of the farm families, it is necessary to look for the optimum use of resources through shift from conventional rice farming to integrated farming systems. Rice based farming system involving rice, other field and horticultural crops, agro-forestry, fish, birds, livestock and further income generating enterprises will be the right approach in this respect. However, this will be more relevant in the risk prone rainfed ecologies which are mostly located in the eastern part of the country. Rice based integrated farming systems can provide household food, nutrition, income and employment without degrading the environment.

Site selection

Low lying rice field with sufficient water holding qualities for fairly long time and less prone to occasional flooding are primary considerations for integration of fish farming. Generally, clay soil is best for this purpose. Areas with such type of soil, higher ground water table, uniform contour preferably with one lower end and drainage possibilities will be desirable in view of the relatively less construction cost. However, site nearer to farm house with easy access is preferred for better management.

Farm shape and size

The shape of the farm should be desirably rectangular of square. Rectangular farm is advantageous in terms of field preparation and management particularly in the case of rainfed lowlands which are usually sloppy towards the water course. This type of farm provides bigger perimeter as well as more area for longitudinal fish movement.

Square shaped farm on the other hand, may do well in flat lands. But irregular shaped farm is not good in respect of construction and crop management particularly fish. Anyway, farmer can develop suitably as per his own convenience. Its size may vary depending on the fish culture system. For fish seed rearing the preferable size may be around 0.20 to 0.1 ha while for table fish farming it can range from 0. 4 to 1 ha or even more.

Field design and construction

(i) Dykes

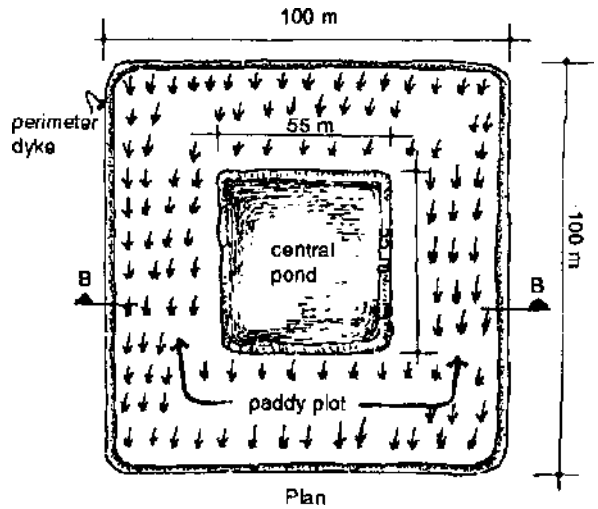
Dykes (bund) all-around must be strengthened and raised higher (at least 20 to 30 cm) than the maximum flood levels. During construction, the excavated soil should be well compacted, besides keeping allowance for natural compaction and erosion. For this purpose, around 0.5 to 1m wide berm, of existing field between pond/ trench and dike should be kept. Side slopes of the dykes depend on the nature of soil; more gentle (1:2-3) in sand can be steeper in clay (1:1). Grass pitching on side slopes of dykes will be preferable for stability. Napier grass and /or creeper vegetable can also be grown in the slopes of the bunds which will check soil erosion and also produce fodder and food as well. Crest width of dikes may vary from 50 cm to 2.5m or more in the case of vegetable and horticultural crops farming.

(ii) Refuge

A refuge is a pond, trench or low point in the rice –fish field which shelters the fish during drying out of the field, besides facilitating their management. The soil dug out for construction of refuge is utilized for making the dykes. However, traditional rice-fish systems lack refuge. The morphometry of refuge varies with the land types, hydrology of the field and culture system. Usually, one-tenth of the field is used for construction of refuge system as per the following four designs

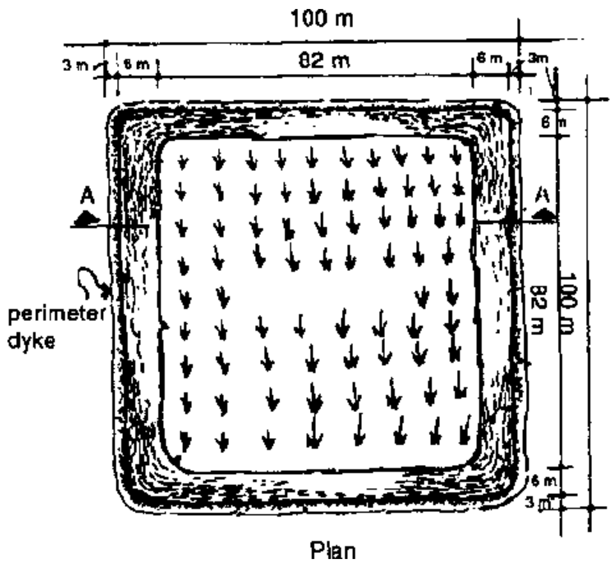
Central pond type.

This type contains rice area in the fringes, preferably sloping or connected by narrow shallow trenches (around 50 cm to 1 m wide and 20 to 70 cm deep) to a central pond sump. The sump should be at least 1 m deep. The dyke construction may be costly in this design. This system is good for basin type of large lowland and irrigated paddies.



Perimeter canal type.

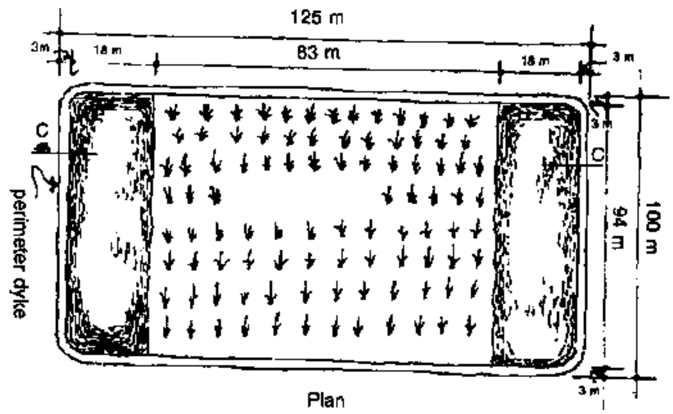
In this type, rice in the middle is surrounded by a canal all- around. Size of canal may vary from 1 to 3 m wide and 1 to 1.5 deep. This design is good for large fields on very flat land, but can be expensive and needs either extra construction or sacrificing a portion of canal for entry into the plot.



Lateral Trench Type

This design provides trenches on one side preferably in the lower region of the field. The size of the trench should be minimum 1 m wide and 1 m deep. This design may be better for relatively small farm in irrigated or waterlogged lowland.

This design involves construction of a small pond (even two in the case of very large field) at the lower portion of the field. The pond can connect the rice area by a number of narrow trenches (up to Im wide) or by two wide (2 to 3 m) side benches. This design is widely applicable on flat or gently sloppy lands in small or large paddies. This system has an edge over the others because of more water holding, less risk and scope of crop / farm diversification. However, in the case of porous soil, this design can aggravate seepage.



Outlet

Usually the rice -fish field needs a good outlet for rapid draining of flood water. This can be made of hume pipe or any other strong materials firmly placed in soil or with in concrete base. It may also have inlet when regular watering is required as in irrigated paddy. The diameters of inlet and outlet depend on the volume of water flow. Those should be screened for avoiding entry or escape of fish.

The Traditional Rice based farming System in India

In irrigated rice ecology, carp fingerlings of natural stock are collected by traps in the inlet/outlets from rice fields irrigated from Godavari river in East Godavari district of Andhra Pradesh with fish yield of 3 kg/ ha. In rainfed lowlands and deep water rice ecologies capture fisheries are mainly followed realizing around 3 to 300 kg of fish /ha during and after rice growing period in the rice field seeded/planted with mostly traditional rice varieties yielding around 1.0 to 3.0 t grain / ha.(Dehadrai, 1988, Ghosh, 1992)). The productivity of fish and prawn in coastal saline areas ranges from 100 to 2000 kg / h a / y r (Ghosh, 1992). In Meghalaya rice-fish farming as flow through system in the terraces and also in valleys/ plains. Trap-sum method is followed in *few* areas in the coastal part of Orissa (brackish water areas). In flood prone areas of Brahmaputra valley, rice-fish farming is extensively practiced. In West Bengal Rice-fish farming is practiced by the farmers mostly in rainfed and some irrigated areas mainly in Midnapore and 24 Parganas districts. The field design includes one pond refuge of about 1.5 to 2 m deep covering around 8-10% of the area and raised bunds all around. Mostly Eucalyptus trees are planted 3 to 4ft apart since this plant is preferred because of fast growing and a cash crop, in demand for construction and fuel purpose. In this type of farming, a crop after rice (mostly Jaya cross in Midnapore district) taken in *rainfed* condition during *kharif*. Capture fisheries of mostly catfish, perch and murrel types are trapped in the pond along with the water and later harvested after drying of the field. Around Rs. 1,500/- to 2,000/- are obtained by the farmers from fish in one acre unit.

Improved rice based integrated farming system

Rice –fish farming system:

Eastern India, in particular with about 5.6 m ha irrigated area and 14.6m ha rainfed lowlands of the total 26.58 m ha rice area, offers high potential for rice-fish farming system, especially in view of the resources, food habits and socio-economic needs of the people. ICAR- National Rice Research Institute, Cuttack has developed three adoptable models: 1) Rice-fish diversified farming system for semi-deep areas (upto 50 cm water depth), 2) Multi-tier rice-fish horticulture crop based farming system for deep water (upto 1 m or more water depth) and 3) Rice based integrated farming system for irrigated lowlands. These rice-based farming systems models have been validated and upscaled in farmers' fields through farmers' participatory mode (FPM).

Rice –fish diversified farming system for rainfed lowland areas

In order to improve and stabilize farm productivity and income from rainfed water logged lowland areas, national Rice Research Institute, Cuttack has developed an adoptable technology of rice-fish diversified farming system. Farm size may vary from minimum of about one acre to one hectare or more. Field design includes wide bunds (Dykes) all around, a pond refuge connected with trenches on two sides (water harvesting come fish refuge system) and guarded outlet. The approximate area allotments will be, 20 % for bunds, 13 % for pond refuge and trenches and rest 67 % for main field. The pond refuge measures 10 m wide and 1.75m deep constructed in the lower end of the field. The two side trenches of 3 m width and average 1 m depth have gentle (0.5%) bed slope towards the towards the pond refuge. Small low cost (Thatched/asbestos top) duck house and poultry unit are constructed on bunds with a floor space of about 1.5 sq.ft. for each duck and 1 sq.ft. for each poultry bird. Poultry unit maybe projected upto 50 % over the water in the pond refuge to utilize the dropping as fish food and manure in the system. In such case birds can be housed in cage of made of wire net. A small goat house is made on the bund with floor space of about 2 sq.ft for each animal.

Production Technology

Production Technology broadly involves growing of improved photo-period sensitive semi tall and tall wet season rice varieties with field tolerance to major insect pest and diseases. The suitable rice varieties are Gayatri, Sarala, CR Dhan 500, CR Dhan 505, Jalmani, Varshadhan for Orissa, Sabita, Jogen, Hanseswari for West Bengal, Sudha for Bihar, Madhukar and Jalpriya for eastern uttar Pradesh and Ranjit, Durga and Sabita for Assam. Management of insect pest in rice crop is done with the use of sex pheromone traps, light traps and botanicals (Netherin/ Nimbicidin spray at 1%). Indian major carps(Catla, Rohu , Mrigal) *Puntius sarana*, exoctic carps (common carp, silver carp silver barb) and fresh water giant prawn (*macrobrachium rosenbergii*) are grown along with the rice crop and later in the refuge after the rice crop is harvested. Fish fingerlings of 3-4" size and prawn juveniles of 2-3" size are released in a ratio of 75 % and 25 %, respectively at 10,000 per hectare of water area after sufficient water accumulation in the refuge and in the field. Fish and prawn are regularly fed at 2% of total biomass with mixture containing 95 % of oil cake +rice bran (1:1) and 5 % of fish meal. After rice, various crops like watermelon, mung sunflower, groundnut, sesame and vegetables are grown in the field with limited irrigations from the harvested rainwater. On bunds different seasonal vegetables are cultivated round the year including creepers on the raised platform, spices and pineapples are grown in shades. The fruit crops on bunds include varieties of dwarf papaya, banana T x D coconut and arecanut. Flowers like tuberose marigold etc. are also cultivated on the bunds. Both straw and oyster mushroom cultivation are done in the thatched or polythene enclose. Bee rearing is practice in 2-3 bee boxes on bunds. Agro-forestry component on the bund include short term plantation of mainly *Accacia* spp. (*A. mangium, A. auriculiformes).* Animal component constitutes improved breeds of duck, poultry birds and goats. Ducks are raised in the rice field upto the beginning of flowering stage and later in an enclose in pond refuge till the harvest of rice crop. Live *Azolla* is released @0.5 -1.0 t /ha and is maintained to supplement duck feed and also to some extent fish feed, besides nutrition to the rice crop. Fresh water pearl culture is integrated in the system using the host mussel (*Lamellidens marginalis)* which is normally available in the lowland rice ecology. Components can however, be included in the system based on location –specific requirements.

Design and Layout

Rice –fish–livestock-horticulture based farming system for rainfed lowland areas

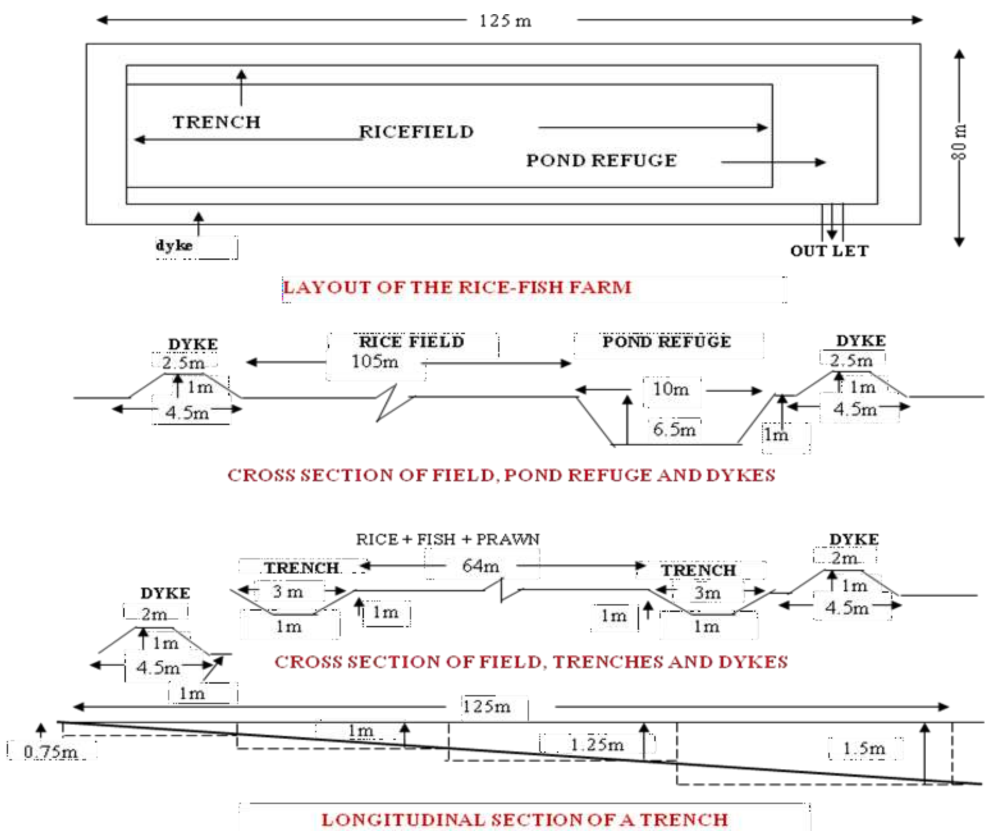


Figure 1: Layout of Rice –fish –Livestock- Horticulture based farming system for rainfed lowland areas

Productivity and economics

The rice fish farming system can annually produce around 16 to 18 t of food crops, 0.6t of fish and prawn, 0.55 t of meat, 8000-12,000 eggs besides flowers, fuel wood and animal feed as rice straw and other crop residues from one hectare of farm. The net income in the system is about Rs. 76,000 in the first year. Subsequently this increases to around 1, 30,000 in the sixth year. This system thus increases farm productivity by about fifteen times and net income by 20 folds over the traditional rice farming in rainfed lowlands. The rice fish system also generates additional farm employment of around 250 – 300 man-days/hectare/year.

Rice-Fish-prawn-horticulture-agro-forestry based farming system for deep water

With the aim of enhancing farm productivity in deep water areas (50—100 cm water depth), a multi-tier rice-fish –prawn horticulture crops-agro-forestry based farming system model has also been developed in 0.06 hectares area at NRRI, Cuttack. The design of the system includes land shaping in the form of uplands(Tier I and tier II) covering about 15 % of field area followed by rice field area of 40% as *rainfed* lowland (tier III) and deep water (tier IV). This rice field is connected to a micro water shed cum fish refuge (pond) of 20 % area for growing of fish and prawn with the rice crop. Raised and wide bunds are made all around using 25 % of the farm area. The production technology includes growing of high yielding varieties of *rainfed* lowland rice (Gayatri, Sarala. Pooja) in tier III and deep water rice (CR Dhan 500, CR Dhan 505, Jayanti Dhan and Varshadhan) in tier IV along with the fish and prawn during wet season. Dry season crops like sweet potato, mung, sunflower, groundnut, vegetables are grown after lowland rice in tier III. Dry season rice is cultivated after the deep water rice is harvested in their IV. Harvested rain water in the pond refuge is used for irrigation of the dry season crops. Improved varieties of perennial (mango, guava, sapota) and seasonal fruit crops (Papaya, Banana, Pineapple) are grown in upland (tier I). Round the year different seasonal vegetables and tuber crops (sweet potato, elephant foot yam, yam bean, colocasia and greater yam) are cultivated in tier II (Upland). Agro-forestry (*Acacia mangium*) and plantation crops (Coconut and areca nut) are planted on the northern side of the bunds. Greater yam is grown with the support of trunk of agro forestry tree. The productivity of the system is about 8 t of rice crop/hectare, one tone of fish and prawn per hectare, 20-25 t of vegetables/ha and 8.5 to 51.7 t of tuber crops/ha. The cropping intensity in this system greatly increases to 170 % in field and 360 % in the upland.

Multi-tier rice-fish-prawn-horticulture-agro-forestry based farming system for deep water

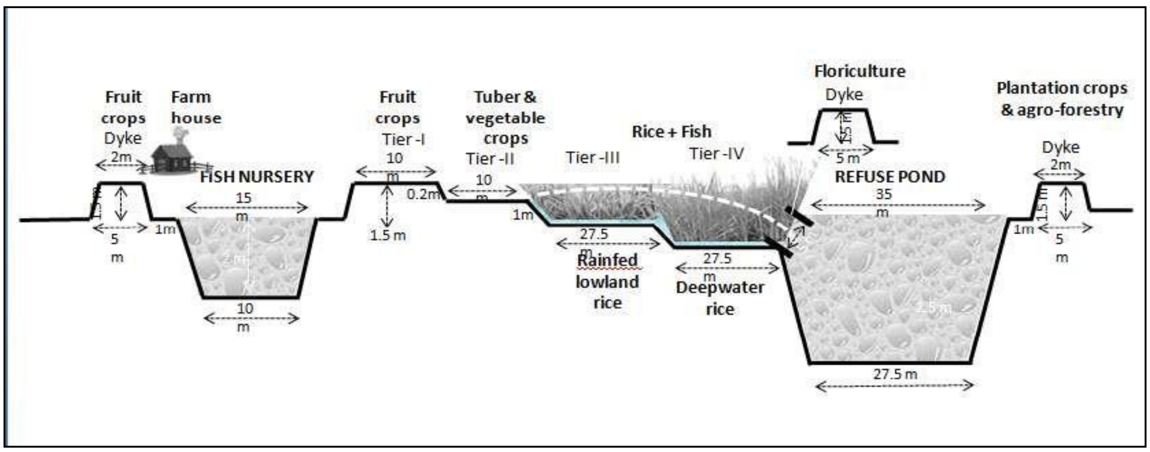


Figure 2. Transverse Section through length of a Deep water Rice-fish Farm (1 ha area)

Rice-ornamental fish culture

In order to utilize the rice ecology for value added aquaculture, the technique of breeding and culture of ornamental fishes in irrigated waterlogged rice field has been developed at NRRI, Cuttack. The rice field is renovated to make a pond refuge and raise bunds all around. Ornamental fishes like Blue gourami, Red gourami, Pearl gourami, Guppies are bred and cultured with rice (lowland varieties) crop during wet season. During the dry season, rice (Naveen) crop is grown along with ornamental fishes with irrigation. About 25,000- 6, 00000 ornamental fish/ha can be produced in the system, in addition to 3.5t and 5.0t of rice grain during wet and dry season, respectively. Such farming can be taken up by women farmers including Self Help Groups.

Rice based farming system under irrigated condition

With the objective of improvement of livelihood of small and marginal farmers, rice based integrated farming system model for irrigated areas has been developed at NRRI, Cuttack

Production Methodology

Site selection and layout: About an acre of integrated farm area is required for the farming system. 30% of the area is converted to two rice fish fields of 600 sq.m area each with a refuge of 15 % area and another 30 % area is developed into two nursery fish ponds of equal size of fingerlings rearing. The remaining 40% (1500 m2) area is utilized as bunds for growing vegetables, horticultural crops and agro-forestry.

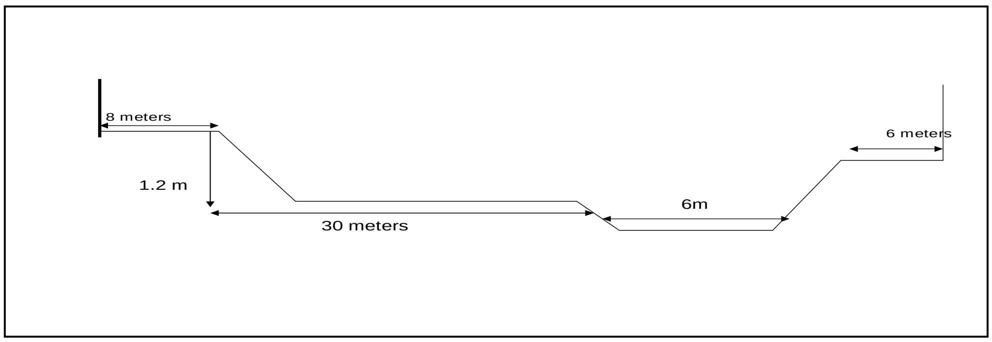


Figure 3 : Transverse section of the rice based integrated farming system for irrigated area

Rice based integrated farming system model for small and marginal farmers

Three rice crops are grown in the sequence of kharif rice (var.,Sarla/Durga) followed by rabi rice (Naveen/Satabdi) and then summer rice(Vandana/ Sidhant). Yellow stem borer pest is controlled by using sex pheromone traps or by applying1 % Nethrin/Nimbecidine. Fish culture is taken up with catla, rohu and mrigal species. The fish fingerlings are reared in the two nursery ponds and are used for culture with rice crop in the system. The excess fingerlings are sold out. On the bunds agro-forestry plants like teak, Accacia, sisoo, neem, aonla and bamboo are planted on the northern and southern bunds. Horticultural crops such as banana, papaya and arecanut are grown on the bunds. Pineapple and spices are cultivated in the shade.

Flowers like marigold. Hibiscus and Jasmine are also cultivated in the western bund in 50m^2 area. Two plants of lemon and each of guava, jackfruit, mango and litchi are also planted on the southern bund near the farm house to meet the household requirement. One poultry and one duckery unit are integrated in the system in which 40 poultry birds are raised during the dry seasons.(October to April) and 20 ducks are reared during the wet season (July to December).

Productivity and economics

Three crop of rice yields 800 to 1000 kg of grain per year. Entire produce is sufficient to cater the need of the small farm family. The straw is used for the cattle feed, mushroom base and roof of the farm house. Rest of the straw is sold to earn Rs. 500-1000 per year. Afetr two – three months of rearing, fish fry worth of Rs. 4000- 5000 is sold to the other farmers. Fish are harvested according to the need after the size becomes 250-300 g after 6 months or 0.5-1.0 kg after a year. The income from fish rearing in the system is Rs. 20,000. Pulses (mungbean, blackgram and pigeonpea) taken on the slope and bunds are just enough to meet the protein requirement of the farm family.

Crop Enterprises from the bunds

Seasonal vegetables grown on the bunds are the source income to the farm family and this practice is also labour intensive. Staggered sown vegetables on the bunds give a good return of Rs. 25-30/2.5 m^2/30 days. Brinjal and chilly are the most profitable crops as these can be taken by rationing without much labour input in an area of about 200 m^2. Cucurbits taken on the bamboo frame over the trench give a good return. When the whole bund area managed properly with regard to unit area per unit of time, it fetches a return of Rs. 8000- 10,000. From the bund area, 50-60 bunches of banana and about 20 kg of papaya plant can be harvested in a year and the produce is used for consumption as well as sale. The surplus produce gives the net return of Rs 2000 to 3000 which can meet the midterm money requirement of the farm family. An additional amount of Rs 1600 t 1800 per year can be achieved from the disposal of arecanut, aonla, bamboo after 3-4 year, which will go up to Rs. 16000 to 18000 from fifth years onwards with the disposal of 15-20 sticks of bamboo per year, 5-6 quintals of arecanut, 40-50 kg of aonla and 30-40 kg of spices (turmeric and ginger)/ 20 m^2. This monetary return can be utilized by the farm family for the personal needs and the purchase of farm inputs. As the tree like Teak, Sisoo, Acacia have high monetary value after 20-25 years; a farmer can expect a high return upto Rs. 1 lakh to 3.5 lakhs from the trees of farm unit. From the bird unit 40-50 kg of meat from red leghorn/ Giriraj is produced every two – three months which give a net return of Rs. 8000-10000 per year. Apart from the meat the 10-12 kg of poultry dropping is used as manure. Mushroom beds each of $2m^2$ taken on the bunds is sold at a profit of Rs. 10 per kg with the expenditure of Rs. 40 per bed. Eventhough flori-culture is not a profitable but can be used to meet the household religious activity and aesthetic requirement. The system in the subsequent years provides net earnings of Rs. 1,500-3,300 per month besides, high employment generation of 450-500 man days per year, thus restricting the migration of farm community (Sinhababu *et al.*, 2007)

References

- Behera, U.K. and Mahapatra, I.C., 1999. Income and employment generation of small and marginal farmers through integrated farming systems. *Indian Journal of Agronomy*. 44(3): 431-439.
- Behera, U.K. , Jha, K. P. and Mahapatra, I.C. 2004 Integrated management of available resources of the small and marginal farmers for generation of income and employment in eastern India. *Crop Research* 27(1): 83-89
- Dehadrai, P.V.1992. Opportunities for women in rice-fish culture, p. 367- 372. *In* C. R. Dela Cruz, C. Lightfoot, B.A Coastal- Pierce, V. R. Carangal and M.P. Bimbao (eds). Rice-fish and development in Asia ICLARM Conf Proc 24, 457
- Ghosh-1992. Rice fish-farming development in India: Past, present and future.p. 27- 43. In CRdeala Cruz, CLightfoot, BACosata- Pierce, VR Carangal and MPBIMbao (eds.). Rice-fish research and development m Asia -ICLARM Conf. Proc. 24, 457 p
- Lightfoot, C. 1998. Integration of aquaculture and agriculture: a route to sustainable farming system. Naga. The ICLARM Quaterly 13(1): 9 -12.
- Pullin, R. S. V.1998. Aquaculture, integrated resources management and the environment. In: Mathias, J. A. Charles, A. T. Baotong, H. (Eds), Integrated Fish farming. Proceedings of a workshop on Integrated Fish Farming, 11-15

- Singh, K., Bohra, J.S, Singh, Y. and Singh, J.P., 2006. Development of farming system models for the north-eastern plain zone of Uttar Pradesh. *Indian Farming* 56(2):5-11
- Sinhababu, D. P., Poonam, Annie and Rao, K. S. 2007. Integrated rice based farming systems. Pp49-51. In Souvenir for Regional Agriculture Fair 2007 at Central Rice Research Institute, Cuttack.

Management of Rice Crop in Rice-Fish System

Sanjoy Saha

ICAR-National Rice Research Institute, Cuttack – 753 006, Odisha

Rice crop is generally cultivated in diverse ecologies which differ from each other in water availability and depth of standing water during growth. In India, rice is generally grown to an area of 44.4 million hectare. About 50% of total rice production comes from 4 States viz., West Bengal, Andhra Pradesh, Uttar Pradesh and Punjab while Bihar, Orissa, Tamil Nadu and Madhya Pradesh contribute about 33% of total production.

About 17.3 million hectare of rice grown area is under rainfed lowland in the country where the success of rice cultivation depends upon the monsoon rain. The rainfed ecologies (flood prone, lowland and upland) are mostly in eastern India which accounts 58% of the total rice area of the country. Farmers in these areas mostly grow mono crop of traditional rice with very low inputs and poor management due to various adverse situations such as excess water, flash flood, cyclone, drought and pests and diseases. The productivity as a result is very low (1.0 1.5 t/ha).

Rice crop in this fragile ecosystem experiences several production constraints mainly due to heterogeneous stress situations evolved in this lowland ecosystem and usual crop growth is impaired by the biotic and abiotic factors there in. The following production factors are considered harmful due to their adverse affects exerted at different crop growth periods and therefore, become the determinant to the ultimate grain yield.

Major constraints in rice production under rainfed lowland:

A. Abiotic factors:

- Unpredictable monsoon rains
- Inadequate rainfall or adequate rain with uneven distribution.
- Flash flood of different depth and duration.
- Deficit moisture stress initial /or terminal draught.

B. Biotic factors:

- Wild rice and weeds like grasses and sedges at initial stage and submerged and aquatic weeds at later stage.

- Insect pests like yellow stem borer, green leaf hopper, brown plant hopper, leaf folder, rice hispa or gall midge.
- Disease like bacterial leaf blight, sheath blight, sheath rot, blast, brown spot, false smut, tungro etc.
- Other bio-agents like nematodes, rats crabs or birds.

C. Socio-economic constraints:

- Limited resources.
- Reluctance of high investment due to insecure output.
- Risk avoidance attitude.
- Non availability of inputs at proper time.
- Lower priority compared with favorable irrigated lands.

Approach for cultivation under rainfed lowlands:

Under such situation, the productivity per unit area per unit time can be substantially enhanced by adopting suitable cropping and or farming system approach. The approach should be to investigate different farm enterprises based on the available resources i.e farming system approach.

The main aim of this approach is

- To ensure higher productivity
- To raise the income of farm family
- To generate more employment opportunities to farm families.

Scope and objective of farming system concept:

- To understand the physical and socio economic environment within which agricultural production takes place.
- To gain an understanding of the farmer in terms of his or her skills, constraints, performances and aspirations.
- To comprehend and evaluate existing important farming systems in particular the practice and performance of these systems.
- To improve the identification of problem and opportunities for change in existing farming system and these by better focus research on specific key aspects.
- To evaluate new or improved systems or system components on-farm in major production areas under normal farm conditions.

- ❖ To assist the extension, monitor the adoption and assess the benefits of improved farming systems.

Rice – fish system:

It is one of the approaches of farming system for rainfed rice ecology particularly in the eastern India where the resources, food habits and other socio-economic cultures in this part of the country are in favor of this system. The region generally receives a very good amount of rainfall due to strong activity of south west monsoon prevails during the period of June to October. This rainfall can be utilized properly by adopting an integrated rice-fish farming system model for rainfed lowland ecology of eastern India.

Components of rice-fish system:

The major components of rice-fish system are

i) Rice which generally raises in the field

ii) Fish generally grows in the pond (refuge tank) by utilizing the harvested rain water stored during monsoon season.

Other components are

- ❖ Vegetables grow both on the bunds as well as in the main field all throughout the year.
- ❖ Fruit crops on the bunds.
- ❖ Various short duration pulses like greengram, blackgram or oilseeds like sesamum, groundnut, sunflower etc. in the rice field during the winter / summer season with limited irrigation from the stored water in the refuge tank.

Agronomic management of rice crop in 'Rice – Fish' system:

I. Selection of varieties:

Non-dormant seed, unsynchronized flowering, unusual lodging are often encountered due to inappropriate varietal selection relating to that particular ecology. Semi tall or tall, photoperiod sensitive long high yielding rice varieties with stiff straw, lodging resistant and tolerance to early as well late submergence are preferable eg. Varshadhan, CR Dhan 501, CR Dhan 507, Durga, Gayatri, Sabita, Jalapriya, Jalmagna etc. depending upon the regions.

II. Land preparation:

In the medium deep or deep water lowland rice ecology, the soil is generally clay or clay loam type which needs one deep ploughing during the summer season combined with minimum tillage at the time of final land preparation. Addition of farm yard manure @ 5-10 t/ha depending upon the availability further improves the productivity of main rice field.

III. Time of sowing:

Dry seeding is mostly preferable under such situation. Sowing should be done at least 10-15 days before the start of normal monsoon rain. The pre-monsoon rains help in early establishment of the crop stand.

Transplanting is not desirable in this system but if it is required, should be finished early (before first week of July) will before water stagnation by using 35-40 days old and healthy seedlings.

IV. Stand establishment:

Crop stand suffers from inadequate seedling emergence, seedling uprooting etc., due to improper time and method, quality and quantity of seeding. This call for adopting improved stand establishment method which helps enable the young seedlings to withstand the onslaught of flooding. Seeding in rows behind plough at 20 cm apart or by drilling using seed drill or by dibbling in furrows gives a good crop stand. A seed rate of 80-90 kg/ha in case of seeding in rows or 100 kg/ha in broadcasting helps for a better crop stand.

V. Fertilizer management:

A fertilizer dose of 40 kg N and 20-30 kg each of P_2O_5 and K_2O/ha is to be applied once at the time of sowing or transplanting in deep water rice ecology or in areas where chances of early submergence is less, the 'N' fertilizer can be applied in two splits, half at the time of sowing and rest half after first weeding at 30-35 days after sowing.

VI. Weed management:

Losses due to weed account 35 – 40% of the ultimate grain yield in this fragile ecology. Integrated weed control measure comprising different indirect control measures like summer ploughing, crop rotation, introduction of fishes, Azolla etc. along with direct control measures like chemical and mechanical control measures etc. reduce the weed substantially.

i. Pre emergence application of pendimethalin at 750 g/ha can control the early flash of rasses and sedges.
ii. In areas where chances of early submergence is less mechanical weeding by operating a finger weeder (20-25 days after emergence)
iii. Operation of cono weeder/power weeder in line sown /transplanted plot at 2-3 cm water level helps to control the weeds at 30 -35 DAS/DAT
iv. Release of grass carp and common carp at later stage of rice crop helps to check the weed growth

Important observations related to weed control:

- Adoption of proper crop rotation helps in reduction of weed problem
- Rotating rice with upland crops (grain legumes) reduces weed population.
- Rice-maize systems reduce *Scirpus maritimus*.
- Rice-pulses reduce *Cyperus difformis* population.
- Grass crap / or common carp on weeds.

Fish farming and its management under rice-fish system

P.K.Sahu

Crop Production Division

ICAR-National Rice Research Institute, Cuttack-753 006

Growing fish in lowland rice field has been a common practice in most of the rice producing Asian countries. In Indian context, catching fish from low land rice field is an age-old practice.There is vast scope and potentiality of integrated rice-fish system in rural development. It not only ensures sustainable utilization of both land and water resource but also increases farm production and income. Land topography, quantity and period of water availability, water retention capacity of soil, and soil fertility are the main deciding factors for culture of fish in the rice ecosystem.

In India the three Indian major carps , viz., Catla, *Catlacatla* (Ham.), rohu, *Labeorohita* (Ham.) and mrigal, *Cirrihinusmrigala* (Ham.) are cultured alone or alongwith three other exotic carps viz. silver carp, *Hypophthalmichthys molitrix*, grass carp(*Ctenopharyngodonidella*) and common carp (*Cyprinuscarpiocommunis* L) . Besides freshwater prawn species like giant freshwater prawn *Machrobrachiumrosenbergii* and *M. malcolmsonii* are cultured along with the above carp species. In rice-fish system, all the above species can be incorporated with exception of grass carp which should be stocked cautiously for their feeding habit as they damage the tender rice plant after development of the pharyngeal teeth.

In general the fish production system comprises of two systems i.e seed rearing system and grows out culture system.

1. **Seed rearing system**

Availability of seed of desired species and size at appropriate time is considered as the most important aspect behind the success of fish culture. Rearing of the fish and prawn seed of economically important species, like Indian major carps and giant freshwater prawn is a short-term(3-4 months) process and therefore is suitable for rainfed low land condition (up to 25 cm water depth with 3-4 monthswater stagnation period. The shallow to medium deep rice ecosystem comes under this category. Because of thehigh requirement of water, long term grow out fish culture is not economical particularly in irrigated system. However, the irrigated rice ecosystem can be exploited for the short-term nursery (hatchling to fry and rearing (fry to fingerling)purpose.

Seed rearing activity can be undertaken in the bounded lowland rice field where water remains for a period of 3-4 month in a year. Rice plant being a hindrance to fish seed harvest, method of single stocking and partial harvesting can be followed in this system.

2. Grow-out culture system

Grow-out fish culture is possible in medium deep (25-30 cm water depth) and deepwater (50-100 cm) rice eco system where adequate water is available at least for 6-7 months. However, in this system construction of water harvesting structure in the form of pond refuge will ensure availability of water round the yearfor fish culture .Either of the two of the following methods can be followed for fish culture in thissystem.

i) Single stocking-single harvesting for one year

ii) Single stocking-multiple harvesting

Steps of fish production in rice-fish system

i. Construction of pond refuge and trench

The pond refuge at one end, and trenches in two sides leading to pond refuge are two be constructed before rainy season. The dykes are to be well compacted in case it is newly constructed. In existing system the silt deposited earlier has to be scrapped, both from refuge and trenches, and spread on the dykes all around.

ii. Land preparation

Minimum tillage of once in a year is the best method for land preparation which has to be accomplished before rice cultivation. One deep ploughing during March/April followed by two to three harrowing during the final land preparation makes the plot ready for rice sowing. Care should be taken for proper land leveling to ensure uniform crop establishment.

iii) Sowing of rice seed

Direct seedingthrow sowing is normally followed especially in low land and deep areas for ensuring sufficient height of rice plant by the time the plot area gets inundated with rain and run-off towithstand the water logging situation. Besides, sowing has the advantage over transplanting,as the process of puddling may lead to soil erosion and subsequent siltation in both refuge and trenches. Medium to deep water rice varieties are sown in this system. Usually line sowing, dibble seeding, skip row method of sowing is followed to provide fish passage to ease the fish movement in the rice field flooded with water.

iv) Pond Refuge Preparation

a) Liming

Soil plays important role in mineralization of organic matter and supply of nutrients to the overlaying water column. Slightly acidic to neutral soil with pH 6.5-7.0 is productive. Low soil pH always associated with low productivity and therefore proper soil correction is made by applying lime of required dose.The effectiveness of lime used for soil correction also depends on the type of lime.Liming is also done as a disinfecting agent in pond refuge with a neutralsoilpH and for correction of water pH or control of turbidity in subsequent period of culture operation.

Lime requirement for soil correction during pond refuge

Amount of lime substance required (t/ha)							
Soil pH	**Pure$CaCO^3$**	**Agril. lime**	**Calcite**	**Dolmite**	**Hydrated lime**	**Quick lime**	**Shell powder**
6.5	2.5	2.5	2.8	2.8	4.2	2.3	3.2
6.0	5.0	5.5	5.6	5.7	8.5	4.6	6.4
5.5	7.5	8.3	8.4	8.5	12.7	6.9	9.6
5.0	10.0	11.1	11.1	11.3	17.0	9.2	12.8
4.5	12.5	13.9	13.9	14.2	21.2	11.5	16.0
4.0	15.0	16.6	16.7	17.0	25.5	13.8	19.2
%Efficiency	100	90.2	89.7	88.3	58.9	108.5	78.2

Source: Jena *et al* (2009)

b) Manuring and fertilization

To increase the availability of plankton, which is preferred food for the fishes, fertilization is carried out with both organic manures and inorganic fertilizers. Manuring is done earlier than inorganic fertilization.Further, manuring is done when there is enough water in the trench. The commonly used organic manures are cow dung or poultry droppings. The manure has to be made to solution form and the supernatant is to be spread on the water surface. The different doses of manure are cow dung:10-15 t/ha/yr or poultry manure:5-7 t/ha/yr applied in 3 to 6 split doses depending on the water quality.

c) Stocking of fish seed

After 15-20 days of the manure application the fish seed are stocked in the system. The stocking density in rice-fish system is maintained at 2.5-3.0 million hatchling/ha, 0.1-0.2 million fry/ha and 5,000-10,000 fingerling/ha for nursery, rearing and grow out system, respectively. In single stocking and single harvesting grow out period for one- year period, the stocking density is maintained for 5,000-6,000 fingerlings/ha whereas the density can be increased to 5,000-10,000 fingerlings/ha for the six months crop. Fish fries are usually stocked at 20,000-30,000 fry/ha incase of single stocking and multiple harvest system.

d) Transplanting of rice

When sowing of paddy could not be done in the rice field, transplanting of seedling is done after thorough land preparation, preferably when the water level is around 5-10 cm on rice field. A dyke of 190-15 cm is raised around the rice area before puddling to avoid heavy siltation in trenches and pond refuge and also to prevent the turbid water from mixing with the pond refuge water.

e) Opening of dyke

One month after rice transplantation, the dyke around the transplanted area is opened at many places to allow fish to enter into the field. The water level in rice field is maintained at 10-15 cm deep and increased to 20-30 cm after rice tillering.

f) Feed management

The available natural fish foodorganism may not be sufficient to meet the demand when stocking density of fishis high.. In rice ecosystem, though some amount of extra natural feed is available to the fish in the form of rice insects, aquatic weeds and detritus matter, these may not be sufficient and in such case supplementary feed is provided. The most commonly used supplementary feed is a combination of oil cake (groundnut oil cake/mustard oil cake) and rice bran at 1:1 ratio. When prawn is cultured along with carps in the system, additional animal protein in the form of dried fish powder, blood meal etc. have to be periodically supplemented with the oil cake and rice bran combination.

The amount of daily ration of feed required is calculated based on the estimated biomass of the fish. Feed requirement is calculated as follows:

Quantity of feed required (Kg) = Fish biomass (Kg)X % feeding

Where, Fish Biomass = No. of fish released Survivability (%) X Average Body Weight

The daily ration of feed is given in two splits one in the morning and other in the evening. The feed should be given at same place (platform), same time and of right amount. Excess feeding may result in excess left over feed leading to degradation of water quality and increase in production cost. Therefore the provided feed has to be regularly checked for any shortage or excess, and accordingly the amount is increased or reduced.

g) Health management

Fishes are periodically sampled for checking body weight, survivability, health condition and outbreak of any diseases. Appearance of disease should be timely checked to minimize the production loss. Sometimes prophylactic treatments are advisable prior to appearance of diseases.

Freshwater prawn undergoes periodical moulting and after each shedding of exoskeleton they become weak and lethargic during the inter-moult period and become vulnerable to cannibalism and attack from predators. Therefore, some kinds of shelter in the form of broken tiles, asbestos sheet, pipes and palm leaves are provided in the refuge for their protection.

h) Harvesting

In grow out system, some fishwould have grown to table size by the time the rice crop is ready to harvest. During this period water usually recedes to the trenches and pond refuge making the harvest easy. In round the year culture, only harvestable size fishes are harvested leaving the small one for further growth.

Vermicomposting and Nutrient recycling under Integrated farming system

B S Satapathy and S K Mishra
ICAR-NRRI, Cuttack

Introduction

Vermicomposting is a biological process by which all types of organic waste like crop residues, kitchen wastes, market wastes, bio-wastes of agro based industries, livestock wastes, spent waste of mushroom and weeds are converted into value added product like vermicompost. It is a simple technology for converting partially decomposed organic wastes into organic manures with the help of earthworms. It involves breaking down of complex organic materials into nutrient rich compost by earthworm by its ingestion and digestion. In this process worms help in transforming organic waste materials into high quality manure with ample amount of macro and micro nutrients for plant growth and development. The process is very simple and can be easily executed by the farmers and farm women in their back yards. It is not only a cost effective method to convert organic waste into useful nutrient rich manure but the method is also an environmental friendly technology which can easily be adopted by the small and marginal farmers of Odisha. It is helpful in sustainable agricultural production without pollution hazard to soil, water and environment. The technology is very useful for kitchen gardens, urban horticulture and organic agriculture.

How vermicompost differ from compost?

Vermicomposting is a simple biotechnological process of compost making and differs from normal composting in several ways. It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10–32°C (not ambient temperature but temperature within the pile of moist organic material). The process is faster than composting, because the material passes through the earthworm gut and worm manure are rich in microbial activity and plant growth regulators, and fortified with pest repellence attributes.

Importance of vermicompost

▪Vermicompost is rich in plant nutrients like Potassium, Nitrate, Sodium, Calcium, Magnesium, and Chloride and have the potential for improving plant growth than Fertilizer. A comparative statement of nutrient status of vemicompst and normal garden compost are presented in table 1.

Table 1. Nutrient composition of vermicompost and garden compost.

Nutrient element	Vermicompost (%)	Garden compost (%)
Organic carbon	9.8–13.4	12.2
Nitrogen	0.51–1.61	0.8
Phosphorus	0.19–1.02	0.35
Potassium	0.15–0.73	0.48
Calcium	1.18–7.61	2.27
Magnesium	0.093–0.568	0.57
Sodium	0.058–0.158	<0.01
Zinc	0.0042–0.110	0.0012
Copper	0.0026–0.0048	0.0017
Iron	0.2050–1.3313	1.1690
Manganese	0.0105–0.2038	0.0414

▪Nutrients in vermicompost are in readily available form and are released within a month of application.

•It also contains growth promoting hormone “Auxins”, “Cytokinins” and flowering hormone “Gibberellins” and soil enzymes secreted by earth-worms thus has a positive effect on vegetative growth, stimulating shoot and root development.

•It contains some antibiotics and actinomycetes that help in increasing resistance of crop plants against pest and diseases.

•Vermicompost also has very high porosity, aeration, drainage and water holding capacity which will be helpful for maintenance of soil health. Ansari and Jaikishna 2011 reported significant improvement in the soil quality with the application of vermicompost produced from sugarcane bagasse and rice straw.

▪The fruits, flowers vegetables and other plants grown using vermi-compost are reported to have better keeping quality.

Advantages of vermicompost

• It provides efficient conversion of organic wastes/crop/animal residues.
• It is a stable and enriched soil conditioner.
• It helps in reducing population of pathogenic microbes.
• It helps in reducing the toxicity of heavy metals. Heavy metal content in the vermicompost produced from industrial waste has no adverse effects to the environment and for human health when applied as biofertilizer since its content was for below the limits set (Baker et al 2014)
• It is economically viable and environmentally safe nutrient supplement for organic food production.
• It is an easily adoptable low cost technology.

Types of earthworms:

Earthworms are small, soft, cylindrical bodied invertebrates that play a vital role in soil ecosystem maintenance. About 3600 types of earthworms are reported in the world and they are mainly divided into two types: (1) burrowing; and (2) non-burrowing.

(i) Burrowing earthworms (*Pertima elongata* and *Pertima asiatica*) are pale, 20 to 30 cm long and live for 15 years and live deep in the soil and come onto the soil surface only at night. Make holes in the soil up to a depth of 3.5 m and produce 5.6 kg casts by ingesting 90% soil and 10% organic waste.

(ii) Non- burrowing earthworms are red or purple and 10 to 15 cm long with life span of only 28 months (*Eisenia fetida* and *Eudrilus eugenae*) live in the upper layer of soil surface. Eat 10% soil and 90% organic waste materials and convert the organic waste into vermicompost faster than the burrowing earthworms. They can tolerate temperatures ranging from 0 to 40°C but the multiplication rate is more at 25 to 30°C and 40–45% moisture level in the pile.

Selection of earthworm species is one of the important criteria to produce good quality manures in specified time period. The red wiggler or tiger worm (*Eisenia fetida* or *Eisenia andrei*) are commonly used earthworm, but African Night crawlers (*Eudrilus eugeniae*) are another set of popular composters can be used for vermicomposting. The *E. fetida* earthworm species was a more efficient producer of vermicompost biomass than *E eugenae* (Singh *et al* 2008). But E eugenae is more efficient than other earthworm species like Perionyx excavatus and Lampito mauritii.

▪Important characteristics of most common red earthworm (*Eisenia foetida*): body length 3-10cm, body weight 0.4-0.6g, maturity 50-55d, conversion rate 2.0 q/1500worms/2 months, cocoon production 1 in every 3 days, incubation of cocoon 20-23days.One earthworm reaching reproductive age of about six weeks lays one egg capsule (containing 7 embryos) every 7-10 days. Three to seven worms emerge out of each capsule. Thus, the multiplication of worms under optimum growth conditions is very fast. The worm lives for about 2 years.

• For initial inoculation, farmers are advised to collect the earthworm cultures from reputed agencies or firms located in their region

Red earthworm (*Eisenia foetida*) *Eisenia andrei*

Methods of vermicomposting:

(i) Pits below the ground

Pits made for vermicomposting are 1 m deep and 1.5 m wide. The length varies as required.

(ii) Heaping above the ground

The waste material is spread on a polythene sheet placed on the ground and then covered with cattle dung. Earthworm population, biomass production and production of vermicompost are higher in heap method (51 kg) than in the pit method (40 kg).

(iii) Tanks above the ground

Different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks can be used for preparation of tanks of dimensions suitable for operations

(iv) Cement rings:

Vermicompost can also be prepared above the ground by using cement rings of size 90 cm in diameter and 30 cm in height.

(v) Commercial models

Methods of vermicompost

Several commercials models have been developed by various organizations. The points to be consider for development of the permanent structure commercial model for vermicomposting is listed below.

• A well-drained land with shades is preferred for construction of Vermicomposting unit.

•A thatched roof shed preferably open from all sides is required for making vermi beds.

•The sheds should be erected in east-west direction length wise to protect the site from direct sunlight.

•To facilitate drainage the base of the site should be raised at least 6 inches above the ground level.

• The size of the shed depends upon the quantity of waste to be treated and the availability of space.

•An area of 12 ft x12 ft would be enough for three 10ft x 3ft x 2ft (Length x Breadth x Height) vermibeds with 1 ft space in between the beds.

•The height of roof can be kept at 7-8 feet from the centre and 5-6 feet from the sides.

• Prepare the vermi beds by bricks and cement mortal keeping the bottom of the bed without plastering.

•A water channel should be made around the top of the brick wall to deter ants from entering the beds.

• Keep drainage outlet at lower side of bed to collect vermiwash.

Portable Rhino vermi bed method:

▪Low cost readymade portable vermicomposting beds of size 12ft x4ft x 2ft made up of Polyethylene net window with one netted outlet at the bottom of the bed (Fig 4).

▪ Rhino bed method is very easy to install and easy to carry/shift from one place to another.

▪ This method is superior than permanent brick walls methods in terms of moisture retention capacity and quality of final product produce.

Materials for vermicomposting

Crop residues like, sorghum straw and rice straw, dry leaves of crops and trees, pigeonpea stalks, groundnut husk, soybean residues, vegetable wastes, weeds before flowering, fiber from coconut trees and sugarcane trash can be converted into vermicompost. In addition, animal manures, dairy and poultry wastes, food industry wastes, municipal solid wastes, biogas sludge and bagasse from sugarcane factories also serve as good raw materials for vermicomposting.

Process of vermicomposting

• Chop the available crop residues, kitchen wastes, market wastes, bio-wastes of agro based industries, livestock wastes, weeds etc into convenient size and shade dried for few days (10-15 days)

• Put 4-6 inch layers of the shade dried organic waste materials in to the bottom of the bed and sprinkle 1-inch layer of partially decomposed cow dung over it. Over this layer another layer of organic residues is spread followed by spraying of dung slurry uniformly. This process is repeated till the spread of the organic residues 6 inch above the top of the pit. Five percent dung slurry was uniformly distributed on the top of the organic residue sufficient to wet the surface

•After partial decomposition of organic residues (attained in 10-15 days) the earthworms are released @ 1 kg (around 1000 worms) per bed, consisting of 1 ton organic residues, by making holes at the top of the bed on four corners and centre of the pit.

•The bed can finally be covered with a jute bag or mat to protect earthworms from birds and insects.

• Sprinkled water daily on the vermi beds according to the requirement and season to keep them moist (40-50%).

▪ Sprinkling of water should be stopped when 90 % bio-wastes are decomposed.

▪Normally after 45-60 days, organic refuse changes into a soft, spongy, sweet smelling; dark brown compost will be ready for collection.

•The appearance of black granular crumbly vermicompost on top of the vermi beds indicates maturity of the compost.

•The mature vermicompost is light in weight and does not emit any foul smell. The P^H of the mature vermicompost remains in neutral range.

•Harvest the vermicompost by scrapping layer wise from the top of the pit and heap under shed.

•The harvested vermicompost has to be sieved. Sieving helps in the separation of the earthworms, cocoons and eggs from the compost.

•After sieving, the compost should be shade dried for a couple of hours, packed and stored in shade.

▪As an alternate to sieving of whole amount, gather the compost in small heaps and leave under ambient conditions for a couple of hours when all the worms move down the heap in the bed . Separate upper portion of the manure and sieve the lower portion to separate the earthworms from the manure.

▪The culture in the bed contains different stages of the earthworm's life cycle, namely, cocoons, juveniles and adults. Transfer this culture to fresh partially decomposed feed material. The excess as well as big earthworms can be used for feeding fish or poultry.

▪Prepare another pile about 20 days before removing the compost and repeat the process by following the same procedure as described above

Precautions during the process

• The floor of the unit should be compact to prevent earthworms' migration into the soil.

• 15-20 day's old cow dung should be used to avoid excess heat.

• The organic wastes should be free from plastics, chemicals, pesticides and metals etc.

• Materials of animal origin such as eggshells, meat, bone, chicken droppings, etc are not suitable for preparing vermicompost.

• *Gliricidia* loppings and tobacco leaves are not suitable for rearing earthworms.

▪A mixture of tobacco waste with rabbit manure in the ratio of 1:5 was found to be lethal to the earthworms ( ).

• Aeration should be maintained for proper growth and multiplication of earthworms.

• Optimum moisture level (40-50 %) should be maintained.

• 18-25 ^{0}C temperature should be maintained for proper decomposition.

• The earthworms should be protected against birds, termites, ants and rats.

• Adequate moisture should be maintained during the process. Either stagnant water or lack of moisture could kill the earthworms.

• After completion of the process, the vermicompost should be removed from the bed at regular intervals and replaced by fresh waste materials.

Use of Vermi-compost

•With increase in awareness of organic farming in rural and urban area, the demand for vermin-compost is increasing.

•Vermi-compost can be used as a component of integrated nutrient management to reduce the use of inorganic fertilizers in agriculture.

•It can be used as soil conditioner to maintain soil health and quality.

▪Vermi-compost can be used for all crops: agricultural, horticultural, ornamental and vegetables at any stage of the crop.

▪For general field crops: Around 2–3 tonnes per hactare vermi-compost is used by mixing with seed at the time of sowing or by row application when the seedlings are 12–15 cm in height. Normal irrigation is followed.

▪For fruit trees: The amount of vermi-compost ranges from 5 to 10 kg per tree depending on the age of the plant. For efficient application, a ring (15–18 cm deep) is made around the plant. A thin layer of dry cow dung and bone meal is spread along with 2–5 kg of vermi-compost and water is sprayed on the surface after covering with soil.

▪For vegetables: Application of vermi-compost @ 1t/ha in the nursery bed produces healthy and vigorous seedlings. Use vermi-compost 0.4 to .5 kg/plant at the time of transplanting of seedlings as basal dose and subsequently apply at 45 days after planting (before irrigation).

▪For flowers: Vermi-compost is applied at 750–1000 kg per hectare

▪For vegetable and flower crops vermi-compost is applied around the base of the plant. It is then covered with soil and watered regularly.

Other products and by-products of vermiculture

Vermiwash and worm meal are two major by-products of vermicomposting.

▪Vermiwash is a liquid that is collected after the passage of water through a column of worm action and is very useful as a foliar spray. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules.

▪The liquid byproduct can be used in agriculture as fertilizer and growth promoter.

▪Fully grown worms could be separated and dried in an oven to make 'worm meal' which is a rich source of protein (70%) for use in animal feed such as poultry, fishery, pigs, pets etc.

Products of vermiculture

***Economics*:**

One vermiculture unit having 3 Nos. of vermibeds (size 12 x4 x 2 foot) can produce about 3 tons of vermicompost and a farmer can get net return of Rs18300 in 90 days (Table 2).

Table2: Economics of vermicomposting

Inputs			
Materials	Quantity	Rate (Rs.)	Amount (Rs.)
Depreciation cost of vermibed (5year lifespan) and shade	3 Nos	600.00	1800.00
Cowdung	Two tractor load	1000.00	2000.00
Organic residues	Four tractor load	500.00	2000.00
Vermiworm	3kg	400.00	1200.00
Miscellaneous items (gunny bag,packing materials etc)	Ls		500.00
Labour			
Filling of pits (4MDYS),watering(10 MDYS), harvesting (6 MDYS) and packing (4 MDYS)	30 MDYs	300.00	9000.00
Total production cost			16500.00
Output			
Vermicompost	3000kg	10.00	30000.00
Verms	12kg	400.00	4800.00
Total return			34800.00
Net profit			18300.00
Rupee return per Rupee invested			1: 2.10

Vermicomposting and nutrient recycling under IFS:

A lot of organic residues and byproducts like paddy straw, weeds, dried leaves, vegetable residues, residues of pulse and oil seed crops, banana plants and other residues of fruit crops, twigs of silvicultural crops, animal dungs, animal urines, bedding material of poultry birds, poultry dropping are available for making vermicompost as a component of integrated farming system. In a one hectare farming system model having rice in *kharif* and summer season in 0.65 ha, vegetables, fruit crops and silvicultural plants in 0.25 ha, goats (10 nos), ducks (50), poultry birds (50) can generate organic residues and byproducts of about 8-10 t per annum. By utilizing these available organic waste around 3-4 t of vermicompost can be produced in from one-hectare area under IFS. The vermicompost generated inside the system is sufficient to provide nutrient requirement of the crops grown in the system. Thus vermiculture as a component of IFS acts favors reuse of organic waste for the production of valuable organic manures like vermicompost and vermiwash which can be used for crop production. Vermiculture proved as a green technology to sustain the production by reuse and recycle principles and thus reduces the use synthetic chemicals and fertilizers for crop production.

Conclusion

Worm or vermiculture is a technique for recycling of biological wastes into a rich organic fertilizer, for producing high-protein feed for poultry and fishery. Vermicomposting is a highly environment friendly, economically viable and efficient biological process to convert partially decomposed organic matter into compost amenable for assimilation by plants. Nutrients in vermicompost are in readily available form and are released within a month of application. Vermicompost also has very high porosity, aeration, drainage and water holding capacity which will be helpful for maintenance of soil health. The process is very simple and can be easily executed by the farmers and farm women in their back yards. It can easily be adopted by the small and marginal farmers of Odisha. It is helpful in sustainable agricultural production without pollution hazard to soil, water and environment. The technology is very useful for kitchen gardens and urban horticulture. Demand for vemicompost in present scenario of crop production and availability of sufficient raw materials for vermicomposting encourages unemployed youth and farmers to take vermicomposting as enterprise to meet their livelihood.

Role of horticulture in IFS

Gobinda CH Acharya and Meenu Kumari
Central Horticultural Experiment Station
ICAR-Indian Institute of Horticultural Research, Bhubaneswar, Odisha-751 019

Horticulture crops perform a vital role in the Indian economy by generating employment, providing raw material to various food processing industries, and higher farm profitability due to higher production and export earnings from foreign exchange.

- Horticulture crops are a source of variability in farm produce and diets.
- They are a source of nutrients, vitamins, minerals, flavour, aroma, dietary fibres, etc.
- They contain health benefiting compounds and medicines.
- These crops have aesthetic value and protect the environment.
- The comparative production per unit area of horticultural crops is higher than field crops
- Fruit and plantation crops can be cultivated in places where the slope of land is uneven or undulating. Mango and cashew nut are cultivated on a large scale in hilly and hill back area of the Konkan region.
- The crops are useful for cultivation in wasteland or poor quality soil.
- Such crops are of high value, labour intensive and generate employment throughout the year.
- Horticultural produce serves as raw material for various industries, such as processing, pharmaceutical, perfumery and cosmetics, chemical, confectionery, oils and paints, etc.
- They have national and international demand and are a good source of foreign exchange.

Present status of horticultural crops in India

India's total horticulture production is estimated to increase marginally to 314.87 million tonne (mt) in the 2018-19 crop year, as per the official data of Ministry of Agriculture. An official statement said, "The total horticulture production of India is projected to be at 314.87 million tonnes that is 1.01% higher than horticulture production in 2017-18". Last year the horticulture production stood at 311.71 mt. The area under horticulture crop also went up to 25.6 million hectare from previous 25.43 million hectare.

Prospects of horticultural crops

The diverse agro-climatic conditions and rich diversity in crops and genetic resources enable India to produce a wide range of horticultural crops round the year. Horticulture sector encompasses a wide range of crops like fruits, vegetables, flowers, spices, plantation crops like coconut, beverages like tea and coffee and some medicinal and aromatic plants.

Consumption pattern of horticultural produces: it has been observed that consumption of various horticultural commodities including fruits, vegetables, mushroom are on rise, particularly in rural areas. Still the per capita consumption of fruits and vegetables is less than the nutritionally required level. Given the expected rise in the per capita income and changes in the dietary preferences, the demand for fruits and vegetables is poised to rise in times to come as well.

Export of horticultural produce: Horticultural sector accounts for about 37% of the total exports of agricultural commodities. Export of horticultural commodities from India has increased 8 times since 2001 to reach 14856 crore (nominal prices) in 2015-16.

Employment opportunities: Studies show that farmers engaged in the production of fruits and vegetables often earn higher farm incomes than farmers that are engaged in the production of cereal crops only.The horticultural industry offers a variety of jobs, both directly and indirectly. This includes nursery management, on-farm production, florist, employment in agro-chemical industries, small scale processing, marketing of fresh fruits & vegetables and processed products etc.

Importance of horticultural produces in human diet: Vegetables constitute an important component of the human diet. They are natural sources of vitamins and minerals, like calcium, phosphorus and iron, carbohydrates and proteins. Vegetables increase the palatability of food and eliminate acidity developed due to the consumption of non-vegetarian foods. They are a valuable source of roughages, have a higher digestibility coefficient and remove constipation. Similarly, fruits have been recognized as a good source of vitamins and minerals, and for their role in preventing vitamin C and vitamin A deficiencies. Consumption of fruits and vegetable per capita in India is only about 120 and 250 g/day/ person, which is less than the minimum dietary requirement of 200 and 300g/day/person. Forty per cent of the world‘s malnourished children are in India and 60 per cent of Indian women are anaemic.

Processing and value addition: On account of increased demand to processed and value added products, there is a tremendous scope for horticultural crops as they are highly remunerative for processing. Industrial uses: Horticultural crops, specifically fruits can be used for various industrial uses.

Role of Horticulture in Integrated Farming System: The preceding para highlighted the importance of horticulture to the human being. As the natural resources are sinking very fast, either horticultural based farming system or existing farming system where horticulture can be included should be given priority. Farming system is an integrated resource management strategy for obtaining economic and sustained crop and livestock production and preserving the resource base with high environmental quality. Integrated farming system, a component of farming system research, introduces a change in the farming techniques for maximum production in cropping pattern and takes of optimal utilization of resources. The farm wastes are better recycled for productive purposes in the integrated farming system. Integrated farming system includes suitable combination of agricultural crops, horticultural crops, multipurpose trees and shrubs, besides integrated agro-aquaculture (IAA). There is immense scope for the integration of fisheries and livestock under IAA. Further, the development of horticultural land use system with mixed horticultural crops including fruits, vegetables, root crops, spices and ornamentals grown under optimum management conditions can be more remunerative on long term basis with least gestation cycle.

Examples of different types of cropping/ farming system:

- Horti-silvi-pastoral system: The horti-silvi-pastoral system has great potential to provide a sustainable land use system, which would maintain an acceptable level of production of fruits, vegetables, fuel wood, timber, fodder etc. and at the same time, conserve the basic resources (mainly soil) on which production depends.
- Multi-tier/ multi-species cropping system: Cropping system like Coconut/arecanut/ perennial fruit crops + black pepper/ betel vine (vine) + Assam lemon/ banana/ papaya + ginger/ turermic/ cucurbits; where the natural resources are fully utilized. Apart from maximum utilization of natural resources, this system helps in improvement of micro-climate for different beneficial micro-organisms, employment generation and maximum yield per unit area.

- Integrated farming system- Rice based farming system which includes a combination of field crop, horticultural crops, duckery/ poultry, fish farming having higher economic return.

Major constraints for successful implementation of IFS

- Lack of scientific cultivation practices
- Lack of availability of genuine planting materials
- Lack of village seed bank
- Poor linkage between extension personnel and growers
- Lack of marketing facilities
- Lack of knowledge on post-harvest handling and processing
- Financial constraint

Future thrust

- Identification of potential areas for different horticultural crops
- Post harvest handling and processing
- Strengthening government nurseries/ govt accredited nurseries.
- Training to farmers/extension functionaries
- Exploration of organic farming
- Exploration and utilization of location-specific underutilized/ unutilized horticultural crops
- Crop diversification with new entries
- Market intelligence and facilitation of marketing of produce

Conclusion:

Any farming system can be sustainable and economically viable by appropriate planning, following Good Agricultural Practices. Development of location-specific, purpose-specific IFS with concerns for safe food and environment should be addressed. Emphasis should be given for existing native vegetation and security to local environment while developing Integrated Farming System.

Integration of tuber crops under IFS

M. Nedunchezhiyan

Regional Centre of ICAR-Central Tuber Crops Research Institute, Dumuduma, Bhubaneswar-751019, Odisha

Corresponding author email: mnedun@gmail.com

Tuber crops are rich source of energy and carbohydrates although each of them also provides other important nutrients as well. Tropical tuber crops supply 28.5 kg food annually and 75 kcals energy/head/day. This amounts to 3.9% of total energy consumed by a person in a day. Tropical tuber crops include cassava (*Manihot esculenta*), sweet potato (*Ipomeas batatus*), greater yam (*Dioscorea alata*), white yam (*D. rotundata*), lesser yam (*D. esculenta*), taro (*Colocasia esculenta*), tannia (*Xanthosoma sagittifolium*), elephant foot yam (*Amorphophallus paeniifolius*), yam bean (*Pachyrrhizus erosus*), coleus *(Solenostemon rotundifolius*) etc.

Tropical tuber crops are having varied growth habit, drought and flood resistance and crop duration. Though tropical tuber crops are perennial in nature but domesticated as seasonal/ annual. This provides an opportunity for staggered harvesting as per household and market needs. Tropical tuber crops are also having great flexibility in planting and can fit into any cropping/ farming system. This is possible because the propagating material is asexual stem or vine or tuber cuttings. As the economic part is swollen roots or modified stem, photoperiod has no significant effect on yield forming factors. Thus tropical tuber crops are both thermo and photo insensitive. However, extreme high and low temperature affects the growth and yield. Tropical tuber crops grow well in marginal soil with fewer inputs where other crops usually fail to grow. They are tolerant to drought and some of them grow fast and provide a wide soil cover to prevent erosion. It also produces high amount of dry matter per unit area per unit time compared to cereals. They are most efficient in converting solar energy, for example cassava producing $250x10^3$ kcal/ ha and sweet potato $240x10^3$ kcal/ha as compared to on $76x10^3$ kcal/ha for rice, $110x10^3$ kcal/ha by wheat and $200x10^3$ kcal/ha for maize. Thus tropical tuber crops are suitable candidature to include in crop diversification programme. These crops have great flexibility in mixed cropping systems to generate additional employment and income. Crops like yam and elephant foot yam grow as intercrops in horticultural and plantation crops. Tuber crops are capable to utilize available resources more efficiently especially in partial sunlight and residual moisture (Nedunchezhiyan and Laxminarayana, 2006). Tropical tuber crops are rich in minerals and vitamins.

Sweet potato

Sweet potato (*Ipomoea batatas* L. Lam.) is cultivated through out the tropics, subtropics and warmer temperate regions. In India, sweet potato is cultivated in 0.112 million ha with the production of 1.09 million tonnes (NHB, 2013). Odisha ranks first in area (43,460 ha) and production (4,10,100 tonnes) (NHB, 2013). Sweet potato roots and tops are highly nutritious, which can be used to combate nutritional deficiencies in many parts of the developing world. The roots are primarily used as human food after boiling, frying, steaming and baking. Value added products like noodle, liquid glucose, sorbitol, manitol, yoghurt, wine, ethanol etc are also prepared from sweet potato. Apart from source of energy, roots also contain significant quantities of water soluble vitamins *i.e.,* ascorbic acid, thiamin, riboflavin and niacin. The contents of pyridoxine, folic acid and pantothenic acid may be relatively high. Raw leaves and tender tips are also excellent sources of ascorbic acid and some of the B-vitamins especially riboflavin which is deficient in many Asian diets. Orange flesh sweet potatoes contain beta carotene as high as 14 mg/100 g fresh tuber (Nedunchezhian and Ray, 2010). Regional Centre of ICAR-CTCRI, Bhubaneswar has released purple colour anthocyanin (85 mg/100 g fresh tuber) rich variety Bhu Krishna. Green tops and culled tubers are used as animal feed. Foliage is good for hay making.

Sweet potato is a short duration (100-120 days) crop can be grown during rainy season in hilly and plateau regions and post rainy season in plains with supplemental irrigation. Sweet potato can be intercropped with cereals and pulses (Nedunchezhiyan et al., 2011). Nedunchezhiyan et al. (2010a) and Nedunchezhiyan (2011) reported that strip intercropping of sweet potato and pigeonpea (1:1 ratio) increased net income and improved the soil health. Nedunchezhiyan et al. (2010b) also reported that incidence of weevil reduced when sweet potato was strip intercropped with maize. Nedunchezhiyan et al. (2004) also recommended sweet potato as an intercrop in upland rice for a contingent plan against the crop failure as well as for soil and water conservation. In Odisha, rice-fallow-sweet potato is a popular three-year rotation in uplands which minimising weed infestation and sweet potato weevil incidence, rebuilding of soil fertility status and greater rice productivity (Nedunchezhiyan et al., 2004).

In rice-based cropping system in the coastal plains of Odisha, West Bengal, Karnataka, Tamil Nadu and Andhra Pradesh, sweet potato is planted after harvest of rice to take advantage of the residual soil moisture and fertilizers (Nedunchezhiyan et al., 2004).

Sweet potato planted with minimum tillage in rice fallow required lower irrigation water than conventional method of planting (Nedunchezhiyan et al., 2012, 2013).

Cassava

Cassava (*Manihot esculenta* Crantz) is a starchy root tuber crop. It is popularly known as tapioca, produces more calories/unit area. It is grown in Asia, Africa, South America and Latin America. In India, cassava is being cultivated on an area of 0.24 m ha with a production of 6.7 m t (FAOSTAT, 2005). Cassava is an important crop in South India (Kerala, Tamil Nadu and Andhra Pradesh) and is slowly spreading to Western (Maharastra) as well as Eastern (Odisha) and Northeastern (Assam, Meghalaya and Tripura) India.

Cassava tubers are utilized primarily as human food after boiling, frying, baking or steaming. The other uses of cassava are in industry where it is used for production of starch, liquid glucose, dextrin, high fructose syrup, monosodium glutamate, alcohol and preparation of biodegradable plastics. The starch is also used in textile industries in warping and to produce ply wood. Cassava produces huge foliages. The foliage can produce up to 5 t of crude protein per hectare per year (Moore, 1976). Leaves and tubers also form an important component of animal feed and are extensively used in feed for cattle, poultry and swine. Green foliage is used for silage making. Culled tubers and thippi is used as animal feed as well as fuel in starch industries.

Cassava is a long duration crop. In Odisha, it is grown in Koraput, Rayagada and Gajapati districts where monsoon rain is for 4 months (June-September) and residual moisture is available for 2 months (Ocotber-November) due to cyclonic depression. Usually it is grown as sole crop. Maize and pigeonpea can also be intercropped with cassava for higher returns and soil health.

Greater yam

Greater yam (*Dioscorea alata*) is grown throughout the tropics and sub-tropics, where rainfall is sufficient for their growth. In India, though yam is cultivated in all most all the state in homestead gardens. It is a most common crop in tribal belts. Greater yam is commercially cultivated in certain specific locations in Andhra Pradesh, Bihar, Gujarat, Kerala, Odisha, Madhya Pradesh, Tamil Nadu and Rajasthan.

Normally greater yam tubers are consumed as boiled, baked or fried vegetables. In West Africa it is mostly eaten as stiff glutinous dough called ‘fufu’. They contain 18-20% starch with mucilaginous substance. Extraction of starch is difficult in yams but on cooking the sticky character is lost. Greater yam also contains alkaloids, tannins and steroids which have pharmaceutical value.

Greater yam is a long duration crop and it requires staking for trailing. Maize is a suitable intercrop in greater yam (Nedunchezhiyan et al., 2006). After harvest of maize cobs, the haulm will be supporting greater yam for trailing. Greater yam is intercropped in coconut gardens.

Elephant foot yam

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) is cultivated for its edible corms in India, Philippines and Malaysia. Elephant foot yam or Suran or Jimmikand is gaining popularity because of its yield potential and culinary properties. In India, it is cultivated in Andhra Pradesh, Bihar, Gujarat, Kerala, Maharashtra, North-eastern states, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal. The starchy tuberous corm is rich in dietary fibre and ash. It is also rich in potassium, calcium, phosphorus, zinc and vitamins. The corm is consumed as vegetable after boiling, baking and frying. Young leaves are also used as vegetable after chopping and boiling. Elephant foot yam corms are also used as medicine in many preparations. They are recommended in case of piles, dysentery, asthma, swelling of lungs, vomiting, abdominal pain and as blood purifier. The paste of corms is applied externally to reduce pain in arthritis.

In wide spaced elephant foot yam, close growing pulses, turmeric and ginger were recommended as intercrops (Nedunchezhiyan and Byju, 2005; Nedunchezhiyan, 2014). Elephant foot yam also grown as intercrop in coconut gardens, mango, litchi and cashew orchards.

Taro

Taro (*Colocasia esculenta* Schott.) is most important and one of the oldest crops. Taro otherwise known as cocoyam is grown throughout the tropical and sub-tropical countries. Two types of taro – eddoe (*Colocasia esculenta* var. *antiquorum*) and dasheen (*Colocasia esculenta* var. *esculenta*) are commonly cultivated throughout India. The eddoe type is commonly called arvi and dasheen as bunda. Eddoe type is most prevalent as vegetable. In India, it is grown in all most all the states, but commercially cultivated in Andhra Pradesh, Tamil Nadu, Kerala, Orissa, Uttar Pradesh, Maharastra and Gujarat.

Taro is a tuberous vegetable crop consumed after boiling and seasoning. Tubers are used for chips production and starch making. Taro starches are used in talc along with kaoline. Young leaves and petioles are also consumed as green vegetable. Culled tubers are used as animal feed especially for pigs.

In upland ecosystem, taro is grown as sole crop as well as intercropped with maize. In low land ecosystem, it is grown as sole crop.

Yam bean

Yam bean (*Pachyrrhizus erosus* (L) Urban) popularly known as potato bean. In India it is called 'Mishrikkand' in Bihar, 'Kesaru' in Eastern Uttar Pradesh and 'Sank alu' in Orissa, West Bengal and Assam.

The starchy conical or turnip shaped fleshy tubers are eaten. High sugar content in tubers imparts sweet taste when eaten raw. The fresh tubers are used as salad and can also be made into chips. The young tubers have crisp juicy and refreshing flesh. The over matured tubers become fibrous, hence unsuitable for consumption. In China mature dried roots are reported to be used as a cooling agent for people suffering from high fever. In many countries young immature pods are used as a vegetable. The stem is tough and fibrous and is used for making fish nets in Fiji. The mature seeds have high content of alkaloids and insecticidal properties. In many developed countries the tubers are processed, canned and many sweet preparations are made.

Yam bean is propagated through sexually developed seed. Generally it is cultivated as sole crop. Maize is intercropped in yam bean to provide staking support apart from additional yield. Yam bean also intercropped in sweet potato fields to reduce sweet potato weevil incidence.

Tuber crops based integrated farming system

During the year 2014-15, the participatory research on Tuber crops based integrated farming system (0.4 ha model) under upland ecosystem was conducted in Khanjuguda (village), Chakapada (Block), Kandhamal (District), Odisha state by the Regional Centre of ICAR-CTCRI, Bhubaneswar under AICRPTC-Tribal Sub Plan. Tuber crops based integrated farming system (0.4 ha) was laid out in 52 tribal researcher fields. The components of tuber crops based integrated farming system and their area of cultivation were given in the Table 1. Sole rice cultivation 0.4 ha was laid out in four tribal researcher fields as a check. Land preparation for sowing/ planting crop components was initiated as soon as pre-monsoon rain received. Farm yard manure 10 t/ha was applied at last plough and incorporated. Sowing/ planting were carrying out June months onwards. Rice was transplanted with 22-25 days old seedling raised in nursery. The spacing adopted was 25 x 15 cm. Ragi was also raised in nursery and transplanted 20 days old seedling at 25 x 15 cm spacing. Maize and red gram were sown at 60 x 30 cm spacing. Tuber crops were planted in ridge and furrow system. Sweet potato, yam bean, greater yam, elephant foot yam, taro and cassava were planted at 60 x 20, 60 x 30, 90 x 90, 90 x 90, 60 x 30, 75 x 75 cm spacing respectively. Vegetable crops were sown at recommended spacing. Weeding was carried out as and when required. Greater yam, elephant foot yam and taro mulched with dried leaves and paddy straw immediately after planting. 'Handi Khata' was sprayed 30 days after planting of tuber and vegetable crops as a prophylactic measure against pests and diseases. It act as repellent against pests. It reduces root and tuber rot diseases and nematode infection. It also acts as growth enhancer.

Broken rice and maize kernels and chopped culled tubers were fed to poultry birds However, during day time poultry birds were scavenging in backyards. The poultry manures collected from the sheds were composted and then applied to crops.

The crops as soon as matured were harvested regularly. Fruits of vegetable crops were plucked as soon matured. Eggs of poultry bird collected regularly. Meat yield of poultry birds recorded at the end of a year. Yields of crops and poultry for the 52 tuber crops based integrated farming system were collected independently; averaged it and presented in the Table 1. Similarly the sole rice crop cultivation data also collected from 4 tribal farmers field independently and averaged it. In tuber crops based integrated farming system, among the crops, sweet potato recorded tuber yield of 516 kg, yam bean tuber yield of 514 kg, rice 381 kg and greater yam tuber yield of 376 kg. The Vanaraja poultry bird attained live weight 35 kg and produced 400 eggs. The tuber crops based integrated farming system registered gross and net returns of Rs 52170 and Rs 34770, respectively. The B: C ratio of 3.00 was realised in the tuber crops based integrated farming system. Lenka et al. (2013) also reported greater income when tuber crops were included in the cropping system.

Table 1. Integrated farming system components yield and economics (0.4 ha)

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	B: C ratio	Employment generation (man-days)
1	Rice	0.20	381	11430	5500	5930	2.08	44
2	Maize	0.03	62	930	350	580	2.66	3
3	Ragi	0.02	25	500	250	250	2.00	2
4	Redgram	0.02	14	700	250	450	2.80	2

5	Sweet potato	0.04	516	5160	1400	3760	3.69	6
6	Yam bean	0.03	514	7710	1200	6510	6.43	6
7	Greater yam	0.02	376	7520	2000	5520	3.76	10
8	Taro	0.02	305	6100	1400	4700	4.36	6
9	Elephant foot yam	0.008	115	2300	700	1600	3.29	3
10	Cassava	0.002	38	380	250	130	1.52	2
11	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.01	237	4740	1500	3240	3.16	12
12	Backyard poultry	20 (nos.)	35	3500	1200	2300	2.92	8
		Egg	400	1200	500	700	2.40	2
Total		0.4	2630	52170	17400	34770	3.00	106

Check/Control

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	Employment generation (man-days)
1	Rice	0.4	800	24000	11000	13000	88

Rice Rs 30/kg; Maize Rs 15/kg; Ragi Rs 20/kg; Redgram Rs 50/kg; Sweet potato Rs 10/kg; Yam bean Rs 15/kg; Greater yam Rs 20/kg; Taro Rs 20/kg; Elephant foot yam Rs 20/kg; Cassava Rs 10/kg, Vegetables Rs 20/kg; Poultry live bird Rs 100/kg; egg Rs 3

The gross and net return from sole rice cultivation was Rs 24000 and Rs 13000, respectively. The employment generated in tuber crops based integrated farming system was 106 man-days (Table 1), whereas sole rice cultivation recorded 88 man-days. Inclusion of tuber crops in the integrated farming system spread the employment opportunities through out the year. Pali et al. (2012) also reported generation of additional 12 days employment in 0.4 ha pond based integrated farming system. Inclusion of long duration tuber crops like grater yam, elephant foot yam and taro spread the labour requirement for a longer period. Thus dependency on out-side labours was much less in tuber crops based integrated farming system. Whereas in rice, ragi and maize cultivation the total employment generated was spread within seven months (June-December) only.

Part of the yields of grains, tuber crops, vegetables, egg and meat were sold for cash income. By marketing of vegetables, tubers, egg and meat a farmer is able to earn sufficient money to meet out daily needs. Further, the availability of tubers for household consumption for long period due to high storability along with other vegetables, rice, egg and meat enhanced food and nutritional security of the household. The cash income improved the livelihoods of the farm families and celebration of festivals.

Conclusion

Tropical tuber crops are most suitable under climate change. Its great flexibility in planting and harvesting is the most spectacular feature and fitting into any cropping/ farming system. Tropical tuber crops give assured returns in spite of natural calamities like drought and floods because the economic part is asexually formed and remains under ground. The productivity of tuber crops is quite high compared to cereals and pulses and doubles the farmers income. Many of the research findings concluded that tuber crops based integrated farming system increased farmers income 2-3 times

References

FAOSTAT, 2005. Area, production and productivity of root and tuber crops. FAO Statistics 2005. Available HTTP: http://apps.fao.org.

Moore, C.P. 1976. So del torraje de yucca en la alimentacion de ruminantes. In: memoria del seminario Internacional de Ganaderia Tropical, Acapulco, Guerreso Mexico 8-12, March 1978. Pp. 47-63.

Nedunchezhiyan, M. 2011. Evaluation of sweet potato (*Ipomoea batatas*) based strip intercropping systems for yield, competition indices and nutrient uptake. *Indian Journal of Agronomy*, 56 (2): 98-103.

Nedunchezhiyan, M. 2014. Production potential of intercropping spices in elephant foot yam (*Amorphophallus paeoniifolius*). *Indian Journal of Agronomy*, 59 (4): 596-601.

Nedunchezhiyan, M. and Byju, G. 2005. Productivity potential and economics of elephant foot yam based cropping system. *Journal of Root Crops*, 31 (1): 34-39.

Nedunchezhiyan, M. and Laxminarayana, K. 2006. Tuber crops based cropping system in eastern India. Kisan World, 45-46.

Nedunchezhiyan, M. and Ray. R.C. 2010. Sweet potato growth, development production and utilization: overview. In: Sweet potato: post harvest aspects in food, Ray, R.C. and Tomlins, K.I. (Eds.). Nova science Publishers Inc., New York, pp. 1-26.

Nedunchezhiyan, M., Byju, G. and Naskar, S.K. 2006. Effect of intercrops and planting pattern on incidence of anthracnose, productivity potential and economics of greater yam (*Dioscorea alata*). *The Indian Journal of Agricultural Sciences,* 76 (2): 132-134.

Nedunchezhiyan, M., Byju, G. and Ray, R.C. 2012. Effect of tillage, irrigation and nutrient levels on growth and yield of sweet potato in rice fallow. *ISRN Agronomy 2012*: 1-13, Article ID 291285, doi: 10.5402/2012/291285.

Nedunchezhiyan, M., Laxminarayana, K., Rajasekhara Rao, K. and Satapathy, B.S. 2011. Sweet potato (*Ipomoea batatas* L.)–based strip intercropping: I. Interspecific interactions and yield advantage. *Acta Agronomica Hungarica*, 59 (2): 137-147.

Nedunchezhiyan, M., Rajasekhara Rao, K. and Satapathy, B.S. 2010a. Productivity potential, biological efficiency and economics of sweet potato (*Ipomoea batatas*) – based strip intercropping systems in rainfed Alfisols. *Indian Journal of Agricultural Sciences*, 80 (4): 327-330.

Nedunchezhiyan, M., Rajasekhara Rao, K., Laxminarayana, K. and Satapathy, B.S. 2010b. Effect of strip cropping involving sweet potato (*Ipomoea batatas* L.) on soil moisture conservation, weevil infestation and crop productivity. *Journal of Root Crops,* 36 (1): 53-58.

Nedunchezhiyan, M., Sinhababu, D.P. and Sahu, P.K. 2013. Effect of soil amendments and irrigation regimes on minimum tillage planted sweet potato (*Ipomoea batatas*) in rice (*Oryza sativa*) fallows under lowland conditions. *Indian Journal of Agricultural Sciences,* 84 (3): 371–375.

Nedunchezhiyan, M., Sivakumar, P.S., Naskar, S.K. and Misra, R.S. 2004. Growth potential of sweet potato in rice based cropping system. In: *National Symposium on Recent Advances in Rice-based Farming Systems*, 17-19 November 2004, Abstracts, pp. 86.

NHB. 2013. National Horticultural Board. www.nhb.org.

Pali, G.P., Sahu B., Savu, R.M., Chaudhary, J.L., Sharma, G.K. and Thakur, A.K. 2012. Integrated farming system models for sustainable productivity and income of small and marginal rainfed rice farmers of Chhattisgarh. Extended Summaries Vol 3, 3rd International Agronomy congress, Nov. 26-30, 2012, New Delhi, India pp 943-944.

INTEGRATED DUCK FARMING

S C Giri and A. Poonam

Regional Centre, ICAR-Central Avian Research Institute

Bhubaneswar – 751003

Now-a days agricultural practice is no more confined to single cropping pattern. Farmer always tries to harvest more from a unit land by introducing varieties of crops which always gives more and continued income throughout the year. Therefore the concept of integrated agricultural practice came to existence.

What is integrated agricultural practice?

When two or more agricultural practices tried combindly in one field with each crop helps other for growth and production: ultimately resulting higher income to farmer is termed as integrated agricultural practice. The crops selected for integration need to be synergistic to each other. In integrated agricultural practice always there is one major crop where as other crops are supplementary to the major one that causes continuous income source for the farmer.

Benefits of Integrated agricultural practice:

- Better and efficient use of land for production.
- More yields and more income from unit land area.
- Cost of expenditure for each crop is reduced as one crop supplements something for growth and production of other crop.
- Increase in soil and water nutrient for subsequent crops.
- Croping intensity is more.
- Less labor intensive.
- Availability of more food product to farmer from a piece of land for livelihood.
- Involvement of farmer’s family is more in such type of practices.
- Farmer will get income throughout the year as the harvesting time varies with crops.
- Return from one crop may help for investment in other crop; thus the farmer may not need loan for investment.
- Loss in one crop due to calamity may be avoided to certain extent.

Poultry as a component in integrated agricultural practice:

Livestock as a whole plays a vital role in integrated agriculture with crop and aquaculture. But poultry (chicken and duck) has limited sphere. Even chicken may not be suitable as a better component for such practices as the birds causes much lossess to horticultural crops in many times. Again chicken being scavenges on land causes social conflict in villages. But ducks on the other hand can be well corporate in to various components like rice, horticulture and aquaculture. Even duck production for rural farmers have a lot of benefits which is enlisted.

Advantages of duck farming for rural farmers:

- Easy source of protein for nutritional security of the farmer family.
- Ducks utilise feeding source from both land & water
- It is less labour intensive
- Less infrastructure and least capital investment required for duck farming.
- It gives constant source of income (though little)
- There is always high demand of egg and meat in the market.
- Ducks withstand natural calamities
- R.D. & Bird flue is not found in ducks as it frequently observed in chicken production.
- Less social conflict
- Can be integrated with other crops (duck-fish-rice)
- Friendly for women participation

There are various models developed with duck as an important component and implemented successfully in farmer's field.

1. **"Fish-Duck integrated CARI Model" :**

Duck is water fowl whose natural habitat in water bodies. Keeping the birds in confinement and providing commercial feed may not be economically sustainable always especially for the small and marginal farmers. But rearing with extensive management in village ponds or with semi-intensive management is undoubtedly profitable and viable for rural farmers.

In this model one hundred day old ducklings are brooded under light with commercial duck starter mash for one months of age. The growing ducks are introduced to the fish pond by 5-6th wks of age. They will partially collect their feeding source from ponds (weeds, snails, mollusks etc). Later on fish fingerlings are introduced to which ducks cannot catch. Both the components simultaneously grow in same pond for 5-6 months. A low-cost duck shed need to be constructed in the bank of the pond for night shelter of the birds. The kitchen wastes, leftover food of the houses, vegetable peels, fish scales and offal are offered to the birds as supplementary feeding source. Their co-existance helps both in various ways. The ducks used to initiate laying eggs by 5^{th} month of age and continued atleast for one year. During this period the fishes (carps) attain marketable size. Little feed for fish is offered depending on the stocking density. The benefits of this model are:

- ❖ The droppings of the ducks help in growth of planktons as it is rich in nitrogen and best used as the feeding source for fishes.
- ❖ Due to swimming of ducks, there will be no precipitation on surface of water. (Precipitation prevents proper oxygenation in water.)
- ❖ Ducks help in maintaining proper and uniform water temperature of pond. In a still water body, the surface water get heated to certain extent and the surface feeder (fish) move to middle / bottom causing disturbances in ecology.
- ❖ Ducks used to consume weeds and predator fishes that keeps the pond clean.

This model is well adopted by farmers in village condition. However, there is limitation of number of ducks which need not cross 100 per hecter. More no of ducks causes degradation of water quality and shortage of feed for them is usually observed.

Duck-Fish integrated practice

2. "Rice-Fish-Duck Integrated Model"

In this model rice is the major component followed by fish and duck. Ten feet width and 1.5 ft depth water retaining space is created in the internal periphery of the rice field where water will retain always. Centre space is occupied by rice. Land preparation for rice cultivation and brooding of ducks are continued simultaneously. 15-20 days after plantation of saplings, the growing ducks and fish fingerlings are introduced after which there will be no application of pesticides. All three components will grow simultaneously with their available feeding source form the same land. Almost 3-4 months they will co-exist in same environment. Ducks have the low cost house nearby as night shelter. Ducks are avoided to field during flowering stage of rice..After 4 months the ducks will initiate laying when rice are about to harvest and fishes must be attaining 0.6 - 0.8 kg body wt. However, as the water will retain for few more days in the deeper periphery, the fishes and ducks can be reared in the field even after the rice harvest. This model is more profitable and viable in coastal states of the country. The benefits of this model:

- More income per unit land.
- Less chemical fertilizer is required as droppings of dicks are rich in nitrogen
- Sufficient plankton growth will be there for feeding of fishes.
- Control of stem-burrower is there as the insect is swallowed by ducks.
- Ducks will get sufficient feeding from the field.
- The limitation of the model is the optimum no of ducks per hecter is 100 nos.

Management of ducks for egg production

Breeds/ varieties of Ducks

1. **Khaki Campbell**: Brown colours, small size birds but are good layer (more than 300 eggs per bird).
2. **White Pekin**: White in colour, comparatively large size birds, fast growing, poor laying quality but good met quality.

3. **Muscovy/ Moti**: Black and white plumage, large birds require less water, wild type, poor layer but highly disease resistant and known for quality meat.
4. **Crossed Native Ducks**: They are the product of crossed between Khaki Campbell and Indigenous ducks. They are multi-coloured plumage, medium in size, good layers (240-280 eggs), hardy, good foragers and best suited for Indian coastal climates.

Khaki Campbell White pekin Muscovy (Moti) Native ducks

Brooding:

- Day old ducklings are to be kept in the house where floor is to be covered gunny bags which are to be changed for drying in every alternate day during the brooding period.
- Clean water is to be provided four times a day in the commercially available chick drinkers or else flat trays covered with a wire net can be used for this purpose.
- Chick mash added with equal amount of water should be provided in plastic trays (one tray for 20 birds) *ad-libidum*.
- An electric ball (200 watt) to be hang at least 2feet height from the floor to provide the necessary temperature during the brooding period. Chick guard are to be used to avoid moving away of ducklings from the source of light.
- A reflector may be fixed behind the ball, so that the heat and light will be spread over the area uniformly.
- Feed and water are to be provided simultaneously.
- Brooding period is normally 15 days during which normal brooding practices mentioned as above is to be practiced.

Growing stage:

- After brooding stage is over, the ducklings are to be exposed to the open space around the home with a constant watch to protect them from the predators.
- Supplementary feed (chick mash) may be given for another week till the ducklings are able to collect their feed requirement from outside. During this

period, sufficient clean water is to be provided to the birds either on plastic trough or on cement or earthen pots.

- After one month of age, ducklings are to be allowed to enter the pond but care must be taken to prevent casualty or mortality due to predators.
- At the end of the day, supplementary feeds like broken rice, wheat and kitchen wastes should be provided. It will be of great help for better growth during this period.
- Maize and ground nut oil cake should not be offered to the ducks as it is a potential source of aflatoxin to which ducks are more susceptible than chickens.

Sex differentiation in ducks:

After four month of age, sex of the ducks prominently marked by the following characters:

1. Female ducks sounds more as compare to its male counterpart.
2. Feathers on the tail prominently curled in male ducks.
3. Sometimes a ring like colouration in the neck is found in the male ducks especially in Khaki Campbell and Crossed Native ducks.
4. Male birds (drake) are comparatively heavier than female (ducks).

Laying behavior of Ducks:

- Under free range, ducks (Khaki Campbell/ Crossed native) usually lay eggs around 20 weeks of age. if the feeding sources from pond is good enough, If sufficient feed is available they may start laying even before 20 weeks of age.
- Ducks usually lay eggs during the late night to early morning, which helps to collect all the eggs from the shed.
- Sand on the floor prevents breakage of eggs. Earthen pots with little rice husk inside may be kept in the corner of the duck house, so that ducks will lay eggs inside the pots which will help to avoid breakage and dirty eggs.
- During laying period, ducks need more feed along with Calcium, Phosphorous. Little supplementation of minerals helps for better production.
- Equal amount of broken rice, wheat and oil cakes added with little Salt and Calcium powder should be offered into the female ducks during afternoon, so that they may lay more eggs for a longer period.

- Ponds rich in aquatic weeds snail, water hyacinth and other water plants like azola etc. nourish the ducks in a better way and there is little need to provide supplementary feed to the ducks.
- The average sizes of the eggs are above 60gms which fetch higher market price for the farmers than chicken eggs.

Health management:

Ducks are less susceptible to disease than chickens. Sometimes change in climate for a long period and non-availability of sufficient water during summer may per-disposes for reduced productivity and poor health of the bord. Duck plague, a dreaded disease in ducks with symptoms like frequent offensive watery discharge with high fever is observed. The disease spreads sporadically and rate of mortality is quite high. However, incidence of duck plague is rare and vaccination of the birds against duck this disease at the age of 3-4 month will protect against the disease. Aflatoxin (a fungus) in feed seriously affects the health and productivity of ducks. Paralytic symptom with poor health condition is observed during early period. But a feeding of the birds from natural source like ponds, the incidence of *Afflatoxicosis* is quite meagre.

Duck production is one of the best animal husbandry practice for women in villages. Due to their high productivity, less disease and better adaptability this practice gaining much popularity in the country especially in coastal states and tribal belts. More attention need to be paid by government and NGOs for availability of critical inputs like day old ducklings, feed and vaccination so that a significant rise in the egg production will be made in future days to come which will cause a revolution in egg production for eradication of mal nutrition among infants and women.

Integration of Livestock in Integrated Farming System

Ranjan Kumar Mohanta
Subject Matter Specialist (Animal Science)
Krishi Vigyan Kendra, ICAR-National Rice Research Institute, Cuttack

Suitable integration of crop, vegetable, fruit, mushroom, bee, livestock and poultry depending upon the farming system, land resource and other available resources in the integrated farming system leads to its success. Livestock i.e. cattle, buffalo, sheep and goat play a major role in stabilizing an integrated farming system by utilizing the agricultural wastes and less important materials and convert them to high value products like milk, meat, wool, dung etc. Besides the profit margin is more than crop sector and they become part of our lives.

Integration of small ruminant in Integrated farming system

Sheep and goat are being considered as ATM of farmers as they are being sold as and when money is needed. They are also exploited commercially as the investment is very minimal due to low cost of shed and animals. The feed and fodder cost is also low due to their dependence on variety of leaves and almost no competition with humans for feed. Even a small child can easily handle them. The financial return is also high and time required for realizing the profit is very less.

Breeds and General Management

Out of several types of goat and sheep breeds, locally available Black Bengal goat and Kendrapada sheep are prolific breeders with twinning and triplets are common. The navels are dipped in iodine to protect them from infection. Kids are weaned at three months, but castration should be done before 12 weeks for optimization of growth and removing the musky odour of rams or bucks. In addition, if the hooves are growing or the animals are not doing enough walking then hoof trimming should be done in every 6-8 weeks. The average gestation period is between 145- 155 days. So in two years, we can get three-four lambs and 6-8 kids normally. In every 2-3 years, the bucks or rams of an area should be interchanged with the bucks or rams to prevent slow growth by inbreeding depression. As they are seasonal breeders and mostly breed during September to December, they may be given flushing ration and special care must be taken. The identification marks may be given in the form of tattooing, neck chains, branding or ear notching.

	
Black Bengal goat	Kendrapada Sheep

Housing

Simple shed constructed with low cost materials with proper ventilation/air movement and mud flooring in east-west orientation is sufficient for getting its optimum production efficiency. The sheds should be constructed in an elevated area to prevent water stagnation in high rainfall areas. Floors of the shed should be firm and should have the capacity to absorb water. The floors should be constructed in such a way that it should be easily cleaned. If the animals are kept in open area, make a covered area to be used for sheltering during night and adverse climatic conditions. Separate structures are required for sick animals and young ones. Regular cleaning of house and fortnightly application of lime on floor is essential for disinfection of shed. The manure pit should be constructed at a distance from the shed. The surrounding of shed must be free from weeds and stagnant water.

Feeding

The new-born kid/ lamb should be offered sufficient amount of colostrum immediately after birth and then sufficient of milk. The young ones will nibble after 15 days and slowly eat green roughages along with milk. At one month of age the young ones should be provided with the concentrate mixture with 22% CP upto 3 months of age. As in younger stage, their stomach is like us and they grow at a faster rate if fed adequately. After that adequate grazing in the pasture and 50-200 g/animal/day concentrate mixture depending upon the age, pregnancy and lactation is given. Dry fodder is also given during night in summer months and during rainy days.

In last one month of pregnancy, the fetal growth is the maximum and lack of enough energy in the feed can cause pregnancy toxaemia in ewes. So, in addition to grazing, these pregnant animals should be fed with concentrate mixture @ 150–250 g/animal/day till 3-4 days before parturition. It is usually preferable to feed lightly on the day of parturition, but allow plenty of clean, cool water. Similarly, during breeding time concentrate must be fed for optimizing reproduction. Separate feeders and water troughs should be placed for concentrate feeds, green fodders and water. Feeding and watering should follow the same schedule, everyday. If feed is changed suddenly animal may not feed properly, so introduce new feed slowly and in small amounts till animal gets used to it. Leaves or branches should be kept in hanging condition for goats as they are browsers. Clean and wholesome drinking water should be available in sufficient quantity. If not fed any concentrate mixture then supplement with 5-10 g of mineral-vitamin mixture particularly before mating, last part of pregnancy and after kidding for 2-3 months. Fodder trees can be grown around the shed or at the fences, which act as a source of feed for the growing animals.

Parasites and Disease Management

Parasites are one of most important constraints which decrease the body weight gain and productivity of animals. So, the small ruminants should be dewormed on a regular basis, i.e. every 8-12 weeks. The animals should be taken for grazing after dew has been gone and sunlight is strong, i.e. after 10 AM.

In sheep and goat, the major losses in productivity and lives are due to diseases like enterotoxaemia (sudden death in healthy animals after returning from grazing), peste des petits ruminants (PPR with signs of fever, loss of appetite, stomatitis, gastroenteritis, profuse serous nasal discharge accompanied by sneezing, coughing and pneumonitis), neonatal death, foot and mouth disease and pox (with pox lesions throughout the skin and mucous membranes) in addition to other diseases. However, these diseases have high mortality, especially the first two diseases. Once started, there is not much one can do. The loss is very high. So vaccinating the animals should be done to get the maximum from small ruminant production. Weak, debilitated, pregnant and infested animals should not be vaccinated. They should be dewormed prior to vaccination. Booster dose must be given whenever available as it strengthens the protection from disease. Generally vaccination against enterotoxaemia, PPR and pox are given after 4 months of age for annual protection; but FMD vaccine has to be given twice a year. Vaccination is a must for endemic regions which saves many lives and protects from economic loss. In case of disease outbreak, plan for cleaning and disinfecting house and equipments is needed. In farms, detailed record keeping of animals' health is essential. Neonatal mortality can be prevented by improving the level of nutrition in advanced stages of pregnancy (last 6 weeks), ensuring hygienic condition in the kidding sheds, providing proper bedding, and ensuring early feeding of colostrums. If foot dips containing disinfectants are provided at the entry of the farm with proper hygiene and sanitation, diseases can be minimized.

Small ruminant production economics is very much encouraging if housing, vaccination and feeding are given proper attention and can provide dividends. As an enterprise, its investment is less and return is good in quick time.

Integration of dairy in Integrated farming system

Dairy is an important component of integrated farming system. Milk is an important part of our daily diet and is considered as a complete food. It is considered to be best food for child, sick, old and debilitated persons. Milk products demands are increasing day by day due to their nutritional importance of daily life. Dung is being used as fuel in terms of dry fuel or gobar gas in addition to its use as vermicompost or fertilizer for crop production. Besides economic use, cows and bullocks are considered as sacred and part of family life. The financial return is also high and time required for realizing the profit is very less.

Breeds and General Management

Out of several types of cattle breeds, our local breeds are either upgraded with other Indian/Deshi breeds like Red Sindhi, Gir, Tharparkar and Sahiwal or cross-bred with exotic breeds like Holstein-Friesian and Jersey. If feed are plentily available go for crossbreeding, otherwise upgrading is best as they are more suitable for Indian condition and less susceptible to diseases. The average gestation period is about 283 days. So in a year, we can normally expect a calf. Adequate dry period of at least 60-90 days should be kept before calving. It helps in proper growth of fetus and helps in keeping the milk yield optimal is subsequent lactation.

AI should be preferred for breeding than local bulls. Otherwise the calves will be low yielders and may suffer from many genetic diseases. The pregnant cow should be separated from other animals before child birth. Immediately after birth, the cow licks the calf. If not, remove any mucous or phlegm from the calf's nose and mouth which helps in stimulating breathing and circulation. Then rub and dry the calf with a dry cloth or gunny bag. The calves after birth should be cared well, naval cord should be tied about 2-5 cm away from the body and cut 1 cm below the ligature by new blade or sterilized knife and navels are dipped in tincture iodine or boric acid or any antibiotic to protect them from infection.

Calves should be identified by ear tattooing at birth or after by neck chains, branding or ear notching. They should be dehorned within 7-10 days after birth with red hot iron or caustic potash stick or electrical method for easy handling. The calves should be housed in groups in pens and after 6 months males and females may be separated. Calf should be kept in clean and warm place with dry and soft bedding material to avoid pneumonia. Deworming and proper management is required to prevent Diarrhea (calf scour) which causes mortality in calves. If there is any extra teat other than regular 4, remove at 1-2 months of age. The males should be castrated at 8-9 weeks of age and weaned at three months.

Grooming of the cows and washing of the buffaloes before milking help in clean milk production. Daily brushing will remove loose hair and dirt from the coat. Regularity in milking is essential for getting optimal amount of milk as increase of milk in the udder will reduce further secretion of milk. Before milking udder and teats must be cleaned properly using potassium permanganate or luke warm water and washed by a clean towel for getting rid of extra water in the udder or teats to get clean milk. Milking should be done with whole hand not with fingers except in case of very small teats where whole hand milking cannot be done. Rapid, continuous, dry hand milking should be practiced and should be completed within 7-8 minutes without undue jerking of teats.

Record keeping: Every animal should be identified and particulars pertaining to milk, fat %, feed taken, breeding, drying and calving dates should be recorded. The body weight of calves should be taken after birth and then at regular intervals to know the growth rate. All information about breeding, feeding, infection and disease information, deworming medicines and dates, vaccines administered etc. should be recorded.

Housing

Cattle housing should be constructed on the infertile uplands to prevent water stagnation in high rainfall areas. As described in sheep and goat section, the shed may be simple but with proper ventilation/air movement. Floors of the shed should be firm, sloppy, free from pits or stony edges and should have the capacity to absorb water. The floors should be sloppy with a drainage system to immediately drain urine after urination and it should be easily cleaned. The drain should fall into a pit or manure pit at a distance from the shed, otherwise parasites and insects will grow rampantly. Regular cleaning of house and fortnightly application of lime on floor is essential for disinfection of shed. The surrounding of shed must be free from weeds and stagnant water. Care should be taken to see that the animals are not affected by direct rays from sun or cold winds of winter and direct rain in rainy season.

Feeding

The new-born calf should be offered sufficient amount of colostrum immediately after birth and then sufficient of milk to get adequate maternal immunity and nutrients. After 15 days, straw and green fodder in little amount should be kept before the calf for nibbling along with milk. It will help in its rumen development. At one month of age the young ones should be provided with the concentrate mixture with 22% CP up to 3 months of age. They grow very fast in this age if offered proper feed because at this stage, their stomach is like us and they can utilize the nutrients properly by their true stomach. After that adequate grazing in the pasture and offering concentrate mixture depending upon the age, pregnancy and lactation is important. Dry fodder is must but if given in chopped form utilized properly. The heifer should be fed sufficiently to produce normal growth. They need relatively more protein than energy in the early stage. As heifers body weight is more essential than age for breeding purpose, feeding of heifer has very important role in its future production and reproduction performance.

In last one month of pregnancy, the fetal growth is the maximum and enough energy in the feed should be there. So, in addition to grazing, these pregnant animals should be fed with concentrate mixture @ 1 kg /animal/day till 2-3 days before parturition. Laxative feeds like wheat bran should be fed about 3 kg per day for about 3 - 5 days before and after calving. It is usually preferable to feed lightly on the day of parturition, but allow plenty of clean, cool water. Before delivery signs of swelling of external genetalia and swelling of udder may be observed. If there is any difficulty, provide veterinary help. After calving external genitalia and flank region should be cleaned and dried along with offering warm water. Cows generally expel the placenta within 2-4 hours after calving. Sometimes the udder will be swollen just before calving. Remove the milk partially. Similarly, during breeding time concentrate must be fed for optimizing reproduction.

Separate feeders and water troughs should be placed for concentrate feeds-green fodders and water. Feeding and watering should follow the same schedule, everyday. Concentrate mix is fed before or during milking, when as roughages after milking. This practice will avoid dust in the shed. If feed is changed suddenly animal may not feed properly, so introduce new feed slowly and in small amounts along with the old feed till animal gets used to it. Green fodder or Azolla or grasses have good amount of nutrients and help in increasing milk production if offered adequately. Clean and wholesome drinking water should be available in sufficient quantity.

Provide green fodder with hay or straw as an animal desires, so that all its maintenance requirements are met with through forage only. Provide extra concentrate @ 1 kg for every 2.5 liters of milk. Supplementation of 20-50 g of mineral-vitamin mixture and 20-30 g salt particularly before mating for one month, last 3-4 months of pregnancy and after calving for 3-4 months helps the cow and calves in many ways by improving production and reproduction traits. Fodder trees can be grown around the shed or at the fences, which act as a source of feed for the growing animals.

Parasites and Disease Management

Infestation with external or internal parasites decreases the body weight gain and productivity of animals. So, the cattle should be dewormed on a regular basis, i.e. every three months intervals. In winter, the animals should be grazed after dew has been gone and sunlight is strong, so that the larvas of parasites do not rest on leaves and go to ground. In case of grasses cut in the morning, may be dried in the sun for about half an hour before feeding.

In cows, the major losses in productivity and lives are due to diseases like black quarter (BQ; affliction of young and healthy animals with hind quarter muscle affected. If not treated early animal dies, vaccination is the best option), haemorrhagic septicaemia (HS; contagious bacterial disease caused *Pasteurella multocida* characterized by an acute, highly fatal septicaemia with high morbidity and mortality; high humidity and temperature favors the disease; Signs are high fever, depression, reluctance to move, salivation and nasal discharge, painful and oedematous swelling of the throat, extending to the brisket, congested mucous membranes, respiratory distress, calves may have a haemorrhagic gastro-enteritis, death in 6-48 hours after onset of clinical signs, recovery is rare), foot and mouth disease (FMD; with lesions throughout the skin and mucous membranes of foot and mouth), blood protozoan diseases like babesiosis, theileriosis and trypanosomosis etc., neonatal death and mastitis in addition to other diseases. However, most of these diseases are contagious and spread through contaminated feed, water, air or vectors like mosquitoes, flies, fleas or ticks. As the loss is very high and in most of the diseases, if once started, there is not much one can do. So, vaccinating the animals should be done to get the maximum production. Weak, debilitated, pregnant and infested animals should not be vaccinated. They should be properly dewormed prior to vaccination. Booster dose must be given whenever available as it strengthens the protection from disease. Generally vaccination against FMD, BQ and HS are given by our Animal Husbandry Department in minimal charges. Vaccination is a must for endemic regions which saves many lives and protects from economic loss. In case of disease outbreak, plan for cleaning and disinfecting house and equipments is needed. In farms, detailed record keeping of animals' health is essential. Neonatal mortality can be prevented by improving the level of nutrition in advanced stages of pregnancy (last 6 weeks), ensuring hygienic condition in the sheds, providing proper bedding, and ensuring early feeding of colostrums. If foot dips containing disinfectants are provided at the entry of the farm with proper hygiene and sanitation, diseases can be minimized. Milking should be complete and hygienic to avoid occurrence of mastitis. Clean milk production practices must be followed to avoid clinical and subclinical mastitis which cause a great loss to our milk production.

Integration of livestock into integrated farming system helps in ensuring good return on investments in addition to food and nutritional security along with social security. As an enterprise, the return is also very good in quick time.

Further Reading

Alcock, R., de Neef, R., de Villiers, H., Dugmore, T., et al. 2015. Goat Production Handbook Mdukatshani, Heifer International-South Africa and KwaZulu-Natal Department of Agriculture and Rural Development.

Divers, T.J. and Peek, S.F., 2007. Rebhun's diseases of dairy cattle. Elsevier Health Sciences.

http://agritech.tnau.ac.in/animal_husbandry/animhus_cattle_care&management.html

http://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/HAEMORRHAGIC_SEPTICEMIA.pdf

Seasonal Mushroom Cultivation under Integrated Farming System

Srikanta Lenka[1], Jyoti Nayak[2], Annie Poonam[1] and A.Mahanty[2]

1: ICAR-NRRI, Cuttack 2: ICAR-CIWA, Bhubaneswar

Mushroom is a highly nutritious and delicious food. Mushrooms, like many other fungi are responsible for the degradation and transportation of animal and plant substances, thereby restoring soil fertility and maintaining biological equilibrium. From a total of about 200 types of edible mushrooms in India, paddy straw mushroom (*Volvariella spp.*), oyster mushroom (*Pleurotus spp.*), button mushroom (*Agaricus spp.*) and milky mushroom (*Calocybe indica*) are grown commercially.

Mushroom contains 20-35% protein (dry weight basis), which is more than in vegetables, fruits and are as good as animal protein. In addition to high quality protein, mushroom contains fairly good amount of vitamin C and vitamin B complex group particularly thiamin, riboflavin and niacin. It also contains high quantity of potassium, sodium and phosphorous. As compared to other food substances, potassium-sodium ratio in mushroom is very high which is beneficial for the patients suffering from hypertension.

Mushrooms are low calorie food with very little fat and suitable for patients suffering from obesity. With no starch and very low sugar, mushroom has been accepted by the diabetic patients. Mushroom with low fat and rich linoleic acid, being free of cholesterol is very beneficial for the heart patients.

Mushroom cultivation is a good vocation for income and employment generation. Its cultivation method is very simple which can easily be carried out by rural women. It requires comparatively less land area than other agricultural enterprises. It is estimated that a profit of Rs. 3500 per month can be obtained from the cultivation of paddy straw mushroom and oyster mushroom by investing Rs. 25000/- per year in an area of 400 square feet.

Cultivation method of Paddy Straw Mushroom

- Take 24-26 bundles (12-13 kg) of paddy straw. Cut the upper portion (panicle end) and separate leaves from the straw. Soak the straw bundles in water for 12 hours.
- Then take out the bundles from water and sterilize the bundles using hot water.

- For commercial cultivation, straw is disinfected with Formalin or carbendazim 50WP (100 liters of water containing 100 ml of Formalin or 100g carbendazim 50WP) or boiled water for one hour.
- Remove the mushroom seeds/spawn (450 g) from the bottle. Divide it into three equal parts. Take 200 g of half-powdered pulse such as gram/pigeon pea/horse gram/ black gram/ green gram and divide into three equal parts.
- Make wooden/ bamboo frame of size 1 mtr × 1 mtr and put it on bricks. The foundation / frame must be strong and firm enough to hold the load of the mushroom bed. Open the bundles and place five bundles of soaked sterilized straw side by side on the platform. Place the first part of the spawn on the straw about 4-5 cm from its edges. Keep small pieces of spawn leaving 8cm gap. Spread the spawn with any powdered pulse (pigeon pea/Bengal gram/horse gram) as mentioned above.
- Then place a second part of five bundles over first layer in opposite direction and place the spawn and pulses in the similar way.
- Again place a third layer of straw with five bundles over the second layer in opposite direction and place the spawn and pulse powder on the middle portion of the bed in this layer.
- Finally cover the fourth layer with 3-4 straw bundles and press lightly.
- Completely cover the bed with transparent plastic sheet.
- Remove the plastic sheet after 6-7 days, when the mycelium has thoroughly spread over the whole bed and its growth is visible from the outside. This would take about a week at 35 ˚C.
- Then spray the mushroom bed with 2 liters of water lightly by a sprayer at least twice daily.

Harvesting

- The first phase of mushrooms will emerge after 12-14 days from the date of the paddy straw mushroom bed preparation. The second and third phase of mushrooms will come out after an interval of 5-7 days. Spray water 12 hours before plucking of the mushroom.

Yield

- About 1.5-2 kg per bed

Climatic requirement for paddy straw and oyster mushroom production

Particulars	**Paddy straw mushroom (*Volvariella spp.)***	**Oyster mushroom (*Pleurotus spp.)***
Temperature (˚C)	25-38	20-30
Humidity	85-95	80-85
Light (lux)	1000	200
Moisture content of the substrate	65	65
Month of cultivation	March to September	October to February

Cultivation method of Oyster mushroom

- Take 4-6 paddy straw bundles (2 kg) and separate the leaves from the straw. Cut the straw with a sharp cutter with 5-7 cm length after discarding the panicle portion.
- Soak the straw in water for 12-16 hours.
- Boil the soaked paddy straw for one hour. Dry in shade for 3-4 hours.
- After the excess water drained out, divide them into four equal parts.
- Boil 250 gm of wheat for 20-25 minutes in water.
- Remove the spawn from the bottle with the help of a clean sterilized stick / aluminium rod and divide the mushroom spawn into three equal parts after removing from the bottle.
- Similarly, divide the boiled wheat grains into three equal parts. Take polythene of size of 60 cm × 40 cm and close its one end with the help of a thread made up of plastic / jute / coir. Spread the first part of the straw inside the polythene and then spread one part of the spawn on the first layer. Likewise prepare the second the help of straw, spawn and wheat. Finally, prepare the fourth layer of the straw over the third layer and press it lightly by hands inside the polythene.
- Tie the top of the polythene and make 15-20 holes. Keep the oyster mushroom bag in dark place for 10-12 days. After this, remove the polythene from the mushroom bed and hang the bed by the help of plastic/jute thread. From day 13, spray water on the bed twice daily.

Some nutritional facts about paddy straw mushroom:

Nutrient per 100 g of mushroom			
Paddy straw mushroom		Oyster mushroom	
Fiber, total dietary	2.5 g	Energy	333 K cal
Calcium, Ca	10 mg	Protein	22.22 g
Iron Fe	1.43 mg	Iron	80 mg
Phosphorous	61 mg	Cholesterol	0
Potasium	78 mg		
Selenium	15.2 µg		
Cholesterol	0		

Source: https://fdc.nal.usda.gov/fdc-app.html#/food-details/168582/nutrients

Source: https://fdc.nal.usda.gov/fdc-app.html#/food-details/395548/nutrients

Paddy Straw Mushroom

Oyster mushroom

Harvesting

The first phase of mushroom fruiting will take 7 days from the date of opening of the polythene. Mushroom can be harvested thrice during a period of one month from the first fruiting.

Expenditure, yield and income per bed

Paddy straw mushroom			**Oyster Mushroom**		
Material	**Quantity**	**Cost**	**Material**	**Quantity**	**Cost**
Straw	24-26 bundles	Rs. 25/-	Straw	4-6 bundles	Rs. 5/-
Spawn	1 bottle	Rs. 15/-	Spawn	1 bottle	Rs. 15/-
Pulse Powder	200 g	Rs. 16/-	Wheat bold grain	250g	Rs. 6/-
Polyethene	-	-	Polyethene		Rs. 5/-
Others	-	Rs.10/-	Others		Rs.5/-
Total	-	Rs. 66/-	Total	-	Rs. 36/-
Yield: 1.5 to 2 Kg/bed			Yield: 1.5 to 2 Kg/bed		
Income: @Rs.120/Kg (Rs. 180/- to Rs. 240/-)			Income: @ Rs. 80/Kg (Rs. 120/- to Rs. 160/-)		
Profit: Rs. 114/- to Rs. 174/-			**Profit: Rs. 84/- to Rs. 124/-**		

Disease management under rice – fish system

Manas Kumar Bag

Principal Scientist, Crop Protection Division, ICAR – NRRI, Cuttack

E-mail: manas.bag@gmail.com

Integrated farming system (IFS) is the farming system where simultaneous activities of crop and animal farming are taken altogether. The main purpose of this farming is farming component support one another and thus reducing external inputs. Simultaneous cultivation of food, fodder and trees together with raising of sheep, duck and fishes are taken in this system. Among the food grains, rice is one of the most important crops in this system particularly in eastern India. For sustainable production of rice, proper management vis-a-vis best package of practices should be followed and disease management is an essential component in the package.

Rice crop generally taken 4-5 months and grown in all three season. Depending on the climatic factors rice crop infected by various pathogens causing a number of diseases, some of which are real causes of hindrance of sustainable rice production. Some of the major rice diseases are blast, brown spot, sheath blight, and bacterial blight which interfere in production of rice and cause considerable yield loss. Now-a-days few other diseases like sheath rot, false smut, bakanae, seedling blight and bacterial leaf streak also causing substantial losses of rice production.

Common practices as given below are utmost requirement to maintain disease free crop or to avoid diseases in the field:

- Ploughing of fields during hot summer season, if possible with once with alternate wetting
- Use disease and insect free pure seed.
- Use brine solution before sowing to clean the seed lot.
- Select suitable resistant or moderately resistant variety for endemic areas.
- Seed treatment with carbendazim 50% WP @ 1.5 - 2 g/kg seed or Trichoderma/Pseudomonas @ 5-10 g/ha of seed for seed or soil borne diseases
- Timely planting/sowing.
- Raising of healthy nursery.
- Destruction of left over nursery, removal of weeds from field and cleaning of bunds.

- Normal spacing of 15 x 20 cm to maintain 30-36 hills/ m^2 depending on the duration of the variety.
- 30 cm alley formations at every 2.5 to 3 m distance in sheath blight endemic areas.
- Balanced use of fertilizers and micro-nutrients as per local recommendations.
- Proper water management (alternate wetting and drying to avoid water stagnation) in bacterial blight, bacterial leaf streak, sheath blight and stem rot endemic areas.

Besides the common practices, proper diagnosis is also important to know the causes of the diseases and awareness of timings of appearance of the disease is important for need based application of pesticides or taking appropriate care to manage good health of the crops. Followings are the major and economically important diseases along with their symptom (fig.1), occurrence and need based management practices:

Blast: Symptom of blast is initially white to grey-green spots with darker borders. Older lesions elliptical or spindle-shaped and whitish to gray with necrotic borders. Lesions are wide in the centre and pointed toward either end (typical eye-shaped). Lesions enlarge with time and coalesce to kill the entire leaves.

Time of appearance: Foliar or leaf blast - seedling to tillering stage. Neck-blast - panicle initiation to booting stage.

Management: On appearance of 1-2 spot per leaf spray Tricyclazole 75 WP @ 0.6 g or Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.4 g or Isoprothiolane 40EC @ 1.5 ml per litre of water. Repeat the spray at 7-10 days interval.

Sheath Blight: The disease start with small, ellipsoidal or ovoid, greenish-grey and water-soaked lesions on leaf sheaths near the water line in lowland fields. Under favourable conditions, lesions extend rapidly to cover entire sheath and spread up to the flag leaf.

Time of appearance: Early to late tillering.

Management: On appearance of initial symptom spray Propiconazole 75 WP @ 1 ml or Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.4 g or Validamycin 3L @ 2 ml or Hexaconazole 5EC @ 2ml or Thifluzamide 24SC @ 1ml or Carbendazin 12% + Mancozeb 63% WP @ 2 g per litre of water. Repeat the spray at 10 days interval.

Brown Spot: The disease is known by appearance of typical ellipsoidal, oval to circular brown colour lesions appear on the coleoptiles, leaf blade, leaf sheath and glumes.

Time of appearance: Early to late tillering.

Management: Spray the crop with Propiconazole 25EC @ 1ml or Mancozeb 75WP or Carbendazim 50WP @ 2g of water or Carbendazim 64%+Mancozeb 8% 75WP @ 1.5g per litre of water.

Bacterial Blight: Initially identified by the presence of water soaked lesions move from tip to downwards along the edges of leaves. Gradually symptoms turn into yellow to straw colour with wavy margins.

Time of appearance: Early to late tillering.

Management: Spray Plantomycin @ 1 g or Streptocycline 150 mg + copper oxychloride 1gm per litre of water.

Sheath Rot: The spot appears on the uppermost leaf sheath enclosing the young panicles at late booting stage. The initial symptoms are oblong or somewhat irregular brown spots with dark brown margins and gray centre. Lesions may diffuse reddish brown discoloration on the sheath.

Time of appearance: Late booting stage.

Management: On appearance of initial symptom spray Propiconazole 25 EC @ 1 ml or Hexaconazole 5EC @ 2ml or Carbendazin 12% + Mancozeb 63% WP @ 2 g per litre of water. Repeat the spray at 10 days interval.

False smut: Initially infected grains are hard whitish-grey in colour when visible observed very kinly. Individual grains are transformed to large velvety yellowish to orange to greenish yellow which later become black in colour.

Time of appearance: Late booting to flowering stage.

Management: Spray two times during booting and 50% flowering stages. Spray Copper hydroxide 77% @ 2.5 g or tebuconazole 250EC @ 1 ml or mancozeb 75WP @ 2.5 g per litre of water.

Bakanae disease: The infected plants are exceptionally taller than normal plants, thin with pale green leaves. The affected seedlings die later. In late infections, tillering is reduced and the leaves dry up. In surviving plants, partially filled, sterile or empty grains can be seen at maturity.

Time of appearance: Seedling to tillering stage.

Management: Spray is not much effective. If the 1-2 diseased hill observed, spray carbendazim 50WP @ 1g per litre of water.

Bacterial leaf streak: Initially, small, dark-green and water-soaked streaks in the interveinal zone. Streaks dark-green at first and later enlarge to become yellowish grey and translucent.

Time of appearance: Tillering to booting stage.

Management: Spray Plantomycin @ 1 g or Streptocycline 150 mg + copper oxychloride 1gm per litre of water.

Rice tungro: Leaves turn pale yellow and later reddish orange in colour. Plants get stunted and numbers of tillers are reduced.

Time of appearance: Early to late tillering.

Management: Manage Green leaf hopper by spraying Imidacloprid17.8SL @0.25 ml or thiamethoxam 25WG @ 0.2 g per litre of water.

Proper following of common practices gives enough opportunities to get good production and detection of diseases by their symptoms at the very initial stage along with the need-based management practices help us to achieve sustainable food grain production.

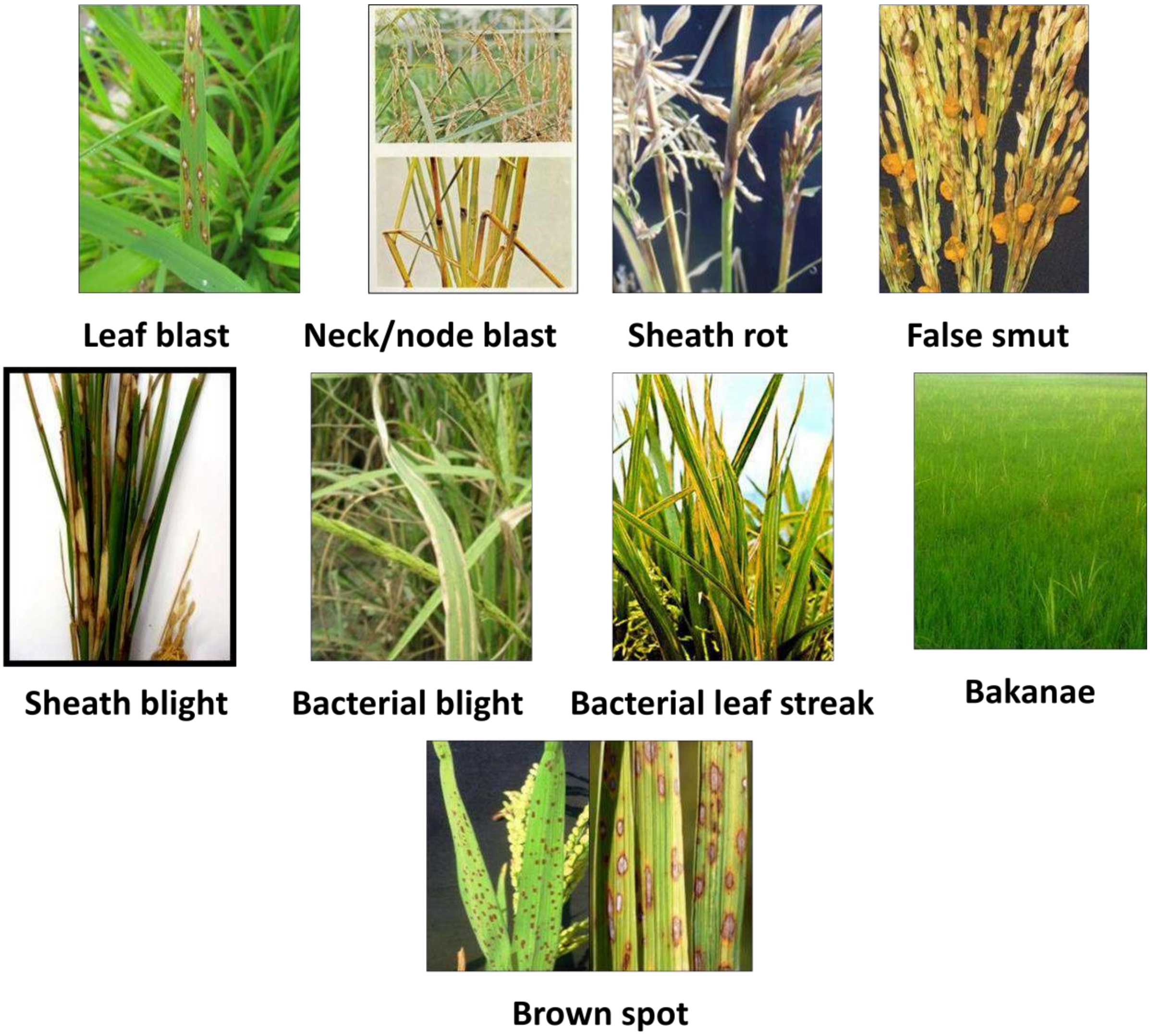


Fig. 1: Symptom of different rice diseases

AGROFORESTRY: AN ALTERNATIVE FARMING SYSTEM

Alok Kumar Patra
Professor (Agronomy)
AICRP on Integrated Farming Systems
Odisha University of Agriculture and Technology, Bhubaneswar- 751003
E-mail: alokpatra2000@gmail.com

Introduction

Man's association with forest is much older than with agriculture. First man was a food gatherer and hunter in forests. Then he realized that the seeds of the fruits he collected germinated, grew into plants and bore the fruits again and thus man started to cultivate foods. Thus, the process of human evolution has been from forests when man learnt the art of domesticating plants and animals. Man's desire to live in a community created settled agriculture. So the origin of agroforestry practices, *i.e.* growing trees and shrubs with food and fruit crops and grasses is traditional and very old. Since then the pressure on the agricultural lands has increased manifolds due to urbanization and industrialization process. Gradually soil is losing its productivity, and the biodiversity is threatened. To increase the land productivity, chemical fertilizers and pesticides are applied in higher proportion, causing environmental pollution hazards.

In these rapidly changing situations, man has two ways to live – one is to tolerate the conditions and the other one is to change them. Now the existence of life is in danger due to pollution, climate change, disease, loss of biodiversity and so on. Under all these circumstances agroforestry has shown that besides sustainable agriculture it can also help promote a better environment. Agroforestry has been recognized as a land-use system which is capable of yielding both food and wood and at the same time conserving and rehabilitating the ecosystems. It has the capability to increase the productivity, maintain the nutrient balance in the soil as well as protect the nature. It has two major roles to play, the productive role and the service role. Trees have the dominant role to play in all agroforestry systems for sustainable agriculture and environmental protection.

Objectives of agroforestry:

The major objectives of agroforestry include

- To reduce pressure on natural forests
- To manage land efficiently so that its productivity is increased

- To encourage tree plantation with agricultural crops and livestock to improve overall productivity, income and livelihoods of rural households, especially the marginal and small farmers
- To meet the raw material requirements of wood based industries and other small cottage industries in rural areas
- To raise the production of small timber used by villagers for agricultural implements, house constructions and other domestic purposes
- To generate employment opportunities for rural people throughout the year
- To protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events
- To use available resources efficiently and economically
- To raise the production of food crops, legumes and tuber crops to meet the rapidly growing food requirements of people
- To raise the fodder production to meet the requirements of domestic animals
- To promote the production of vegetables, fruits, meat, egg and fish for nutritional security of resource-poor farmer families

Benefits from agroforestry

Benefits from agriculture and forestry are limited. But benefits from Agroforestry are infinite - food, fruits, feed, fodder, fuel, fiber, fertilizer, favourable climate and many others. Agroforestry is the system of developing agricultural land in combination with forestry technologies. It helps farmers in terms of controlling land degradation, sheltering crop and livestock, improving their landscape and enhancing wildlife habitat. Benefits from agroforestry can be grouped under three broad categories - environmental, economic or social benefits.

Environmental benefits

1. Reduction of pressure on natural forests
2. More efficient recycling of nutrients by deep rooted trees on the site
3. Better protection of ecological systems
4. Reduction of surface runoff, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes
5. Improvement of microclimate, such as lowering of surface soil temperature and reduction of evaporation of soil moisture through a combination of mulching and shading

6. Increment in soil nutrients through addition and decomposition of litter
7. Improvement of soil structure through the constant addition of humus from decomposed litter

Economic benefits

1. Increment in outputs of food, fuelwood, fodder, fertilizer and timber
2. Reduction in incidence of total crop failure, which is common to single cropping or monoculture systems
3. Increase in levels of farm income due to improved and sustained productivity

Social benefits

1. Improvement in rural living standards from sustained employment and higher income
2. Improvement in nutrition and health due to increased quality and diversity of food outputs
3. Stabilization and improvement of communities through elimination of the need to shift farm activities from one site to other

Scope of agroforestry in India

- Forest cover in the country is 7,08,273 sq km, constituting 21.54% of its total geographical area against the ideal coverage of 33.33%. The forest cover in the hilly districts is only 35.85% compared with the desired 66.66% area. The per capita availability of forests in India is one of the lowest, 0.064 ha against the world average of 0.64 ha. Thus to bridge the gap between desired and available forest coverage in the country, agroforestry is the best intervention.
- Areas presently not available for arable cropping can be put to agroforestry practices. According to the estimation of National Wasteland Development Board, 123 million hectare area of land is lying as wasteland in India. The extent of degraded forests in the country is more than 40 million ha. Besides, about 50 million ha area is degraded due to mining activity. These areas can be reclaimed by adoption of suitable agroforestry practices.
- Large area is available in the form of farm boundaries and field bunds, where also agroforestry systems can be adopted.
- Since land holding is becoming smaller and smaller due to demographic pressure, forest area in the vicinity of the thickly populated villages is diminishing with increasing human demands for fuel, fodder, small timber and other minor products met from the forest.

Thus, by adopting agroforestry in the community lands near the villages, the pressure on natural forest could be greatly reduced.

- The agroforestry plot remains usually productive for the farmer and generates continuous revenue, which is not feasible in arable land. Agroforestry also allows for the diversification of farm activities and makes better use of environmental resources.
- About 87% of the annually harvested wood in India is used as firewood. In addition, at present in rural India 60-80 million tonnes of dry cow dung is utilized as fuel, equivalent to 300-400 million tonnes of freshly collected manure. Thus, there is a vast scope to meet the acute shortage of fuel-wood through agroforestry.
- The grazing lands in almost all parts of the country have to support animals beyond their carrying capacity. Repeated grazing by animals hardly leaves any vegetational element to survive unless specially protected. Inclusion of fodder tree species with suitable grasses in the agroforestry system will check overgrazing.
- Agroforestry provides employment with relatively less investment and that too for unskilled rural community. It has a tremendous potential for rural employment generation due to great diversity of products from homegarden which provides opportunities for development of small scale rural industries and creation of off-farm employment and marketing opportunities.

Different agroforestry systems

Based on the nature of components, agroforestry systems can be broadly classified into agrisilvicultural (agricultural crops + trees), silvipastoral (trees + forage crops), agrisilvipastoral (agricultural crops + trees + forage crops) and other systems like aquaforestry, mushroom in mixed tree species and apiculture with trees. A few common agroforestry systems practiced in our country are given below.

Multispecies tree gardens

In this system of agroforestry, various kinds of multipurpose tree species (MPTS) are grown. The major function of this system is production of food, fodder and wood products. Major woody species planted in this system are *Acacia catechu*, *Phoenix dactifera*, *Artocarpus* spp, *Cocos nucifera*, *Mangifera indica*, *Syzygium aromaticum*, etc.

Alley cropping

Alley cropping, also known as hedgerow intercropping, involves managing rows of closely planted (within row) woody plants with annual crops planted in alleys in between hedges. The primary purpose is to maintain or increase crop yields by improvement of the soil and microclimate and weed control. Tree products are also obtained from the hedgerows. Right kind of tree species is to be planted at right spacing, with proper management to reduce competition between trees and agricultural crops for nutrients, moisture and light. Alley cropping usually includes leguminous trees to improve soil fertility through nitrogen fixation. The suitable species are *Cassia siamea*, *Leucaena leucocephala*, *Glyricidia sepium*, *Calliandra calothyrsus* and *Sesbania sesban*.

Multipurpose trees and shrubs on field bunds

Certain multipurpose trees are used to mark farm boundaries. Unlike live fences, the trees on boundaries need not be closely spaced except when soil erosion control is also desired. Tree growing on farm boundaries requires agreement between neighbouring farm owners to avoid conflicts. Sometimes two rows of trees are planted, one on each side of the boundary, and then each farmer grows and manages his own trees. Initially trees can be established at a close spacing (0.75 - 1.00 m) and then later thinned for poles or firewood to a final spacing of 1.5 - 3.0 m. With double rows the spacing between the rows should not be less than 2 m.

Agroforestry for fuel wood production

In this system, fuel wood species are planted in or around agricultural lands. Tree species commonly used as fuel wood are *Acacia nilotica*, *Albizia lebbeck*, *Casuarina equisetifolia*, *Prosopis juliflora*, *Cassia siamea*, *Eucalyptus tereticornis*, etc.

Gmelina arborea + Arrowroot

Acacia mangium + Pineapple

Protein bank

In this silvipastoral system of agroforestry, MPTs (protein-rich trees) are planted on or around farmlands and rangelands for fodder production to meet the feed requirements of livestock during the fodder-deficit period in winter.

Acacia mangium + Guinea grass

Acacia mangium + *Aloe vera*

Trees and shrubs on pasture

In this silvipastoral system of agroforestry, MPTs are scattered irregularly or arranged according to some systematic pattern, especially to supplement forage production. Perennial woody fruit crops may also be included which is called hortisilvipastoral system.

Home gardens

This is the oldest agroforestry practice. Home gardens are characterized by a high species-diversity and usually 3-4 vertical canopy strata. Many species of trees, bushes, vegetables and other herbaceous plants are grown in dense and random arrangements. But some rational control over choice of plants, and their spatial and temporal arrangement should be exercised to reduce competition among the plants and to increase the production. Most home gardens also support a variety of animals (cow, goat, sheep, pig) and birds (chicken, duck). Fodder and legumes are widely grown to meet the daily fodder and feed requirements. Thus, home gardens represent land-use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops, and livestock within the compounds of individual houses, the whole crop-tree-animal unit being intensively managed by family labour.

Apiculture with trees

In this system, various honey or nectar producing trees frequently visited by honeybees are planted on the boundary of the agricultural field. The primary purpose of this system is to produce honey. Api-silviculture with *Eucalyptus*, *Glyricidia*, *Grevillea*, *Gmelina*, *Leuceana* and *Albizia* species were more remunerative and a good source of generating additional farm income in rural areas.

Multistoried agroforestry

Acacia mangium + Guava + Colocasia

Aquaforestry

The aquaforestry system comprises of composite fish culture in farm ponds, and various trees and shrubs (*Leucaena leucocephala*, *Morus alba*, *Gliricidia sepium*, *Moringa olifera* etc.), leaves of which are preferred by fish are planted on the boundary and around fish ponds. Leaves of these trees are used as feed for fish. Inland fish such as *catla*, *rohu*, *mrigal*, common carp, silver carp and grass carp can be grown in the ponds. In the coastal regions farmers are cultivating fish and prawn in saline water and growing coconut and other trees on bunds of ponds. Now fish culture in the mangroves is also advocated, which form a rich source of nutrition to the aquatic life and breeding ground for fish and prawn. Other terms that have been used for this practice are silvipisciculture, agrisilviaquaculture and aquasilviculture. Some other modified aquaforestry systems are

1. A well-balanced system of animal husbandry including goatery, poultry, duck farming, turtles and fishes in the small ponds in home gardens make a balanced system of high moisture, energy and nutrient use efficiency per unit area.
2. In paddy field, fish can easily be reared by planting trees on field bunds or boundary to provide leaves used as fish feed. This system can be practiced in high rainfall areas.
3. Coconut plants can also be successfully planted on raised paddy field bunds with an alley space of 5 m width depression which is utilized for pisiculture.

Acacia mangium in rice field bunds

Aquaforestry (Coconut + Rice + Pisciculture)

INSECT PEST MANAGEMENT IN RICE

Dr. P.C. Rath
Principal Scientist (Ag. Entomology)
NRRI, Cuttack - 6

Rice Hispa

Nature of Damage-

- Translucent white patches that are parallel to the leaf veins
- White, grub like larvae are seen mining through leaf tissues.
- Spiny black metallic beetles feeds on the upper surface of leaves producing bold white streaks.

Management –

1. Spray quinalphos 25 EC @ 2000 ml/ ha or monocrotophos 36 WSC @ 850 ml / ha orchlorpyriphos 20 EC @ 1500 ml/ ha or Triazophos 40 EC @ 2ml/liter of water.
2. ETL- 2 larva or Adults /hill.

Case worm

Nature of Damage-

- Presence of feeding damage on leaves which are transparent white. Leaf tips are cut, Presence of leaf cases attached onto leaf sheaths or floating on the water with larvae.
- Green larvae or pupae are found along with white feeding symptoms on leaves.

Management-

1. Spray quinalphos 25 EC @ 2000 ml/ ha or monocrotophos 36 WSC @ 850 ml / ha orchlorpyriphos 20 EC @ 1500 ml/ ha or Triazophos 40 EC @ 2ml/liter of water.
2. ETL- 2 larva or Adults /hill.

Leaf folder

Nature of Damage-

- Leaves fold longitudinally and larvae remain inside.
- Larvae scrape the green tissues of the leaves and become white and dry.
- During severe infestation the whole field exhibits scorched

appearance

Management-

1. Spray cartap hydrochloride 50 WP@ 600 g a.i./ ha or monocrotophos 36 WSC @ 850 ml /ha or chlorpyriphos 20 EC @ 1500 ml/ ha orTriazophos 40 EC @ 2ml/liter of water.
2. ETL-2 - 3 freshly folded leaves/hill.

Hoppers (GLH/BPH/WBPH)

Nature of Damage-

- These are sucking insects, confining themselves to basal portion of the rice-plant and deplete plant sap from phloem tissue. As a result, plant gets wilted and dries. Drying of plant starts in circular patches in field and later whole field dries off. This typical symptom is called "hopper-burn.
- Besides, BPH acts as the vector of virus diseases grassy stunt, ragged stunt and wilted stunt.GLH act as the vector of Tungro viral diseases.

Management-

1. Application of Carbofuran 3G @ 10-12 kg/acre or spraying of Imidaclorprid 200SL @ 40ml or Chloropyriphos 20 EC @ 500ml in 200 litres of water. Repeat after 7 -10 days if needed. For effective control spray towards the base of the plant.
2. ETL- 5-7 plant hoppers /hill.

Stem borer

Nature of Damage-

Caterpillars bore central shoot of seedlings and tillers eading to death of central shoot called “Dead Heart”.Panicle turn whitish, erect with chaffy spikelets and can be easily pulled out, is known as "white ears"

Management-

1. Application of Carbofuran 3G @ 10-12 kg/acre or spraying of Chloropyriphos 20 EC @ 500ml or monocrotophos 36 WSC @ 850 ml / ha or cartap hydrochloride 50 WP@ 600 g a.i./ ha or Triazophos 40 EC @ 2ml/litre of water

2. ETL- 5% Dead hearts

Swarming caterpillar/army worm

Nature of Damage-

- Caterpillars eat the leaves of the rice plant leaving irregular notches
- In severe infestation whole leaf and plants are eaten leaving stubs in the field.
- Presence of caterpillars, fecal matter and feeding damage.

Management-

Spray chlorpyriphos 20 EC @ 2500 ml ha/1 or monocrotophos 36 WSC @ 1500 ml ha/1 or acephate 50 WP @ 1200 g/ ha

Gundhi Bug-

The adult of Leptocforisaoratorius is green, light brown or mixed yellow in colour. The adult are slender and about 20mm long. Males and female are 13-14 mm and 16-19mm long respectively. The head is triangular. The antennae consist of four segments. They have long legs. There are stink gland on either side of the abdomen that emit foul odour, hence called stink bug or Gundhi Bug. The grown up nymph are very similar to the adult in colour and size, but they are wingless.

Management –

The population can be suppressed by killing the bug by using light traps.Collection of adult bug using net.Destroy weed to remove alternate host. Keep on hanging the cattle urine soaked gunny bags or cow dung wrapped cloth in the field to attract the bug. Synchronise rice planting to maintain simultaneous crop maturity in the field in an area for equal distribution of bugs in all fields. Conserve predator or rice bug like tiger beetle, Cicindelasexpunctata by using chemical pesticide judiciously. Spray after at least 10 bugs per 100 panicles with pesticide like carbaryl (Carbaryl 5% dust @ 25kg/ha). Spray Fenvalerate 20EC 0.5ml/litre of water.

Economics of Farming Systems and Supporting Schemes

Biswajit Mondal

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

Farmers in India generally practice subsistence farming where they need to produce a continuous, reliable and balanced supply of foods, as well as cash for basic needs and recurrent farm expenditure. Agriculture in eastern India specifically is dominated by rice-rice mono cropping system. Rice covers more than 75% of the total cultivated area. The farmers are mainly marginal and small, who have already exploited 80% of the potential of rice and further scope for enhancing yield is limited. The natural resource is also mostly exhausted. The need for diversification of farming practice is thereby needed as the income of farmers who depend solely on the produce of their traditional mono crop of rice pattern is decreasing due to narrow margin of profitability and changed food consumption habits. Over the last two decades, dietary pattern has been changed due to higher income generation, change in food habit, population explosion has also changed the supply and demand profiles of food. Integrated farming systems (IFS) seems to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirements of food grains, vegetables, milk, egg, meat, etc., thereby improving the nutrition of the small-scale farmers with limited resources. Integration of agriculturally related enterprises with crops provides ways to recycle products and by-products of one component as input of another linked component which reduce the cost of production and thus raises total income of the farm. Multiple land use through integration of crops, livestock and aquaculture led to the optimum use of resources and can provide the best production from unit land area. In other words, Integrated farming system is a resource management strategy to achieve economic and sustained production to meet the diverse requirement of farm household while preserving resource base. IFS can also be practiced as micro business by farm youth for attaining regular income. IFS reduces the risk of failure as often one component or one crop based business leads to market instability. The other advantages of IFS include effective recycling of residues within the farm thereby reducing the cost of production per unit area.

However, the system needs to be endorsed through proper economic analysis before or after adoption of different enterprises into the farming system. The computation of economics is also necessary to convince farmers to adopt the system over traditional mono-cropping cultivation practices in terms of incremental returns and indicators of benefits and expenses. 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/system, a particular enterprise or a particular activity of an enterprise. There are three types of budgeting techniques used in economic analysis i. e. (i) Partial budgeting, (ii) Enterprise budgeting, and (iii) Complete farm budgeting.

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.

Cost of cultivation format

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

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.

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 postproduction 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.

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.

Pattern of Assistance in Various Schemes of Dept. of Agriculture & Cooperation, Min. of Agriculture, Govt. of India for IFS

Broad Activity	Sub Activity	Pattern of Assistance	Name of Scheme
Crop Based Integrated Farming System	Cropping System (CS) with rice, wheat, coarse cereal/oil-seed/fibre/pulse based two crops.	50% of input cost limited to Rs.10,000/-per ha with permissible assistance of maximum 2 ha/ beneficiary.	National Mission for Sustainable Agriculture (NMSA)
	Horticulture Based Farming System (Plantation + Crops/Cropping system)	50% of input cost limited to Rs.25,000/- per ha with permissible assistance of maximum 2 ha/ beneficiary.	NMSA
	Tree/Silvi-Pastoral/in-situ/ex-situ conservation of Non Timber Forest Produce (NTFP) (Plantation + Grass/ Crops/Cropping System)	50% of input cost limited to Rs.15,000/- per ha with permissible assistance of maximum 2 ha/ beneficiary.	NMSA
Livestock based farming system	CB Cows + Mixed farming + Fodder Buffalo +Mixed farming +Fodder Cow/ buffalo+dairy+fodder cow/buffalo + small ruminants	50% of input cost of cropping system including cost of animals with one year concentrated food limited to Rs. 40,000/- per ha (2 milch animals + 1 ha CS) with permissible assistance of maximum 2 ha/beneficiary.	NMSA

	Small Ruminant + Mixed farming + Pasture Poultry/duckery + Mixed Farming Poultry/duckery + Fishery + Mixed Farming	50% of input cost of cropping system including cost of animals/birds with one year concentrated food limited to Rs.25,000/- per ha (10 animals/50 birds + 1 ha Cropping System (CS) with permissible assistance of maximum 2 ha/ beneficiary.	NMSA
	Fishery Based Farming System	50% of input cost of cropping/vegetable system including cost of fish farming limited to Rs.25.000/- per ha with permissible assistance of maximum 2 ha/beneficiary.	NMSA

Source: https://rkvy.nic.in/static/schemes/IntegratedFarming.html

APICULTURE UNDER RICE BASED DIVERSIFIED FARMING SYSTEM

Dr.R.N.Mohapatra

Prof.& PI, AICRP on Honeybees and Pollinators, OUAT Bhubaneswar

PRACTICE OF BEE KEEPING

- Honey bees are the best known, most useful, social and most studied insects. They produce the precious natural product called Honey.
- Honey hunting is an age old practice documented and known from time immemorial.
- Use of honey is known to mankind since Vedic times.
- Honey is used as one of the important constituent of Panchamrut, thus associated with our cultural heritage.
- Bee keeping is a century old practice.
- Scientific bee keeping in India is a practice of only a few decades old.
- At present it has been evolved as an excellent enterprise for rural poor, rich commercial bee keepers and a constituent part of our integrated farming system.

IMPORTANCE OF HONEY BEES AND BEE KEEPING

- After independence bee keeping was taken as an avocation in small scale cottage industry providing income and employment to rural poor.
- Bee keeping was meant for production of honey and other hive products but importance of Bees as pollinators was hardly realized.

WHAT IS BEE KEEPING?

Bee keeping is an art and science of collecting / procuring colonies of desired honey bee species, hiving them in standard and specified bee boxes, installing in appropriate sites, managing optimum number of colonies scientifically round the year and harnessing both direct and indirect benefit of the activities

DIRECT BENEFITS OF THE ACTIVITY

1. **The prime hive products**
    - Honey

2. Other useful products

- Bee wax
- Propolis
- Pollen
- Royal jelly
- Bee venom

HONEY: Honey is the most important primary product of beekeeping both from a quantitative and an economic point of view. It was also the first bee product used by human kind in ancient times. The history of the use of honey is parallel to the history of man and in virtually every culture evidence can be found of its use as a food source and as a symbol employed in religious, magic and therapeutic ceremonies.

COMPOSITION OF HONEY

Constituent	%
Total dissolved solids	70-80
Sugars: Fructose Glucose Sucrose Other higher sugars	38 37 02 0.5
Water	20
Minerals(Potassium,Calcium,Magnesium,Iron,Copper, Manganese, Phosphorus, Sulphur, Chlorine,and traces of Chromium, Nickel,Tin,Silver, Gold etc.)	0.5
Acids	0.2
Proteins and Amino Acids	0.25
Enzymes and Vitamins	Traces

HONEY

- Honey provides instant energy.
- Honey is used as carrier of Ayurvedic medicines.
- It is used to cure a host of ailments like cold, fever, piles, anemia and infections in the throat, skin, eye and intestine.
- Honey is used as ingredient in many commercial products

BEEWAX

- Bee wax occupies a very special position among waxes.
- It is secreted by young honey bees from their 8 wax glands located on the underside of the abdomen.

- Bee wax has extremely wide spectrum of useful applications
- ***Uses:*** Church candles, shoe polish, carbon paper, crayon colour pencil, metal castings and moldings, for polishing optical lens, in candy and chewing gums, cosmetics, for musical instruments etc.(Rs.70-120/kg).

PROPOLIS

- Propolis is a mixture of various amounts of bees wax and resins collected by the honeybee from plants, particularly from flowers and leaf buds. Since it is difficult to observe bees on their foraging trips the exact sources of the resins are usually not known.
- *Apis mellifera* is a good PROPOLISER and produces Propolis

ROYAL JELLY

- Royal jelly is secreted by the hypo pharyngeal gland of young worker (nurse) bees, to feed young larvae and the adult queen bee. Royal jelly is always fed directly to the queen or the larvae as it is secreted; it is not stored

  Uses: Premature babies, old age related problems, psychiatry, chronic tuberculosis, used in cosmetics, in dermatological preparations and creams/ointments (50-80 US $/kg).

COMPOSITION OF ROYAL JELLY

Constituent	Minimum	Maximum
Water	57%	70%
Proteins	17% of dry weight	45% of dry weight
Sugar	18% of dry weight	52% of dry weight
Lipid	3.5% of dry weight	19% of dry weight
Minerals	2% of dry weight	3% of dry weight

POLLEN

- The pollen collected by honeybees is usually mixed with nectar or regurgitated honey in order to make it stick together and adhere to their hind legs. The resulting pollen pellets harvested from a bee colony are therefore usually sweet in taste.
- The partially fermented pollen mixture stored in the honeybee combs, also referred to as "beebread" has a different composition and nutritional value than the field collected pollen pellets and is the food given to honeybee larvae and eaten by young worker bees to produce royal jelly. It is said, pollen is the perfect food because it is the only food source for honeybees other than honey.

BEE VENOM

- Honeybee venom is produced by two glands associated with the sting apparatus of worker bees. Its production increases during the first two weeks of the adult worker's life and reaches a maximum when the worker bee becomes involved in hive defence and foraging.
- It diminishes as the bee gets older.
- Application methods for venom include natural bee stings, subcutaneous injections, electrophoresis, ointments, inhalations and tablets. Used against Rheumatoid Arthritis, Nervous disorders (Cost - Rs.4700-9400 per gram).
- The median lethal dose (LD50) for an adult human is 2.8 mg of venom per kg of body weight.

INDIRECT BENEFITS OF THE ACTIVITY

HONEYBEES AS POLLINATORS

- About 60-70% agricultural /horticultural crops depend upon honeybees for cross pollination.
- In oil seed crops 3 - 5 bee colonies/ha can enhance the yield by 33.0 - 69.0%.
- Honey bees enhances 11 – 79% yield in different crops through pollination.
- Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of all the hive products put together (Kaloo).
- Honey bees alone accounts for 80% of pollination service done by the insects.
- Bees have specialized adoption for pollination.

Increase in production due to bee pollination	
Mustard	10.6%
Sesamum	25.0%
Niger	33.0%
Safflower	64.0%
Sunflower	79.0%
Fruit Yield	
Litchi	5.3 times

SCOPE OF BEEKEEPING IN INDIA

India being one of the leading mega biodiversity countries has all the four important Honey bees species and750 species of bee flora

- Further, introduction of *Apis mellifera* has revolutionized the status of scientific bee keeping in the country
- Cropped area – 160 million ha.
- Crop needing pollination service- 55 million ha.
- Besides, forest, pastures, wastelands and non cultivated lands are also inhabited by diverse vegetation suitable for beekeeping.

Thus, we have ample bee foraging plants for supporting sustainable bee keeping

SCOPE OF BEEKEEPING IN ODISHA

- **Agro-forestry Plants:** *Acacia, Cassia, Albizia* , *Eucalyptus*, Bael, Silk cotton, *Sesbania*, Cashew
- Forest covers 37.34% of the states geographical area.
    - Dense forest : 55%
    - Open forest : 44% Mangroves : 1%
- Horticultural crops - 115 th. hac.
- Agricultural crops - 526 th.hac.
- Crop needing pollination service-486 thousand hectare

BEE KEEPING AS AN ENTERPRISE

- Most suited to landless people or with small land holdings.
- Does not compete with any branch of agriculture.
- Does not require continuous labour.
- Does not require heavy investments.
- Some equipments are required.
- Provides multi source income.
- Improves crop yields through cross pollination

FEAR OF BEE STINGING

Bee stings when:-

- Adverse weather prevails,
- Queen cells are formed,
- Colony remains queen less for long time,
- Shaking bees off the frame,

- Any bee is injured while inspecting the box.

NON AVAILABILITY OF BEE COLONIES

- **INDIA:** As per the minimum recommendation of 2-3 bee colonies /harequires about 150-200 million colonies as against present availability of 1million colonies.
- **ODISHA:** Similarly, at recommendation of 2-3 bee colonies /harequires about 14.58 lakh colonies as against present availability of 64127 colonies.

.LACK OF AWARENESS

- Honey bees are most fascinating creatures and have attracted attention of many people.
- Many people wish and many other start bee keeping without understanding the basics.
- Keeping bee is a very skillful activity.

CONSTRAINTS OF BEEKEEPING IN ODISHA

- **Non-availability** of required number of colonies. Potentiality of our state is over 15Lakhs but present status of colony availability is nearly 1.2lakhs
- There is **no open market** for bee colonies and bee keeping equipments.
- **Lack of support of system** for honey collection, processing, distribution and marketing.
- Inadequate support from Government for HRD and periodic natural calamities adversely affecting the activity.
- Rapid deforestation, non-inclusion of bee friendly plants in avenue plantation and social forestry
- Indiscriminate use of novel insecticides (Neonicotinoids and Diamides)in development agricultural system which are extremely harmful to honeybees.

ECONOMICS OF BEE KEEPING

Estimated cost of 10 units bee hive:

A) Total Expenditure: (For 10 colonies of *Apis cerana indica*

Equipments	Numbers	Rate(Rs)	Total Amount(Rs)
Box	10	2000.00	20000.00
Colony	10	800.00	8000.00
Hive stand	10	300.00	3000.00
Smoker	1	350.00	350.00
Honey Extractor	1	1600.00	1600.00
Queen gate	10	15.00	150.00
Total			**33100.00**

B) Total Expenditure: (For 10 colonies of *Apis cerana indica)*

Sugar 40kg (1kg@ Rs.40)	**1600.00**
Medicines	400.00
Total	2000.00
Grand Total (A+B)	**35,100.00**

C) Income from 10 colonies of *Apis cerana indica:*

Product	**Rate(Rs)**	**1st Year**		**2nd Year & Onwards**	
		Production	**Amount**	**Production**	**Amount**
Honey	1kg @ Rs.450	20	9000.00	60kg	27000.00
Wax	1kg @ Rs.250	0	0.00	1kg	250.00
Colony	1Colony @ Rs.600	10	6000.00	10nos.	6000.00
Total			**15000.00**		**33250.00**

D) Estimation of Profit and Loss:

	1st Year	**2nd Year**	**3rd Year**
Income	15000.00	33250.00	33250.00
Expenditure	35100.00	2000.00	2000.00
Profit	(-)20100.00	(+)31250.00	(+)31250.00
Cumulative Profit & Loss	(-)20100.00	(+)11150.00	(+)31250.00

- Pollinators helps in increased the productivity 25%-35%.
- Durability 15 years.

Importance of Farm machinery in quality seed production of paddy

Er. Prabhat Kumar Guru

Rice (Oryza sativa) is one of the most important cereal crops and most important staple food in the world. India is the second largest producer and consumer of rice in the world. The use of machinery for field preparation operation for rice cultivation is high and most of the farmers of India are using tractor with matching implements for deep ploughing and puddling operation. But the further operation viz. sowing, transplanting, harvesting and threshing is done manually and having very low level of mechanization. There is shortage of farm labours and declining interest of youths in agriculture. With increase in wage rate of farm workers along with cost of other inputs, rice farming is gradually becoming less remunerative. Mechanization of traditional rice farming practices can overcome the crisis and help in drudgery reduction. NRRI has significant role in developing improved rice machinery. Here information about these machines/implements is discussed in details:

1. **Bullock drawn tillage implements:**

Bullock drawn harrows were developed for used by small and medium land holding farmers to prepare the field after initial ploughing operation. NRRI two gang notch type disc harrow is developed for puddling the field. It has two gang with 2 notch type disc mounted over each hollow drum. It has provision for adding weight (sand) inside the drum to get better penetration in the soil. The two gangs are coupled in such way that it, can be pulled by a pair of bullock. Disc harrow is made by using Angle iron, MS sheet, notch discs etc. Its field capacity is 0.35 ha/h .This equipment can be used in light as well as heavy soils by increasing and decreasing the weight. On similar working principle NRRI drum type disc harrowwith 3 plane disc mounted over each hollow drum was developed.

Plate 1 Notch type disc harrow & drum type disc harrow

2. **Sowing implements**

Sowing implements have the most important role to mechanize the rice cultivation by replacing the traditional method of broadcasting in dry soil and manual transplanting in puddled soil condition. NRRI developed plenty of machines to mechanize the sowing operation.

For dry direct sowing of rice row seeding is the most efficient means to sow the crops with optimum seed rate and also with maintained row to row spacing. Row seeding also promotes maximum tilleringand better sunlight penetration to rice plants. Weeding cost is also reduced by using line sowing method.

2.1 Manual drawn sowing implementsfor dry sowing

2.1.1 NRRI single row, two row & three row manual seed drill

To mechanize small land size farms these implements were developed. Provision of fluted roller metering mechanism was given to adjusted the seed rate as per required by the operator. Field capacity for these implements varies from 0.01 ha/h to 0.04 ha/h.The machine saved seeds and labours in sowing of crops along the rows that helped in weeding and inter-culture operation

2.2 Power operated sowing implementsfor dry sowing

Manual operated machine requires higher human efforts and gives lower output. Time is constraint in sowing operation. It this operation delayed than possibly it affects the yield of the crop. If the field is prepared for dry sowing than timely sowing before monsoon is necessary for smooth operation of power operated machinery. So to handle all kind of land situations and get optimum seed rate for sowing here details about some improved machinery particularly for rice sowing are given:

2.2.1 NRRI three row self-propelled hill seeder

For precise sowing of rice seeds in hills this machine is developed. Cup feed type metering mechanism (plastic wheels with grooves on its periphery)is provided in this machine. It has 3.5 H.P. petrol start kerosene driven engine as a source of power. The seed rate is controlled by varying the positioning of seed box. It is made by using Angle Iron ,MS Flat ,GI Sheet, Plastic wheels ,Chain & sprocket etc. Its field capacity is 0.1 ha/h. It is suitable for dry hill seeding of rice with uniform hill spacing.

2.2.2 NRRI Power tiller operated multicrop seed drill

NRRI Five row power tiller operated seed drill was used for dry sowing of crop like rice, wheat, green gram, and black gram etc. It is mounted on the back side of power tiller. Machine is consists of seed box, flutted roller type seed metering mechanism, Frame, Furrow openers, ground wheel, power transmission system, ground wheel lifting mechanism, transport wheels and hitching mechanism. Seed rate adjusting lever is provided on the back side of seed box. Different seed rate for different crop can be adjusted by shifting the position of this lever. Its field capacity is 0.15 ha/h. There was no damage to rice seed in flutted roller when flaps were kept in down ward position.


NRRI three row hill seeder & multi crop seed drill

2.3 Sowing implements for pre germinated seeds

However the dry sowing of rice needs less field preparation and less water as compare to puddling and transplating but due to severe weed growth in dry sowing this technology is not that popular among farmers. Weeds are the main problem in adoption of dry sowing of rice. To improve farmers practice (Broadcast Biasi) efforts have been made by NRRI to develop some implements for line sowing in puddled soil conditions. Pre-germinated paddy seeding has economical and operational advantages over traditional planting methods because it eliminates nursery raising, transportation and physical damage to the seedlings. It reduces the human drudgery in transplanting of paddy and reduce cost of cultivation. Here details of these implements are given:

2.3.1 NRRI three row manual puddle seeder

It has float on the front to avoid sinkage of the machine. Metering device consists of plastic wheels having grooves on its periphery. The seed rate is controlled by varying the positioning of seed box. The seed rate is controlled by varying the positioning of seed box. It is made by using G.I. sheet, MS flat, Angle iron, MS Pipe, plastic wheels etc. Its field capacity is 0.15ha/h.

2.3.2 NRRI six row manual drum seeder

. Three drums each seed drum has two rows can be assembled to form 6 rows of seed drum. Wheels are provided at both ends. These wheels are made up of Light iron rods and adjustable floats are provided for easy operation under puddle field condition. GI sheet, MS flat, MS rod, MS pipe etc material was used for manufacturing the implement. Its field capacity is 0.04 ha/h. One human can easily pull this machine.

Three row manual puddle seeder & six row manual drum seeder

2.3.3 NRRI Eight row self-propelled seeder

It is an eight row, engine operated paddy seeder. It is suitable for sowing of sprouted paddy seed in puddled field. It is suitable for direct seeding of high yielding rice varieties. The machine comprised of a light weight diesel engine, power transmission system, seed drum, main frame, float, ground wheel and tail wheel. The self-propelled system reduces the human drudgery in transplanting of paddy and reduces cost of cultivation. This machine is made by using GI sheet, MS flat, MS rod, MS pipe, angle iron, power system of VST tiller 8 row transplanter and speed reduction gear box etc. Its field capacity is 0.24 ha/h. It is Suitable for sowing of sprouted paddy seed in puddled field.

NRRI Eight row self-propelled seeder

3. NRRI four row manual rice transplanter

The four row manual transplanter (NRRI design) was comprised of floats, a main frame assembly made of MS pipe that supported the seeding tray made of G.I sheet, pushing lever tray indexing mechanism, picker bar assembly and handle. Manual rice transplanter can be used for timely operation and reduced cost of cultivation with better crop yield. Its field capacity is 0.03 ha/h. It is suitable for transplanting of 20-25 days old mat type rice seedlings. It saves about 30-40% labour requirement and 40 % cost in transplanting operation.


4. Weeding equipment's

Weeding is most laborious job in rice farming. By using some improved weeders farmers can minimize the time requirement and cost for the weeding. Here some weeding equipment's developed by NRRI are discussed in details:

5.1 NRRI Finger weeder

It can be used for upland as well as lowland rice. Operator moves the handle forward and backward so that the weeds get uprooted by both direction motion. The fingers of weeder can work between the rows and between the plants.The fingers have been suitably spaced so that there is no clogging during operation. One labour can operate this weeder. Its field capacity is 0.02 ha/h. It is low cost hand tool witch reduced labour requirement by 35-40% and was found to be ergonomically suitable for farm women.

5.2 NRRI Star-Cono-Weeder

It is suitable for weed cutting, churning and mulching in wet land. The stars and conical drums cut the weeds and churn them into the soil. Float controls working depth and does not allow rotor assembly to sink in the puddle. It is operated by pushing-pulling action. The orientation of rotors create a back and forth movement in the top 3 to 5 cm of soil and helps in uprooting the weeds. The weeder is make by the use of MS flat, GI sheet, MS Pipe etc. It field capacity is 0.017 ha/h.It reduces labour requirement by 50-75 % and was found ergonomically suitable for local labour.

NRRI Finger weeder& NRRI star-cono-weeder

Custom Hiring

Custom hiring services (CHS), an important mechanism through which most small holders can access services of agricultural machinery.

QUALITY SEED PRODUCTION IN RICE

BC Marndi
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 programme:

Multiplication of the high yielding varieties immediately after they are notified and their distribution to farmers is very vital in a crop improvement programme. 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 programme 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 → Foundation Seed → Certified Seed, Four - Generation model with Breeder Seed → Foundation Seed I → Foundation Seed II → Certified Seed and Five - Generation model with Breeder Seed → Foundation Seed I → Foundation Seed II → Certified Seed I → Certified Seed II.

Indian Seeds programme 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 programme.

Production of Nucleus seed:

To start a nucleus seed programme 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.

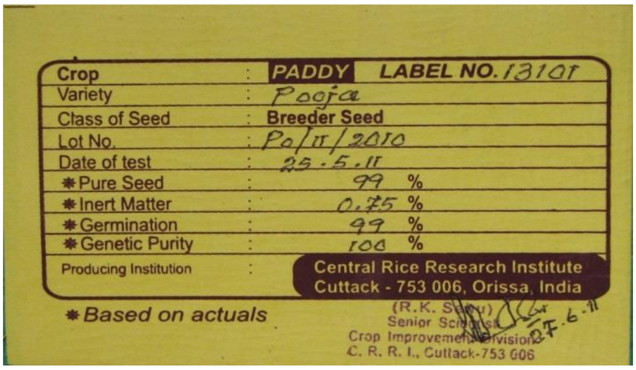
Breeder Seed:

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 ltr 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 in 1 mtr 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 mtr width and sow pre-germinated seed. Protect from bird damage. Seed Rate For high yielding varieties is 30 kg per hectre.

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 1/4th 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.

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.

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.

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 test and Moisture content test.

Purity test:

Purity denotes the percentage of seeds (by weight) belonging to the variety under certification.

Working sample is closely examined to classify it into the following components:

Pure seeds (seed of variety under certification)
Seeds of other varieties of the same crop
Seeds of other crops
Seeds of weeds/objectionable weeds
Inert matter (sand, straw, stones, soil, pebbles)
Defective seed (broken & shrunken seeds)

Maximum permissible limit for each of these impurities are fixed for different class of seeds.

- **Purity of the seed is calculated on weight basis**

$$\boldsymbol{Purity}\ (\%) = \frac{\boldsymbol{weight\ of\ Pure\ Seed}}{\boldsymbol{Total\ Weight\ of\ the\ Working\ Sample}} \times \mathbf{100}$$

- **A. Cultivar Purity Test:**

Done by-

1.Examination of seed in the laboratory:

Examination of morphological features of seeds, such as length, width, thickness, shape, weight, colour etc., and comparing them with those of the authentic sample.

Grow-out test:

- Determines the genetic purity of a given seed lot of a released cultivar and the extent to which the submitted sample confirms to the prescribed standards.
- Size of the submitted sample: 500 grams for Paddy
- Plot size and spacing varies depending on crops
- Observations are made both on qualitative and quantitative traits of the test and the authentic sample plots during the entire growing period.

Grow-out test:

- The frequency of the off-type plants is to be recorded.
- Permissible off-type frequency:
    - 0.05% per 8000 plants scored
    - 0.1% per 4000 plants scored
    - 0.2% per 2000 plants scored
    - 0.5% per 800 plants scored
    - 1.0% per 400 plants scored

Rice	Row Ler (m)	Spacing (cm)between			Number of replicat
		Plants	Rows	Plots	
Very early to Medium	6	15	20	45	2

Late & Very late	6	25	30	60	2

Germination or seed viability test:

- Germination is determined as per cent of seeds that produce or are likely to produce seedlings under a suitable environment.
- Wet filter paper method:
  - Seeds are germinated on wet filter paper placed in petridishes. The petri dishes are kept under controlled conditions for germination.
  - Germinated seeds are counted and percentage of germination is calculated.
  - Generally 4 samples are plated for a reliable test.

$$Germination\ (\%) = \frac{Total\ number\ of\ Seeds\ germinated}{Total\ number\ of\ Seeds\ Plated} \times 100$$

Germination or seed viability test:

- Tetrazolium Method:
  - The chemical 2,3,5-triphenyl tetrazolium chloride (or Tetrazolium chloride in short) is colourless, but it develops intense red colour when it is reduced by living cells.
  - Soak seeds overnight in tap water
  - Split all seeds longitudinally by a scalpel so that a portion of the embryo is attached with each half of the seed
  - Place one half of each seed in a petri dish and cover with 1% aqueous solution of tetrazolium chloride for 4 hours
  - Wash seeds under tap water
  - Count the seeds in which the embryo is stained red

$$Viable\ Seed\ \% = \frac{No.\ of\ Stained\ Half\ Seed}{Total\ no.\ of\ Half\ Seeds} \times 100$$

  - Method is: faster and cheaper .requires no controlled environment.

Moisture content test:

- Moisture content is determined as per cent water content of seeds by oven method or by moisture meter.
- In oven method, weighed seed samples are dried at 130 ˚C for 90 minutes in an oven; and the dried seeds are weighed again. The loss in weight represents the weight of water lost due to drying.

$$Moisture\ Content\ (\%) = \frac{W_1 - W_2}{W_2} \times 100$$

Where, W1 = Weight of seed sample before drying
W2 = Weight of seed sample after drying

- Moisture meters measure the moisture content of seeds very efficiently. It measures the resistance of seeds to an electrical current that varies with the moisture content.

Production of Nucleus seed:

For production of nucleus seed for MAS-bred varieties, while growing panicle progeny row it is advised to take DNA samples from each progeny row and go for DNA fingerprinting to ascertain the presence of the particular transferred gene in the panicle progeny.

KnowYourFaculty

S.N.	Topic	Faculty	Contact details
1	Integrated Farming System: Concept and Principles	Dr. B.S. Satapathy Scientist Crop Production Division ICAR-NRRI, Cuttack-753006, Odisha	88221 99996 bsatapathy99@gmail.com
2	Site selection, Design and field construction for site selection	Dr. Annie Poonam Principal Scientist Crop Production Division ICAR-NRRI, Cuttack-753006, Odisha	9437071534 anniepoonam16@gmail.com
3	Fish farming and its rearing under rice –fish system	Dr Pradeep Kumar Sahoo Assistant Chief Technical Officer Crop Production Division ICAR-NRRI, Cuttack-753006, Odisha	9437137406 pradeep_crri@rediffmail.com
4	Vermi-composting and nutrient recycling	Dr. B.S. Satapathy Scientist Crop Production Division ICAR-NRRI, Cuttack-753006, Odisha	88221 99996 bsatapathy99@gmail.com
5	Integration of horticulture crop under IFS	Dr. Gobinda Ch Acharya Principal Scientist Central Horticultural Experiment Station	94399 55433 gobinda1971@gmail.com
6	Integration of tuber crop under IFS	Dr.N. Nunduchezien Principal Scientist Regional Centre, ICAR- CTCRI, BBSR	79784 88514 mnedun@rediffmail.com
7	Integration of poultry and Duckery under IFS	Dr. S.C.Giri Principal Scientist, Regional Centre-CARI	94378 88004 scgiri12@rediffmail.com
8	Integration of livestock (Cow/goatary etc.) in IFS	Dr.Ranjan Kumar Mohanta SMS, ICAR-NRRI, Cuttack	8763671060 mohanta.ranjan@gmail.com
9	Seasonal mushroom cultivation under IFS & Disease Management under rice-fish system	Dr.S.K.Lenka Principal Scientist Crop Protection Division ICAR-NRRI, Cuttack-753006, Odisha	82491 77693 srikantalenka@yahoo.in
10	Quality seed production in rice	Sri. R.K.Sahu Senior Scientist, Crop Improvement Division ICAR-NRRI, Cuttack-753006, Odisha	94373 86275 rabinksahu@yahoo.com
11	Agro-forestry- an alternate farming system	Dr.Alok Patra, Professor, OUAT, BBSR	9437313160 alokpatra2000@gmail.com.
12	Insect disease management under rice-fish farming	Dr. Manas Kumar Bag Principal Scientist, Crop Protection Division ICAR-NRRI, Cuttack-753006, Odisha	80185 68165 manas.bag@gmail.com
13	Insect pest management under rice-fish farming	Dr. P.C.Rath Principal Scientist & Head, Crop Protection Division ICAR-NRRI, Cuttack-753006, Odisha	7978653054 pcrath67@gmail.com
14	Economics and schemes supporting farming system	Dr. B.Mondal Principal Scientist Social Science Division ICAR-NRRI, Cuttack-753006, Odisha	88953 22975 bisumondal@rediffmail.com
15	Climate Change and its importance of Rice-fish system	Dr. A.K. Nayak, PrincipalScientistCrop Production Division ICAR-NRRI, Cuttack-753006, Odisha	
16	Apiculture under rice based diversified farming system	Dr. R.N.Mohapatra Professor, OUAT, BBSR, Odisha	9437937551 hbouat1983@gmail.com

Supported by :

Seshadev Pradhan
Ashutosh Panda
Bhakti Prakash Mallick
Rashmi Ranjan Mohapatra
Smruti Ranjan Patra
Saroj Kiro
Diptikanta Mohapatra
Soumya Tanaya Sahoo

BSCIC NABCB QM 030
ISO 9001 REGISTERED
BN10448/9364:0914

Compiled by: **Dr. Annie Poonam**
Photography: **Shri Bhagaban Behera**

ICAR-National Rice Research Institute, Cuttack, Odisha 753006