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National Training Programme on Rice-based Cropping Systems for Different Ecologies

2—9 August 1999

Lecture Notes

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Foreword

THE National Training Programme on Rice-based Cropping Systems for different Ecologies sponsored by the Directorate of Extension, Ministry of Agriculture, Government of India is being organised at the Central Rice Research Institute, Indian Council of Agricultural Research, Cuttack, from 02 August 1999 to 09 August 1999 for the Extension Officers of various states. The concept of rice-based cropping system aims at maximising resources available with the farmers to increase crop intensity and add more avocations in the farm to increase over all production per unit area, and in the farm income.

Progress in rice research for the past few years has made it possible to harvest rice earlier, whenever, there is sufficient moisture in the soil, allowing for one more crop on the same land in year in quick succession. There is also a possibility of harvesting rain water; and to use it as a life-saving irrigation for the next crop. Crops needing lesser water for its development have been identified. It is also possible to add avocations such as fishery, birds, piggery, horticultural crop, and vegetable in rainfed lowlands for suitable habitat improvement and management.

We are pleased to organise this training, and look forward to the Extension Officers of various states in extending help to farmers' in translating this technology into actual practice, and also to increase farmers' income in a sustained manner. Recent trends in agricultural technology and dissemination involves the extensive use of computers. For the first time, in this training programme, an introduction to computer systems and the world wide web has been included, so that trainees can get information on the internet for their use.

I thank Dr. M. Venugopalan, Principal Scientist and Head, Extension, Communication and Training, and his team for coordinating and conducting this training programme, and also to the resource scientists of this institute for providing the training to the trainees.

We hope that this lecture note will be useful to the trainees in implementing rice-based cropping system at the farmers' level.

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Preface

THE primary objective of Rice-based Cropping System is to include two or more crops for increasing the crop intensity and crop production per unit area and time without hampering soil fertility. This requires selection of right varieties suitable for agroclimatic regions, management of soil, fertilizer, weeds, water, control of pests and diseases, and superior management of timely operations. The Rice-based Cropping System besides helping in food production, also generates employment potential in the village throughout the season as well as improves the economic condition of the farmers.

The National Training Programme on Rice-based Cropping Systems for different Ecologies under the financial assistance the Directorate of Extension, Ministry of Agriculture, Government of India, New Delhi, from 02 August 1999 to 09 August 1999 for Extension Officers of different states is being held at CRRI, Cuttack.

Dr. K.C. Mathur, Director, CRRI, has indicated the importance of Rice-based Cropping Systems for increasing crop production, and its scope for adoption. The lecture notes included in this training manual by our resource scientists are based on their experiments and experience in their respective subjects.

I hope that this lecture notes would result in better performance of the task involved in Rice-based Cropping Systems. I thank the Director, CRRI, and the Directorate of Extension, Ministry of Agriculture, Government of India, New Delhi, for their cooperation and help for organising this training programme. I also thank the Staff Members of the Division of Extension, Communication, and Training, CRRI, for their wholehearted support and cooperation.

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RICE AND RICE BASED CROPS IN DIFFERENT ECOSYSTEMS IN INDIA - ISSUES AND STRATEGIES

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Agricultural production in general and food grain production in particular are playing a significant role in India to meet the ever growing demands of increasing population. Among food grains, rice alone contributing about 40 per cent with a current production level of 84 million tonnes harvested from about 43 million hectares. In fact, agricultural productivity of a nation is measured not in terms of quantum of production of any particular crops, but in terms of out put per unit area per unit time. This is often expressed of cropping intensity. If a single crop of rice is grown in a year on a piece of land, then the cropping intensity of that land is expressed as 100. If two crops are grown, then the cropping intensity becomes 200 and so on. The available data reveals that the average cropping intensity for the country is 125, indicating that only 25 per cent of the arable land is double cropped. However, the cropping intensity varies from region to region and state to state. Generally, the cropping intensity is depends up on the several coplicated factors of which source of water is an important factor. Based on the cardinal issuses of hydrology and its diversity, the rice lands are gropped into the following three main categories :

A. Irrigated
B. Rainfed uplands
C. Rainfed lowlands

A. Irrigated

This ecology occupies 17.8 million hectares in the country accounting for only 42 per cent of the total rice land with an average yield of 2.24 t/ha. High yielding rice varieties released so far for this ecosystem are 272 of which 24 from Central Rice Research Institute (CRRI).

The concerns

- Disciplined delivery of water and drainage
- Crop growth duration ranges from 90 to 145 days
- Mostly grown with dwarfs, although in pockets semi-tall/tall are grown
- Management of nutrients are important
- Grown as pre-monsoon, monsoon and post monsoon (summer crop)

- Management of many serious biotic stresses during the entire crop growth period

Rice-based cropping sequences used by farmers in different areas

- Rice-Rice-Rice
- Rice-Wheat-Rice
- Rice-Rice-Legumes/Groundnut
- Rice-Legumes-Rice
- Jute-Rice-Rice/Wheat/Potato
- Rice-Vegetables/Legumes
- Rice-Wheat-Vegetables/Legumes/Fodder
- Rice-Wheat
- Rice-Cotton
- Rice-Legumes/Oilseed

B. Rainfed Uplands

This rice occupies 7.0 million hectares and contributes 6.0 million tonnes to the total rice production. Till recently, non-availability of suitable varieties has been the prime constraint for increasing rice production and productivity. As a consequence, 95 high yielding rice varieties has released of which 12 from CRRI.

The concerns

- Management of periodical and terminal drought
- Drought escape and tolerance mechanisms
- Low yield potential for traditional varieties being used
- Resistance/tolerance to blast, brown spot, stem borer, gundhi bug and termites
- Replacement of broadcast method with line sowing
- Improving crop stand
- Management of weeds
- Management of soil fertility and moisture

Rice-based inter and sequence crops taken by farmers in come areas

- Green gram, Pigeon pea, Groundnut, Cowpea and Black gram are ideal as inter crops
- Groundnut and Green gram are good sequence crops

C. Rainfed lolands

Based on the depth of standing water and its duration, this ecology is further divided into three sub-systems viz., favourable lowlands (0-40 cm water depth), un-favourable lowlands (41-75 cm water depth) and deep water rice (76-

120 cm water depth). However, the levels of water depth are not rigid. When monsoon fails some un-favourable lowlands become favourable lowlands.

Favourable lowlands

This ecosystem is considered almost similar to irrigated system. Total area under this ecosystem is 10 million hectares. Dry seeding in May ensures better stand. The average productivity of rice in this ecosystem is 1.2 t/ha. High yielding rice varieties released so far for this ecosystem are 100 of which 8 from CRRI.

The concerns

- Suitable varieties with high yielding potential, desired type of photo-sensitivity and submergence tolerance
- Crop stand establishment for direct seeded crop
- Replacing beaushening with line seeding coupled with interculturing or improving beaushening practice
- Use of blends both organic and inorganic fertilizers
- Tolerance to pests and diseases
- Rice-fish-different crop farming system
- Suitable relay and rice based cropping systems with pulses

Rice-based crop sequences taken by farmers in certain areas

Groundnut, tomato, cucurbits, pigeonpea, blackgram, greengram, mustard and okra as sequence crops.

Un-favourable lowlands

This ecology occupies 6.0 million hectares. Rice crop is direct seeded in April and May. The average productivity is 1.0 t/ha. Basal application of fertiliser helps to maintain plant population as splits are not possible. High yielding rice varieties released so far for this ecosystem are 40 of which 8 from CRRI.

The concerns

- Development of semi-tall, stiff strwed, large panicle type varieties with desired type of photosensitive, thermo-insensitive and tolerance to cycles by submergence
- Tolerance to drought at initial crop growth stage
- Maintenance of plant population
- Tolerance to stem borer, cut worm, bacterial blight, iron toxicity and Zn deficiency
- Improving rice-fish farming system

Suggested rice based crop sequences

Green gram and Cowpea are suitable sequence crops.

Deep-water rice

The total area under this type of rice cultivation is 1.5 million hectares. Generally water level is around one meter and in some cases it may reach up to 3-5 meters. Seedin in March-April may results good yields. The average productivity is 0.6 t/ha. High yielding rice varieties released so far for this ecosystem are only 5.

The concerns

- Varieties with high yield which elongate if needed and tolerance to YSB and Ufra and repeated submergence
- Maintaining good plant population
- Agronomic management of the crop
- Use of different cropping systems to reduce YSB, bacterial blight, nematodes, rats and weeds incidence

Rice-based crop sequences which some farmers take in different regions

Vegetables, Mustard and Lentil as sequence crops.

Issues And Strategies

There is need to increase rice production and sustain it in all rice growing environments of the country, giving due emphasis to consolidate the yield gains already achieved in irrigated ecosystem and to increase the yield levels further under the ecologically harsh environments of the rainfed ecosystem. Add more avocations on the farm to increase farm income.

The major issues are :

- Increasing rice productivity
- Achieving sustainability by conserving the resource endowments
- Protecting fragile environments
- Relieving pressure on potential environments
- Adding more farm avocations to reduce dependance on off farm activities
- Addressing issues of social equity
- Increasing opportunities for women in rice farming and reducing their drudgery

Strategies :

Some of the major strategies to achieve the production target about 95-99 million tonnes of rice by 2000 AD are as follows:

1) **Consolidation of yield gains under irrigated ecology and utilise hybrid rice technology and Boro rice production system**

- Understanding and arrest the decline in yield and sustain yield growth with IPM, INM, IDM and soil health care
- Raising productivity with new plant type, hybrid rice and Boro rice
- Improve fertilizer use efficiency
- Add/substitute more value crops

2. **Enhancement of production and productivity of rainfed ecology**

- Development of better adapted HYVs
- Risk distributing crop management techniques
- Raising genetic yield celling by exploitation hybrid vigour and new plant type
- Exploitation of productive but underutilised environments through lowland Boro rice or deepwater and Boro system
- Adding more on farm avocations like rice-fish farming system, seed multiplication, poultry, piggery, horticulture etc.

3) **Cost effective and environment friendly production technologies in all ecosystem**

- Integrated pest management (IPM), & integrated weed management (IWM) and integrated disease management (IDM)
- Integrated nutrient management (INM)
- Alternative weed management practices

If efforts are intensified in the most favourable areas for rice, the production can be sharply increased with the present day technology, provided the necessary support is made available in the form of required inputs. Consolidation of yield gains under irrigated conditions can be achieved by understanding the problems associated with the decreasing fertiliser use efficiency and unstable production growth and checking them properly. Soil health is another critical issue. Rice has to be made competive to other high value crops which may replace rice in many irrigated rice areas. Similarly, for enhancement of production and productivity in rainfed areas, suitable high yielding varieties are needed coupled with proper nutrient management.

Exploitation of hybrid vigour in rice is well recognised as an appropriate strategy as has been realised in China's progress in rice production. Commercial exploitation of hybrid vigour in rice in China, enabled 20-30% yield advantage and thus elevate the average yield to 6.5 t/ha from over 18 m ha. If 60-70 per cent of irrigated rice area could be brought under hybrid cultivation in India, it would contribute about 10-12 million tonnes of additional rice in India. In addition, intensive research efforts should also be made to develop the hybrids which are suitable for upland and lowland rainfed conditions where the present average yield is quite low, but have huge untapped potential.

With the advent of high yielding hybrid rice in high productive areas and popularisation of HYV in rainfed rice, the demand for plant nutrients would increase. To realise their full potential, higher doses of balanced fertiliser are a pre-requisite. Balanced fertilisation in accordance with nutrient demand by crops would ensure high productivity, whereas imbalanced use of fertiliser can lead to soil degradation and also a decline in crop productivity. Generally, bulk of fertiliser use on rice has been confined to irrigated area having 45% rice acreage while rainfed uplands and lowlands receive little fertiliser. The future efforts, therefore, should be concentrated in increasing fertiliser use in these areas to match the present day HYV developed for these areas which are low input responsive.

Another area that requires attention is the use efficiency of applied fertilisers, particularly nitrogen. Despite impressive growth in N consumption over the years, efficiency of fertiliser N in lowland rice remains low and is attributed to N losses from the soil-plant system through volatilisation, run-off and leaching.

Assured availability of water is another important factor in rice production. Bulk of the area under rice in India depends on the rainfall for its water need. Increasing use efficiency of water will not only ensure rice production in the existing area but also will facilitate bringing additional areas under irrigation and thereby increase the total production.

Increased productivity of rice cannot be sustained unless the declining trends in soil fertility resulting from the nutrient mining process due to continuous cropping is checked. The use of organic manures alone has the drawback of low content of plant nutrients and its slow release character. Its limited availability due to various reasons has further prevented its widespread applicability. Various constraints associated with the production, storage and use have not allowed large scale use of biofertilisers. Hence, integrated nutrient supply through chemical fertilisers, organic manures like green manures and biofertilisers like azolla has to be encouraged to maintain and sustain a higher level of soil fertility and crop productivity.

In order to obtain maximum yield to feed the ever increasing population in the years to come, instead of concentrating on the fertilisation of a single crop, rice based cropping as well as farming system as a whole should be considered. Since high yielding and hybrid varieties need considerable amount of nutrients for sustained productivity, a renewed approach to fertiliser management in rice-based cropping systems has become more relevant. For efficient nutrient management in cropping systems, a quantitative evaluation of the role of preceding crops and the residual effect of nutrients applied assumes great importance.

Integrated rice based farming system like integrated rice with fish, poultry, dairy and mushroom cultivation is another viable concept for sustained productivity in today's agriculture. Various research results have indicated its advantage over conventional system of cropping. For instance conventional cropping system is susceptible to high degree of risk and uncertainity and provides only seasonal, irregular, uncertain income and employment to the farmers. With a view to reduce the risk and uncertainity of income from crop enterprises and to decrease the incidence of pests and diseases and to reduce the time lag between investment and returns, it is imperative that the farmers should include such type of enterprises in their production programme which can generate year round income regularly. This calls for systems approach in farming. Moreover, adoption of farming systems also result in better utilisation of resources, higher and regular income and employment opportunities throughout the year. The recycling of wastes makes the system ecofriendly.

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OPPORTUNITIES FOR INCREASING RICE YIELD

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The rice production level has to be raised to 95 mt by 2000 AD to meet the demand of about 1000 million population. As the scope of increasing the rice area is limited, it is necessary to increase the productivity of the land. This can be achieved increasing the yield ceiling of the varieties as well as improving management practices are required.

The productivity of rice of different states in India varies from 1 t/ha to 3 t/ha. The data collected from various sources are:

Productivity (t/ha)	States
Above 3	Punjab, Tamil Nadu
2.5-3	Haryana, Andhra Pradesh, Goa
2-2.5	Karnataka, West Bengal
1.5-2	Kerala, Uttar Pradesh, Jammu and Kashmir, Gujrat, Maharastrà, Manipur, Tripura
1-1.5	Orissa, Assam, Bihar, Madhya Pradesh, Rajasthan, Himachal Pradesh, Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh.

To increase production and productivity it is highly required to improve:

i. Yield ceiling through crop improvement
ii. Narrowing yield gap through crop production and protection
iii. Maintain sustainability of production through maintain soil health and water resources.

Yield barriers in rainfed uplands are:

- Drought: Morroberakan, IRAT, CR 143-2-2
- Weeds: Early vigour
- Poor soil: Acidity, P-deficiency, AL-toxicity and NPK-deficiency
- Pysiological: Better translocation from stem to grain after flowering
- Panicle/m^2 (tiller No.): Most affected

Identification and use of suitable donors

Irrigated: Disease/pests/sterility

Components for yield improvement in rainfed lowlands are:

Submergence tolerance early/late: Vegetative stages
Donors-FR 13A, Khajara, Luni farm
Drought tolerance (Initial stage)
Photosensitivity (Specific time)
Thermo-insensitivity (Floodering)
Iron-toxicity tolerance
Panicle weight type
Stiff straw

Improving physiological efficiency (metabolic processes) are:

- Presently-photosynthetic efficiency through increased leaf area and leaf longivity
- Desirable improvement: translocation of metabolites, low photo-respiration, redirecting photosynthetic pathway from C-3 to C-4 system (enzymes) and low light efficiency.

Opportunities to raising yield ceiling:

- Hybrid rice- 3 lines, 2 lines and 1 lines
- Boro rice (Improvement & mechanism)
- Super rice/plant type
- Increased physiological efficiency
- Biotechnology

Adoptible technologies:

- Rainfed uplands: sowing in row
- Irrigated lands: hybid rice (TP) and super rice (D/S)
- Rainfed lowlands: timely seeding/planting
- Deep water: Boro rice
- Post-flood: Super fast rice
- Export: Basmati rice and non-basmati

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SUITABLE RICE-BASED CROPPING SYSTEMS FOR ALLUVIAL SOILS OF COASTAL ORISSA

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Coastal Orissa has been endowed with resources like abundant sunshine, temperature, fairly good rainfall and ground water. Humid tropical climate presents a tremendous scope of growing crops throughout the year in this zone. In spite of all these, the state have lagged behind in terms of productivity compared with many other states, mainly due to under-utilization of natural resources. The problem is further aggravated due to diversity in soil, topography, purchasing power of the farmers, the location-specific technology, uncontrolled cattle grazing and poor availability of inputs (appropriate seeds, fertilizers and plant-protection chemicals) t, the small, marginal and ecologically handicapped groups. Recent price hike in fertilizers, unassured marketing and processing facilities are the other bottlenecks in the way of achievement.

An attempt was made at tile Central Rice Research Institutê, Cuttack, to generate and disseminate location-specific technology for rice and rice-based cropping systems for rainfed and irrigated ecosystems in the recent years. The idea gained momentum after the -basal cropping system with the financial support or the Ford Foundation.

Under this Project, apart from generating rice technology all possible attempts were made to utilize natural resources, intensifying cropping intensity and improving productivity, especially in the rainfed as well as fully irrigated ecosystems. Rice-based farming systems were designed and tested involving farmers at every stage, from problem diagnosis to planning, implementation of project and documenting the findings including their frank opinion about the generated technology.

After taking early rice in uplands, efforts were made to raise crops suited to particular ecosystem in sequence based on soil and climate. Similarly, attempts were also made on medium as well as lowlands to raise fields of rice and follow-up crops in sequence with medium-duration and late-duration rices. This was done in rainfed as well as in irrigated ecosystems especially considering low cost of technology like optimum time and methods of seeding or planting, choice of appropriate crop varieties, moderate input use, low-cost weed management and plant protection of resource-poor farmers. A number of crops including cereals, vegetables, oilseeds and pulses were grown in the trials to made the farmers self-sufficient for meeting their requirement and disposal of remarkable surplus. After a thorough experimentation on different crops under available weather condition, crop calendar for uplands was prepared. The results obtained under different categories of land with alluvial soils are given in Tables 1, 2 and Figures 1 to 3.

Rainfed uplands

Farmers of the coastal Mahanadi alluvial zone belonging to villages of Mallipur, Mangadeipur, Khentalo, Isani Berhampur etc. of Cuttack district had uplands with fertile alluvial soil having sufficient depth with water-table within 1^{-2m}. The high-yielding semi-dwarf rice variety, Annada maturing in 105-110 days was capable of giving 4.5 and 5 tonnes under good management in such soils. This zone receives fairly good amount of rain (1,400-1,500 m) from June to October, hence reasonable good crops are feasible even on residual soil moisture supplemented with water-table contribution through capillary rise. Farmers were receptive and co-operative. On-farm research yielded valuable information. A number of crops tomato, pigeonpea, groundnut, mustard, urdbean and horse gram-were taken in sequence with Annada. Farmers adopting traditional system of rise-urdbean fetched a maximum of Rs 6,330/ha even after adopting a high-yielding variety of rice (Annada) and improved variety of urdbean (T9). By adopting a system of rice-tomato sequence the farmers fetched a reasonably good price of tomato owing to early tomato and raised their net income up to Rs. 30,000/ha from traditional rice-urdbean system. The new system helped the farmers double their income apart from supplying a pulse for their family. rice-mustard (Pusa Bold) under alluvial uplands increased their net income at least 1.5 times that of their old system (Table 1). The farmers of this locality got impressed with the rice-tomato system so much that few farmers have taken up commercial seed production of tomato.

Irrigated upland

This category of land with irrigation facility of their production inputs can sustain 300% cropping intensity. On-farm data presented in Table 2 show that the farmers of Gopalpur, Khentalo, Manga-deipur and Mallipur villages with allivial soil and irrigation facility got the highest income from rice-rajmash-maize (green cobs) sequence, followed by rice-cucumber-maize (Fig 3). Among the individual crops, brinjal gave the highest net return followed by maize from green cobs. The success of such programme depends on the willingness of farmers to earn more, prompt agricultural operations, availability of good seed and other production inputs, and the marketing facility. Rice-rajmash-maize (for cobs) gave a net return of Rs.29,950/ha to the farmers of Raghunathpur, having lift-irrigation facilities. The second best sequence was rice-cucumber-maize (for cobs) which gave a net return of Rs. 19,700/ha. Rice-maize-cowpea was the third best sequence fetching nearly Rs.27,000/ha (Table 2). This sequence was liked by the farmers having few heads of milch animals, as the green fodder from maize (after harvest of green cobs) as well as cowpea are highly palatable for milch cattle, which raised their milk yield.

However when the cost: benefit ratio was calculated rice-cucumber-maize and rice-maize-cowpea systems gave the highest benefit of Rs. 2.50 for the investment of Re 1. These systems were followed by rice-rajmash-maize which gave Rs. 2.29 for Re 1 investment. As an individual crop, maize and cowpea gave the highest r benefit of Rs.3 for Rs.1 investment followed by cucumber (Rs. 2.86) and greengram or mungbean (Rs.

2.50) crops. Rice gave the benefit of Rs. 1.38 only for Re 1 investment which indicated for increasing the cropping intensity to improve the economic status of the farmers.

Irrigated medium land

Medium lands with assured irrigation, where rice varieties (Moti or Padmini) maturing in 145 days are grown, is generally free by November end. The next crops are sown by first week of December. Under such a situation, it 8 s found that 2 crop sequences rice-maize-cowpea and rice-tomato-okra, gave the highest net return of Rs.30,000/ha (Table 3). These sequences were followed by rice-rajmash-okra (Rs.26,500/ha), and rice-sweet potato (Rs.26,000/ha).

Result on cost: benefit ratio indicated that rice-maize-cowpea gave the highest return of Rs. 2.86 for Rs. 1 investment. This was followed by rice-sweet potato sequence giving Rs.2.65 for Rs. 1 investment. As an individual component maize and cowpea crops gave the highest return of KS 3 each for Re 1 investment. These were followed by sweet potato (Rs. 2.85). It is worth mentioning that fodder cultivation gets least importance by the farmers of Orissa so under such conditions sweet potato vine proves to be excellent fodder for milch as well as draught animals. these vines, on being preserved may act as seed material for the ensuing rainy season crop to be grown on uplands. Rice gave Rs 2.14 only for Re 1 investment which indicates the need to grow more remunerative crops to improve the economic status of farmers.

Lowland ecosystem

Lowlands are generally situated at some distance from villages or homestead areas and are vacated by long-duration rice by the end of December, thus have limited choice of crops. In Orissa. stray cattle menace is a serious problem. Lowland soils are heavy and take some time to come in condition for proper tilth, thus sowing of second crop gets delayed. Under rainfed lowlands after rice, a short-duration crop of greengram is feasible only. Attempts have been made to grow watermelon, bitter gourd, pumpkin and okra under protection from stray cattle.

However, these crops except greengram need pot irrigation. So, on being provided the irrigation these crops can give good returns.

In canal-irrigated areas, due to water accumulation, there is no option except growing a *dual* rice (summer rice) hence, rice-rice is a very common sequence in lowlands. In rainfed lowlands, however, rice-greengram gave a net income of Rs.11,100/ha.

In the irrigated condition rice-cowpea gave a net return of Rs.24,000/ha compared with Rs.12,000/ha from rice-rice sequence.

Table 1. Yield and net returns from different Annada rice-based sequences grown on rainfed uplands (on residual soil moisture) alluvial soil of Mangadeipur, Millipur and Khentalo villages of Cuttack during 1994-93.

Crop sequence	Yield of economic products (kg/ha)	Net return from *rabi* crop	Total net returns from sequence (Rs. kg/ha)
Rice-tomato			
BT 2	30000	30000	34830
BT 1	25000	25000	29830
Punjab Keshari	28000	28000	32830
Rice-pigeonpea			
DA 8	1562	3300	8130
DA 16	1560	3000	7830
UPAS 120	1500	2800	7630
ICPL 87	1225	2050	6880
Rice-groundnut			
AIS 8907	2600	7000	11830
TMV 87	2500	6000	10830
Rice-mustard			
Pusa Bold	1400	5500	10330
Pusa Bahar	1350	5000	9830
YSB 9	1250	4000	8830
Rice-urdbean			
T 9	500	1500	6350
Rice-chickpea			
CGH 2	1500	3000	7830
CGH 55	1350	2700	7530

Rice Net return Rs 4630/ha

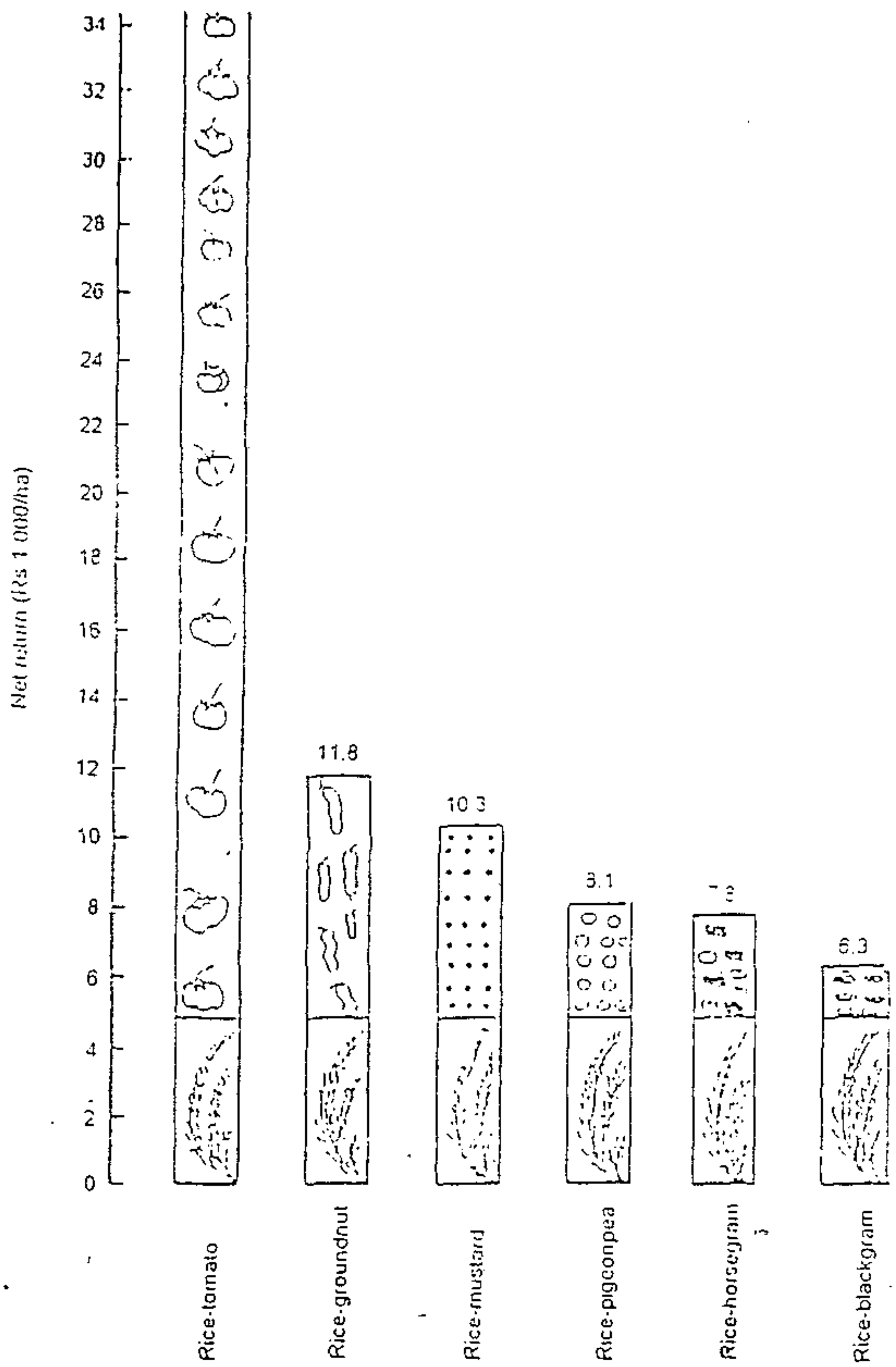
Table 2. Yield of economic produce and net returns from different Annada rice-based cropping sequences in *irrigated* uplands of Khentalo, Raghunathpur villages of (Cuttack) during 1984–93

	Crop sequence	Variety	Fertilizer dose (kg/ha) N:P$_2$O$_5$:K$_2$O	Yield of economic products (tonnes/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)		Cost : benefit ratio *
T_1	Rice–*rajmash*–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	maize	PDR 14	60 : 40 : 40	1.5	4 750	10 250	29 950	1 : 2.16
		Ganga 5	120 : 60 : 60	40 000 (green cobs)	5 000	15 000		1 : 3.00
								(1 : 2.29)
T_2	Rice–cucumber–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	maize	Winter Variety	60 : 45 : 60	20.0	3 500	10 000	29 700	1 : 2.86
		Swarna Composite	120 : 60 : 40 (green cobs)	40 000	5 000	15 000		1 : 3.00
								(1 : 2.50)
T_3	Rice–maize–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	cowpea	Swarna Composite	120 : 60 : 60	40 000 (green cobs)	5 000	15 000	27 200	1 : 3.00
		Russian Giant	20 : 40 : 40	15.0 (fodder) 1.0 (seed)	2 500	7 500		1 : 3.00
								(1 : 2.50)
T_4	Rice–*rajmash*–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	bhindi	PDR 14	60 : 40 : 40	1.5	4 700	10 200	23 450	1 : 2.17
		PK/Satpatria	60 : 40 : 40	5.0	3 500	8 500		1 : 2.43
								(1 : 2.02)
T_5	Rice–potato–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	sesame	Kufri Chandramukhi	120 : 60 : 40	20.0	7 000	13 000	23 300	1 : 1.88
		Vinayak/S 14	40 : 20 : 40	0.6	3 000	5 600		1 : 1.67
								(1 : 1.74)
T_6	Rice–ground-		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	nut–mungbean	AIS 8907/AK 12-24	20 : 40 : 60	2.0	6 000	12 000	21 700	1 : 2.08
		Pusa – 105	20 : 30 : 30	0.75	2 000	5 000		1 : 2.50
								(1 : 1.90)
T_7	Rice–		60 : 40 : 40	4.5	3 400	4 700	21 200	1 : 1.38
	brinjal	Pusa Purple long	120 : 60 : 40	15.0	8 900	16 500		1 : 2.85
								(1 : 1.72)
T_8	Rice–mustard–		60 : 40 : 40	4.5	3 400	4 700		1 : 1.38
	mungbean	Pusa Bold	50 : 40 : 40	1.0	3 400	7 000	16 700	1 : 2.06
		Pusa 105	20 : 30 : 20	0.8	2 000	5 000		1 : 2.50
								(1 : 1.90)

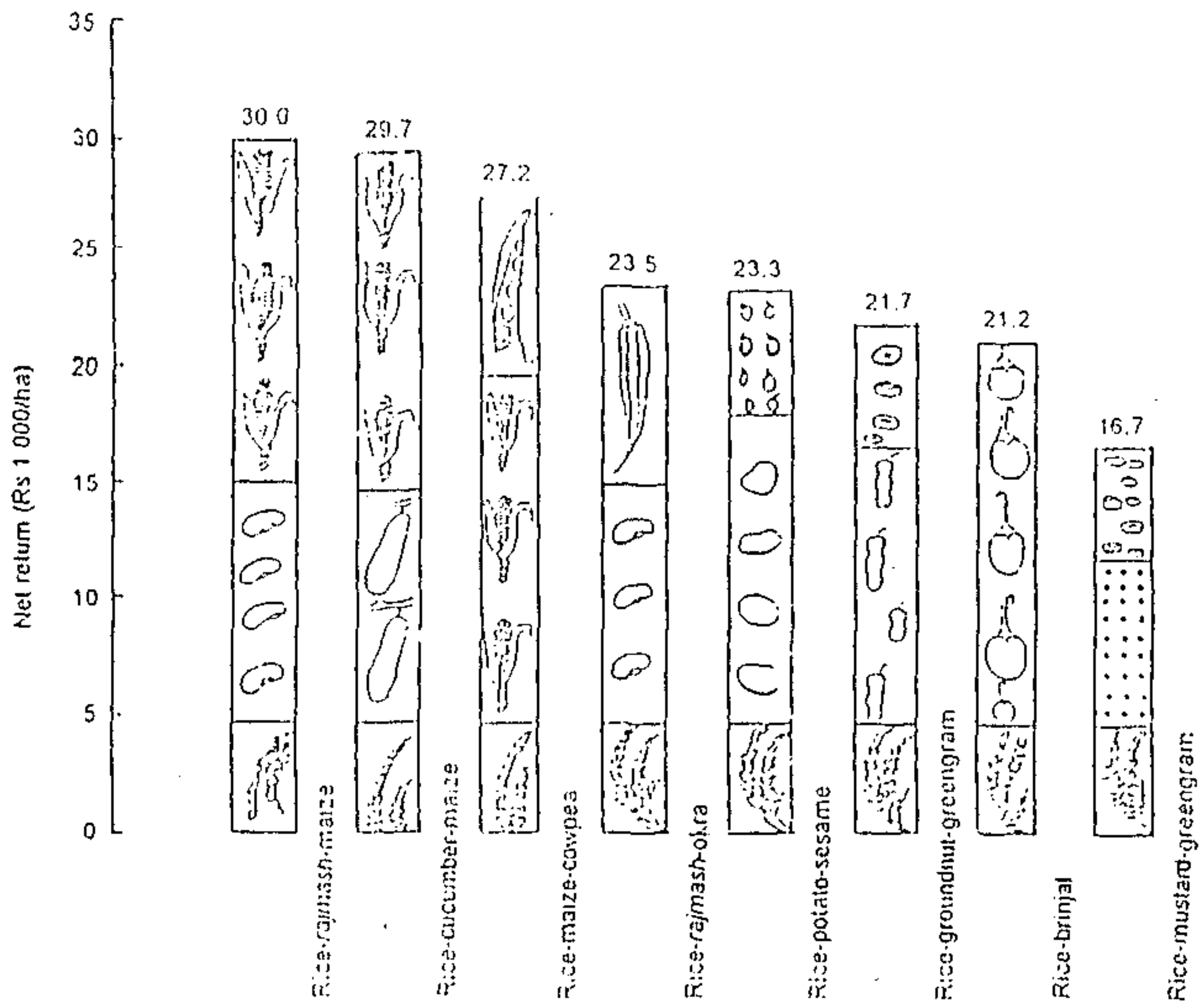
Cost of produce (Rs) : Rice 1.8/kg; *rajmash* 10.0/kg, maize 0.50/cob; cucumber 0.68/kg; cowpea 0.4/kg (fodder) and 4.0/kg (seed); *bhindi* 2.4/kg; potato 1.0/kg; groundnut 7.6/kg; brinjal 2.0/kg; mustard 10.4/kg and mungbean 9.3/kg

Price of fertilizer (Rs) : Urea 3.33/kg; single superphosphate 2.24/kg; muriate of potash 4.87/kg and diammonium phosphate 7.74/kg

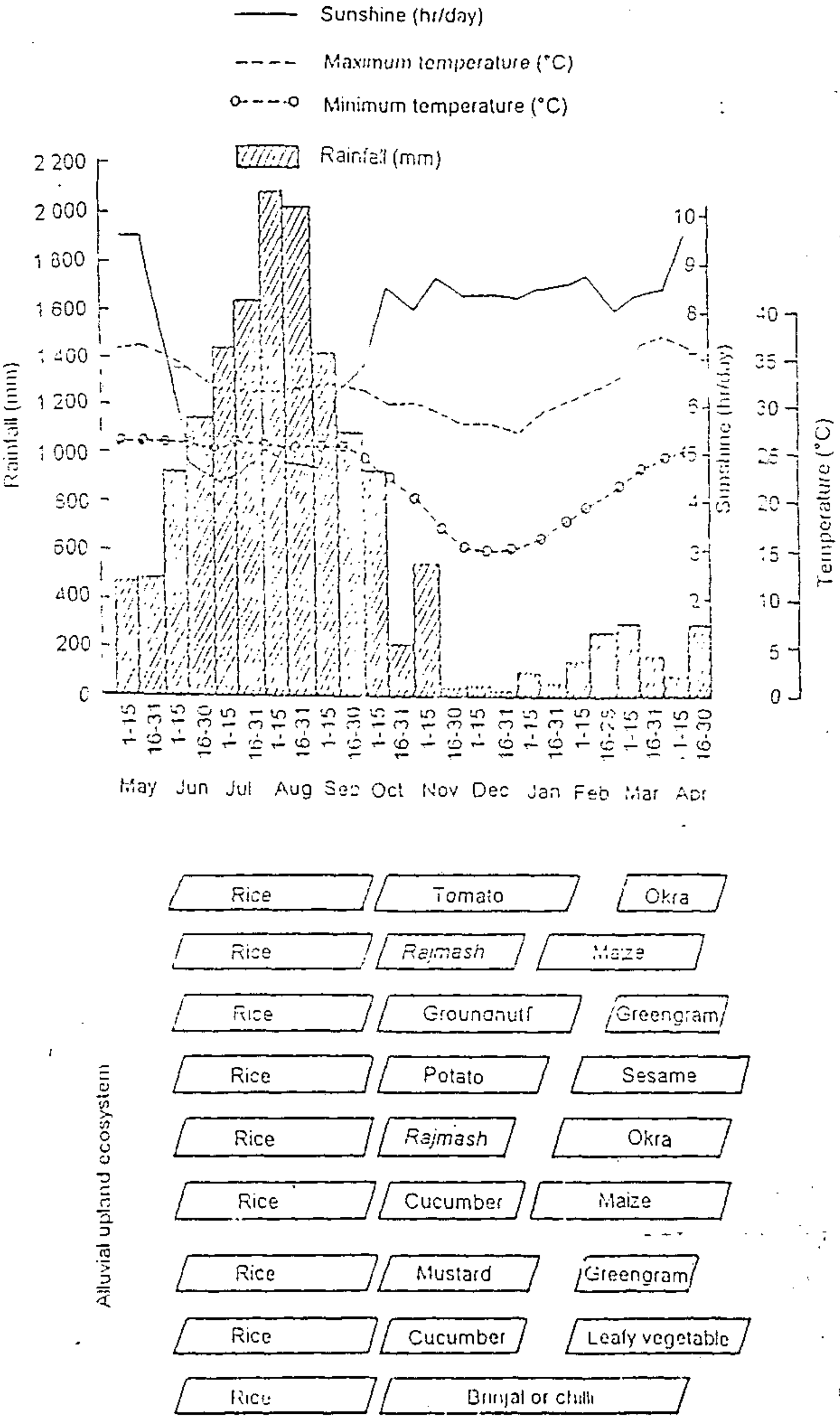
*Figures in parentheses indicate the calculated cost : benefit ratio for a particular cropping system



Net returns from different rice-based cropping systems in Mahanadi alluvium (rainfed uplands) during 1984–89



Net returns from different rice-based cropping systems in Mahanadi alluvium (irrigated uplands) during 1984–89


Sunshine (hr/day)
Maximum temperature (°C)
Minimum temperature (°C)
Rainfall (mm)
Rainfall (mm)
Sunshine (hr/day)
Temperature (°C)
2 200
2 000
1 800
1 600
1 400
1 200
1 000
800
600
400
200
0
10
9
8
6
5
4
3
2
40
35
30
25
20
15
10
5
0
1-15
16-31
1-15
16-30
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Alluvial upland ecosystem
Rice
Tomato
Okra
Rice
Rajmash
Maize
Rice
Groundnut
Greengram
Rice
Potato
Sesame
Rice
Rajmash
Okra
Rice
Cucumber
Maize
Rice
Mustard
Greengram
Rice
Cucumber
Leafy vegetable
Rice
Brinjal or chilli

INTEGRATED NUTRIENT MANAGEMENT IN RICE

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Plant nutrient budgeting for India in recent years shows that nutrient removal from soil by all crops far exceeds the supply made through chemical fertilizers, posing a serious threat to long term sustainability of crop production. Integrated nutrient management (INM) achieved through combined use of all possible sources of nutrients such as chemical fertilizers, organic manures, green manures, crop residues, biofertilizers and industrial wastes and their efficient utilization, can possibly meet the total nutrient demands and restore or improve soil health. Besides INM can optimise crop yields, improve quality of crop produce and decrease energy consumption in agriculture.

Long-term use of optimal doses of N, P and K with FYM or compost improves soil physical health, increases rice yield (0.4-0.7 t/ha/crop) over NPK and results in favourable balance of available nutrients in different soils. Urea and FYM applied in equal proportions on N basis at 60 and 90 kg N/ha give comparable rice yields with entire N applied through urea. In rainfed lowland direct sown rice, basal seed furrow placement of NPK or reduced zone placement of amide/ammonium fertilizers minimises nutrient losses and increases fertilizer use efficiency significantly.

Studies in China show that waterlogged composting of animal dung, rice straw and milk vetch with river mud or tank silt greatly reduces N losses both in compost pit and in rice field after its application because mineral N remains as NH_4^+-N in waterlogged compost. This process is more efficient than ordinary composting. Still more superior is the process or biogas fermentation which conserves almost entire-N (94%) of the input materials in the final manurial products.

Experiments on green manuring conducted at a rainfed lowland site of the Central Rice Research Institute for 6 years revealed that *Sesbania aculeata* grown as an intercrop with direct sown rice contributed 56 kg N/ha as against 66 kg N/ha from the sole crop of green manure which preceded transplanted rice. In terms of rice grain yield and N utilization, green manuring was at par with or even superior to chemical N applied at the rate of 60 kg/ha. Nitrogen fixation during first 30 days of growth was only 17 kg with *Sesbania rostrata* and 25 kg/ha with *Sesbania aculeata*. It was equalized to around 61 kg N/ha in both the species in 45 days of growth after which the N_2 fixation was higher in *S. rostrata* than in *S.aculeata*. Despite the better performance of green manuring, its adoption has declined dramatically over the past several years because of unreliability of green manure crop establishment under rainfed conditions, non-availability of seeds and labour intensive/expensive field operations. The limitation of seed supply can be overcome by transplanting *Sesbania* plants with wide spacing in transplanted rice field. To economise the practice of green manuring, relay cropping of green manure with irrigated rice or growing double or multipurpose legumes like greengram or cowpea and green manuring after one or two pluckings of pods have been suggested. Rice crop also benefits from biological nitrogen fixation if a pulse or leguminous oilseed crop is either included in the cropping system in rainfed uplands.

India has a vast potential of crop residues. But their use in INM is limited because of their alternate utilities as animal feed, fuel and roofing material. The crop residues with wide C : N ratio like rice straw even with 40 kg N/ha depressed crop yield for the first 2-3 years after which yield significantly increased over chemical N alone because of improvement of soil fertility. Whenever crop residues are in excess of local needs, the balance should be used to supplement chemical fertilizers.

Blue-green-algae (BGA), *Azolla* and diazotrophic bacteria are the common N_2 fixers in rice field and constitute a major component of INM, neutral to alkaline soils (pH 7.5 - 10.0) rich in available P, low flood water N, turbidity-free shallow water depth, moderately high temperature (30-35°C), bright sunshine and less frequent rains favour growth and N_2-fixation of BGA. The reported N_2-fixation by BGA varies from 0.5 to 80 kg N/ha/crop, with an average of 27 kg N. In studies at CRRI, Cuttack fresh biomass production ranged from 4 to 28 t/ha with N contribution of 4-32 kg/ha. Successful algalization produced average additional grain yields of 0.35-0.45 t/ha and was equivalent to about 20-30 kg fertilizer-N.

Azolla is the most potential biofertilizer for rice grown under irrigated or shallow lowland conditions. A standing water depth of 5-10 cm, slightly acidic to neutral soils (pH 6-7) with high available P and low organic C, low flood water N, moderate temperature (25-30°C) and reasonably high light intensity are favourable for its growth and N_2-fixation. A standing *Azolla* crop accumulates 20-146 kg N/ha, with an average of 70 kg N. Field studies conducted at CRRI for the past two decades have shown an average contribution of 25-30 kg N/ha. Growing *Azolla* once before planting or after planting produces an additional grain yield of 0.5 - 2.0 t/ha and is equivalent to application of 30 kg of fertilizer N.

Azospirillum and *Azotobacter*, the important bacterial biofertilizers contribute significantly to the positive N balance of rice soil. Neutral to slightly alkaline soils rich in organic matter favour the bacterial proliferation. Application of organic matter with wider C : N ratio is always beneficial. The reported potentials of heterotrophic and associative N_2-fixation are 10-30 and 1-7 kg N/ha, respectively. With inoculation, grain yield increased by 5-30% over uninoculated control. A complete knowledge of interactions between these microbes and the environment is necessary for developing the viable management strategies.

The N contribution from BGA and diazotrophic bacteria are not enough to grow a rice crop and, hence, need to be supplemented with N fertilizers. The crop response due to their inoculation is maximum at moderate levels of 30-45 kg N/ha. On the other hand, the entire N requirement of rice can be met by growing 2-3 crops of *Azolla* both before and after planting. Besides, *Azolla* is comparatively more tolerant to combined N and can be used even at higher N levels. The inhibitory effects of combined N on these organisms can be alleviated by using slow-release fertilizers and application through deep placement.

Phosphorus solubilizing microorganisms (PSM) efficient in solubilizing both native as well as added P and root associated mycorrhizae (mainly VAM fungi) capable of increasing the availability of nutrients to plants are the important phosphatic biofertilizers for rice. Inoculation with PSM like *Bacillus*, *Pseudomonas* and *Aspergillus* increases grain yield by 5-20% and is equivalent to application of 30-50 kg P_2O_5/ha through P fertilizer. Inoculation with VAM fungi leads to several folds increase in P inflow to plants and increases grain yield significantly. Quality control of BGA, bacterial and VAM cultures and mass production of *Azolla*.

Quality control of BGA, bacterial and VAM cultures and mass production of *Azolla*: Inocula, however, need greater attention to achieve success in the large scale adoption of biogertilizer technology.

For major sources of N, viz., green manure biological (*Sesbania aculeata*), Azolla (*Azolla carolineana*), *Azospirillum* and blue green algae in combination with chemical sources of N have been evaluated for their efficiency in improving N nutrition and yield of rice, cv. Gayatri in a field experiment conducted under favourable rainfed lowland conditions at CRRI, Cuttack during 1997-98 and 1998-99. The results revealed that i. green manuring with *Sesbania aculeata* supplemented with top-dressing of prilled urea t 21 days after transplanting and panicle initiation, ii. green manuring supplemented with deep placement of urea supergrannules, iii. polymer coated urea (controlled release N fertilizer) alongwith prilled urea at 1:1 proportion and iv. Azolla dual cropping with basal dressing of prilled urea were significantly superior to the other INM practices involving Azospirillum + urea or blue green algae + urea in improving N uptake and grain yield of the rice crop.

Periodical analysis of wet soil samples for amide, ammonium and nitrate contents indicated longer and higher availability of N in the zone of placement of urea supergranules (upto 45 days) than in prilled urea broadcasting treatment. There was relatively faster release of N with a greater N availability during the reproductive stage of the rice crop in case of green manuring supplemented with urea topdressings than in the other INM practices. A separate study on patterns of N mineralisation from *Sesbania aculeata*, Azolla and blue green algae in unplanted submerged soil confirmed that N availability in soil was significantly higher with *Sesbania aculeata* green manure than with the other two biological sources of N at 8, 15, 30, 45 and 75 days after their incorporation into soil.

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EFFECT OF SOIL PHYSICAL ENVIRONMENT IN RICE BASED CROPPING SYSTEM

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Wet land rice ecosystem

Rice Lands

Rice is widely adopted to its environment. It grows in lessmoist unsaturated soil as a dry land crop or it can grown in soil submerged during most part of its growth period. Physiographically and hydrologically rice lands are divided into three categories; pleurial, phreatic and fluxicial which broadly conform to upland, medium to low land and typically lowlands with intermediate to deep level of submergence, respectively. In monsoon areas most rice is grown on phreatic environment where the water table is close to or above the soil surface throughout wet season and where bunding retains surface water. Phreatic soils are generally poorly drained mainly because of the presence of a high water table. Plurial lands of higher elevations have been terraced for rice production. These soils are difficult to puddle due to their low clay activity. Percolation losses of water and nutrients are a serious problem. Other soil problems of considerable importance are drought, soil acidity and phosphorous deficiency. Fluxial rice soil occupy lowest landscape position. They are difficult to drain and subject to flash or extended flooding Erratic occurrence of rainfall results in a poor yield of rice.

Submergence effects

Although rice grows well in flooded soil submergence affects the normal growth and yield of the crop. Some rice can tolerate total submergence for 10 days but most die after 1 or 2 days. Submergence drastically reduce exchange of gases between soil and atmosphere. Diffusion coefficients of gases in water are about 10^4 times of those in air. As a result oxygen concentration declines and carbon dioxide concentration increases in the submerged soil. Carbon dioxide concentration usually is not toxic to rice because the required oxygen is transported to the roots through intercellular spaces of the rice plant. Submergence helps in maintaining a favourable thermal regime in rhizosphere as water has a buffering effect on soil temperature continuous submergence sets up an anaerobic soil condition. The oxygen initially present in the soil is rapidly consumed by the micro-organisms and microbial reduction of inorganic compounds then follows in succession. Under anaerobic condition toxicities may occur in relevant areas due to increase in concentration of ferrous and manganese ions or certain organic acids in the soil solution. Coatings of ferric hydroxides are commonly observed on root surfaces in strongly reduced soils. Drainage facilities of these soils acid to be renovated for removal of toxic effects.

Degradation of soil structure

Wet cultivation on puddling severely destroys soil structure. Besides this wetting of soil itself breaks down soil aggregates by its slaking action and by dissolution of cementing agents in reduced soils. Elimination of noncapillary on transmission pores decreases permeability but increases water retentions at low tensions. It reduces percolation losses of water and nutrients and helps in maintaining a water regime that favour rice growth particularly where water table remains at a lower depth. The effect of puddling on surface soil structure depends on soil texture and aggregate stability. Aggregate stability is determined by the amount and type of clay fraction; organic matter and hydrous exides which form interparticle bonds; and the electrolyte concentration of the soil solution.

Subsoil compaction

Continuous wet tillage causes compaction of soil below the puddled layer. The clay particles are translocated down and are deposited in the wider pores and figures at subsurface depth blocking the pathways for buck movement of water nutrients and air. Physical compaction with precipitation of iron, manganese and silica hardens the compacted layer. It limits infiltration and internal drainage and intellects root growth. Loans favour compaction while olays do not. Low permeability saves water and reduces nutrient losses by leaching.

DRY LAND SYSTEM

Drying effects

Puddled soil dries more slowly than unpuddled soils due to the lack of transmission pores. A puddled soil may take several weeks to dry and to reach a workable moisture content. Drying causes soil to shrink, irreversibly. This may lead to development of figures in the surace soil. Ploughing produces hard, medium to large clods that provide poor seedbed tilth and seed soil contact for dry land crops. Larger clods enhances evaporation losses and seed zone soil dries faster affecting germination of the seeds. Soils with high activity clay and large specific surface area are easily puddled but they are more cohesive and on drying form massive cloddly structure. Roots find it difficult to penetrate through the finger pores of the hard soil mass. With heavy rain or excess irrigation, puddled soil has poor aeration longer than unpuddled soil.

Crop establishment

During dry season the rice fields after remain idle for non-availability of irrigation water. Farmers grow short duration pulses on residual soil moisture without tillage or with improper tillage. Germination and stand establishment is often poor in cloddy soil and the success of the crop depends much on the occurrence of off season rainfall. Nevertheless rice soil profile at the end of the wet season contain enough water to support a short duration crop of legume, wheat, maize or sorghum. The proper seed bed tilth could not be achieved in a poorly aggregated soil. This is also true for the premonsoon establishment of direct seed rice.

Regeneration of soil structure

Restructuring process starts with flocculation of clay partials. Interparticle bonding depends on the physico-chemical properties of the soil particles and the organic material associated with the micro-aggregates. Wetting and drying cycles addition of organic matter and application of gypsum and phosphates promotes granulation. Wet tillage should be avoided as far as possible. Where puddling is indispensable the surface soil may be puddled to a minimum depth only. A reducing tillage system needs to be developed for optimizing the soil physical condition in a rice-based cropping system.

GREEN MANNURING FOR RICE AND RICE BASED CROPPING SYSTEM

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Green manuring is the practice of training down the green undecomposed plant materials into the soil. The main purpose of incorporating green manure in soil is to increase the crop yield and maintenance of soil fertility. The influence of green manuring is mainly due to the addition of organic matter and nitrogen through it. The decomposition of green matter result in the formation of available nutrients and humic substance. The later in turn, increases the exchange capacity, improves soil physical properties like water holding capacity, aeration, drainage and granulation which are essential for successful growth of the subsequent crop after rice.

The bulky organic materials like FYM and compost contain very low amount of nitrogen and are resistant to mineralization. It takes very long time .o derive the benefit out of these materials. Green manures are readily mineralizable, hence they supply the plant nutrients quickly and sustain for a longer time to satisfy the need of the growing plant. The water soluble chemical fertilizers like urea and ammonium sulphate supply the plant nutrients immediately but are prone to various type of losses.

Promising green manure crops

Sesbania, Sunhemp, Guar (Cluster bean), Gliricidia, Indigofera, Vetch, Cowpea etc.

Green manures suitable for rice

For early duration rice cultivars. quick growing green manures such as Sunhemp, dhaincha and mung varieties are suitable. these crops can be sown on the onset of monsoon in the month of April-May and give generally 6-8 t/ha green manure when nearly six-week old. Lowland areas are susceptible to waterlogging, only Sesbania spp. are suitable as they can withstand high moisture situations. The contribution of nitrogen from soil. chemical fertilizer (urea) and green manure (*Sesbania aculeata*) towards yield and N utilization of rice under rainfed lowland situation indicated that the sole crop of green manure contributed 65.8 kg N/ha, while the inter crop contributed 56.1 kg N/ha. the utilization of green manure nitrogen by rice crop was less in the inter crop than in the sole crop.

Green manure cops suitable for sowing in Standing rice

It may not be always possible to grow a green manure crop separately to apply to the wetland rice due to delay in receiving the monsoon rain or other practical difficulties. In such case, the green manure may be seeded in the standing crop of rice or at harvest. It is a common practice in southern states to sow wild indigo in the standing rice crop before harvest of paddy and keep it for incorporation to the soil for the next rice crop. Studies conducted at CRRI indicated that Sesbania speciosa and Cassia leschanaultiana were promising for sowing in standing rice crop. When Sesbania speciosa was sown in the standing rice crop in April, the growth was sluggish but it picked up with the onset of monsoon and gave nearly 14 t GM/ha by the end of July.

Advantages of green manuring over chemical fertilizer

The chemical fertilizers particularly the nitrogenous fertilizers are subjected to different types of losses. The losses are mainly due to leaching, volatilization and denitrification.

In addition to these, some amount of the applied fertilizer is immobilized in the pool of soil organic matter,. The results obtained from different experiments indicated that the rice recovered only 3540% nitrogen and the rest of the nitrogen is either immobilized or lost. The quantification of different losses further indicated that the losses are maximum during the first fortnight of N application. Moreover, heavy doses of N enhances the losses. It was observed that the losses from organic materials are relatively low.

Under shallow water ecosystem in situ green manuring was as efficient as chemical fertilizer. Application of 50°O N through green manuring and the rest in two equal splits at active tillering and panicle initiation stages through chemical fertilizer (urea) was as efficient as chemical fertilizers applied in three splits (50÷2925) and sometimes proved to be better.

In a rice-fallow-rice cropping system under two levels of nitrogen application (60 and 1N kg N/ha) with or without green manuring snowed that increasing level of ^{15}N resulted in higher N recovery by the first rice. Green manuring in conjunction with urea increased the recovery from the fertilizer N (2.9%). At higher level, however, th recovery from fertilizer dsoreased by 10.8% possibly because of more loss. Green manuring did not appear to have positive effect on second rice crop when the utilization of residual N is concerned.

In rice-pulse-rice, recovery of ^{16}N by the first rice crop increased from 29% to 33% due to green manuring which supplied 40 kg N/ha. There was increase in the recovery of ^{15}N by the second green grain and third crop of rice due to green manuring. There was more retention of ^{15}N in the soil. The unaccountable N was also decreased by 6% when N was supplied in conjunction with green manuring.

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WEED MANAGEMENT IN RICE AND RICE-BASED CROPPING SYSTEMS

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Rainfed upland rice

Aerobic soil environment and optimum temperatures in rainfed uplands in wet season encourages germination and growth of graminaceous, weeds, followed by sedges and dicots. The most important problematic weeds that occur in rainfed upland ecosystem are *Echinochloa colonum, E. crus-galli, Eleusine indica, Setaria glauca Cynodon dactylon, Digitaria Sanguinalis* and *Dactyloctenium aegyptium (grases), Cyperus rotundus, C. iria, Fimbristylis miliacea (sedges), Acanthospermum hispidum, Cleome viscosa* and *Agertum conyzoides (dicots)*.

Crop-weed competition: Crop-weed competition is the severest in dry-seeded upland situation and comparatively lower in wet-seeded and transplanted rice cultures. The losses in grain yield due to unchecked weed competition in upland situation are very high in the range of 50-97% obviously due to more competitive grassy weeds which are tolerant to low moisture stress situations unlike rice. The first 30-40 days after seeding is considered critical for crop-weed competition and delay in weeding further substantially reduces the yields. Weeds compete severely for nutrients and depending upon the intensity of weed growth, the depletion may be up to 86.5 kg N, 12.4 kg P and 134.5 kg k/ha. Crop-weed competition is higher in short duration varieties (generally grown in monsoon season on uplands) than that of long duration varieties because weeds mature rapidly and hence short duration varieties have weed competition for proportionately longer time than long duration varieties. Among the short duration cultivars, the weed competition is more severe in semi-dwarf than semi-tall varieties.

Integrated weed management: In India, upland farmers grow tall varieties, adopt broadcast method of seeding with high speed rates of 100-150 kg/ha and undertake on hand weeding only. A bullock-drawn spike toothed harrow (Bida) is also used to control the weeds. Undertaking 2-3 hand weedings is highly labour intensive (150-165 man days/ha. Besides hand weeding operation in upland rice often coincides with transplanting operation of medium land rice. Hence there is a need for developing cost-effective weed control methods. Since the weed problem is severest in combine different methods of weed control (both direct and indirect) for keeping the weeds below threshold levels. It would be more appropriate to combine weed smothering varieties, crop husbandry practices that help in better canopy formation and minimize weed competition and use of alternative cost effective methods of weed control such as herbicides and mechanical methods. The semi-tall varieties of 110-120 cm plant height with rapid germination, better initial vogour and moderate tillering are preferred. Studies conducted at CRRI revealed that the varieties Kalinga III and RR 151-3 are better competitors than semi-dwarf varieties like Annada and Heera. The newly developed rice varieties Vandana also is being considered as one of the weed competition cultivar. The other weed competition cultivars are RR 2-6, RR 20-258, RR 139-1 and RR 51-1. It would be better to undertake summer tillage in order to control problem weeds such as *Cyperus rotundus* in stead of leaving the land fallow. Further, by appropriate land preparation, stale seed bed technique, which involves elimination of flushes of weeds before sowing of rice it is possible to minimize the weed competition. Similarly the other crop husbandry methods such as row seeding, use of higher seed rates (70-100 kg/ha) and N management involving split application rather than single basal application also help in minimizing the weed competition. Thus these practices can be judiciously combined with other direct methods of appellation.

For saving costly labour for weeding, it is appropriate to use mechanical weeders such as wheel hoes for finger weeders or blade does for reducing the weed competition. Chemical weed control using herbicides is a cost effective weed control technology to hand weeding practice. The post-emergence herbicide propanil (Stam F34) @ 2-3 kg/ha is highly effective in controlling the graminaceous weeds especially *Echinochloa colonum* and *E. crus-galli* when applied at 12-15 days after sowing when the weeds are at 2-3 leaf stage. The promising pre-emergence herbicides which provides effective weed control in the initial stages of crop growth are butachlor (Machete 50EC, Delchlor 50EC, Hiltachlor 50EC etc), thiobencarb (Saturn 50EC), anilofos (aniloguard 30EC, Arozin 30EC) and oxadizon (Ronstar 25EC) etc. Pre-emergence application of butachlor at rates of 1.5-3.0 kg/ha control majority of weed flora in upland situation. Supplementary hand weeding after butachlor application becomes necessary to control the second flush of weeds. Better efficacy of oxadiazon thiobencarb, pendimethaalin and anilofos was reported. It is appropriate to mention here that all the herbicides are to be sprayed using 500 litres of water per hectare. The pre-emergence herbicides are to be applied 2-3 days after sowing before the emergence of weeds in direct seeded upland. Recent studies at CRRI indicated that the new herbicide formulations quinclorae (preemergence) at 1.0 kg a.i./ha and butanil (3 lt) post emergence were effective in controlling weeds.

Rice crop is direct seeded in dry condition before monsoon of transplanted early in earit July. Since the condition in direct-seeded lowlands is similar to that of uplands, weed flora in both the situation are similar. In transplanted condition, however, there is predominance of sedges and dicots. However, with gradual accumulation of monsoon rains, aquatic weeds (submerged, emerged and floating types) predominate irrespective of whether the crop is direct seeded or transplanted.

The most problematic weeds in rainfed lowlands are *Echinochloa crus-galli, Digitaria sanguinalis, Leersia hexandra* and *Leptochloa chinensis (grasses), Cyperus iria, C. difformis, Scripus articulatus* and *Fimbristylis miliacea (sedges) Eclipta albc, Sphenochlea zeylanica* and *Ludwigia parviflora* and *Chara zyelanica, Monochoria vaginalis* and *Ipomoea aquatica* and specific weeds such as wild rice *Oryzae nivara, Oryza rufipogon* and *Oryza officinalis.*

The grain yield losses due to weed competition in rainfed lowlands are in the range of 30-36%. The weed incidence is dependent upon the hydrological situations and generally higher in shallow submerged (0-30cm) areas and with higher depths of water in intermediate deep (0-50cm), semi-deep (0-100 cm) and deep (>100 cm) submerged areas, the weed incidence tends to be low. In the initial stages, the crop faces the competition from grasses and sedges since the situation is similar to that of upland and with the accumulation of water, aquatic rice. The weediness of wild rice is attributed to its competitiveness with cultivated rice and its ability to cross pollinate with it. The seeds of wild rices shatter quickly. The purity of cultivated rice is contaminated due to wild rices.

Land preparation plays an important role in minimizing weed competition in lowland rice. Work at CRRI indicated that a reduction of weed biomass and increase in grain yield with increase in number of ploughings from one to three during summer months. Traditionally farmers practice an operation known as *beushening* or *biasi* in eastern India states- Orissa, M.P., Bihar and to alesser extent in Assam, West Bengal and U.P. This operation involves shallow cross ploughing in the fields 30-40 days after sowing in shallow water (5-10 cm depth) followed by leveling. By this operation the thick population of rice is thinned and later it is followed by redistribution of seedlings and gap filling. This operation is considered to be a low cost weed control practice since hand weeding is expensive and impracticable. Studies at CRRI indicated that use of cono-weeder can supplement country plough for *beushening* operation. Further studies also revealed that *beushening* operation supplemented with hand weeding hand weeding and gap filling increased the yields of lowland rice (Utkalprabha) by 41% over unbeushened and unweeded crop due to better weed control due to better weed control, crop thinning and soil loosening, improving soil aeration. No differential response of rice varieties of different plant height- Tulasi (semi-tall), Gayatri (semi-dwarf) and Utkalprabha (semi-tall) to beushening operation was noticed. Similarly there are possibilities of introducing herbicides technology under *beushening* system. Application of preemergence herbicide like butachlor or thiobencarb at 1.5 kg/ha help in minimizing weed competition. This practice however does not improve crop productivity where water depth went beyond 40 cm due to non-establishment of rice seedlings.

Research information on chemical weed control on rainfed direct under seeded rice higher water depth is scanty. Since lowland rice resembles upland rice in the initial stages, herbicides suited to upland rice can be conveniently use. The herbicides butachlor and thiobencarb each at 1.5-2.0 kg/ha and oxadiazon at 0.6 kg/ha proved effective in controlling the weeds. However control of aquatic weeds is beset with problems because of presence of excess water. Available literature indicates that the aquatic weed *Chara* and other algal weeds would be controlled by the application of $CuSO_4$ and oxadiazon.

since wild rices cause significant yield reduction of domestic rice, farmers in eastern India generally prefer to grow purple leaf varieties o rice in areas where wild rice exists. This facilitates weeding out wild rice. However, these purple leaf varieties are not good yielders and hence purple stemmed varieties with green foliage are better. The high yielding purpose stem varieties are also very limited. Recently a variety, Kalashree was developed at CRRI, Cuttack and is well suited for wild rice infested situations. Another variety Shyamala developed by IGAU, Raipur is also suitable for wild rice infested areas. The following cultural practices are helpful in minimizing the wild rice problems.

- By direct seeding of pre-germinated crop on fields that have been flooded or cultivated as is done
- By transplanting rice in lines after puddling the field
- By row seeding where wild rice growing between rows can be easily recognized and weeded out
- By using appropriate crop rotations

Since the research information in this direction is limited, this has to be considered as the priority area of research.

Irrigated rice

Rice under assured irrigation accounts for 20-36% of the area in eastern India. However during dry season, 100% area is under irrigation. In irrigated areas, modern varieties with high fertilizer and intensive practices are grown. These factors are responsible for high incidence of weeds. Herbicide use pays dividends in controlling weeds in this ecosystem. In both western India in states of Punjab and Hariyana almost the entire areas under rice is covered by herbicides for controlling the weeds because of high wages rates. In eastern India also the herbicide consumption figures are showing an upward trend. In Orissa, the district Sambalpur accounts for high herbicide consumption.

There are two methods of cultivating rice under irrigated condition. Those are: transplanted system and direct sowing of sprouted seed on puddled soil. The second method is more appropriate in dry season in eastern India (in high rainfall regions) since during *kharif*, the rainfall interferes with the crop stand making this practice ineffective. Because of puddling and maintenance of water level in the field, the population of sedges viz., *Cyperus difformis, C. iria, Fimbrislylis milincea* and *Scirpus mucronalus* predominate and some water loving weeds such as *ludwigia parvifloraa, Sphenoclea zeylanica* and *Marsilea quadrifolia* both problems.

The following Hebrides are provided promising for control of weed in irrigated rice:

Name of the herbicide	Dose kg a.i./ha	Time of application (DAS/DAT)
Butochlor	0.75-1.0	7
Thiobencarb	0.75-1.0	7
Anilophos	0.4	7
Pretilachlor (with safener)	0.6	7

Studies are in progress to find out the performance of low doses - high efficacy herbicides like ethony sulfur, acetochlor and cinmethylin. Work is also in progress to evaluate safened herbicides for increased crop safety.

Rice-based cropping systems-weed dynamics

To increase crop production from an unit area, it is necessary to increase crop intensity by growing crops after rice in different land situations. With the adoption of the multicrop systems and intensive cultural practices, weed problems also are increasing necessitating appropriate control measures. Rotating rice with upland crops results in reduced infestation of water tolerant weeds. Dry seeded rice generally has more weed problems than transplanted rice. In Tamil Nadu, rice-rice-blackgram/cotton rotation, the population of *E. colonum* was less in the second rice crop compared to the first one but its population was less in rice-fallow-cotton. *Cyperus difformis* in rice-rice-cotton while it was decreased in rice-rice-blackgram sequence.

Weed flora shifts

With continuos practice of use of a particular herbicide in a crop or growing of a particular crop/cropping sequence over a period of time, there is a likelihood of shift in the weed flora from one community to the other.

Herbicide use: Successive application of the same herbicide may cause shift in weed flora. there are chances of shift from annuals to perennials. There are instances of build up of *Cyperus rotundus* with the use of pendimethalin.

Multiple cropping: Crop rotations through involve weed smothering and land covering crops such as legumes are helpful in reducing the growth of weeds to some extent. Similarly in upland situation, intercropping systems involving rice and legumes such as cowpea help in suppressing the weed competition. There are reports from IRRI that there is large shift in weed floristic composition between sole rice and that rice intecropped with *Azolla pinnata*. In sole rice, the weed community was dominated by *Monochoria vaginalis*. When *Azolla* was added to rice, the population of *Monochoria vaginalis* was reduced by 91%, while the biomass of *E. crus-galli* was increased by 226%. *Azolla* reduces *Marsilea minuta* and increases and increases *Cyperus difformis*. Similarly in rice-wheat cropping which is practiced in northern India. the grassy weed *Avena ludoviciana* and *Phalaris minor* have become more problematic. Similarly use of short statured rice varieties with erect levels and upright canopy causes greater light penetration and high fertilizers cause increased weed growth. Another cropping system rice (wet season) and maize (dry season) was useful in reducing the problematic weeds like *Scyrpus maritimus*. Similarly jute-rice-potato system was found to be the best for controlling the weeds because potato cultivation involves intensive tillage.

Integrated weed management (IWM) strategy for rice-based cropping system

IWM rationally combines both direct and indirect methods of weed control and has to be cost effective. Some of the key points are important in this context are:

In monocropped rice in eastern India in both uplands and lowlands off-season tillage helps in reducing the weed growth considerably by preventing the weed seed setting and exposition the rhizomes of difficult weeds like *Cyperus rotundus* to the host weather in summer.

In different rice-based cropping systems it is essential to adopt cultural practices that are useful providing an advantage for the crop plants to suppress weeds. Establishment of higher level of crop stand, timely fertilizer application, mulching and weed competition cultivars are important.

Inclusion of weed smothering crops in rotation helps n reducing the weed competition in the cropping systems. It is also at fact that some specific weeds are associated with certain crops and rotation of crops with dissimilar life cycles of cultural conditions so at to break the life cycle of weeds are useful.

While using the herbicides in cropping system, it would be borne in mind the residual nature of the herbicides that are being used. Generally herbicides recommended for rice such as butachlor and thiobencarb do not have much residual effects on the succeeding crops.

The different herbicides promising for different non-rice crops which are frown in rotation with rice are as follows:

Wheat: Isoproturon @ 1.0-1.5 kg/ha-preemergence

Maise: Simazine and atrazine @ 1.0-1.5 kg/ha-preemergence

Alchlor @ 2.0 kg/ha

Groundnut: Alachlor @ 1.5-2.0 kg/ha-preemergence

Nitrofen @ 1.5-2.0 kg/ha

Fluchloralin @ 0.75-1.25 kg/ha

Jute: Alachlor @ 1.5-2.0 kg/ha-preemergence

Nitrogen @ 1.5-2.0 kg/ha-preemergence

Pulses(blackgram, pigeonpea and cowpea): Alachlor @ 1.0-2.0 kg/ha-preemergence

It can be concluded that by following appropriate and timely weed control in rice-based cropping systems it is possible to achieve higher yields and incomes.

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INTEGRATED MANAGEMENT OF RICE DISEASES

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Rice is the principal cereal grown in India in 42.1 million hectare for sustenance. Because of its vastness and diverse agroclimatological conditions methods of rice cultivation differs from region to region. The wide adoption of HYVs of rice (62.4%) in the country by farmers has opened a new vista of increased use of chemical fertilizers, pesticides and weedicides. Due to intensive and changed cultivation practices and use of higher quantity of chemical fertilizers minor disease like sheath blight, sheath rot, false smut and rice tungro virus in addition to blast and bacterial leaf blight have occupied a prominent place in the disease scenario of the country. Therefore in the present disease-management strategies, the options lie in the manipulation of resistant genes in rice cultivars, suitably tailored cultural practices and judicious use of effective chemicals on the basis of surveillance.

The ecofriendly concept of integrated disease management with proper surveillance is the only viable method to combat rice diseases successfully.

These important rice diseases occur both in wet and dry seasons except false smut and tungro which occur only in the wet-season crop in eastern India (Table 1). The predisposing factors responsible for the outbreak of major rice diseases vary (Table 2). Keeping these factors in mind one can make strict survey and surveillance of diseases for adopting appropriate control measures.

Host resistance is the cheapest and direct method for control of diseases. Several disease resistant and tolerant rice varieties and donors were identified (Table 3). Clean and healthy seed is the most important factor to reduce the seed-borne inoculum of fungal and bacterial diseases. Rice varieties with multiple resistance is more meaningful to be grown in integrated disease management programme (Table 4).

By manipulating suitably cultural practices taking into account of all the predisposing factors, the disease intensity can be reduced to a great extent. Maintenance of field sanitation, viz., burning of diseases straw, stubbles, chaff, eradication of disease-harbouring weeds and deep summer ploughing of the field are some of the visual practices adopted. Top-dressing of nitrogenous fertilizers in split disease is to be done and basal application of N fertilizers can be differed by 8-10 days in blast-endemic areas and calcium ammonium nitrate can be used in basal application for bacterial blight-endemic areas to reduced the disease severity.

Need-based application of effective chemicals should be carried out by economizing chemical control like manipulating chemical dosages judging the severity of the diseases, considering economic threshold levels of diseases using a low volume sprayer etc. Economic threshold levels identified for various diseases are mentioned in (Table 5).

It is of prime importance to treat rice seeds with seed-dressing fungicides, viz., Beam 75, Fungorene, Bavistin 25 SD @ 1g : 500 g of seeds prior to sowing. The effect is pronounced up to 60 days after sowing in rice blast when Beam, 75 and fungorene are used. For bacterial blight control, treating seeds for 12 hr in a mixed solution of 0.05% wettable cereasan and 0.02% Agrimycin-100, followed by hot water treatment at 52-54°C for 30 minutes of soaking seeds in 100 ppm streptocycline solution overnight are found to be effective in eradicating seed-borne inoculum. This seed treatment programme is cheaper than spray schedule in the field which is not followed by farmers strictly. Three fungicides, viz., Hinosan (1 ml/litre water), Bavistin (2 g/litre water) and Dithane M-45 (2.5 g/litre water) are effective for controlling blast and brownspot diseases

Drug resistance

Excepting for false smut, carbendazim is widely recommended for control of blast, sheath blight, sheath rot and also brown spot diseases. The mode of action of this fungicide is that it interferes with spindle fibre at cell division. So these is chance for pathogen to develop drug resistance. So wherever carbofuran is recommended it is advisable to use another chemical in rotation.

Since last few years, false smut disease of rice is assuming prominence causing severe yield loss (12-37%), under persistent cloudy days before flowering, low maximum temperature. Chemicals, viz., copper oxychloride (fungicide), phorate and monocrotophos (insecticides) control false smut successfully when sprayed 4-5 weeks before flowering.

Identification of tungro in farmer's field

Extension staff and farmers encounter great difficulty in identifying the tungro infected plants as several other factors like nutritional disorder, cold and drought also produce identical symptoms.

1. In case of nutritional disorder, the effect will be uniform and all plants in a field will have the same height with yellowing, whereas, in tungro infected field, there will be irregular growth and plants will have different height.

2. In case of nutritional disorder, the root growth is very much normal or at times more; but in case of tungro infected plants the root growth is very poor.

Where does tungro virus remain round the year

Its survival round the year depends upon the host range of the virus.

1. It survives in the principal host plant where rice is grown continuously round the year. Rice stubbles play a major role in its survival.

2. During off seasons it survives through wild rice species viz., *O. nivara*, *O. perenis* and *O. barthii*.

3. Some of the weeds have been found out to harbour tungro virus. They are *E. indica*, *H. compressa*, *S. tremulus*, *P. monspelienses*, and *H. zeylanica* (dicot weed).

Causes of epidemic of RTV

Quick transmission of the virus by GLH, rapid build up of vectors under favourable conditions and long distance migration of vectors pose a favourable condition for tungro epidemics.

- The crop should be in young stage (less than 50 days old)
- The growing of sensitive cultivars in the field.
- The presence of virus inoculum in the vicinity of the field.
- The presence of viruliferous GLH in the locality.
- Early rain in the monsoon season helps in the multiplication of GLH early in the year.
- The spread of tungro is faster in wide spacing than the close spacing of crop.
- Presence of external water stress for a long period during the early stage of crop helps in increasing the severity of tungro disease.

Conclusions

Integrated disease management in rice is a practical, eco-friendly programme which tends to minimize the use of chemical. Greater reliance is put on genetic resistance in host plants and cultural control measures. The success and glory of such an ideal programme rests on research on its components and demonstration in farmer's fields.

The integrated approach should include selection of disease free seeds, right choice of cultivars, judicious use of fertilizers and organic manures, proper date of sowing, seed treatment and needbased crop protection measures

Table 1. Seasonal incidence of important rice diseases in Orissa

Disease	Period of disease incidence	Peak period
Blast		
Rainy season (*kharif*)	July-Sep	Sep-Oct
Summer	Dec-Apr	Mar-Apr
Sheath blight		
Kharif	Sep-Oct	Sep-Apr
Summer	Mar-Apr	
Sheath rot		
Kharif	Oct	Oct-Nov
Summer	Apr-May	May
Brown spot		
Kharif	June-Nov	Oct-Nov
Summer	Mar-Apr	Apr
Bacterial leaf blight		
Kharif	Aug-Nov	Sep-Oct
Summer	Jan-Apr	Mar-Apr
Bacterial leaf streak		
Kharif	Aug-Oct	Sep
Summer	Feb-Apr	Mar
False smut		
Kharif	Oct-Nov	Nov
Rice tungro virus		
Kharif	Aug-Nov	Oct

Table 2. Pre-disposing factors for the outbreak of major rice diseases.

Blast	Borwn spot	Sheath blight	Bacterial blight	Tungro virus complex
1. Low night temperature of 20 - 24°C with high RH 90%	1. Rice plants become more susceptible at the time of flowering and maturity than at young stages	1. An optimal temperature of 28-32°C with high RH (95%)	1. Lateritic and alluvial soil favour more diseases	1. Raising of nurseries alluvial soil in the field adjacent to ratoon crops
2. Copious dew formation occurring in susceptible stage of crop	2. The disease occurs in sever from either at high or low N level	2. Application of higher dose of N fertilizers	2. Waterlogging conditions encourages disease development	2. The early monsoon break (Apr and May) helps in building of higher vector population
3. Light showers of rain continuing for few days of cloudy weather persisting for few days	3. Plants grown in soil deficient in K, Ca, Mg and Zn suffer from this disease severely	3. Early sowing and early transplanting encourages more disease development	3. Excessive use of N fertilizers from tillering to maximum tillering stage encourages diseases development	3. Late transplanting invites more disease as the prevalence of vectors in nature coincides with early stage of crop
4. Less sunshine hours	4. Plants grown in leached soil exhibit severe infection than on those grown in unleached soil	4. More number of seedlings/hill invite higher disease incidence	4. Growing of the crop under shade favours disease development	4. Occurrence of drought in early part of season helps in attracting more number of green leaf hopper to infected rice plants
5. Acidic soils favour blast	5. Heavy rainfall in Sep accompanied by temperature of 25-30°C followed by continuous cloudy weather in Oct-Nov favours severity of disease	5. Presence of root knot nematodes render plants more susceptible	5. Pruning of leaves at the time of transplanting favours disease development	5. Growing of weed hosts like *Echinochloa colona*, *Hemarthia compressa*, *Hydrolia Zeylanica* supply inoculum

6. Growing rice seedlings on raised seedbeds. *Dry soil* favours blast occurrence	6. Heavy rainfall in Sep accompanied by temperature of 25-30^{0}C followed by continuous cloudy weather in Oct-Nov favours severity of disease	6. Plants with luxuriant growth suffer more than plants with less tillers
7. Application of high dose of N fertilizers 80 kg N/ha. Ammonium sulphate favours blast		

Table 3. Disease resistant or tolerant rice varieties in India

Disease	Varieties
Blast	Asha, Archana Annapurna, Annada. Bhagawathi, Birsa Dhan 101. Deepa Daya, Jimalaya1 Himalaya 2, *Indira*, IR 36, Jajati, Kshira, Lalat Lakshmi. Moti, Nagarjuna. Narendra 80, Pratap, Panidhan, Pathara, Pusa 205 Rasi. Ratnagiri 1, Rama Rajeswari, Sarathi, Samalei, Salivahana, Sneha, Sona Triveni, Vandana
Bacterial blight	Asha, Ananga. Deepti, Daya, Gayatri, Govinda, IR 36, IR 20, Jajati, Lalat Mahalaxmi, Mahendra, Pathara, Parijat, PR 4141, Ramkrishna Shankar, Sufala, Seema, Usha
Sheath blight	Aruna, ADT 39, CR 1014, Manaharsali, Ratnagiri, Nalini, PTB 33 Pankaj, Swarnadhan, T 141, Vikramarya
Rice tungro virus	Annapurna, Amaravati, Basmati 370, Indira, IR 20, Kshira, Moti Pragati, Padmini, Pusa 2-21, Seema, Srinivasa, Triveni, Udaya, Vanaprava, Vikramarya, Vikram, Vytilla 3
False smut	Latisail, MTU 3, Sugandh, Tadukan, Zenith

Table 4. Varieties with multiple resistance.

Sl.No.	Variety Name	Gall midge	BPH	Blast	Sheath blight	RTV
1	ADT 37	R	T	T	T	T
2.	ADT 38	R	T	T	-	T
3.	ASD 18	R	T	T	T	T
4.	Chandana	R	T	T	T	-
5.	Heera	R	-	T	-	T
6.	HKR 120	-	T	T	T	-
7.	IR 36	R	T	-	T	-
8	IR 50	-	T	S	T	T
9.	Kshira	R	T	T	-	T
10.	Manaharsali	T	T	T	T	-
11	Seema	-	T	T	-	T
12.	Tara	R	T	T	-	T
13.	Udaya	R	T	-	-	T
14	Vikramarya	T	T	T	T	R
15.	Vytilla-3	-	-	-	T	T

R = Resistant *T = Tolerant*

Table 5. Threshold levels identified for different diseases

Foliar blast	:	Brownish lesions with light gray center 3-5 lesions/leaf
Neck blast	:	2-3% neck infection with the damaged region near the neck
Sheath blight	:	Lesions of 5-6 mm in size with gray center and lesions confined to lower one-fourth length of the tiller when 2-3 plants/m^2 infected
Bacterial blight	:	When 2-3 leaves/m^2 show typical symptoms of blight at the time of active tillering stage
Tungro virus complex	:	1 tungro infected plant/m^2 and 2-3 GLH/hill

INTEGRATED INSECT PEST MANAGEMENT

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Application of all the available insect pest management skills judicisously in order to get sustainable economic return without endangering the environment is the aim of integrated insect pest management. Thus integrated pest management has been defined as "A pest management system that in the context of the associated environment and the population dynamics of the pest species utilises all suitable techniques and methods, in as compatible manner as possible and maintains the pest populations at levels below those causing income injury" by FAO.

Insect pest management in rice is important as it is grown in almost all the states of India covering a total area of 42 m ha. Again in the last several decades there is a growing change in the rice cultivation in the form of introduction of high yielding, fertilizer responsive varieties and adoption of intensive crop management practices. Concomitant with the change in rice cultivation. the rice environment became conducive for the growth of several insect pests, which cause damages to the rice crop and results in the reduction of crop yield. It is estimated that about 30% yield is lost due to insect pests. The role of insects in a rice based cropping system is better understood with a comprehensive knowledge about the major insect pests that damage all types of crops. Therefore, identification of insect pests and their management has remained as an important component in the production system. Here, emphasis was laid on the identification of insects because in the cropping environment there are several insects which are harmful and several others which are harmless.. Many of the harmless insects are beneficial for farmers serving as predators and parasites on harmful pests. Therefore it depends on farmers to properly identify the pests in order to control them effectively and conserve the predators and parasites in the field.

Depending on the population pressure of pests, the mode of control measures to be adopted should be finalised. The management schedule should be operationally feasible, economically viable and environmentally safe.

More than one hundred species of insects damage the rice crop but 5 to 100 types of them are economically important. Identification of location specific problem is a prerequisite in order to select the suitable variety. Depending on the most prevalent insect pest a suitable resistant/tolerant variety may be selected, so that the crop can be saved from the major pest.

Site specific cultural practices may be followed such as:

- Soil testing in order to apply necessary amount of fertilizer
- Deep summer ploughing

- Destruction of strubbles and weeds
- Seed disinfection
- Root dip treatment of seedlings to be planted
- Early and synchronised planting
- Maintaining right distance between rows & lines
- Judicious water management
- Planting with skip rows in BPH endemic areas
- Weed management
- Survey of insect pests and diseases

Survey can be done by mere observation or by using light traps or sex phenomone traps.

Some of the mechanical control measures are very useful for specific pest which may be followed such as:

- Collection of eggs, larvae and pupa and their destruction
- Mass collection of insects through light traps or phenomone mediated traps
- Destruction of infested leaf tips as in case of hispa damage
- Dislodging of defoliating larvae by means of playing ropes in the field and draining out them by draining out water from the field.

It is desirable to identify the predators and parasites and conserving them in the field. Release of Trychogramma *japonicum* in the field in order to control stem borer may be under taken.

After following all these measurers if the insect population crosses the economic threshold level, chemical control measures may be under taken. Therefore, it is desirable to know the economic threshold level of different insect pests.

Economic threshold level of different pests

Stem borer	:	5% dead hearts or 1 mon or egg mass/sq mt
Gall midge	:	5% silvershoots
Brown plant hopper or white backed planthopper	:	5-10 xymph or adult/hill
Green leafhopper	:	10-20 xymphs or adult/hill
Leaf folder	:	2 freshly damaged leaf/hill

Keeping the ETL in view the following insecticides can be applied in the field.

Granular insecticides like Thimet 10G or Carbofuran 3G @1kg a.i./ha may be applied or emulsifiable concentrates like Chlorpyrifos, Monocrotophos, Quinalphos, Oxydemeton-methyl, Phosphomidon etc. can be applied at 0.5kg a.i./ha.

Besides there are some precautionary methods of insecticide application which are economical and environment friendly. They are seed treatment like treating 100 kg seeds with Chlopyrifos 1kg a.i. so that the plants can be saved from white ants, white grubs, mole cricket etc. Seedling root dip treatment like dipping the roots of seedling for 12 hours in 0.02% concentration solution of chlorpyrifos so that the plants will be saved from the early infestation till 20 days.

Thus a combination of different methods of insect management will be more helpful in realising the desirable grain yield of rice.

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ROLE OF NATURAL ENEMIES IN THE MANAGEMENT OF RICE PESTS

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The rice ecosystem comprises of a large number of insect pests, predominant being the stem borers, gall midge, planthoppers, leaf-folders and gundibug. Similarly a large number of parasites and predators are also available in this ecosystem and a balancing machinism operates to keep the pest population at a low level. It is mainly the disruptive action of certain chemical insecticides that upsets this balance. However, taking advantage of their natural existence the scope of exploiting the potential of natural enemies in the management of rice pests is encouraging.

Natural enemies available in the rice environment could be grouped into three categories; predators, parasites and pathogens. Amongst, predators are the most conspicuous forms and consume many preys during their life span. Usually they are general feeders. They consist largely of spiders, dragon flies, damsel files, beetles and bugs. They need to be conserved in the rice environment.

A parasite is defined as an organism that lives in or on another host usually larger living organism (host) and requires only one or partial individual to complete its life cycle. The insect parasites on insects are called as parasitoid species. when a parasite attack a host externally it is called as ectoparasite (e.g. *Goniozus* sp.) when internally it is known as endoparasite (e.g. *Cardiochiles* sp.). A primary parasite is any species attacking a particular host. A parasite that attacks another parasite is called a secondary parasite or hyper parasite (e.g. *Orgilus* sp. on *Cardiochiles* sp.). If the host is attacked by many individuals of the same parasite species, it is called super parasitism (e.g. *Trichogramma japonicum* on egg of yellow stem borer). When the host is attacked by more than one species of a primary parasite the term applied is an multiple parasitism.

Parasites are more host specific and may be host stage specific. Some of them are amenable to mass rearing and thus their conservation and releases may be undertaken in the rice fields. Some familiar examples of rice pest parasitoids are *Trichogramma* sp., *Apanteles* sp., *Platygaster oryzae, Macrocentrus* sp., *Anagrus* sp., *Cardiochiles* sp. *and Thecocarcelia* sp. They belong mostly to insect orders, Hymenoptera and Diptera. Most of the female parasitoids have a long ovipositor.

Main-groups of pathogens reported on rice pests belong to fungi, viruses and bacteria. They are microscopic in nature and many of the viruses are host specific. They are not visible to naked eye except when they form colony. Their presence could be know through observation dead or rotten insects in the field. Some familiar examples are *Beauveria, Metarhizium,* granulosis viruses. Commercial formulations of the well known bacteria *Bacillus thuringiensis* are now available in the market (e.g.

Dipel, Bactospine, Halt). The pathogens are usually amendable to mass production in the laboratory. They could be tried in the laboratory. They could be tried in the field in a small scale through spraying of aqueous solution of diseases insects. It is mostly effective against leaf feeding cater-pillars.

Natural enemies of a few major pests of rice have been identified and their beneficial role quantified. Parasitism of yellow stem borer egg masses due to *Telenomus* sp. and *Trichogramma* sp. reaches upto 90%. Parasitism due to *Platygaster oryzae* an egg-larval parasitoid of gall midge is low early in the season rises to 40-50% in the tillering phase and reaches 80-95% by the end of the season. Larval parasitism of *Cnaphalocrocis medinalis* due to *Cardiochiles* sp. reaches upto 40% in the wet season. Role of natural enemies in regulating the populations of BPH below economic injury level is well established. Use of broad spectrum insecticides kills the natural enemies which result the resurgence of pests like BPH and leaffolders. Among the predators, spiders along with the green bug play an important role in limiting the population of BPH. Besides, this spider eggs also support rice pest parasitoids as reservoir hosts. Provision of hibernacula by way of placing straws on bunds after harvest facilitates recolonization when the crop is grown again.

Some of the factors that adversely affect the activities of natural enemies are indiscriminate or prophylactic use of insecticides, cannibalism, hyperparasitism and the fragile rice ecosystem. Between insecticide spray and granular formulations the latter is preferable. However, phorate possibly has come of fumigant action. Due to its application pupal parasitism o leaffolders was adversely affected. They spray formulation of monocrotophos, chlorpyriphos application reduced the egg parasitism of yellow stem borer immediately, but was restored again within a fortnight. Thus it is advisable to recommend insecticide application only when it is essential.

Some of the factors which encourage natural enemies activities are provision of hibernalcula, shelters or nectar producing plants like mustard in rice environment.

Trichogramma japonicum and *T. chilonis* have been used in the field to reduce populations of pests like yellow stem borer and leaffolder. The augmentative release of *T. japonicum*/ *T.*/ *chilonis* @ 1 lac/ha/week for six weeks 35 days after transplantation is recommended. The Trichocards should be placed above the canopy and 20-25 mt apart, avoiding 3-4 border rows. Besides release manual collection of yellow stem borer egg masses and putting them in bamboo cage-cum-percher is also helpful to increase the parasitoid population.

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AGRONOMIC MANAGEMENT OF HYBRID RICE

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At the current rate of population growth in India, the requirement of rice by the turn of century is estimated to be around 95 million tonnes. The total rice production during the current year is around 82 million tones. Thus within next five years, a production increase of around 13 million tonnes has to be achieved to sustain the self sufficiency achieved in the early 80s, by large scale adoption of semi-dwarf high yielding varieties coupled with improved management practices. The task is quite challenging and the options available are very limited in view of plateauing trend of yield in high productivity areas, decreasing and degrading land, water, labour and other inputs. Among the various possible genetic approaches to achieve this target, hybrid rice technology is the most feasible and readily adaptable one, as has been demonstrated in the Peoples Republic of China, during the last two decades. Presently, 55 per cent of the 32 million ha of rice area in China is under hybrid rice, accounting for more than 66 per cent of the total rice production.

The long cherished goal of developing and using rice hybrids in Indian agriculture, has been accomplished with the release of 4 hybrids for commercial cultivation in 1994. Subsequently 3 more hybrids have been released by the public sector. Few hybrids from private seed sector also being successfully marketed. Many more promising hybrids are in the offing. The prospects of large scale adoption of hybrid rice technology in India appears to be bright. During the wet season 1996, it is estimated that more than 60,000 ha area has been planted to hybrid rice in various parts of the country with maximum area in Andhra Pradesh followed by Karnataka and Tamilnadu. It is envisaged to cover 2.0 million ha under hybrid rice in favorable irrigated ecosystem by 2000 AD. The target areas are Punjab, Haryana, Western Uttar Pradesh and irrigated areas of Andhra Pradesh, Karnataka and Tamilnadu.

Hybrid rice has its own specific characteristics in the development of individual plants and population structure. Further, the requirement of inputs like fertilizer, water and other cultural practices are different as compared to the conventional varieties. So mastering those characteristics and adopting suitable agronomic management practices are the key components for realizing the yield potential and successful large scale cultivation of these hybrids. A comprehensive package for cultivation of hybrids in various identified target areas in different seasons is being developed, so as to exploit the full potential of these hybrids, and thereby making cultivation of hybrids a clear cut profitable enterprise for the rice farmers.

Sailent features

- Hybrids have a convincing yield advantage of at least one tonne per hectare more than the highest yielding inbred cultivars with similar maturity duration.
- Higher productive tillers and more number of grains per panicle
- With slight modification can be successfully grown under similar management practices as for common varieties

Suitability of varieties

The performance of hybrid rices is reported to be highly location-specific. At present the varietal choice is limited since only a few hybrids are available for cultivation. The suitability of these hybrids for a particular location depends on their duration, plant characteristics and the land situation in which they are grown. A number of newly developed hybrids (115 - 125 days duration) at different research institutions of the country were evaluated at the Central Rice

Research Institute, Cuttack for their yield performance in both wet and dry seasons. Among them, ProAgro 6201, KMRH-2 and DRRH-1 were promising with yield levels of 3.65 to 4.22 and 5.39 to 5.60 during wet and dry seasons respectively. These varieties showed an yield advantage of about a tonne per hectare over the check varieties of highest yielding inbred cultivars like IR 36, Ratna and CR 749-2-20 of similar duration (Table 1 & Table 2).

Nursery raising

Hybrid rice seeds cost more and need replacement every season. It is necessary to cut down costs on seed by optimizing seed rate through appropriate adjustment of seeding density in nursery and seedling number per hill while planting. Hence, proper management of nursery raising is important for its profitable cultivation. Nursery should be sown in the first week of June for *Kharif* crop and in the second week of December for *rabi* crop. A total 600 sq m area is required for raising nursery to transplant one hectare in the main field. Prepare 1-1.5 m wide nursery beds of any convenient length. Apply 5 kg urea, 10 kg single super-phosphate with 5-10 times well rotten FYM and 5 kg muriate of potash before final levelling. Broadcast 15 kg pre-germinated seeds (soak the seeds overnight in water, incubate in warm moist condition for 36-48 hours or until germination) on this well prepared nursery bed. The optimum seed density is 1 kg seed/40 sq.m. Thick sowing of seeds would lead week seedlings. To check the damage by the birds and for better germination, broadcast a thin layer of well decomposed powdered FYM manure immediately after broadcasting the seeds.

Keep the nursery beds moist for first few days and weed free. After the seedlings are about 1 inch high, keep a shallow layer of water. Top dress the nursery beds with 5 kg urea per 600 sq.m about 10 days before transplanting. All these practices ensures healthy and robust seedlings which are pre-requisites for higher yield.

Land preparation and transplanting

The land should be well puddled and levelled in order to reduce water loss through percolation. Give a gap of at least 10 days between initial and final puddling, for better weed control and nutrient availability.

Hybrids were more sensitive to extreme temperatures at flowering especially at lower temperatures, than the conventionally bred varieties. Therefore it is desired to plant them in time preferably in the second week of July and January for *kharif* and *rabi* crops respectively. Experimental results showed that though mid-July planting is ideal for good yields, first week of August has been identified as the latest period in wet season by which crop has to be planted to avoid undue loss in yield (Table 3). Delayed planting seems to have a detrimental effect on growth and seed-filling process which ultimately reduces the yield. At Hyderabad July 25th planting date registered significant higher grain yield as compared to August 5th and 15th plantings. The percentage of reduction in grain yield was of the order of 14 and 34 under August 5th and August 15th planting dates respectively as compared to July 25 planting accounting to a reduction of 90 kg grain per day. Similarly at Pantnagar July 15 planting recorded the higher grain yield. The reduction in grain yield was significant accounting to 7 per cent (43 kg grain reduction per day). These results thus suggests that the maximum yield potential can be realized from rice hybrids by planting the crop during the month of July.

The ideal and optimum plant population for good crop under normal planting conditions is 3,33,000 plants/ha. To achieve this the crop should be planted in the main field at a row-to-row distance of 20 cm and plant-to-plant distance of 15 cm. In case of random planting ensure 33 hills *per sq.m*. To ensure proper crop stand it is better to transplant 2 seedlings/hill instead of one in situations where there is possibility of flooding at initial stages particularly during wet (*Kharif*) season. Otherwise one seedling per hill is sufficient as hybrid seedlings have more tillering capacity.

An experiment conducted during the wet season 1996 in order to evaluate the performance of hybrid rice (CV. VRH 2) under different methods of planting, spacing and seedling densities showed that skipping one row after transplanting four continuous rows produced comparable yield as that of conventional planting (Table 4). Among the different seedling densities, in normal season where there is no stagnation of water at planting, no significant differences in grain yield among 1, 2 and 3 seedlings/hill were observed indicating that one seedling per hill was adequate enough for achieving higher yield and saving on cost of seed

Fertilizer Management

Efficient fertilizer management is the key to improve the grain yield and response to added fertilizers in any crop production system and so in hybrid rice cultivation. The dose and time of fertilizer application depends up on many factors like basic soil fertility, the varietal reaction with pests and diseases, weed incidence and cropping pattern, besides the source and method of its application and synergistic effect with other nutrients. However for normal soils following fertilizer schedule is recommended for *kharif* and *rabi* crops.

Kharif (wet season)

Basal dose	: 50 kg N, 40 kg P_2O_5 and 50 kg K_2O/ha
3 weeks after transplanting	: 25 kg N/ha
6 weeks after transplanting	: 25 kg N/ha

Rabi (Dry season)

Basal dose	: 60 kg N, 50 kg P_2O_5 and 60 kg K_2O/ha
3 weeks after transplanting	: 30 kg N/ha
6 weeks after transplanting	: 30 kg N/ha

Delayed application of N and K coinciding with flowering can help realize the full potential of hybrid rices. Preliminary observation trial conducted at CRRI during dry season 1997 revealed that delayed N and K (fraction of the total recommended N & K) application at heading increased grain yield by reducing percentage of unfilled grains.

Weed control

It has been established that there is considerable reduction in grain yield if weeds are not removed within three weeks of transplanting. Therefore, in order to achieve good yield target the weeds should be removed as early as possible. The use of herbicides in controlling weeds is both efficient and economical. Cost-effective weed control could be achieved by pre-emegence application of herbicides like butachlor 50 EC or thiobencarb 50 EC @ 3.00 l per hectare or machete/delchlor granules @ 30 kg per hectare or Saturn granules 6% @ 25 kg per hectare within 2-3 days after transplanting in 4-5 cm standing water. The liquid formulations may be mixed with 150 kg of sand per hectare and broadcast uniformly. Use of liquid formulations mixed with sand or loose soil is as effective as granular application and it is far more economical in comparison to granules

Insect pest and disease control

The pest problem in hybrid rice is comparatively more severe than that of other varieties. Leaf & plant hoppers , leaf folder, stem borer, gall midge and hispa are some of the serious pests that affect hybrid rice. Rats also cause considerable damage to the crop. The emergence of white ear heads after flowering due to stem borer causes losses in yield up to 50-60 per cent. The plant hoppers can be controlled by spraying the crop with 800 ml Ekalux 25 EC (Quinolphos) or one litre of Coroban/ Dursban 20 EC (Chloropyriphos) or 560 ml of Thiodan 35 EC (Endosulfan) or 560 ml of Nuvacron 36 SL (Monocrotophos) in 100 litre of water per acre. To control stem borer, apply Furadon 3 G @ 10 kg/acre or spray the crop three times i.e. 30, 50 and

70 days after transplanting with 250 ml of Dimecron or 560 ml of Nuvacron/Monocil 36 SL (Monocrotophos) or 1 litre of Coroban 20 EC (Chloropyriphos) in 100 litre of water per acre. To control leaf folder spray the crop with 250 ml of Folithion/Sumithion 50 Ec (fenitrothion) or 400 gms of Sevin 50 WP (carbaryl) in 100 litres of water per acre.

Rice blast, bacterial leaf blight, sheath blight and false smut are the major diseases. Suitable preventive measures are important for keeping the yield losses at the minimum. To control blast, spray Hinosan @ 1 ml/litre as soon as the incidence noticed. Give one more spray after 10 days. Sheath blight can be controlled by spraying Bavistin @ 1g/liter or Rhizolex 50 WP @ 1 g/litre as soon as the disease is noticed

Harvesting

Timely harvest would avoid any loss due to shattering and improve milling quality. Therefore, harvest the crop at optimum moisture content of about 18% and dry till 14% moisture level. The normal harvesting time is 25-30 days after complete flowering

Economic evaluation of hybrid rice technology

People outside China still have their doubts about the economic viability of hybrid rice technology. The question in their mind is would the level of yield increase that they are getting will be sufficient to pay the extra expenditure involved. The reports from various parts of the country suggests distinct economic advantage. In hybrid rice cultivation no extra expenses are involved except the cost of seed and to some extent extra cost on fertilizer plant protection measures. A preliminary estimate indicates that even if all these costs (10-15 per cent higher than the growing of conventional varieties) are taken into account, the yield advantage of approximately 1 t/ha can well take care of these costs and one can expect a net additional profit of about Rs. 2000-2500 per hectare over the conventional varieties. The advantage to the seed producer will be still much higher

Tips for profitable cultivation of hybrid rice

- Grow hybrid rice in assured irrigated areas where nearly the potential yield of the existing high yielding varieties is being realized
- Adopt proper agronomic management practices so as to exploit the full potential of the hybrids. Agronomic management of hybrid rice differ considerably from that of conventional varieties, primarily because of heterosis. Differences are most pronounced at the seeding and the vegetative growth stages. Fertilizer, water and cultural management manipulate yield components canopy structure and field population.
- For raising healthy seedlings broadcast 15 kg pre-germinated seeds on well prepared nursery bed measuring 600 sq.m. The optimum seed density is 1 kg seed/40 Sq.m. Thick sowing of seeds would lead weak seedlings .
- Hybrids are more sensitive to extreme temperature at flowering, especially at lower temperatures, than conventionally bred varieties. So plant the crop at optimum time preferably in the second week of July and January respectively for wet and dry seasons
- Transplant 25-30 days old seedlings at the rate of one seedling per hill at 20 x 15 cm spacing in the main field.
- Apply the recommended N (100 kg N/ha in wet season and 120 kg N/ha in dry season) in three splits 50% basal, 25% at tillering and the rest 25% at week before panicle initiation. Avoid using over dose of N fertilizers which may effect grain filling and damage by insect pests and diseases.

- Ensure timely and suitable weed control measures in order to get better response to the added inputs.

- Adopt need based control measures for controlling insect pests and diseases.

- Harvest the crop at optimum moisture content of about 18% and dry till 14% moisture level.

- **BUY FRESH HYBRID SEED EACH SEASON FOR BUMPER HARVEST** Do not use the grains harvested from commercial crop of hybrid as the seed for the next crop. The yield will drastically reduce due to segregation and loss of hybrid vigour.

Table 1. Response of certain promising Hybrids to nitrogen application, Wet season 1996

Variety/Culture	N0	N50	N100	N150	Mean
Grain yield (t/ha)					
ProAgro 6201	3.16	4.19	4.67	4.53	4.14
DRRH-1	2.99	3.43	3.98	4.19	3.65
KMRH-2	3.26	4.22	4.64	4.74	4.22
Ratna	2.30	2.78	3.33	3.40	2.95
Mean	2.93	3.66	4.16	4.22	

C.D. (0.05) for varieties (V)	0.13
for N levels (N)	0.11
for V at same N	0.23
for N at same V	0.22

Table 2. Response of certain promising Hybrids to nitrogen application, Dry season 1997

Variety/Culture	N0	N50	N100	N150	Mean
Grain yield (t/ha)					
ProAgro 6201	3.75	5.20	6.35	7.10	5.60
Amarsiri	3.35	4.70	5.80	6.50	5.09
DRRH-1	3.50	5.00	6.10	6.95	5.39
Ratna	3.00	4.30	5.55	5.80	4.66
IR 36	3.20	4.50	5.85	6.15	4.93
CR 749-2-20	3.00	4.20	5.30	5.50	4.50
Mean	**3.30**	**4.65**	**5.83**	**6.23**	

C.D. (0.05) for varieties (V)	0.21
for N levels (N)	0.19
for V at same N	0.31
for N at same V	0.22

Table 3 : Effct of date of planting on grain yield of hybrids, wet season 1995

Location/ Date of planting	Grain yield (t/ha)			
	DRRH-1	APHR-2	PA-103	CRH-1
HYDERABAD				
July 25th	5.05	5.78	5.88	-
August 5th	4.80	4.80	4.81	-
August 15th	3.77	3.73	3.54	
PANTNAGAR				
July 15th	6.08	6.43	6.20	6.21
July 25th	5.08	6.06	5.85	6.19

	Hyderabad	Pantnagar
C.D. (0.05) for varieties (V)	NS	NS
for Dates of planting (D)	0.51	0.31
for V at same D	NS	NS
for D at same V	NS	NS

Table 4. Grain yield of Hybrid rice (Cv. VRH 1) as affected by planting geometry and seedling number per hill, Wet season 1996

Planting geometry	One seedling/hill	Two Seedlings/hill	Mean
15 x 15 cm normal	4.44	4.29	4.37
15 x 15 cm skip (1 row after every 3 rows)	4.35	4.51	4.43
20 x 15 cm normal	4.78	4.81	4.80
20 x 15 cm skip (1 row after every 3 rows)	4.48	4.60	4.54
15 x 15 cm skip (1 row after every 4 rows	4.57	4.63	4.60
20 x 15 cm skip (1 row after every 4 rows)	4.63	4.81	4.72
Mean	4.54	4.61	

C.D. 0.05 for planting geometry(s)	: 0.23
for seedling number(M)	: 0.19
for S at the same level of M	: NS
for M at the same level of	: NS

HYBRID RICE

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Rice is the staple food for about 65% population in India. It occupies about 42 million hectares accounting to 34% of the area under food crops and 42% area under cereals. The rice production has increased from 30 million tonnes in 1965 to a surplus level of 82 million tonnes in 1994-95. The first green revolution achieved during mid 60s was due to the large scale adoption of semi-dwarf high yielding varieties coupled with improved management practices. This has enabled us not only to do away with imports but to accumulate rice in buffer stocks in excess quantities. Between 1966 and 1994, area under high yielding varieties has increased from 2.51 to 64.6% and rice area increased from 35.47 to 42.24 million hectares. Indian rice exports steadily increased from 400.000 tonnes in mid 80s to 5.5 million tonnes in 1995-96 placing India in second position.

The growth rate of yield declined from 6.5% during 1965-75 to 2.57% during 1985-95 in northern states and it was more or less stagnant at around 2.6% in south. At the present population growth, India has to produce not less than 2.5 million tonnes of milled rice every year to sustain the present level of self sufficiency. It is targeted to produce about 95 to 99 million tonnes by 2000 AD to cope up with the growing population. The task is quite challenging and the options available are very limited in view of plateauing trend of yield especially in high productivity areas, decreasing land area, water, labour and other in puts. Among the various possible genetic approaches to a achieve this target, hybrid rice technology is the most feasible and readily adaptable technology. this has been demonstrated in the Peoples Republic of China, during the last two decades. Presently 55% of the 32 million hectares of rice area in China is under hybrid rice, accounting for more than 66% of the total rice production. This technology is expected to bring about the second green revolution in India.

About 42% of the country's total area is under irrigated ecosystem which contributes 55% of the total rice production. If 60-70% of the irrigated area is brought under hybrid cultivation, it would contribute about 10-12 million tonnes of additional rice. The shallow low lands occupy 9 million hectares which contribute about 12.7 million tonnes of rice. It would be possible to expand the hybrid rice cultivation to shallow lowlands and boro areas of West Bengal, Assam and Orissa to raise the production further.

Though, the efforts for development and use of hybrid rice technology in India were initiated in 70s, these were mostly of academic nature, rather than goal oriented. Prompted with the success in the development and cultivation of hybrid rice in China, ICAR started conducting research on this line since 1982 at CRRI, Cuttack; IARI, New Delhi; Rice Research stations at Kapurthala and Mandya. After getting convinced from this preliminary research regarding the potential and feasibility of hybrid rice technology ICAR identified this as a top priority area and initiated a time bound, goal oriented network programme on hybrid rice since 1989 in collaboration with the IRRI, Philippines. This project was further strengthened with the assistance from UNDP/FAO since 1991. Now this project is being operated as a national research network with twelve centres across the country with the DRR, Hyderabad as the coordinating center. This network has two lead centers, Kapurthala in Punjab and Mandya in Karnataka; three strategic centers, primarily for conducting basic research are located at DRR, Hyderabad; CRRI, Cuttack and IARI, New Delhi. The seven associate centers for conducting region specific adoptive research are located at Coimbatore (Tamil Nadu), Maruteru (Andhra Pradesh), Chinsurah (West Bengal) and Karjat (Maharashtra). Besides the public sectors like State seed corporations, National seed corporation and other private seed agencies like, pro-agro, Mahyco, ITC-Zeneca, Nuzibudu and many others are actively engaged in conducting research and Hybrid rice seed production activities. Recently, Mahyco research foundation also supports financially to this network through ICAR. Initially high productive areas like Punjab, Haryana, Western UP and Irrigated areas of Andhra Pradesh, Karnataka and Tamil Nadu were identified for deployment of hybrid rice technology and later to other rice growing areas.

The procedure for developing F_1 hybrids in self pollinated crop plants like rice is different from other crop plants. Further hybrid varieties are different from the conventionally breed varieties. The conventionally breed varieties accumulates productivity genes that perform well under homozygous condition, while hybrid varieties assemble genes that perform well under heterozygous condition (F_1). Because of this, farmers have to procure hybrid seeds each time fresh.

The technique of hybrid rice development involves the use of three parental lines, viz. the cms A line, the maintainer B line and the restorer R line. The introduced cms lines (WA source) from China were found to be unsuitable and as such could not be used directly in our breeding programme. Hence the male sterility was transferred from the Chinese cms lines to the well adopted, broad based genotypes of the country. Now, a number of cms lines are available not only on WA back ground but also on other diverse male sterile cytoplasm in the country. In this three lime breeding method development of hybrid needs two steps-multiplication of cms lines (A/B) and production of hybrids (A/R). For this, the cms lines (A) are planted along with the maintainers (B) to produce cms lines and restorers (R) to develop hybrid varieties in suitable row ratios. The seeds collected from A lines of A/B plots form the cms seeds, part of which can be used again for A line multiplication and the other part for hybrid (A/R) seed production. The seed borne on A line of A/R plots is the F_1 hybrid seed which is supplied to the farmers as commercial hybrid seed. The quantity of seed set depends on the extent of natural outcrossing. Because of the self pollinated nature of rice, natural outcrossing is very low. However, by adopting suitable seed production techniques, the out crossing rate can be increased. Synchronisation of flowering of the two parental lines (A/B or A/R) is the crucial factor for achieving higher seed yields. Depending on the growth duration of the parental lines, the seeding dates are adjusted to get proper synchronisation of flowering. Further any differences in flowering can be manipulated through spraying of certain chemicals and cultural practices. For prolonged availability of pollen, male parents are seeded 2-3 times with an interval of 4 days between sowings. To increase the outcrossing rate, certain supplementary pollination techniques during peak anthesis time are employed. Isolation of A/B and A/R seed production plots from other rice plots are most important to maintain the purity of the produced seed. Isolation distance of 100 m around A/B and 40 m around A/R seed production plots is recommended. Rouging of female and male parents is most important to maintain purity.

Harvesting of pollen parent (maintainers and restorers) from the seed production plots is done first after which the female A lines are harvested. Because of this cost intensive seed production practices the cost of hybrid seed is very high (Rs. 60/- to 100/- per kg at present). However, due to the high vigour and good tillering in the hybrids, planting of single seedling/hill is recommended thereby bringing down the seed rate to 15 kg/ha only.

As a result of concerted, goal oriented, time bound and coordinated efforts, four rice hybrids with yield advantage of more than 1 t over the standard check varieties were released first in the country during 1994 by the state variety release committees. These are APHR 1 and APHR 2 for the Telengana and Royalseema regions of Andhra Pradesh, MGR 1 for Tamil Nadu and KRH 1 for Karnataka state. Later on, two more Hybrids CNRH 3 for boro season in West Bengal during 1995 and DRRH 1 for Andhra Pradesh during 1996 were released for cultivation. Besides these public sector bred hybrids a few hybrids developed by private seed agencies like Pro Agro Hybrid Rice International, Mahyco, SPIC-PHI Biogene, Hindusthan Lever Ltd., Vikki's Agro Tech, Nazibudu, JK Agro Tech, ITC Zeneca, Amareswari etc are popular. However, the hybrids developed so far are meant for irrigated lands. Long duration hybrids suitable for rainfed shallow lowland situations are being developed and would be available shortly. Besides these, hybrids with aroma (scent) would be made available in a short time during 1996, about 60,000 hectares was covered under rice hybrids. It is targeted to cover about two million hectares under hybrid rice by 2000 AD. However, most of the hybrids are found to be location specific.

Hence, hybrids are to be tested extensively through on-farm test centers to evaluate its suitability in various locations.

Since, the hybrid varieties are the F_1 plants, the seeds borne on these F_1 plants are F_2 seeds which segregate for grain and cooking quality features. Hence, many a times, the cooked rice of the hybrids varieties are not good. However, this can be avoided by carefully choosing the parental lines (A and R lines) which have identical cooked kernel characteristics for developing rice hybrids. Further, it is seen that most of the released hybrids are susceptible to various insect pests and diseases. Similarly, resistance can be incorporated into hybrids using suitable parents. During the early phase of heterosis breeding, the emphasis was mostly on yield heterosis. Now during the second phase due emphasis is being given for developing hybrids with better cooking and eating quality and farming resistance to major pests and diseases.

As the 3 line system of developing hybrid rice varieties is highly cost intensive and cumbersome, scientists are now engaged in 2 line system through the use of appropriate male gametocide, identification of photosensitive genetic male sterile (PGMS) and theromosensitive genetic male sterile (TGMS) lines. In this system no restorer lines are needed and any parent can be used as the male parent. The hybrids are developed by growing the male sterile line (Females) along with the pollen parents adopting suitable row ratios in specific environments where a critical day length (PGMS) or temperature range (TGMS) induces the female parent to maintain the complete male sterility for atleast 30 days. Male sterile seeds are produced in other environments where they are normally male fertile. This two line system is relatively easier to handle and the seed cost would be comparatively low. Efforts are also under way to develop one line system of exploiting heterosis through apomixis in which case farmers need not procure fresh hybrid seeds year after year as the heterosis is fixed in the hybrid variety. This can be achieved through the transfer of obligate apomictic gene from wild grasses into rice through genetic engineering. However, it is still in the infant stage. Once it is achieved, the hybrid rice would be popular, and economically viable.

The recent developments in rice biotechnology viz., anther culture, protoplast culture, fusion and regeneration, DNA transformation, molecular tagging etc. have opened new avenues in hybrid rice breeding. The success in protoplast culture has made it possible to produce cybrids which enable immediate transfer of cytoplasmic male sterility into elite breeding lines of rice, thus avoiding cumbersome process of backcrossing protoplast technology may also be used to produce alloplasmic lines of rice having cytoplasm from various wild species and related genera. These lines will result in the cytoplasmic diversification of male sterility sources. Molecular markers can help to tag genes associated with wide compatibility, TGMS, fertility restoration and apomixis.

RICE TECHNOLOGIES FOR RAINFED ECOSYSTEMS-PROBLEMS AND PROSPECTS

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Rice is the most important food-crop of India, occupying 43.3 m ha with a total production of 81.3 mt (1996-97) (Table-1). This production level is required to be raised to 95 m t by 2000 AD to meet the demand of about 1000 million population. Since the scope of increasing rice area is limited, it is necessary to increase the productivity of the land for which increasing the yield ceiling of the varieties as well as improving management practices are required.

With the introduction of high yielding varieties in 1965-66, mainly suitable for irrigated lands, most of the yield increase have come from irrigated lands. However, from the recent trend of production in the country, it is seen that there is a plateauing of yield levels in irrigated areas. Hence, it is expected that the required higher production in rice, atleast in the current decade, will come from rainfed rice areas which has the potentiality to produce more.

In India, rainfed rice occupies about 58% of the total rice area of which flood-prone lowland occupies 70% and the rest 30% by drought-prone upland. The major ecosystem wise area, productivity and number of high yielding varieties released are given in Table 2. It can be seen from the table that barring the irrigated and favourable (shallow) lowlands, the productivity is low compared to national average in other ecosystems, hence concerted efforts are need to improve productivity of these handicapped ecosystem.

Production constraints in rainfed uplands

Out of total area of 7 m ha (Table 2) under rainfed uplands in the country 5.2 m ha (70.4%) are present in eastern India with a productivity of only 0.8 t/ha. The major constraints are:

1.Socio-econimic constraints

i. Small and scattered holdings

ii. Unawareness to modern techniques

iii. Poor mechanisation

iv. Poverty

2.Production constraints

i. Low plant population due to broadcast method of sowing
ii. Erratic rainfall and soil moisture stress causes drought during seeding, vegetative and flowering stages
iii. Soil erosion leads to losses of soil, nutrients and moisture
iv. Poor soil fertility leads to poor crop stand, high tiller mortality, low panicle density and grain number per panicle
v. Soil problems like 'P' deficiency, 'Al' toxicity and 'Mn' toxicity in acid soils and 'Fe' deficiency in alkalic and calcareous soils
vi. Inadequate use of fertilizers and herbicides
vii. Severe weed infestation
viii. Incidence of pests and diseases- (*pests:* gundhibug, termites, mealy bugs, stem borer etc. and *diseases:* blast, brown spot, sheath blight etc.)
ix. Continuos use of traditional varieties
x. Lack of seed mormancy
xi. Difficulties at the time of harvesting, threshing and drying in the event of rains in September and October
xii. Narrow genetic base of modern high yielding short statured varieties.

Prospects of improving production

1. Non-monetary inputs

i. Summer ploughing
ii. Line seeding (seed-drills/behind the plough)
iii. Timely seeding (by 1st week of June with pre-monsoon shower)
iv. Proper plant type (semi-tall/semi-dwarf depending upon soil types)

2. Improved management practices

i. Proper seed rate (100kg/ha for proper plat population in the field)
ii. Proper HYVs of rice (drought tolerant/drought avoidant types)
iii. Timely weeding (may be pre-emergence weedicides)
iv. Timely application of fertilizers
v. Disease/pest management

3. Improving cropping intensity

i. Feasibility of relay/sequence cropping depending on availability of residual moisture (in red soil, sequence cropping with linseed and lentil appears to be useful).
ii. Intercropping with grain legume or pigeonpea found profitable.

Production constraints in rainfed lowlands

i. Poor cop establishment due to early drought and/or early submergence
ii. Deep submergence/water logging at the early stages of crop growth suppresses tillering and increases plant mortality
iii. In direct seeded crops weeds and some times wild rices became one of the major constraints for higher production
iv. Inadequate and imbalanced use of fertilizers and other agronomic inputs
v. Water logging and poor drainage leads to accumulation of toxic substance (iron toxicity, sulphide injury etc.)
vi. Coastal salinity in Orissa and West Bengal due to high water table containing saline water.
vii. Incidence of pests and diseases- (*pests:* stem borer, gall midge, cutworm, GLH, leaffolder etc. and *diseases:* bacterial blight, sheath blight sheath rot, tungro, false smut etc.).
viii. Low light intensity at flowering
ix. Delay in monsoon often leads to delayed planting
x. Continuos use of traditional low input responsive and low yielding varieties
xi. Premature lodging of tall varieties
xii. Non-availability of better genotypes with flood/submergence tolerance at early and late vegetative stages.

Production constraints in deepwater rices

i. Inadequate plant population due to seedling mortality
ii. Continuos water logging leads to suppressed tillering and plant mortality
iii. Incidence of pests and diseases (stem borer, ufra, bacterial blight etc.)
iv. Damage due to crabs during flooding period and rats at different growth stages
v. Lack of suitable high yielding varieties with submergence tolerance and elongation ability
vi. Traditional monocropping of rice with long fallow period

Steps for improving production

i. Summer ploughing
ii. Line seeding (wherever possible)
iii. Timely seeding (last week of May)
iv. Basal application of fertilizers (NPK)
v. Use of proper HYVs of rice

For transplanting situations

i. Raising super seedlings
ii. Timely planting
iii. Use of proper HYVs (photosensitivity/thermo-insensitivity)
iv. Integrated nutrient management (INM)
v. Water management (drainage)
vi. Timely harvesting/post harvest management

Future strategies to improve rice production in rainfed ecologies

i. Consolidation of holdings
ii. Water harvesting and moisture conservation in uplands
iii. Development of drainage system in lowlands
iv. Reclamation of coastal saline/acid soils
v. Cost effective and environment friendly production strategies
    - integrated pest management
    - integrated nutrient management
    - integrated weed management
vi. Enhancement of production and productivity of rainfed ecologies by developing better adopted HYV's (Table 4 and 5)
vii. Strengthening of seed multiplication, distribution and storage facilities
viii. On-farm and adoptive research for identification of location specific constraints and developing appropriate technologies
ix. Strong researcher, extension worker and farmer linkage
x. Raising genetic yield ceiling
    - exploitation of hybrid vigour
    - new plant type
xi. Exploitation of productive but under utilised environments
    - Boro rices
    - Late planting of Aman/Sali

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Table 1. Area, Production and Yield of Rice

Year	Area (million ha.)	Area growth rate(%)	Production (million tonnes)	Production growth rate(%)	Yield (kg/ha)	Yield growth rate (%)	% Coverage Under Irrigation
1950-51	30.8		20.6		668		31.7
1955-56	31.5	0.5	27.6	6.0	874	5.5	34.9
1960-61	34.1	1.6	34.6	4.6	1013	3.0	36.8
1965-66	35.5	0.8	30.6	– 2.4	862	– 3.2	36.5
1966-67	35.3	-0.6	30.4	-0.6	863	0.1	37.9
1967-68*	36.4	3.1	37.6	23.7	1032	19.6	38.6
1968-69	37.0	1.6	39.8	5.8	1076	4.3	38.4
1970-71	37.6	1.1	42.2	3.9	1123	2.9	38.4
1975-76	39.5	1.0	48.7	2.9	1235	1.9	38.7
1980-81	40.2	0.3	53.6	1.9	1336	1.5	40.7
1985-86	41.1	0.4	63.8	3.5	1552	3.0	42.9
1990-91	42.7	0.7	74.3	3.0	1740	2.3	45.5
1991-92	42.7	0.0	74.7	0.5	1751	0.6	47.3
1992-93	41.8	- 2.0	72.9	– 2.4	1744	- 0.4	48.0
1993-94	42.5	1.0	80.3	10.2	1888	0.3	48.6
1994-95	42.8	- 0.7	81.8	1.9	1911	1.2	49.8
1995-96	42.8	0.2	77.0	2.7	1797	-2.9	-
1996-97	43.3	0.9	81.3	2.1	1879	1.3	-

Note : **Green Revolution period.*

Source : *Agricultural Statistics at a Glance, 1998*, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India

Table 2. Ecosystem wise area, productivity and no. of HYVs released sofar in India.

Sl.No	*Ecosystem*	Total rice area (m.ha)	Productivity clean rice (t/ha)	No. of HYVs released	
				All India	CRRI Cuttack
1	Irrigated land	17.8	2.50	272	23
2	Rainfed upland Rainfed lowlands	7.0	0.80	95	12
3	Shallow (favourable) (0-30 cm water depth)	8.1	2.40	100	11
4	Intermediate (30-50 cm water depth)	4.0	1.50	25	7
5	Semi-deep (50-100 cm depth)	3.0	1.00	15	-
6	Deep (> 100 cm depth)	2.4	0.60	5	-
	Total (All India)	42.3	1.92	512	53

Table 3. Ecosystem-wise representative varieties and scope for improvement

	Ecosystem	Representative HYV	Yield range t/ha	Deficiency
1	Rainfed upland	Heera Kalinga III Annada	2-4	• Drought tolerance • Weed Competiveness • Better panicels • Pest/Disease • Dormancy
2	Irrigated medium lands	Ratna IR 36	4-6	• Better panicles • Better HI • Pest/Disease • Sterility
3	Rainfed lowlands			•
	Shallow	Savitri Gayatri	2-8	• Submergence tolerance • Thermo insensitivity • Adaptability across states • Adaptability to changed environment • Pest/disease • Duration
	ii Intermediate	Tulasi Panichan	2-6	• As in shallow system
	iii. Semi-deep	Sabita Nalini	1.5-4	• Submergence tolerance High yielding potential
	iv. Deep water	Jalamagna Jalanidhi	1-3	• Non-elongating • Non-elongating

Table 4. List of most promising high yielding varieties of rice for different situations.

	Variety	Total duration (days)	Average yield (t/ha)*	Remarks
I. For drought-prone/post-flood rainfed areas				
1.	Heera (Super fast rice)	68	3.0	Semi-dwarf with resistance BL, GM, RTV and with seed dormancy
2.	Kalyani-II	65	2.0	Semidwarf
3.	Sneha	80	3.0	Semi-dwarf, gandhibug tolerant
4.	Turanta Dhan	75	2.5	Semi-dwarf
II. Varieties for rainfed uplands:				
1.	Kalinga-III	85	3.0	Semi-tall, L.S. grain, cold tolerant
2.	Neela	90	4.0	Semi-dwarf with resistance to GM, BL, early seedling vigour
3	Vanaprabha	90	1.5	Semi-tall, RTV tolerant
4.	Pathara	90	3.0	Semi-dwarf with good seedling vigour
5.	Vandana	100	4.0	Semi-tall, good for lateritic soil
6	Tara	100	4.0	Semi-dwarf
7	Subhadra	100	3.5	Semi-dwarf
8.	Parijat	110	4.0	Semi-dwarf, wider adaptability
III. Varieties for irrigated lands				
1.	Saket-4	115	4.0	L.S. grain, SB/RTV resistant
2.	Ratna	120	4.5	L.S. grain. SB/RTV resistant
3.	Sarasa	120	5.0	L.S. grain, tolerant to RTV and early submergence
4.	Lalat	125	5.0	Multiple tolerance to pests and diseases
5.	IR 36	125	4.5	Multiple tolerance to pests and diseases
6	Udaya	135	4.5	Tolerant to BPH
7.	Kranti	135	5.0	Suitable in M.P
8.	Hybrid	-	-	-
IV. Varieties for rainfed shallow lowlands:				
1.	Shyamala	140	3.5	Purple plant
2.	Padmini	145	4.0	Semi-tall, very fine grain
3.	Moti	145	4.5	Semi-tall
4.	Swarna	145	4.5	Semi-dwarf, wider adoptability

5.	Savitri (CR 1009)	160	5.0	Semi-dwarf
6.	Gayatri (CR 1018)	165	5.0	Semi-dwarf
7.	Jagannath	150	4.5	-do-
8	Pankaj	150	4.5	-do-
9.	Mahalaxmi	150	4.5	-do-
10.	Samalei	155	4.0	Semi-tall, resistant to GM, BL, RTV, GLH
11	Pooja	150	5.0	Semi dwarf, tolerant to BLB, GM, Late Plant
V. Varieties for intermediate lowlands (30-50 cms):				
1.	Utkal Prabha (CR 1030)	150	4.0	Semi-tall
2.	Tulasi	170	5.0	-do-
3.	Kalasree	160	4.0	Semi-tall with pigmented base
4.	Lunisree	145	4.0	Semi-tall, suitable for coastal saline areas
5.	Rajashree	160	4.0	Suitable in Bihar
6.	Ranjit/Bahadur	155	4.0	Suitable in Assam
VI. Varieties for semi-deep situation (50-100 cms):				
1	Suresh (CN 540)	160	3.0	Semi-tall, fine grain
2.	Biraj (CN 539)	165	3.0	PLS
3.	Sabita	155	3.5	Semi-tall
4.	New culture(CR 580, CR 581, CR 683 etc.)			-do-
5.	Jalaianan	155	3.0	-do-
6.	Jalapriya	160	3.0	-do-
VIII. Varieties for deep water areas (> 100 cms)				
1	Jalamagna	Pure line selection		
2	Jalanidhi	-do-		
3.	TCA 177	-do-		

* Yield potential - generally 30-50% more than average yield

Table 5. **List of rainfed lowland rice cultivars with tolerance to major biotic and abiotic stresses**

Traits	Shallow and intermediate	Semi-deep and deep
Submergence tolerance:		
a) Less elongating type	FR 13A, FR 43B, AC 1213, AC 10556, IR 38784-15-19, IR 3864-4-5, IR 58821-12-10, IR 57539-5-27	-
b) Elongating type	Panidhan. Utkalprabha, Madhukar, CR 626-26-14-1, CR 625-18-1, Suresh	Dhusara, Khajara, Dinesh, Amulya, Matangini, Tilakkachari, Sabita
Dought at seedling	Vaidehi, Kotta bayahunda	Sudha, Janki, Jaladhi-2
Iron toxicity	Mahsuri, Samalei, CR 672-3	CR 617-16-10-2
Coastal saline tolerance	Dasal, Getu, Lonabokra, Damodar, Lunisree, CSR 6, CSR 7-1, Nonasail, Sonamani, Pateni	-
Late planting	CR 1014, Tikkana, Gayatri, Vaidehi, Manoharsali, Kotta bayahunda, Shakuntala, Rajashree. Swarna, Pooja, CR 673-475, CR 683-123	Matangini, Amulya, Sabita
Stability and wider adaptability	Rajashree. Mahsuri	Sabita
Good grain quality	Samalei, Moti, Madhuri, Lunisree, Suresh	Sabita, Sudha, Amulya
Bacterial leaf blight	CR 1002, Mahsuri	Sabita
Rice tungro virus	Moti, Radha, CR 673-475, Samalei	Matangini, Nalini
Sheath blight*	Salivahan, Manoharsali, Neeraja, T 141, CR 1014, Pankaj, Samalei, Mandira	Nalini, Dinesh, Sabita, Matangini
Sheath rot*	Mahsuri, Vijaya, Mahsuri, ARC 7117, Manoharsali, Biraj	-
Stem borer*	Radha, Jogen, Mandira	Amulya, Sabita, Sudha
Green leafhopper	Moti, Radha, Jagannath	CR 581-9, CR 580-17-1
Borwn planthopper	CR 1002, Manasarovar, Nagarjuna, Manoharsali, Pinakini, Chaitanya	-
Gall midge	Moti, Samalei, Manoharsali, CR 95-26-1	CR 581-9, CR 580-17-1

* *Tolerant varieties*

IRRIGATION WATER MANAGEMENT PRACTICES IN RICE

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Rice is known as a semi-aquatic plant. It has ability to adapt in many variable environs. It grows in submergible to semi-drought conditions. For production of 1 kg rice, 15,000 litres of water is used in India as against 6,000 litres in Japan. Studies indicate that with 3,000 to 4,000 litres of water, 1 kg of rice can be grown. Another study shows that contribution of good water management for higher production of rice is 12%, whereas contribution of environment to this is 30%. Research is being conducted at several places for better water-management practices, mainly to reduce conveyance and application losses of irrigation water.

In humid tropics conveyance losses range between 15 to 40% of the diverted flow from sources. Distribution losses range between 30 to 50% of the water turned to the irrigated area. Conveyance loss turns to be high when:

1. Soil texture is relatively coarse
2. Water level in the channel is high
3. Channel is relatively long
4. The maintenance of channels is poor.

The losses tend to be minimal when:

1. Soils are heavy
2. Ditches are free of weeds and silt, and
3. The ditches have control and measurement devices.

With careful management situation, these losses can be kept within 5 to 10%.

Application losses include percolation and seepage losses. Percolation loss is a function of the soil and watertable conditions. This loss generally ranges from 1 to 5 mm/day. Seepage occurs through paddy bunds. In the middle of an irrigation system, loss from one field is the gain for the adjacent field. But at peripheries, particularly near drainage channels or rivers, it is a loss to the system. This factor coupled with loose soils may make seepage loss as high as 20 mm/day. If seepage and percolation losses exceed 10 mm/day, the land is not suitable for rice cultivation especially during dry seasons.

In addition to the losses, the water required to produce optimum yields must satisfy the evapo-transpiration needs of the crop. In most of the tropics, the evapo-transpiration requirement during rainy seasons is approximately 3 to 5 mm/day. During dry seasons, for large irrigated areas 6 to 8 mm/day may be required. For small irrigated areas, this may be higher because of advective energy brought to the area by winds blowing from non-irrigated areas. Various water use efficiencies have been defined to quantify losses.

In India, the seasonal water requirement for rice cultivation ranges between 600 and 1,800 mm, with an average use of 1,200 mm for a 100-day crop. This includes water requirement for evapo-transpiration, percolation and seepage losses, land preparation (minimum 125-200 mm for puddling) etc. Most of the irrigation systems are designed for a continuous flow rate of 1.5 litres/second per hectare. On a continuous basis, it is equal to 13 mm/day. During land preparation stage for rice, generally 50 % more water is delivered from canals. The average duration for land preparation is 21 to 35 days.

Rice plant is very sensitive to shortage of water at certain phases of growth, the most critical being germination and flowering stages. The primary objective of any irrigation system is to deliver the required quantity of water when needed.

Water management practices for rice

Rice-water management practices include:

1. Continuous flooding (static)
2. Continuous flooding (flowing)
3. Intermittent irrigation
4. Rainfed water management.

Continuous flooding (static)

It involves shallow, medium and deep flooding. The water supply must be adequate and water depth is adjusted to the required level on a daily basis.

Continuous flooding (flowing)

It involves shallow, medium and deep flooding depending on the regulated height of the paddy spillways.

Intermittent irrigation

Water is applied rapidly in short intervals, and in sufficient quantity to serve the crop needs until the next irrigation, generally after 4 to 7 days. This method saves a lot of irrigation water without sacrificing the crop yield. A study at CRRI indicated that irrigating the field after 6 days of disappearance of ponded water (5 ± 3 cm) does not reduce the yield appreciably when water saving was in the order of 40 %. When weed problem is limited, one can keep the field in saturated condition throughout, except in primordial initiation stage to full flowering stage, when standing water is essential. The sequence of irrigation that can be followed, is:

1. During and after transplanting: Field should be puddled by puddler or disc harrow to seal the pores. Water must be maintained at a depth of 2 to 3 cm during and for a week after transplanting, for establishment of roots and for stimulating rapid growth of new roots.

2. After 30 days, for a week, the field should be drained for top dressing of fertiliser and removal of weeds.

3. Panicle-primordia development stage: Before beginning of panicle-primordial development stage, field must be flooded to a depth of 5 to 7 cm as water shortage during this and the later stage causes sterility in the crop.
4. After full flowering: The field must be drained gradually again, 15 to 20 days after full flowering stage. This helps in minimising grain shattering loss and better milling qualities.

Rainfed water management

Rainfed water management depends on the control of paddy spillways. Water from a catchment area or small watershed can be stored on the paddy surface and channelled down the slope through spillway and bund management.

Water can be retained on the entire area of the paddies, according to the need of the farmer and mutual understanding between adjacent farmers on the slope. Subsurface seepage becomes an important water source, increasing with distance down the slope from the watershed divide.

Disease, pest and weed control

Standing water minimises weed growth but enhances fertiliser leaching loss. Water management practices may not significantly affect the type or extent of insects and diseases in rice fields except a few, like case worm, whose movement is made easier by floating cases in standing water. But control practices that require absorption of chemicals into the plant are usually helped by flooding. Distribution and stability of granular pesticides are improved at moderate water depths.

Balanced use of groundwater

Excessive use of groundwater where recharge of aquifer is in-adequate, causes lowering of groundwater-table. This has forced farmers in some parts of India to go for deeper submergible pumps or deeper under-ground pump chambers. In some places, sea water intrusion has taken place to main land aquifers, making fertile lands unsuitable to crop growth due to salinity build-up. Yet in other parts of India, like Orissa, only 0.71 to 33.26 % (state average : 9%) of replenishable groundwater is utilised, showing an abundant scope for development of groundwater irrigation systems.

A study of satellite images in CRRI environs shows that, in dry seasons, a maximum of 24 % of the area can be put under rice cultivation to avoid any depletion of groundwater storage; if the crop is to be irrigated by groundwater depending on its aquifer recharge.

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BIO-FERTILIZERS IN RICE CULTIVATION-PROBLEMS AND PERSPECTIVES

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The crop plants like cereals utilise solar radiation for photosynthesis but are unable to fix atmospheric nitrogen. However, there are certain micro-organisams like blue-green algae (BGA) found in free-living state and also in symbiotic association with certain plants like *Azolla* in tropical paddy fields, which have the capacity to harvest both solar energy and atmospheric nitrogen. These, therefore, are considered to be important in maintaining soil fertility. Besides nitrogen, the tropical soils are poor in organic matter and, therefore, continuos addition of organic matter is required to maintain the soil fertility, which could be possible through utilisation of these organisms and various types of wastes or waste products, as being judiciously followed in some of the countries of south-east Asia.

BGA and *Azolla* (in algal association) constitute N_2-fixing photosynthetic biofertilisers for rice and these are being exploited to overcome the problems mentioned above to some extent. A brief description about their cultivation, maintenance and utilisation is given below:

Azoalla

Azolla is an aquatic fern commonly found floating in ponds, lakes, tanks, shallow ditches and channels. It is also observed in rice fields at several locations in the country. Nitrogen-fixing blue-green algae, *Anabaeha Azollae*, always found in the cavities of dorsal leaves of the fern fixes atmospheric nitrogen efficiently and supplies it to *Azolla* plants. Thus, this fernalga system is unique since both photosynthesis and nitrogen fixation occur in the leaves and, therefore, the fern is an attractive resources for photosynthetic production of nitrogen fertilizer. This fern has been domesticated in Vietnam, where it is grown in more than 800,000 hectares of fallow rice fields providing about 50 per cent N to produce 5 t/ha of paddy, and China where it is cultivated in about 1,30,000 hectares of rice. It is also incorporated in rice culture in parts of Thailand and Indonesia. The extensive researches carried out during the last twenty three years at the Central Rice Research Institute on multiplication and utilization of several *Azolla* varieties collected from India and abroad are very encouraging.

Azolla can be conveniently grown round the year under Cuttack conditions and an annual production of about 347 t/ha (fresh matter) in field and 321 t/ha in concrete tanks has been obtained. In terms of nitrogen, about 686 kg N/ha was harvested annually. The occurrence of standing water and application of phosphorus are considered as the essential requirements for rapid multiplication of *Azolla*. Presently superphosphate and furadan and in a week the produce is about 160 kg. By extending its cultivation gradually for two more weeks as stated earlier it is possible to obtain 1000 kg of *Azolla* sufficient to inoculate 1-2 ha of paddy fields. If a plot of 100 m^2 is kept for cultivation of *Azolla*, it is possible to harvest 100 kg *Azolla* every week, which can be spread in paddy fields for further multiplication and fertilisation.

Method of utilisation

As green manuring: Grow *Azolla* before planting in well ploughed, leveled and bunded fields, for which inoculate bout 1-2 t fresh *Azolla* /ha along with superphosphate (10 kg P_2O_5/ha). After formation of a layer in 15-20 days, drain the field, if possible, and turn *Azolla* after incorporation will plough. Transplant rice seedlings after a week. A second layer of *Azolla* after incorporation will provide more nitrogen. One layer of *Azolla* provides 10-20 tonnes of green matter/ha, which is equivalent to 20-40 kg N. The increase in grain yield ranging from 1.0-2.0 t/ha over control is obtained. This method is suitable for both short and long duration rice varieties.

As dual cropping with rice: If water is not available before planting, inoculate *Azolla* on standing water at the rate of 0.5-1.0 t/ha after a week of planting. Recommended dose of superphosphate for rice may be applied in split doses, that is two-third basal and one-third during *Azolla* cultivation. Division of bigger field into smaller plots is required for rapid growth. The use of plant leaves, grasses or straw near the outlet avoids flowing of *Azolla* from field to field. After mat formation drain the field if possible and incorporate *Azolla* into the soil using paddy weeder or leave as such, where it will docompose in due course and increase the grain yield. It is advisable to use basal dose of N fertilize along with dual copping. *Azolla* also checks the weed growth. The use of *Azolla* once as green manuring and once as dual cropping or twice as dual cropping, increased the grain yield equivalent to 60 kg N/ha. This method is suitable for the rice varieties of 100 or more than 100 days duration. It is suggested to avoid use of pre-emergence herbicides such as machete and benthiocarb when *Azolla* is inoculated in rice fields. If the herbicides have been applied, *Azolla* is to be inoculated after 2-3 weeks. Application of field dose of 2,4 D has no adverse effect on *Azolla* growth.

Use of *Azolla* with chemical N fertilizer

Azolla can be safely used along with N fertilizer upto 30-40 kg N/ha. At their higher doses, its growth and N_2 -fixation are decreased significantly. Use of slow-release fertilizers like urea supergranule (USG) and sub-surface placement of N fertilizer are recommended for better *Azolla* growth and higher N use efficiency. Combined use of *Azolla* with N fertilizer upto 150 kg N/ha increased grain yield of rice.

Blue-green algae

Blue-green algae are widely distributed in India in moist to water logged paddy fields. In general, they are found abundantly when conditions for their growth are favourable for a particular period or during the entire cropping season. It was revealed

After formation of a layer in 1-3 weeks, harvest two-third of *Azolla* with the help of a bamboo stick and leave the remaining one-third for further multiplication. More root growth is undersirable since it affects production adversely and also reduces the total N content of *Azolla* biomass. The sick (poorly-growing unhealthy) *Azolla* has to be replaced with the healthy-growing plants from the other fields.

Snails also damage *Azolla* and, therefore these are to be removed either manually or controlled by application of pesticides. Abundance of algal growth is undersirable in production units and these are to be removed manually or by during the fields or by application of copper sulphate at the rate of 10 kg/ha.

Harvested *Azolla* should be re-inoculated in other fields otherwise it will decompose and turn into cipost (3-5 per cent N) which can also be use for vegetable and fruit crops.

Under Cuttack conditions, *Azolla* multiplies throughout the year at the rate of 2-4 times/week. It multiplication is affected adversely when day-night water temperature exceeds 40-32°C. *Azolla* varieties tolerant to high and low temperatures are available.

Although *Azolla* grows well in slightly acidic (pH 6) to alkaline (pH 8) soils optimum growth is attained at near neutral pH and pH lower than 5 or higher than 8 does not support its growth.

It can also be multiplied in concrete tanks, trays and earthen pots on flooded soil under field and in nethouse conditions. during off-season, it can be maintained in the containers mentioned above, besides shade may be provided in field during hot summer.

The sporocarp-bearing plants (produced during November to March) are harvested composted, dried and stored for further use. This produces new *Azolla* plants in 7-20 days after inoculation in flooded soil in pots/trays with frequency of 20-60 per cent megasporcarps are not damaged during decomposition of vegetative plants. The technology for using them for field inoculation is being developed at CRRI.

Large-scale multiplication

The time of large-scale multiplication of *Azolla* is to be determined by the date of transplanting of paddy and the amount of incoulum available. I case transplanting is to be done in the first week of July, multiplication should be initiated in the middle of May. With the available inoculum of about 6 kg and the area to be applied about 2 ha its multiplication is to started by applying 6 kg *Azolla* into an area of 4 m × 3 m after mixing with 36 g superphosphate and 1 g furadan. After 7 days, weight of fresh *Azolla* will be about 18 kg, which can be again extended into an area of 5 m × 6 m with phosphate and furadan as mentioned above. After one week, the produce will be about 54 kg. This *Azolla* is further inoculated in an area of 10 m × 10 m with fresh *Azolla* has to be applied since it does not survive after drying. However, we are trying to develop technology for using sporocaps as the seeding material. *Azolla* production units have to be established, preferably at the block level, to supply cultures to the needy farmers in time. Addition of inoculum in fields depends upon the time left for its multiplication before utilisation. It is used either as green manure-where it is grown before planting or as dual cropping with rice-where it is used after growing for 20 to 30 days, depending upon the inoculum, rice variety and fertilizer schedule. Both practices are combination of both the green manuring and dual cropping can meet the total nitrogen demand of a rice crop. In case of green manuring, fresh *Azolla* plants are inoculated to rice fields at the rate of 1-2 t/ha, 15-20 days before planting. After formation of a mat, it is incorporated into the soil. However in standing water the entire quantity can not be buried and the leftout floating *Azolla* fronds grow along with rice plants and benefit the crop at latter stages of crop growth. One layer of *Azolla* provides about 20-40 kg N/ha.

If maintenance of standing water before planting is not possible, *Azolla* in inoculated at the rate of 0.5-1.0 t/ha after a week of rice transplantation. It grows with rice plants and covers the area in 20-30 days. Thick mat of *Azolla* starts decomposing automatically and, thus, released nitrogen becomes available to the rice plants. It is advisable to turn *Azolla* into the soil with the help of paddy weeder after draining out water for better benefit, although unincorporated *Azolla* is also equally effective, since it decomposes itself. The crop response was studied with these methods using several high yielding verities and significant increase in grain and straw yields was noticed. The use of *Azolla* along with chemical N fertilizer benefited the crop more than *Azolla* for chemical fertilizer alone. Increase N soil fertility and residual effect due to use of *Azolla* are also established. *Azolla* cover also controls about 50 per cent of aquatic weeds growth in planted field.

Methods of inoculum production

Divide nicely ploughed and leveled fields into small plots (10-25 sqm) by raising bunds. Keep 5-10 cm standing water and maintain it till multiplication is continued. Raising the water level to 30cm will not affect *Azolla* growth adversely.

Inoculate fresh *Azolla* at the rate of 0.1-0.3 kg per sqm, depending upon the availability of incoulum. Higher inoculum density is always better for rapid spread.

Mix superphosphate at 4 to 6 kg P_2O_5/ha along with incoulum or sprinkle it after *Azolla* inoculation. rock phosphates are not recommended for *Azolla* cultivation. Few grams of pesticide furadan (0.1 to 1.0 g/kg *Azolla*) may also be mixed with the inoculum or both superphosphate and furadan should be applied after inoculation. No harm to *Azolla* was observed due to mixing of recommended quantity of these chemicals.

Fresh cattle dung at the rate of 1.0-1.5 t/ha can replace superphosphate. The disturbance of mud of the *Azolla* field by stirring also helps in its better growth.

from the work carried out at this Institute that inoculation of BGA could increase the paddy yield to the extent of 20-30 kg N/ha as chemical fertilize. the important aspects in BGA biofertilizer technology are their natural occurrence, cultivation, storage, supply inoculation, interaction with native forms and envrionment, grwoth of inoculum and effect of BGA inoculation rice yield and soil fertility. The amount of N fixed in paddy fields by BGA depends on their growth and fixation varies from a few kg to 50 kg N/ha/season. Only part of the BGA-N is available to the same standing rice crop with the result that in many instances, although plenty of algal growth is observed yet rice crop does not show positive response. The amendments like application of superphosphate in split doses after planting has been found to encourage the growth of native BGA considerably. Algal predators play an important role in deciding their dominance in the field, where high mucilage producing algae are found to be tolerant. Although algal production technique is know since long, yet detailed information on the production under various environmental conditions and soil types, seasons, water, regimes and competition of foreign algae with the native one is lacking. Under Cuttack conditions BGA multiply rapidly during March to May since high temperature, less rain and high light intensity prevail during this period. Fresh BGA were found to be superior for inoculation over dried ones and crop response due to algalization is better during the dry season. 5-10 cm standing water supports growth of both native and inoculated BGA, whereas increased in the water depth adversely affected their growth. Rice crop response to algalisation is comparable to the application of 20-30 kg N/ha through chemical fertiliser. BGA can safely be used with 20-40 kg N/ha of chemical N fertilizer, whereas increasing the N dose further gradually reduced their growth and N_2 fixing potential. Between ammonium sulphate and urea, the latter is found to be less inhibitory to algal growth and N_2 fixation. Incorporation of BGA mat in soil is recommended for better results. BGA are also reported to liberate growth promoting substance. A brief note on method of inoculum production and application in paddy fields is given below.

Method of incoulm production

The production of right type of inoculum is very important for algal utilisation programme. Several methods have been worked out in various countries but most of them are sophisticated and need more investment. The USSR has been raising algae in open-concrete shallow tanks and a similar method was found to be workable in Indian condition. The shallow G.I trays or concrete tanks, beside fields, are being used in India for the production of inoculum of promising algal species. A mixture of blue-green algae- *Aulosira, Gloeotrichia, Anabaena, Nostoc, Wollea, Aphanothece* and *Cylindrosperum* is recommended so that any of the algal species may grow suiting the condition for its multiplication. The details of multiplication are as follows:

Production in trays/tanks

Prepare shallow trays of galvanised iron sheet (4'x3'x9") or cement tank of its double size to have permanent units. the size and number of trays/tanks depend upon the amount of inoculum to be produced. It is suggested to have such permanent structures with proper irrigation and drainage facilities for continuos cultivation.

Keep 34 kg soil in the above size trays/tanks and mix it well with 30 g superphosphate. About 20 mg sodium molybdate may be added if there is response to its addition in a given type of soil. Keep the soil in clogged condition after irrigation. Lime is recommended for acidic soils to raise the pH.

After water becomes clear, sprinkle the starter culture on the surface of standing water. The starter culture must be in healthy condition, possibly collected from local fields (about 40 g fresh material equivalent to 4 g dry weight) for rapid growth. Trays should be kept in open air since algae grown in field condition rapidly multiply after inoculation in paddy fields.

Blue-green algae multiply rapidly during summer due to their preference for high temperature and cover the area in 15 days. Harvest algal mat and use it for inoculation. In off season, algal mat is collected, sub-dried and kept for use. As far as possible, fresh algae should be used as inoculum for better result.

Continue cultivation and harvesting with the above amendments and change the soil after 3-4 harvests. A single harvest from one tray in 20 days is around 500-800 g fresh algae. To prevent insects which eat blue-green algae, add 2-4 g of Biazinon or cytrolance or Furadan. About 75-100 sqm area is required to produce 30-50 kg fresh inoculum within 20 days to inoculate one hectare.

Production fields

BGA grow better in soils having neutral to alkaline pH. As mentioned earlier, its production in field is better during summer, i.e. March to May or June at Cuttack conditions. The following steps are suggested to follow:

- Prepare bunded and leveled plots of 4 sqm each near the water source, maintain standing water upto 5 cm and inoculate locally-collected mixture of fresh BGA dominated by *Aulosira, Wollea, Gloetrichia* and *Aphanothece* at the rate of 500 kg/ha.

- Apply superphosphate (40 kg P_2O_5/ha) and pesticide furadan (2.5 kg/ha) after algal inoculation to obtain better growth.

- Allow BGA to grow for 15-20 days and then harvest the algal mat either manually using a sieve or allow the field to dry for collecting the algal flakes. the algal biomass production is 3-6 tonnes fresh wt/ha during March- May.

Production of Native BGA

By following the above procedure without inoculating BGA the native BGA flora is encouraged to come up fast with a biomass of about 2 t/ha at 40 kg P_2O_5/ha, consisting of mainly species of *Aphanothece, Gloetrichia, Aulosira, Anabaena* and *Wollea*.

N_2-fixing BGA growing in fallow flooded rice fields are also collected before ploughing and used as starter culture on inoculum, for which some knowledge of identifying promising BGA by visual observation is required.

Field application.

The use of dried blue-green algae at the rate of 6-10 kg/ha has been inpractice at CRRI and other locations in the country. Fresh inoculum is better than dried one, sine the later fails to come up in several cases. It is suggested to inoculate fresh algal material at the rate of 50-100 kg/ha (90 per cent moisture) as far as possible. Addition of excess algal material helps to produce more biomass in shorter time. In fact 380-600 kg fresh wt/ha (22.5-37.5 kg/ha dried algal powder) is used in China for better result.

Apply algal material with each crop consecutively for 3-5 season. More amount of inoculum is required in *kharif* (wet season) than in *rabi* (dry season) for rapid establishment.

Inoculate algae after a week of planting in clear water and inoculation should be avoided on cloudy or rainy days. Algae can be used with 20-40 kg N/ha as fertiliser to obtain higher yield.

Apply superphosphate at the rate of 20-40 kg P_2O_5/ha in 2-3 splits for rapid algal establishment. The incorporation of algal mat in soil during weeding provides more nutrient to rice plats and increases the grain yield more than unicorporated fields.

Recommended doses of pesticides and other agronomical practices do not generally interfere with algal establishment, although herbicides like Machete affect the algal growth severely.

Native BGA flora of paddy fields can also be encouraged to produce more biomass and N_2-fixation by applying only 20-40 kg P_2O_5/ha in 2-3 splits in clouded water after transplanting or seeding.

Conclusion

The use of *Azolla* and BGA is economical and eco-friendly in comparison to the chemical fertilisers and both technologies are extended to farmers in the country. It is suggested to produce inoculum locally instead of transporting the material grown at distant locations having different soil/environmental conditions. Extensive programme for both the technologies are required for maintenance, cultivation, distribution and utilization n the farmers' field on large-scale. It is important to note that *Azolla* grows well in soils with acidic to neutral pH and moderate temperature, whereas BGA grow well in soils of neutral to alkaline pH and high temperature.

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RICE-FISH SYSTEM

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Introduction

Cut of around 42.2 million (m) ha of rice area in the country, 17.3 m ha are rainfed lowlands of which 14.2 m ha are in the eastern India. Rainfed lowlands are constrained with varying degree of stresses like submergence, flash flood, drought, pest and diseases, poor condition of the farmers. A monocrop of traditional rice is mostly grown in these areas with poor productivity of less than 1 to 1.5 t/ha. Shifting to farming systems in these uncertain, otherwise high potential areas can only ensure higher and sustainable farm productivity, income and employment.

Why Rice-fish farming ?

Among the different farming options possible in the rainfed lowlands, rice-fish is one of the most acceptable choices particularly in the eastern India, as the resources, food. habits and other socioeconomic conditions favour such farming. Moreover lowland rice ecologies are usually conducive to aquaculture.

Rice-fish system

Rice-fish diversified farming system, called as "rice-fish system", integrates different compatible components like improved rice, fish, prawn and different crops after rice in the field and vegetables, fruits and other crops on the bunds besides providing scope for birds rearing and other enterprises. The technology mainly includes field design construction and production methodologies for the different compo.....ts.

Site selection

Rainfed intermediate and semi-deep water lowlands (30 to 80 cm of water depth), free from repeated floodings are suitable for rice-fish system. The farm size may vary from 0.4 ha to one hectare or more.

Design and field construction

The design includes 2.5 m wide dikes (bunds) all around covering about 20% of the field area, a water harvesting-cum-fish refuge system covering around 13% of farm area in the form of two 3 m wide side trenches having gentle (0.5%) bed slope towards a connecting pond refuge of 10 m width and 1.75 m depth at the lower end and a guarded outlet (design enclosed). Proper dressing and compaction of soil and grass pitching are done to minimize soil erosion. The height of the dikes is keep at least 20-30 cm more than the maximum flood level.

Production technology

Rice

High yielding, semi-tall and tall (120 to 170 cm? photoperiod sensitive long duration(160-180 days) rice cultivars with tolerance to submergence, lodging and insect pests and diseases such as Panidhan Tulasi, Utkalprabha, Kalashree, Lunisree (especially for coastal saline areas) are suitable for rice-fish-system. Rice is preferably dry-seeded well in advance of wet season. Inorganic fertilizer at the rate of 40 kg N and 90 to 30 kg P_2O_5 and K_2O /ha are applied at the time of seeding. Transplanting, if no required, should be done well before water stagnation using old and healthy seedlings.

Fish and prawn

Freshwater Indian major carps (catla, rohu, mrigal) and common carp are grown In combination with two freshwater giant prawn species (*Macrobrachium rosenbergii* and *M. malcolmsonii*). Fish fingerlings of 3 to 4" size and prawn juveniles of 9" to 3" size are released in equal, proportion at 10,000 nos./ha of water area. The fish species comprise 30% surface feeder (Catla), 20% column feeder (Rohu) and 50% bottom feeder (Mrigal and common carp). The stock is regularly fed with oil cake and r ice bran or polish (1:1 @ 2% to 3% of total biomass. Manuring with cowdung or farm yard manure (FYM) up to 10 t/ha and liming at around 200 to 500 kg/ha of water area are done in regular splits. Fish and prawn can be periodically harvested along with the receding water level in the refuge system.

Crops after r ice

Depending on the quantum of harvested water, the crops after rice are selected. Usually crops requiring less water like watermelon vegetables, mungbean, sesame and cowpea are grown after rice in the main field. In watermelon crop use of potassium at 100 to 140 kg/ha of K_2O considerably increases the productivity.

Crops on bunds

One hectare farm can provide a cultivable bund area of about 1,000 sq.m. on the top. Around 50% of this area can be utilized for vegetable farming and rest for fruit crops.

Vegetable farming

During pre-*kharif* and wet season, okra, cowpea, gourds, and leafy vegetables are grown. During winter various types of vegetables like tomato, radish, cabbage, cauliflower, beans, brinjal, beet, carrot, gourds, peas and different leafy vegetables etc. are cultivated. Species can be grown in shades of fruit crops and creeper type on the trunk of fruit plants stored rain water in the refuge system is used for the irrigation of crops.

Crops on platform

Erected platforms covering some area of trenches, pond refuge and bunds can be used for growing creeper vegetables round the year

Fruit crops

Dwarf papaya (Honeydew, Pusa dwarf, Pusa delicious, C-1 hybrid), improved coconut (tall x dwarf hybrid and dwarf banana (cavendish, robusta) including tissue cultured products and arecanut can be taken on bunds. Around 150 papaya plants having 10% male population and each of coconut, banana and arecanut can be maintained.

Productivity and economics

Rice-fish system annually produces about 16 tones of food crops, 0.6 t of fish and prawn besides 5.2 t of fodder in the from of straw in an one hectare farm. This system provides a net annual income of around Rs. 30,000/ha In the first year which accounts for more than twelve times increase over traditional rice farming. The income subsequently increases with the addition of produces from fruit crops like banana, coconut and areconut This system also generates 200 additional man-days in a year.

Benefits of rice-fish system

- This system creates a micro-watershed for effective land use.
- It encourages synergism between rice and fish and thus, increases ,grain yield of rice by about 5-15% and straw yield by 5-9% and decreases input cost due to:

1. Better rice crop stand at the initial stage as well as less damage of biomass at maturity due to fast drainage of excess water from the field to the refuge system.
2. Enrichment of soil organic matter and other nutrients and better crop use of these materials.
3. Recycling of plant wastes (decaying leaves, pollen) and water weeds such as fish food and in turn fish excreta as manure for plants which is ecologically and environmentally sound.
4. Bio-control of rice pests including weeds.

- Facilitates crop diversification, thereby, reduces investment risk.
- Promotes gainful linkages between rice, fish, prawn, vegetables,. fruit crops and other components. This results in better resource utilization as well as conservation of the ecosystem.

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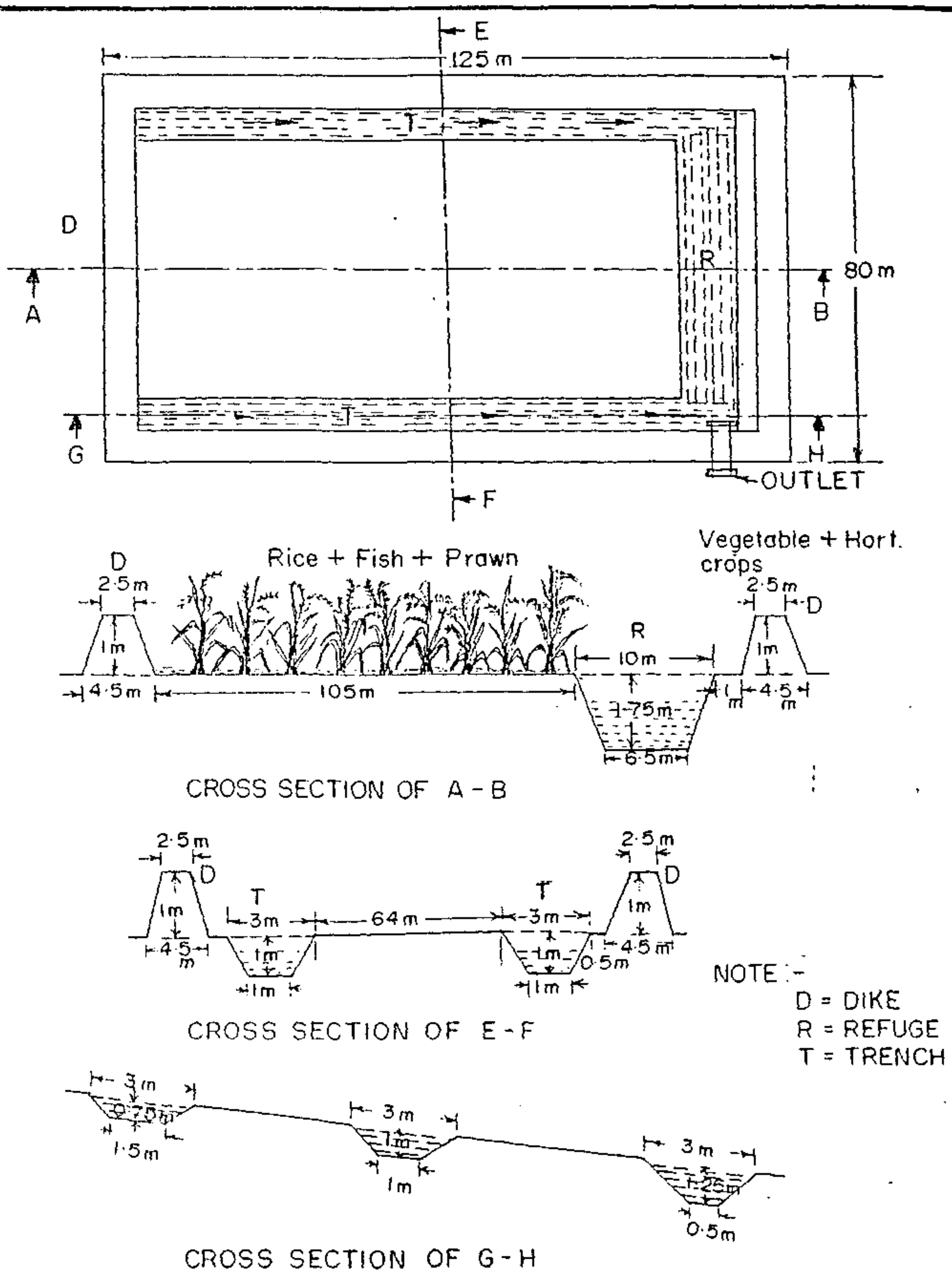

DESIGN FOR RICE-FISH SYSTEM IN RAINFED LOWLANDS (AREA 1 ha)

FEASIBILITY OF FARM MECHANIZATION FOR RICE-BASED CROPPING SYSTEM

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Rice crop is grown under various ecosystems in, India. The traditional rice areas ale the rainfed lowlands. Even though the yield levels of rainfed rice regions have increased considerably still the comparative advantage has been reported in the non-traditional areas where with the use of irrigation. high yielding varieties, fertilizer and mechanization the benefit received by the farmers are far greater than those of eastern India. It is expected that with changing scenario of Indian agriculture the rice which is a crop with low level of water utilization efficiency as compared to other cereals pulses and oilseeds may fade out from the non traditional areas but it is foreseen that rice will continue to grow in the eastern region in the rainfed lowlands as the cost of drainage system of such being high it should not be possible to raise other crops but only rice. Hence rice will continue to be raised in the east. The aim will be to have a production system with low input requirements and higher yield levels. The small level farming systems have to be modified to reduce the cost of rice production. This is possible by two methods, first method is to increased the cropping intensity by adopting rice-based cropping system. The aim will be to raise rice followed by pulses (moong bean), oilseeds (groundnut), or other crops or to develop rice based farming system involving rice fish animal And horticulture crops to enhance overall profitability of the farmers by exploitation of natural resources like underground water solar energy. The water shed management also offers scope for increasing productivity of land. The farm mechanization of field operations post-harvest technology for value addition and development of agro processing industry In the rural areas would help in increasing yield levels reduce losses and improve the quality of produce to compete in international market and generate employment. The other approach is the use of hybrid rice technology and the use of modern molecular tools, tissue culture etc. to Improve the crop varieties which will give better yield levels even under rainfed lowland and reduce the cost of production inputs.

In this lecture the emphasis is laid on the farm mechanization for rise cropping system and the machines which are found suitable for rainfed ecosystem.

Mechanization of small farms

By and large mechanization helps in efficient and timely farm operations, reduce drudgery minimize the harvest and post-harvest farm looses, assures quality, value addition and generates rural income and employment. The farmer is to be provided with a package of tools source of energy/power units and be trained to use them properly for achieving maximum benefit. It is high time that the farmers of eastern

India shall speedily mechanize the rice farming to achieve the second rice revolution in eastern India inorder to maintain the India's leading role in export of rice in foreign markets.

Normally mechanization has been associated with use of tractor power tube well for irrigation and the thresher on the Indian farms. However the mechanization is a continuous process and use to machines, tools, threshers, seed drills help the farmer to reduce the drudgery operational time and helps in achieving higher work output can be termed as mechanization.

The use of country plough for tillage, broadcasting of seed and fertilizer, interculture by hoe and beaushening in lowlands are vogue in most of the areas. This method of rice cultivation needs improvement to overcome the farm operational constraints. To mitigate such problems the following operations with improved implements are suggested.

Rain water conservation

Summer ploughing

It is generally done with the help of mould board plough after the harvest of crop. The soil is Inverted which helps in conservation of rain water killing of soil borne pathogens and control of weeds. The ploughed fields can soak upto 75 to 100 mm of rain water before the surface run off occurs during the onset of monsoon. This also saves the less of top soil in run off.

Bund making

Bund making along the boundary of plots helps in storing of rain water. The bullock drawn bund farmer can help in doing this job efficiently. The 20 cm high bunds can store 15-20 cm of rain water in the field which can be useful for wet seedbed preparation and transplant of seedlings thus help in establishing of plants and controls growth o weeds.

Field preparation and sowing

To prepare the seedbed under rainfed ecosystem: After the onset of monsoon it is suggested to use the bullock drawn disc harrow for wet as well as dry seed bed preparation CRRI disc harrow is designed to prepare the seedbed in two operations. Thus one hectare of field can be prepared in 20 hours of disc harrowing. After the disc harrow operation the fields are levelled by levelling ladder or leveller of bullock drawn type in 5 hours. Thus in 25 hours one hectare field can be prepared.

The proper seedbed is must for operation of animal drawn manual seed-drill. The use country plough normally creates a clody field and it requires 3 to 4 operations to breakup the clods thus it takes more time to prepare the seedbed with traditional system.

The seeds are to be down at shallow depth with a seed drill and for sowing seeds a row type seed drills for rise are developed to do the sowing operation under rainfed lowland and upland fields. In case of wet cultivation the recommendation is to sow the pre-germinate seeds along line and 3/4 row wetland seeders are available for performing of line sowing of wet fields. The sowing of seed drill and wetland seeders have indicated that the plant establishment is better by these methods and yield levels are increased have been proved by many field experiments at Cuttack and other Institutes.

Mechanical transplanting

The transplanting operation for rice crop is to be carried out timely for higher yields and it is labour intensive. The farmers during transplanting season face labour shortage because every farmer is interested to complete the lob in time. The available human power is n sufficient to complete the job of transplanting during the season. Besides the transplanting the farmers is also handicapped to prepare wet seedbed which requires three to four operations country plough as he is not having puddler to puddle the fields. Thus the transplanting delayed. The manual transplanting requires 60 man days/ha. Thus animal draw puddler can be useful implement for the farmers for preparing the puddled fields.

In Orissa only 55% of area can be transplanted it all the labour force available is u on the farms to do the transplanting. This is further reduced if the social custom of transplanting w women only is to be followed.

The use of transplanter for transplanting seedling with manual rice transplanter would reduce the peak labour demand, but the labour requirements at the time of seedlings in trays as mat type seedlings would increased compared to conventional method of nursery raising, but the total labour requirements are less by atleast 100 man-hours/ha.

Control of weeds with improved weeding tools

The use of efficient weeding tools possible only when the crop is sown with a seed drill. The CRRI finger type weeder for weeding upland and lowlands is most suitable tool. Other weeders like rotary type Japanese weeder and IRRI type cono weeder are also recommend for weeding of lowland fields. the chemical and mechanical control of weeds have been reported to be most effective. The long handle weeding tools have three to four times more work output as compared to manual method.

Mechanical harvesting

The optimum time of harvest of rice is around 20% of grain moisture level. Manual harvesting requires 180 man hr/ha, 20 to 25% of time of field operations is spend in harvesting, curing, gathering and transport of crop to threshing floor. For timely harvest of rice crop a vertical coveryor reaper 1.0 m self propelled and walk behind type has been evaluated at CRRI, Cuttack and reported to be a viable machine. It is able to harvest 0.17 ha/h and harvest losses are only 0.4%. A 2.08 m wide tractor front mounted machine was also evaluated. It has a field capacity of 0.32 ha/h with harvesting losses within 0.5%. Thus use of reapers can reduced the total time of harvest by 60% as compared to manual method.

Threshing

The threshing of paddy is done by bullock treading or by pedal operated threshers. The capacity of pedal thresher is about 300-400 kg/day with losses less than 1%. At CRRI a power operated thesher on the same principle as spike tooth type pedal thresher operated by 1 hp single phase motor was developed. the unit is operated by three workers and have an output of 160kg/h. The 5 hp multi-crop threshers when used for threshing of paddy are reported to give 400-600 kg threshed paddy per hour. These threshers can help in reducing the threshing time and losses on the farm level.

Post-harvest processing

The post-harvest operation in case of rice involves cleaning of paddy, drying, milling (separation of rice, bran and husk) and grading. The further procuring operation involves utilization of bran for bran oil and oilcake as animal feed, husk as fuel and for use of industry or for building boards. The broken rice can be used as rice flour and baby food. For eastern region, parboiling before rice milling is carried out. The parboiling operation increases the nutritive value and also helps in high recovery of rice during milling. The CRRI has developed technology for cleaning of paddy, mini parboiling unit, small paddy dryer and storage bin for post-harvest operations performed by the small farmers. these used to be popularized.

Conclusion

the mechanization of farm operations at small farmer level is possible by use of technology developed at CRRI. These are feasible if used on farm for atleast 25 o 30 days during the crop season. One way of increasing their use is to make them usable for the rice based cropping system. This will involve raising of two crops n place of one crop of rice. The second crop to be adopted by farmer depends upon the popularity and marketing ability of the farmers. Oilseeds and pulses offer a great scope in this regards. hence for rice based cropping system farm mechanization is a must even for small farmer to reap the benefits of high productivity levels and achieve timelines in operation.

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DEVELOPING RICE BASED CROPPING SYSTEM UNDER RAINFED LOWLAND ECOLOGIES

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Approximately 38 million hectares of rainfed lowland rice, comprising about one fourth of the worlds' total rice-cropped areas, produces 17% of the global rice supply; whereas, in India, out of 42.2 million hectares of total rice area worlds' largest rice cropped area),17.4 million hectares belong to this ecology accounting for nearly 40% of the total rice area in the country. Uncertainty characterizes rice farming in this fragile ecology rendering very poor rice productivity oscillating between 0.8-1.5 t/ha. Growing environment becomes complex, diverse and risk-prone (hence, identified as CDR Production System) constraining desirable production to be achieved. These multifaceted production constraints keep the farmers away from modern technologies on rice and rice-based farming systems to be adopted for this ecology. However, the rainfed lowlands offer tremendous resource potential to be explored augmenting crop production and can enable lowland farming an attractive enterprise. The crop performance under this situation is considered as an integral measure of several production factors encountered in this micro-environment such as spatial heterogeneity over soil types, topographical sequences, and agro-hydrology. Therefore, it is imperative to intensify studies on cropping system research taking into account the component variability under different lowland ecologies.

Rational: ***why intensify cropping even in lowland***

Recent trends in industrialization gradually grabs the favourable lands, hitherto representing arable farming. Adding to it, 'the dream of a small castle' slashes the cultivable land indiscriminately, depleting the granary pool of the nation. At this juncture, area planted to rainfed lowland rice is gradually expanding and virtually, after a few decades, this ecology appears to be the only area available for agricultural farming.

On the other hand, the countrys' demographic pressure increases geometrically accounting to 96 crores 80 lakhs as against 33 crores during independence. Besides to meet their food requirement, farmers have to have the technology to double the food production in ensuing millennium. The rice production in favourable irrigated situation has already inclined to the yield plateau. Consequently, research to intensify cropping in rainfed lowlands needs adequate attention to explore the possibilities of 'round the year farming' for making the situation worth-remunerative. By the way, about 22 million tonnes of anticipated future increase in rice production in the country is expected to come from rainfed areas only. This estimation of phenomenal increase in food production suffices enough to encourage restructuring our research strategies in a right perspective, deriving maximum benefit from this ecology.

The traditional cropping systems that have been evolved by farmers through mixed experiences of success and failure, over a considerable period of bio-physical and socio-economic variability, need not be ignored; rather, these may be considered having substantial impact being operative and appropriate for the specific situation following their appropriate modification under modern perspective. Here it lies the point of intervention to feed them back with the improved technology relevent to lowland rice based cropping system.

Ecosystem- hydrology

Lowland ecology can be categorized into four classes keeping in view on the inundation pattern experienced therein. The situation where water gets accumulated up to 30 cm (at least for a period of one month) is identified as shallow lowland; similarly, situation experiencing water depth up to 50 cm and 100 cm are considered intermediate and semi-deep water situation, respectively; while water depth beyond 100 cm represents the deep water situation. Out of 40% area under rainfed lowland, 18,9,7 and 6% are under shallow, intermediate, semi deep and deep water situation respectively.

System analysis

This hydrolgical pattern has a great concern on the nature of the cropping to be followed therein. It implies the time-variability in the availability of land for ensuing crops and virtually, seems to be a determinant of the crops to be grown in sequence after kharif rice. By virtue of less water depth, considerable time may be available for growing medium to long duration crops in rice fallow under shallow lowland situations; while the time availability would likely to be declined proportionately with the increase in accumulated water depth. As a consequence, growing short duration legumes/oilseeds may be the right proposition under this intermediate or semi-deep situations. Therefore, the preamble of the cropping in rice fallow should be the duration of the both preceding and succeeding crops. Essentially, the crops in rice fallow should have short duration, preferably ,< 3 months; however, crops sustaining even up to 4 months may be grown under the situations witnessing complete recession of water earlier than other waterlogged situations. Even winter rice can successfully be grown here under assured irrigation facility. Consequent upon the occurrence of these factors, some cropping systems have been developed, appropriately suitable for different lowland ecologies (Table 1). On the other hand, traditional inclination to the conventional system of cropping in different regions may not deploy the full potential of this lowlands. Therefore, efforts have been made to revise the existing cropping systems bringing out return more than that realised in farmers' practice (Table 2).

Salient determinants

A better understanding of the situation encountered under specific ecology may induce appropriately the system development. Followings are the important factors to be considered prior to conceive the idea of designing any cropping system under lowland ecology.

Biotic determinants

Selection of rice variety- highly photosensitive, crop should mature proportionately with the recession of water depth

Selection of sequence crop(s)- short/medium duration, less water requirement, high responsive to minimal cultural operations providing a good stand

Abiotic determinants

Hydrology- indicating the period of land availability for ensuing crops

Soil- high residual moisture status, high inherent fertility

Rainfall- possibility of subsequent winter rain(s) (frequency/intensity) encouraging further crop growth

Socio-economic aspects

Farmers' perception- their interest, their need

Diversion of labourer- availability vs. scarcity

Inputs- facility, timely availability

Community efforts- hazards of stray cattle/grazing

Conclusion

Choice of a cropping system may not constitute the basis for a rational decision; rather, this situation would need specific consideration and profitability has to be viewed with this angle. Socio-economic monitoring and analysis has to be juxtaposed with or as a part of improved cropping system design and assessment thereof. This is one of the most critical elements in this methodology, one that has challenged both the biological and social scientist. Virtually, here it remains the success of developing cropping system under rainfed lowland ecology.

Table 1: Suggested cropping systems for different lowland ecologies.

Ecology (water depth, cm)	*Crops in sequence*
Shallow lowland (0-30cm)	Rice-groundnut/sunflower/caster/okra/ tomato/wheat/maize, Ahu rice-sali rice-pea/tomato/cabage
Intermediate lowland (0-50 cm)	Rice-greengram/cowpea/watermelon/ jute/sesame/vegetables
Semi-deep lowland (0-100 cm)	Rice-greengram/cowpea/lentil
Deep-water lowland (> 100 cm)	Rice-fish

Table 2: Suggested cropping systems for different regions of the country.

Region	*Crops in sequence*
Assam	Rice-mustard (flood affected irrigated areas)/wheat (flood affected rainfed areas)
N-W Bihar	Rice-potato-jute, rice-wheat-jute/rice, rice-maize-jute
Orissa	Rice-rice/groundnut/legumes (greengram, pigeonpea)
West Bengal	Rice-potato-maize/jute/groundnut, rice-wheat-rice/legumes/maize, rice-maize-jute/legumes
Coastal Karnataka	Rice-rice-millets/legumes/groundnuts
Kerala	Rice-rice-legumes/rice
Tamilnadu	Rice-rice-legumes-oil seeds

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THE ROLE OF MOTIVATION IN EXTENSION ACTIVITIES

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Motivation begins when a person perceives a need that must be satisfied. This perception occurs when some form of stimulus attracts a person's attention to the need. The need having been perceived motivates action on the part of the person to satisfy the need. An extension officer wants to introduce a new technology as he perceived well about utility of the technology. This motivates him to use different extension methods to educate the farmers. His main task is to influence the behaviour of the farmers towards predetermined goals. Behaviour is only our intermediate step in chain of events. Motivating forces lead to some manner or form of behaviour, and that behaviour must be directed towards some end. Thus motivation creates awareness, interest and conviction and moves the farmer for adoption.

Extension is nothing but changing behaviour in the right direction. Changing behaviour includes change in attitude, knowledge and skill, if a farmer acquires knowledge and skill, his ability to perform his task is increased. It is generally accepted that knowledge and one's skill in applying it constitute the human trait called ability.

i.e. knowledge × skill = ability

Once attitude is reaching in specific situation in positive way, motivation begins. Attitude × situation = motivation. Motivation and ability together determine human performance.

i.e. ability × motivation = human performance

Further this human performance combines with resources and interacts leads to productivity.

i.e. human performance × resources = productivity

Therefore, the motives, urges, inner drives are the basic forces which direct a person to move him towards his goals.

The motivational drives are:

Achievement	-	to overcome challenges, advance and grow
Affilication	-	to relate people effectively
Competence	-	to do high quality work
Power	-	to influence people and situation

Achievement motivation is a drive. Some people have to overcome the challenges and obstacles in the pursuit of goals. An individual with this drive wishes to develop and grow and advance up the ladder of success.

Characters

- Hand worker
- Trust their subordinates
- Share and receive openly
- Set high goals
- Expect their employees will also be oriented towards achievement

Affiliation motivation is a drive to relate people on a social basis. Persue with affiliation motives work better when they are complemented for their favourable attitudes and cooperation.

Characters

- Select friends to surround their
- Winner satisfaction from being with friends
- They want the job freedom to develop these relationships

Competence motivation is a drive to do high quality work.

Characters

- Seek job mastery
- Develop problem solving skills
- Strive to be innovative
- Expect high quality work from their associates

Power motivation is a drive to influence people and change situations

Characters

- Wish to create an impact on their organisations and one willing to take risks to do so
- Excellent managers
- Rise to leadership positions through successful performance.

In the hiearchy of human needs indicated by Maslow Basic Physical needs (1st) and safety and severity (2nd) needs one of in lower order, whereas belonging and social needs, love and affection (3rd) esteem and status (4th) and self acualication and fulfillment (5th) are in higher order.

Persons having positive motives can reach the highest stage where the milk of human kindness one can achieve with peace of mind.

All human relations is a process of effective motivation of individuals in a given situation in order to achieve a balance of objectives which will yield greater human satisfaction and help to accomplish the development activities. The following ten commandments (Darvar, 1970) will be helpful for the extension personnel for effective motivation.

Ten commandments of effective motivation

Recognise the Individuality of individuals: People are different physically and more psychologically. Do not assume that all the group members are motivated by the same needs or desires. Therefore, ascertain first the needs craving satisfaction in the particular individual's mind so that you can create a motivating situation for him.

Make your subordinates feel important: Human beings want to be appreciated and like to feel important. Therefore, when relevant, ask their opinions and praise them in public. One of the rules often given for human relations, or getting things done through people is "praise in public and criticise in private". Give credit where it is due and show interest in, and appreciation of your subordinates. Use every opportunity to build in your subordinates a sense of importance of their work.

Guide rather than order: The job of the manager is to guide his subordinates towards the attainment of the departmental goals. Instead of giving orders, give suggestions which will produce better results.

Set a good example: The manager sets the style for his people. Subordinates are always watching their superior. They often persume, at times erroneously, that their superiors' conduct is the appropriate one for adoption. Therefore, play up the positive and be a person worth copying.

Show confidence in your subordinates: This will instill confidence in themselves. Adopt the attitude that you are sure that they will do their best.

Listen attentively: A good motivator wants first to understand the facts. Listening can provide deeper understanding. Very often the mere act of listening and permitting the subordinate to talk without interruption results in the subordinate seeing the error of his own opinion.

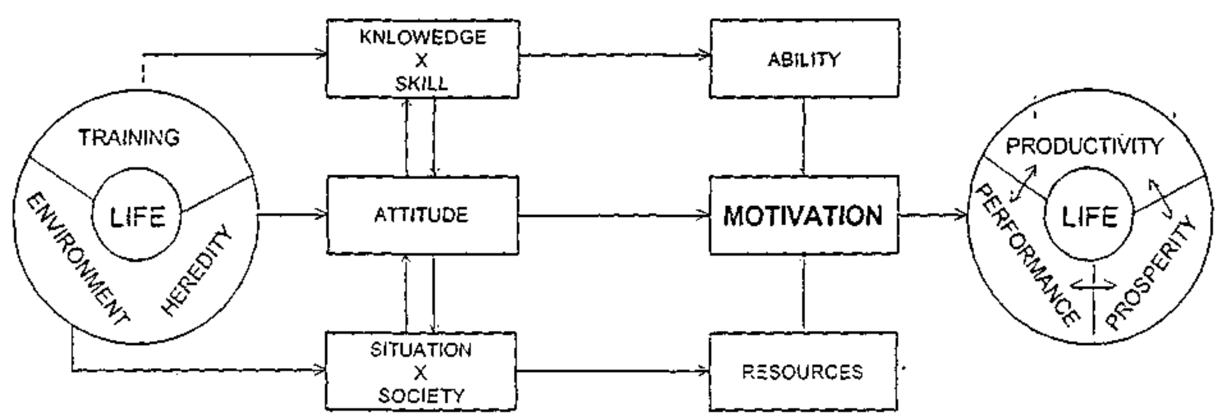
Watch how you communicate: Be careful not only of what you say but how you say it as even the tone of the voice is relevant. Avoid unconscious communications like the frown.

Encourage participation: Wherever possible provide the subordinate with an opportunity to take part in the decisions, particularly where they affect them. Keep them well informed on matters which affect them. Effective participation requires the possession of adequate knowledge by the subordinates.

Do not be secretive: Secretiveness induces frustration in the subordinates. Create a feeling of belonging, team spirit and group cohesiveness through communications.

Make your subordinate: "Want to Do" Things that you want them to do. Making the subordinates want to do the things you want them to do can only be done by an integration of objectives. The subordinates must feel that they will achieve their own goals best by striving towards the achievement of the organisation's goals. This is the most powerful motivational factor.

A conceptual model indicating the role of motivation which leads to performance, productivity of human life and prosperity is given below which includes the other factors like, training, environment, heredity, knowledge, skill, ability, attitude, situation, society and resources. An understanding of these factors help the extension workers to do their job more effectively.



ROLE OF MOTIVATION IN HUMAN LIFE

Reference: Darvar R.S., (1970). Personnel Management and Industrial relations in India. New Delhi : Vikas Publishing House Pvt. Ltd.

⌘⌘⌘

Computer Systems for Information Retrieval and Exchange, and the WWW

Ravi Viswanathan

J. Scientific Officer (Press and Editorial)

Email: raviviswom@hotmail.com

Contents

Central Rice Research Institute
Indian Council of Agricultural Research
Cuttack (Orissa) 753 006
India

Introduction

Computer systems have evolved at a rapid pace. Starting from huge systems occupying a building just for calculation in the 1950s and the 1960s, these systems have miniaturized into desktop super computers, capable of millions of calculations per second. This has resulted in an information explosion leading to exchange of communication across boundaries of countries. Today, the Internet serves the function of a medium capable of providing information on a variety of disciplines from science to culinary to space.

My talk has three objectives:

1. Introduce computer basics.
2. Introduce the Internet.
3. Browse select Internet agricultural web sites for information.

The trainees, based on this introduction to computer systems will be able to impart training to farmers, using latest technology, browse web pages, and exchange information.

The lecture notes is set into three parts: Computer basics, Introduction to Windows 95/98 and Notes of select web sites of agricultural importance.

Acknowledgements

I offer my heart-felt gratitude to:

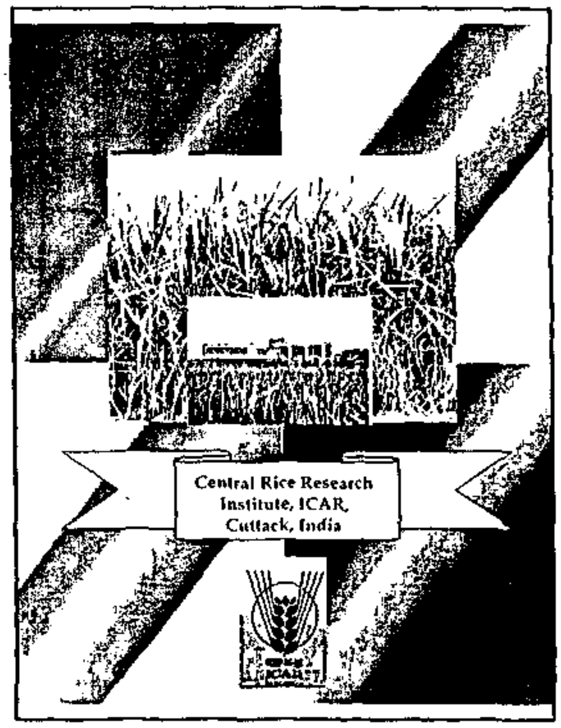
Dr M. Venugopalan, Principal Scientist and Head, Extension, Communication and Training, for proposing my name for the lecture.

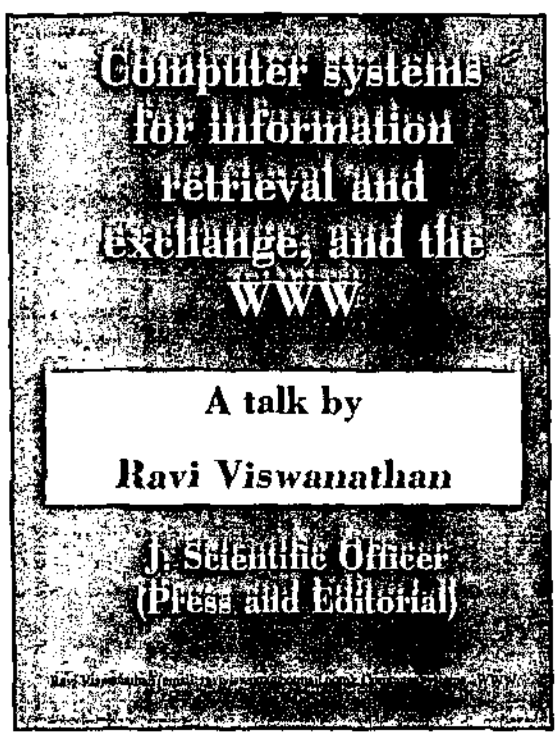
Dr K.C. Mathur, Director, CRRI, for approving the proposal for my lecture.

Dr P.R. Reddy, Principal Scientist, and Head, Plant Pathology, for permission to use the facilities at the Division of Plant Pathology.

Mr U.D. Singh, Senior Scientist for allowing me to use his computer systems.

Staff members of the Division of Extension, Communication and Training for their cooperation and support.


Central Rice Research
Institute, ICAR,
Cuttack, India


Computer systems
for information
retrieval and
exchange, and the
WWW
A talk by
Ravi Viswanathan
J. Scientific Officer
(Press and Editorial)

... basics

...an a computer do?

- ...processing
- ...ation
- ...uting
- Talking
- Limited to your imagination

...uter basics

Hardware | Software

- CPU (central processing unit)
- Monitor
- Printer
- Scanner
- Modem
- Sound card

...mputer basics

...ware

...rating System

- DOS
- UNIX
- Windows95/Windows98
- Linux

Applications

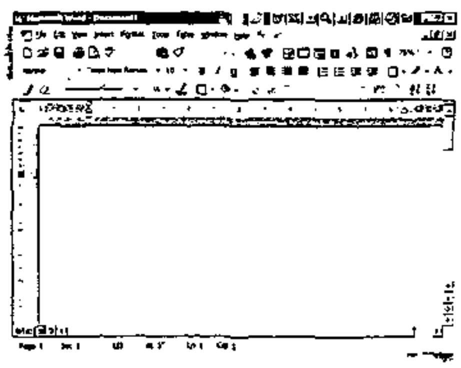
- WordStar
- WordPerfect
- Microsoft Office
- Norton Anti...
- IRRISTAT

...uter basics

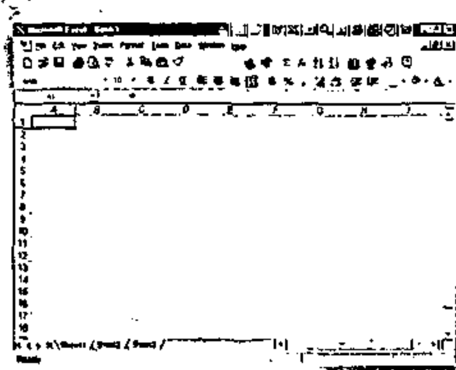
...t Office

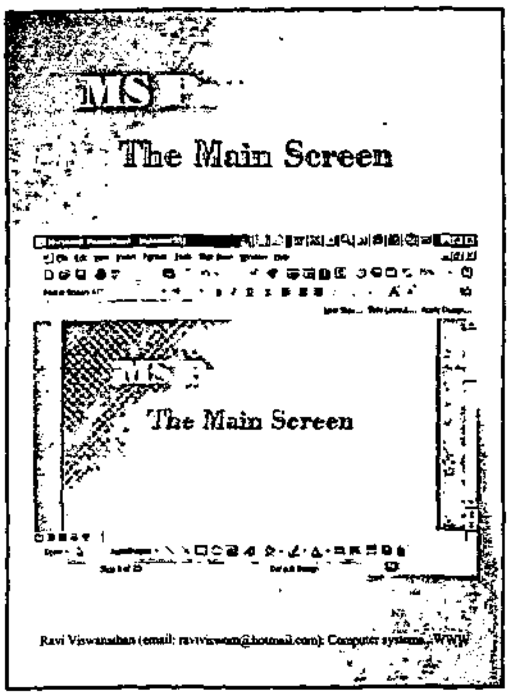
- ...S Word (for word ...ocessing, desktop publishing)
- MS Excel (spreadsheet)
- MS Powerpoint (graphics, charts...)
- MS Access (relational database management system)

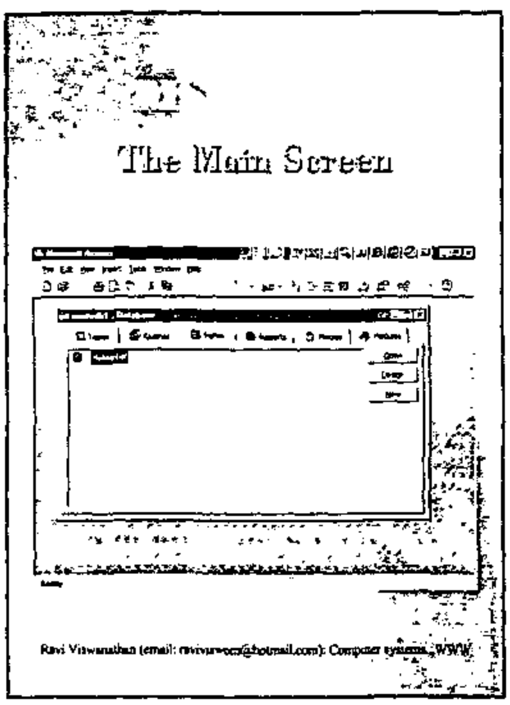
The Main Screen

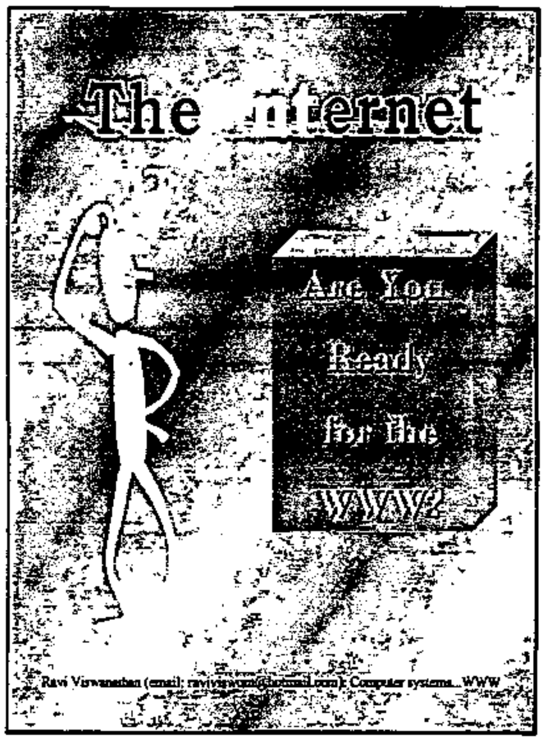


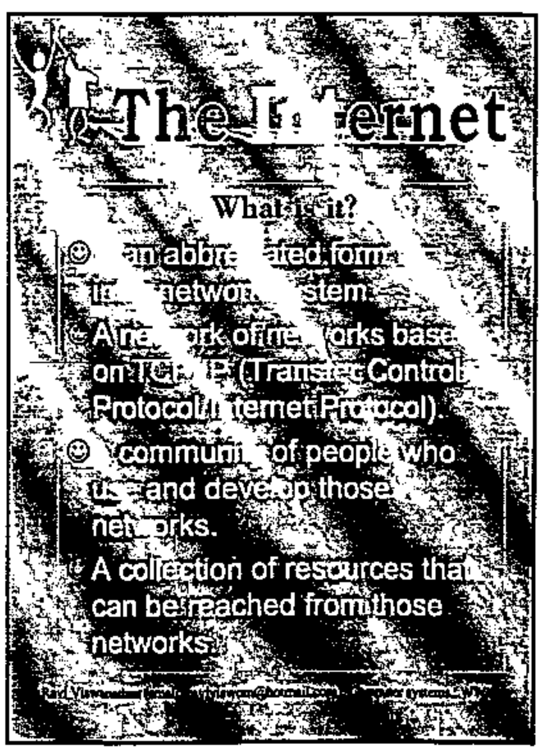
The Main Screen




MS
The Main Screen
The Main Screen
Ravi Viswanathan (email: raviviswom@hotmail.com): Computer systems, WWW


The Main Screen
Ravi Viswanathan (email: raviviswom@hotmail.com): Computer systems, WWW


Are You Ready for the WWW?


What is it?
A collection of resources that can be reached from those networks.

The Internet

[illegible]

Scientists in 1960 attempted to link computers to each other by taking a grant from the Advanced Research Projects Agency (ARPA) of the United States Department of Defense.

Who maintains it?

None. No regular maintenance body.

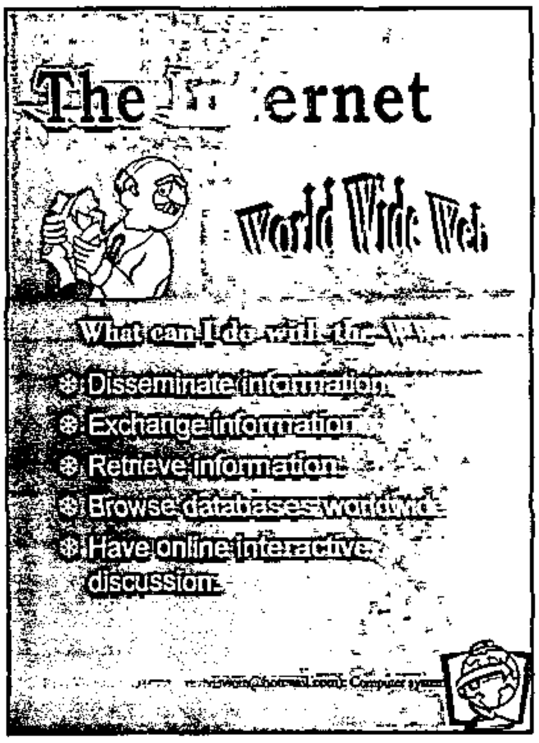
The Internet

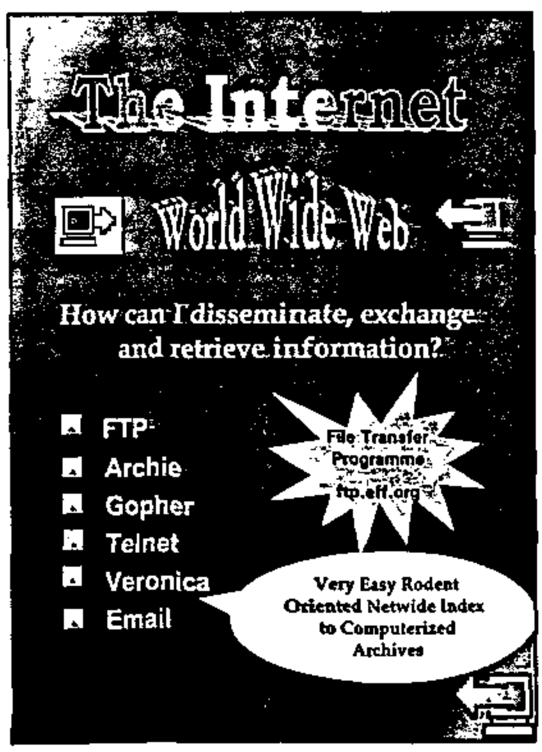
World Wide Web

[illegible]

- ➲Based on hyper-text.
- ➲Words in one document are linked to other documents.
- ➲You need a browser. Microsoft Internet Explorer
- ➲To access type a URL.

Uniform Resource Locator


Disseminate information
Exchange information
Retrieve information
Have online interactive discussion


The Internet
World Wide Web
How can I disseminate, exchange and retrieve information?
FTP
Archie
Gopher
Telnet
Veronica
Email
File Transfer Programme ftp.eff.org
Very Easy Rodent Oriented Netwide Index to Computerized Archives

The Internet

World Wide Web

Email for exchange of info

- Microsoft mail
- Eudora
- Pine

Email address: rsp@icar.delhi.nic.in

User name

Mail server (Domain)

Sub-domain

Country

The Internet

World Wide Web

Internet Relay Chat

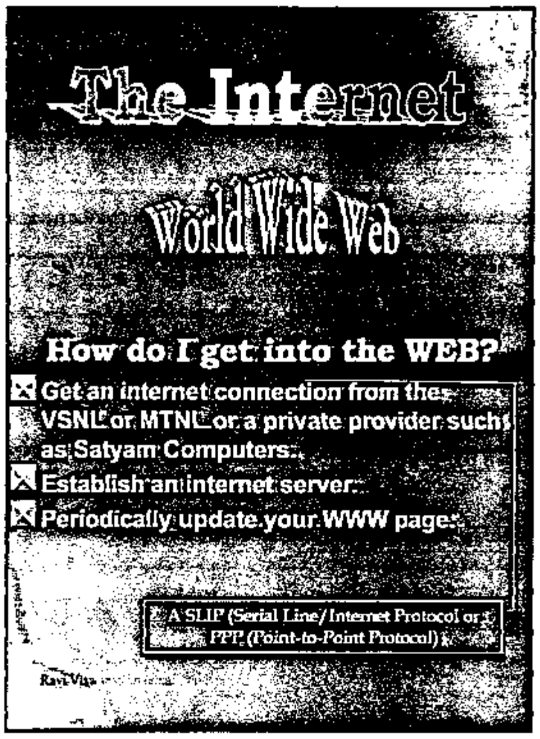
- Online interactive discussion

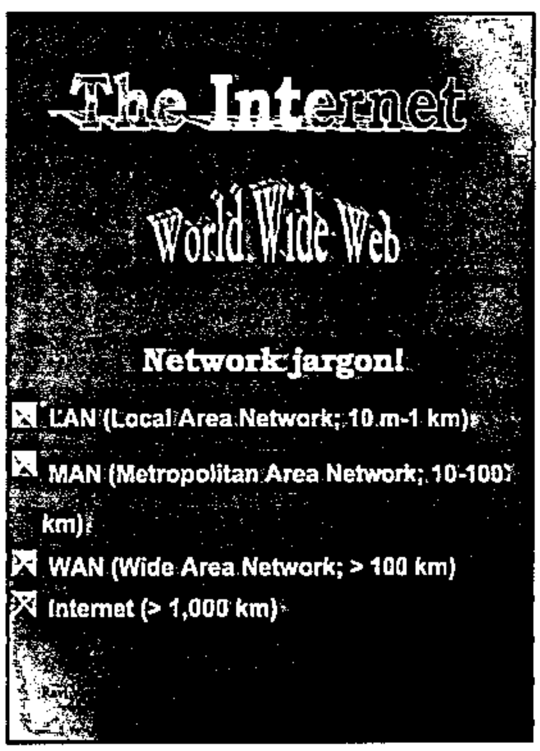
Usenet

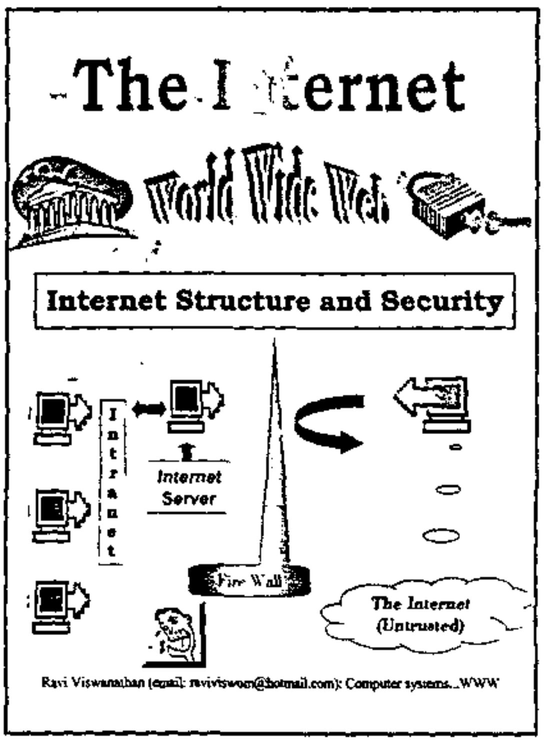
- Meeting place at a global level.
- The building block is a news group.

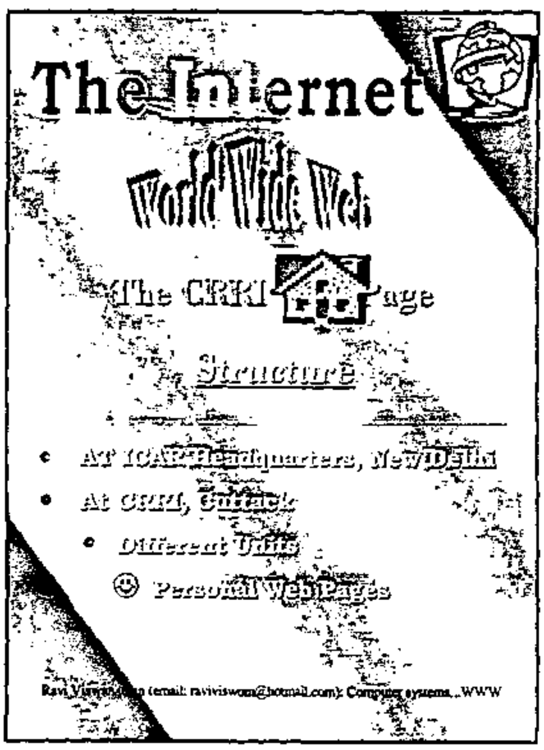
Examples: *bionet:* Research biology

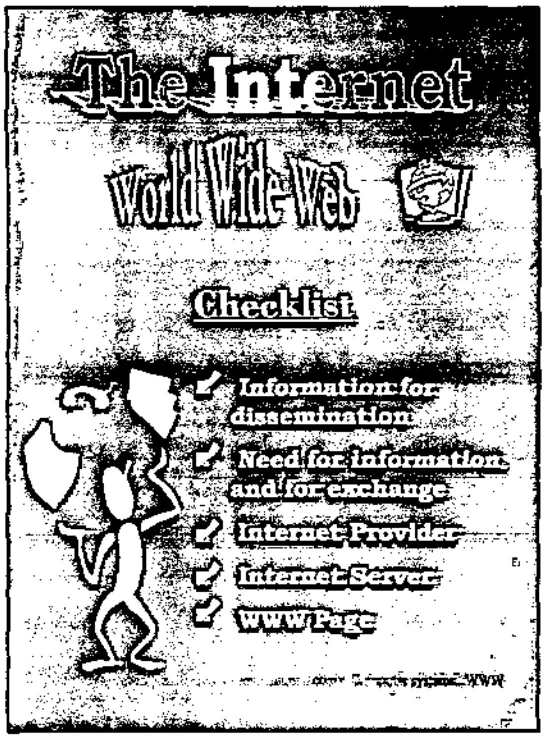
biz: Business; *comp:* Computers

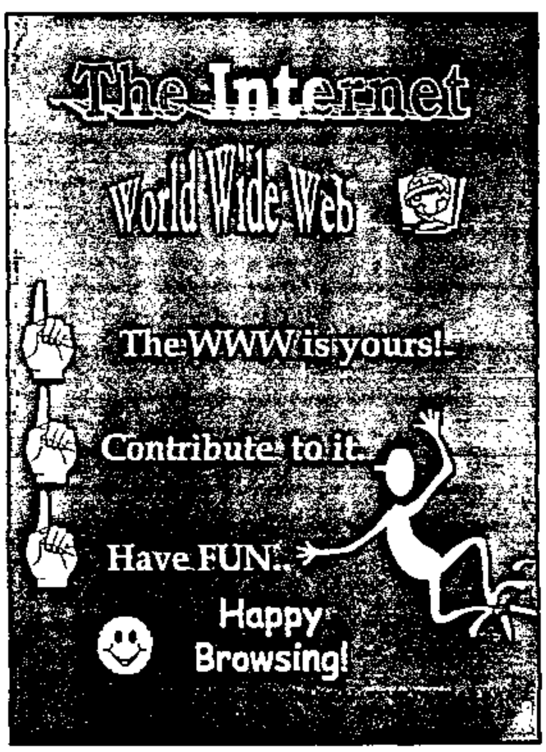

The Internet
World Wide Web
How do I get into the WEB?
Get an internet connection from the VSNL or MTNL or a private provider such as Satyam Computers.
Establish an internet server.
Periodically update your WWW page.
A SLIP (Serial Line/Internet Protocol or PPP (Point-to-Point Protocol)


The Internet
World Wide Web
Network jargon!
LAN (Local Area Network; 10 m-1 km)
MAN (Metropolitan Area Network; 10-100 km)
WAN (Wide Area Network; > 100 km)
Internet (> 1,000 km)


The I ernet
World Wide Web
Internet Structure and Security
Intranet
Internet Server
Fire Wall
The Internet
(Untrusted)
Ravi Viswanathan (email: raviviswom@hotmail.com): Computer systems...WWW


The Internet
World Wide Web
Structure
AT ICAR Headquarters, New Delhi
At CRRI, Cuttack
Different Units
Personal Web Pages
(email: raviviswom@hotmail.com): Computer systems...WWW


The Internet
World Wide Web
Checklist
Information for dissemination
Need for information and for exchange
Internet Provider
Internet Server
WWW Page


The Internet
World Wide Web
The WWW is yours!
Contribute to it.
Have FUN.
Happy Browsing!

Introduction to Windows 95/98

Ravi Viswanathan
J. Scientific Officer (Press and Editorial)
Central Rice Research Institute, Indian Council of Agricultural Research, Cuttack (Orissa) 753 006, India

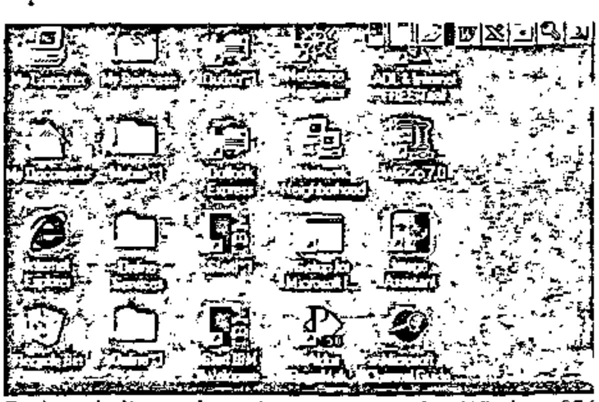
Windows 95/98 is an operating system, a successor to Windows 3.1x. An operating system is the program that manages two interfaces: Interface between user and its applications and the between applications and computer devices and files.

Advantages

- Windows 95/98 is easy to learn and use.
- Windows 95 and its applications run under protected mode that means the non-functioning or corruption of a single errant program does not automatically crash the operating system or any of other programs.
- Multitasking: Windows 95/98 is preemptive multitasking. Programs running in the background do not degrade the interactive program that is running in the foreground.
- Windows 95/98, integrates virtually all your computing tasks and resources such as networks, E-mail, Multimedia, System Administration, Printing, and fax.
- Faster Processing (32 bit processing) enhances system efficiency.
- Long file names.
- Mouse: Left Click activates a command and right click brings up menus.
- Complete Operating System.
- Extensive features for networking and Communication
- Complete protected mode.

Windows 95/98 Desktop

On starting Windows 95/98, you see the Desktop Area as shown below:



Desktop: Indicates the entire screen area when Windows 95/98 is started.

Shortcut Icons

Icons are a graphics representing an object. It allows quick access to commonly used programs or folders or documents.

Start button

Allows access to various menu commands. Used for starting a program, finding a file or getting help. All applications are accessible through this button.

Taskbar

The taskbar shows all open applications in the form of boxes. Allows shifting from one application to another.

Status and Time

Displays current time for internal clock. Provides other status information about the system such as print status

Icons on the desktop

My Computer

It provides the view of computer contents and manages all folders.

Network neighborhood

Network represents a set of computers, which are joined together. Double clicking the icon allows browsing through other files and folders of oth computers on your network.

Recycle Bin

Acts like a wastebasket that is used to restore files.

My Briefcase

This icon is useful when one has a computer in the office, and a laptop (portable computer). It helps to keep data on the laptop and office computer updated with each other. The briefcase is also useful if you use two computers at different places.

Components of Start menu

The START gives access to all the applications available in your computer. Each entry represents an application (such as Windows Explorer) or a group of Applications (such as Accessories). By clicking on an appropriate item you can start an Application.

Documents

You can quickly open a document that you have worked recently by using this command on start menu. Displays last 15 documents, which have been used.

Control panel

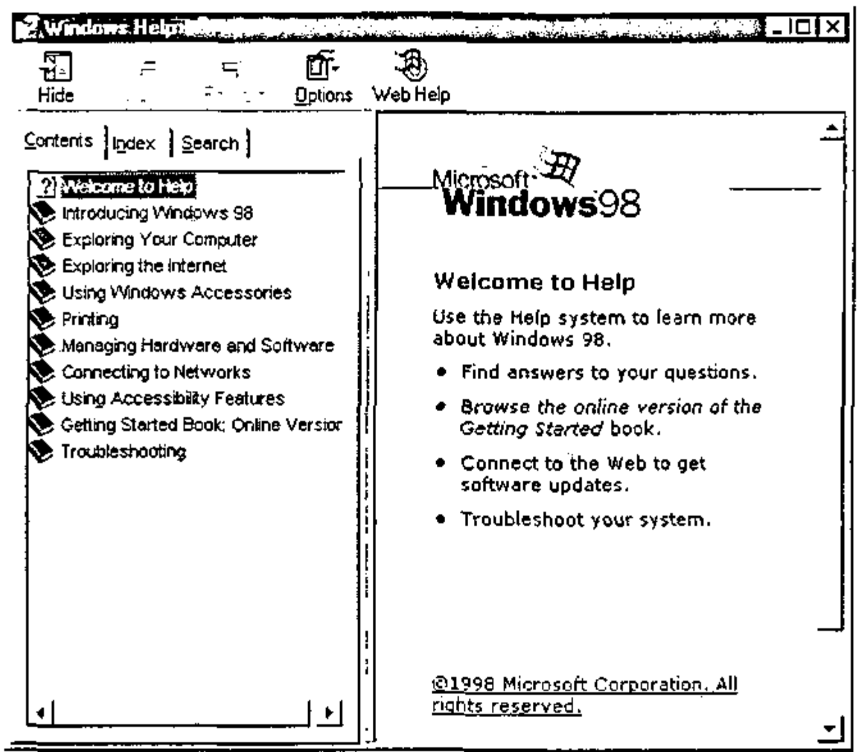
Allows you to change basic settings of the computer, such as Background, Printer and Taskbar.

Find

Find files or computers quickly through the Find command. Allows searching for files by:
1. Specifying Filename or wildcard (*,?).
2. Specifying Date of last modification.

Help

If you don't know how to do something, you can look it up in Help. Just click the Start button and click Help.



Get Help on each item in a dialog box by clicking the question mark button in the title bar and then clicking the item. The Contents tab provides help on topics grouped by subject, and the Index tab provides help to find specific topic listed alphabetically.

Run

❃To start programs directly use the RUN command.
❃In the open box, type the location and name of the program you want to start.
❃If you don't remember the location or name of program file, click Browse.
❃To select a program you started recently, click the down arrow in the Open box, click a program in the list, and then click OK.

Shutdown

Shutdown gives you the following options:

Shutdown the Computer: Use this option, when you want to switch off the computer. Do not turn off your computer until the "*It is now safe to turn off your computer*" message appears.

Restart the Computer: Use this option when some program is misbehaving and is halting the system. Use this as a safer alternate to using the computer's reset button.

Restart the Computer in MS-DOS mode: Gives you the conventional DOS prompt and is used to run DOS softwares.

Files and folders

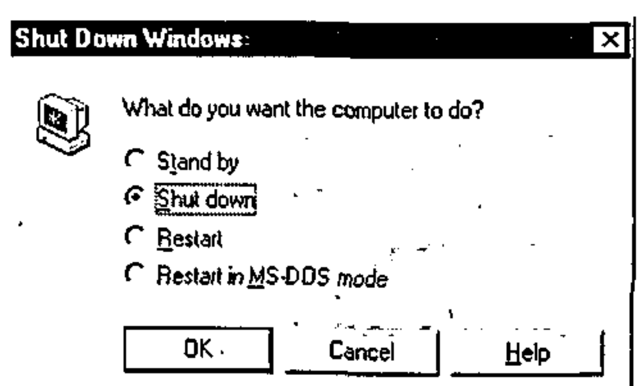
Folders

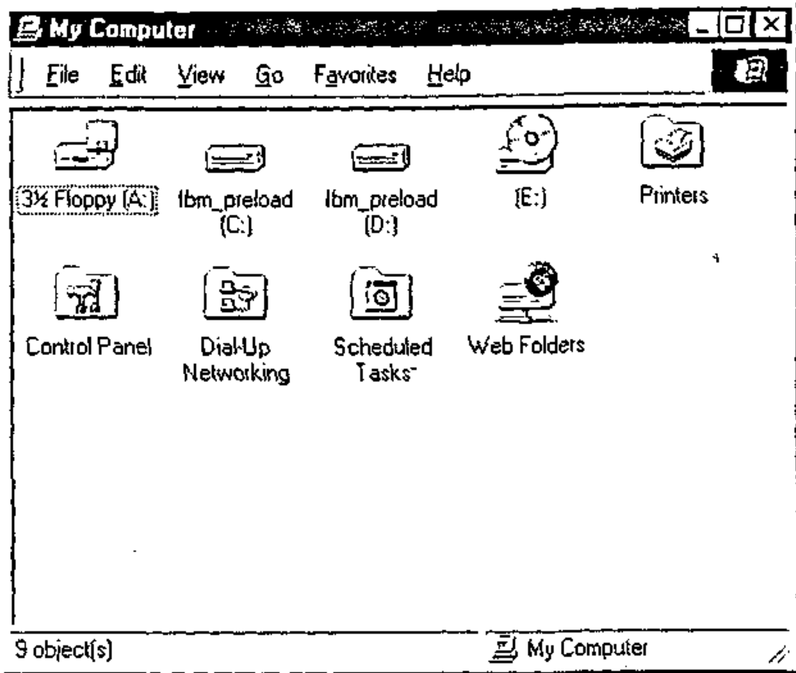
Generally folders are used to organize and manage data in a systematic manner. Folders contain Files and other folders. To create the shared folder across a network, click the right mouse button on desired folder and select the sharing option from properties dialog box.

Files

File is basic unit of storage of information or data. There are two types of files in Windows 95/98: Program Files (Application Files) and User Files, generally referred to as documents.

Windows 95/98 supports long file names up to 256 characters. Three-letter extension can be specified to categorize the files. A folder can't contain two files or folders with the same names.



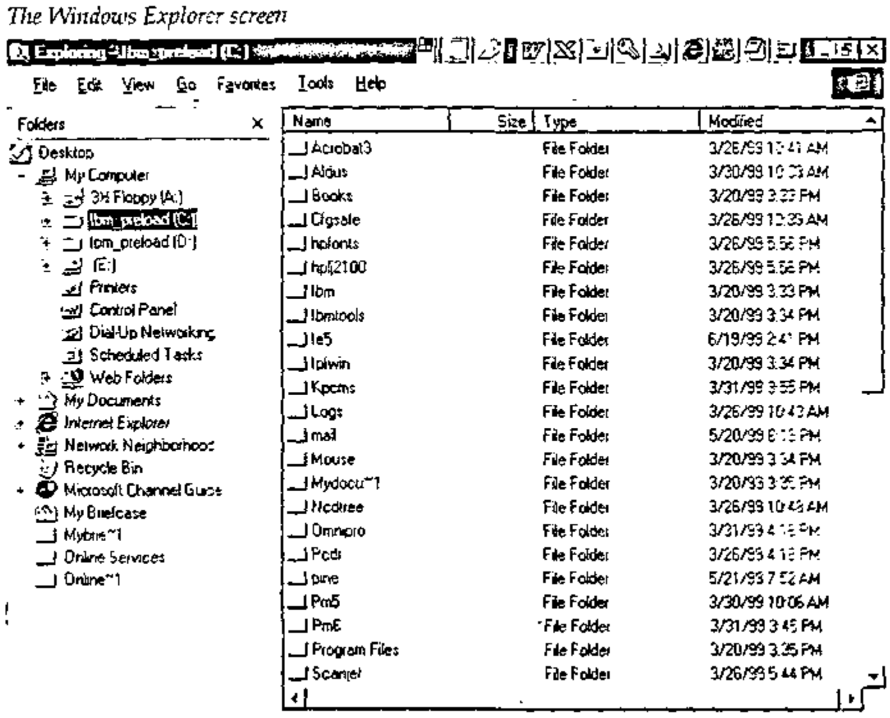


Opening files/folders
❉Double click the My Computer icon to see all the storage devices of your computer.
❉Double click the Hard Disk icon, to see content of harddisk C:.
❉Double click any folder to see all files and subfolders inside.
❉Double click a File, to open and see the contents.
❉Double click an Application to execute it.

Windows Explorer

It gives detailed version of My Computer and performs Disk Management activities.
❉You can start Explorer from program options of the start button.
❉Explorer window is in two panes. Left pane displays Drives and Folders.
❉Current Folder is indicated by open Folder icon.
❉Click on any folder icon to open. Right pane displays files in current folder. The Plus Sign on level indicator signifies sub-folders. To display sub-folders, click on the plus sign.

The Windows Explorer screen



❉View the contents of any file by double-clicking on file icon. This will first open the application in which file was made.
❉Quickly view a document by right clicking the file icon and selecting quick view. This method uses a special viewer, and does not open the application.
❉Quick view may not be available for files in non-standard software like WordStar.

Create a New Folder
❉Click on the folder in which new folder is to be created, on the left pane.
❉Select File Menu, then New Folder, and type in new name.

Moving Files/Folders
❉Open the folder-containing file to be moved.
❉Locate folder into which file is to be moved on the left pane, using scroll bar.
❉Drag the file from right pane, on the target folder on the left pane.

Copying Files / Folders
❉Open the folder-containing file to be moved.
❉Locate folder into which the file is to be moved on the left pane, using scroll bar.
❉Press control key and drag the file from right pane, to target folder on the left pane. Release control key only after entire operation is complete. Al-

ternately drag the file with the right mouse. Select "Copy here" in menu.

Renaming Files/Folders
❊Click on folder or file to be renamed.
❊Click again and type in new name.

Deleting File/Folder
❊Click on folder or file to be removed.
❊Press Delete on keyboard, and then click YES to confirm.
❊Alternately, clicks right mouse on the icon and select delete option.

Restoring/undeleting file/folder
❊Select Recycle Bin at the bottom of left pane.
❊Deleted files appear on the right pane.
❊Drag the file back to desired folder.
❊Alternately, right click the file and select restore.

Customizing the view

In case toolbar is not visible, choose toolbar options in view menu.

Icons

Files on the right pane can be displayed in different sizes

Large icons: Displays each file as a large icon. Click Large icon button on the toolbar. Alternately, select large icon option from View menu.

Small icons: Display each file as a small icon. Uses Vertical scroll bar to view more items. Click small icon button on the toolbar. Alternately, select small icon option from the view menu.

Arranging icon: Files on the right pane can be arranged in alphabetic order of Name, Type, Size or Date. For rearranging files in any order, select Arrange from View menu.

Creating Shortcuts

Provides quick access to an application, folder or document. Shortcut icon always has a small white arrow on bottom left corner. Usually placed on the desktop for quick access. Locate the object in Explorer or My Computer. Using right mouse button, drag the item to the desired location (desktop). Select " Create Shortcut Here" in menu.

Recycle Bin

Recycle bin is an area allocated in hard disk for storing deleted files. Recycle bin is available on the desktop, or in the explorer. All deleted files are stored in the recycle bin, until the designated area is full. When full then the Recycle bin automatically deletes earlier files.

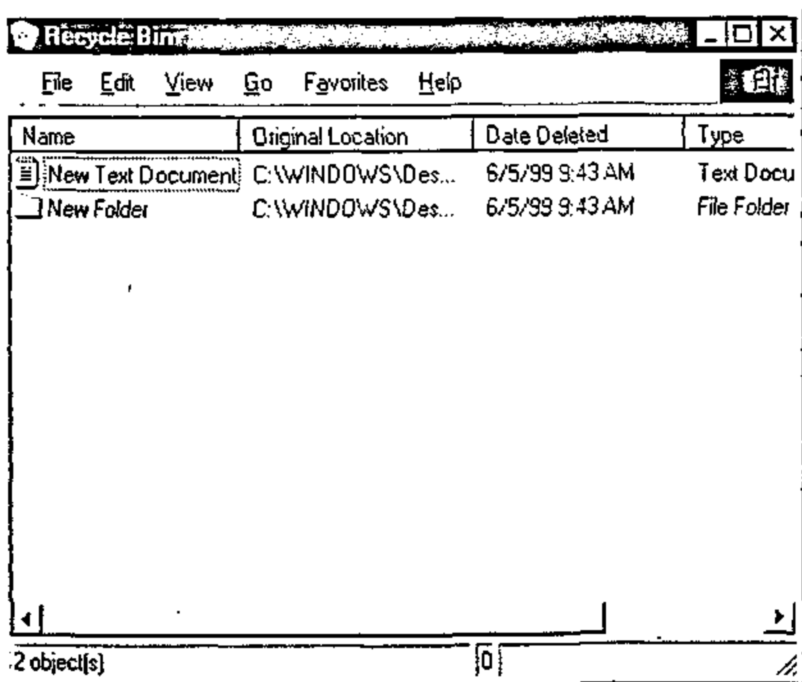
Restoring deleted files from the Recycle bin: Double click the recycle bin icon on the desktop. Click the right mouse button on the files to be removed. Select Restore.

Emptying the Recycle bin: Click the right mouse on the recycle bin icon. Select the "Empty Recycle bin" command.

Allocating space to the Recycle bin: To regulate the size of recycle bin, click the right mouse on the recycle bin icon, and select the properties option. Drag the space regulator, to denote the space required.

Control Panel

You can choose control panel from settings option of start button. Some of the important items are:



Regional settings

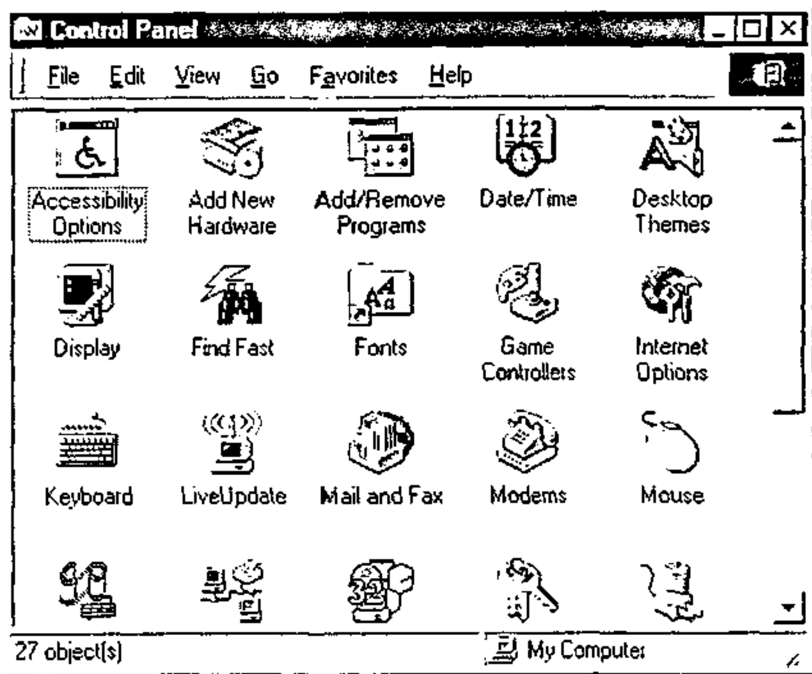
Changing the regional settings affects the way program display dates and currencies. It has the following Tabs:

Regional Settings: Enables selecting language being used.

Number: Select default number formats, such as decimal.

Currency Time Date

The Computer maintains an internal clock. You can change the date of internal clock using this option..This can also be changed by



double clicking the time area of the task bar.

Display settings

The following default options can be changed:

❉Changing the Background.

❉Changing the Screen Saver.

❉Changing the Color Settings.

Alternately, by right clicking on a blank area in the desktop, and selecting properties.

Printing basics

When you print a document in Windows95/98, it is put in a queue. The print manager takes care of the printing and it is done in the background. This means that you could continue working and also printing.

Drag and drop printing: To quickly print a document, which does not need any changes, use drag and drop print. Create a shortcut for the printer on the desktop. Open the Folder containing the required document, using My Computer. Drag the document to the printer shortcut.

The print queue manager

Double click on the printer icon to access the printer queue.

Deleting a print job: Click on any job and press delete from the Keyboard if you wish to delete the entry from the queue.

Reschedule a print job: Click and drag a job from one place to another to reschedule the jobs.

Windows accessories

Many Applications have been built into Windows 95/98, which aid and enhance the usability of this operating system. These applications are generally referred to as Accessories.To get access to these Applications click Start, choose Programs, Accessories and then choose the required accessory.

Some Accessories

WordPad: Is a built in word processor available in Windows 95/98.

Calculator: To calculate. Available in two modes: scientific and standard.

NotePad: A text processor.

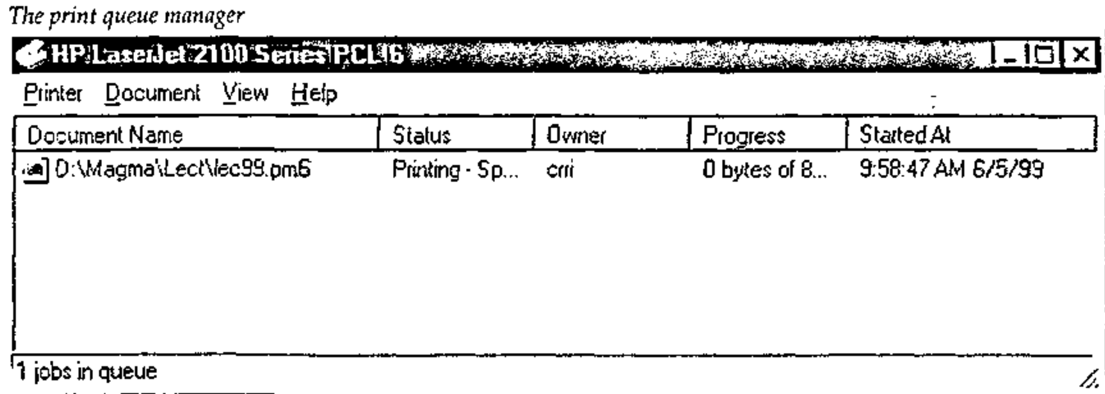
Practical Training

How to shutdown your computer

1: Switch on your personal computer.

The system goes through a sequence of initialization and startup procedures. You see the screen on your monitor filled with the Windows 95/98 logo in a backdrop of azure blue sky.

The print queue manager



2: Select START button on taskbar and click it.
3: Select shutdown option from the menu and click it.
4: Select Yes option from menu and click it.
5: Wait for some time, then you will get a message on screen saying you can switch off your computer.

How to create a folder in the Windows environment

1: Press right mouse button.
2: Select the option New from the context menu and click it.
3: Select the option folder option and click it.
4: Give the name of the folder say Hi and click it.
5: Move the pointer outside and click it.

How to create a file in the folder itself

1: Move the pointer in the folder itself and click it.
2: Click the right button of the mouse.
3: Choose OPEN option and click it.
4: Select FILE option and click it.
5: Choose NEW and TEXT DOCUMENT and click
6: Give the name CTC and click it.
7: Move the pointer in the file itself and click it.
8: Click the right button of the mouse and choose OPEN option.
9: Automatically you will get a Notepad.
10: Write some messages.
11: Move the pointer in the Notepad and choose FILE and click it.
12: Move the pointer to SAVE option.
13: Move the pointer to FILE option and EXIT and click it.

How to copy a file from one folder to another folder

1: Click the folder having the file.
2: Click right button select OPEN and click it.
3: Select the file and click it.
4: Click right button of the mouse.
5: Choose COPY option and click it.
6: Go to the folder where you want to copy the FILE.
7: Click right button select OPEN and click it.
8: Click right button and PASTE it.

How to copy a file from folder to floppy

1: Select the folder from where you want to copy a file and double click it.
2: Select the file, which you want to copy to a floppy and click it.
3: Don't move the pointer in the file itself.
4: Press right mouse button and select SEND TO floppy drive option.

How to copy a file from floppy to folder

1: Choose the option My computer and double click it.
2: Select the drive and click it.
3: Select Edit option and click it.
4: Choose the select all option and click it.
5: Choose edit and copy it.
6: Choose folder *.* and double click it.
7: Edit and paste it.

How to make an icon

1: Press right button of the mouse
2: Select New and click it.
3: Select shortcut and click it.
4: Choose Browse and click it.
5: Select NAV software and click it.
6: Choose open option and click it.
7: Select NAV.EXE file and click it.
8: Select next and finish option and click it.

How to change the icon

1: Click the right button on the icon which you want to change.
2: Select properties and click it.
3: Choose the option program.
4: Now you can change the icon.

How to delete the icon

1: Choose the icon which you want to delete.
2: Press right button of the mouse
4: Select delete option and click it.
5: Choose YES option and click it.

How to restore the icon through Recycle Bin

1: Double click Recycle Bin icon.
2: Select which items you want to restore, click it.
3: Select file option and click it.
4: Select restore option and click it.
5: Select file option and choose close option and click it.

How to load the software

1: Choose the option Start.
2: Select Run option and click it.

3: Choose Browse option and click it.
4: Select Desktop option and click it.
5: Choose the drive from which you want load.

How to start and use WordPad

1: Select *Start* button on the taskbar and click it.
2: Select Program option from the menu, click it.
3: Select Accessories from the sub-menu and click it.
4: Select WordPad from the menu, click it.

The Wordpad application gets launched and you see the program window of WordPad.

Type the following paragraph:

The ICAR is an autonomous apex national organisation registered as a society which plans, conducts and promotes research, education, training and transfer of technology for advancement of agriculture and allied sciences. The ICAR was set up on 16 July 1929 on the recommendations of the Royal Commission on Agriculture. It was re-organised in 1965, and again in 1973. Over the years it has developed a large research and training infrastructure to work on the production and other emerging problems confronted in agriculture to meet the growing demands for food, fodder fibre and fuel. It operates through 45 Central Research Institutes, 4 National Bureaux, 10 Project Directorates, 30 National Research Centres, 90 All India Co-ordinated Research Projects, 261 Krishi Vigyan Kendras and 8 Trainers Training Centres.

After finishing this paragraph

5: Select file option from the WordPad and click it.
6: Select Save as from the file menu and click it.
7: Give the name ectraining and select ok button.

The file gets saved as ectraining.

8: Select close option and click it.

How to start Paint

1: Select Start button on the taskbar and click it.
2: Select Program option from the menu, click it.
3: Select Accessories from the sub-menu, click it.
4: Select Paint from the menu and click it.
5: Draw some picture as you like and save it.

How to switch over between programs

1: Start WordPad program as explained above.
2: Start Paint program as explained above.
3: Select the Paint on the lower taskbar and click it.

The Paint program maximizes and is active.

4: Click WordPad on the taskbar.

The WordPad window comes on full screen.

OR: Use keys Alt + Tab combination to switch between Applications and documents appearing on the taskbar, which are active on the desktop.

How to open documents quickly

1: Select start button on the taskbar and click it.
2: Select Documents from the menu and click it.
3: Select the documents, which you want to open and click it.

How to start Calculator

1: Select Start button on the taskbar and click it.
2: Select Program option from the menu, click it.
3: Select Accessories from the sub menu, click it.
4: Select Calculator from the menu, click it.
5: Calculate the value of the following items:

Add: 9456, 1232, 876 and 90.
Subtract: 4567from 6789.
Multiply: 345 and 456.
Divide: 4500 by 200

How to start Windows Explorer

1: Click the start button.
2: Select Programs from the menu and click it.
3: Select Windows Explorer and click it.

How to switch over between MS-DOS prompt to Windows 95/98 and *vice-versa*

1: Click the Start button.
2: Select Programs from the menu and click it.
3: Select MS-DOS Prompt and click it.
4: To return Type Exit then Enter.

How to find a file or a folder

1: Click the Start button.
2: Select the Find option from the menu.
3: Click Files or Folders from the list. The Find dialog box appears.
4: Click the named field and type the name of the file or your folder you want to locate.
5: Type the drive or Directory name from where the search will Begin.
6: Click Find Now.
7: On Finding all files corresponding to the name specified, a list showing their locations will be listed in the dialog box.

Please find a file named ectraining on your computer .

How to format a floppy

1: Double click My Computer icon from desktop.
2: Select which floppy you want to format it.
3: Press right button of the mouse.
4: Select Format option from the list.
5: Select Start option from the menu.

World Wide Web Virtual Library

AGRICULTURE

Do you have any questions? *Please ask me:*
raviviswom@hotmail.com

This site has been compiled from different sources. I acknowledge their contribution.

- Ag Sites Around the World,clickable maps from IPMnet
- Ag-related Newsletters, periodicals, and electronic textbooks
- Sites in the U. S.
  - WWW Virtual Library Sites Relevant to Agriculture
  - WWW Resources Relevant to Agriculture
    Links and Databases
  - Extension WWW Coordinators and Servers
  - Agricultural/Environmental Safety Information
  - Global Crop Pest Identification and Information Services (from Cornell, under construction)
  - Cornell's Mann Library - USDA reports and statistics from ERS and NASS
  - The National IPM Network for University-based information
  - Horticultural Information

WWW Virtual Library Sites Relevant to Agriculture

- Agricultural Economics
- Agricultural Market Information
- Beer & Brewing
- Biological Control Virtual Information Center

- Biosciences Index
- Biotechnology
- Fish, and other Aquatic Animals
- Entomology
- Forestry
  - Forest Genetics and Tree Breeding
  - Soils and Substrates
- Gardening
- Grains Specialty Library
- Irrigation and Hydrology
- Livestock
- Plant Biology
- Population Ecology Home Page
- Poultry Science Virtual Library
- Sustainable Agriculture Virtual Library
- Veterinary Medicine
- Wool

Resources Containing Lists of WWW Sites Relevant to Agriculture

- Agriculture Network Information Center (AgNIC)
- Agricentral
- Agricultural Economic Recovery & Development Initiative
- Agbiotech Online - Information Systems for Biotechnology (NBIAP)
- Agricultural/Environmental Links - Joe Walker
- Agriculture (Engineering & Technology from EINet Galaxy)

- Agriculture Home Page - Links from FSU
- Center for Integrated Pest Management an NSF Industry/University Cooperative Research Center
- Cyberstacks - Agriculture
- Dryland Cropping Systems Information System from Washington State University
- Entomology Internet Resource List at Iowa State University
- Farmer's Guide to the Internet
- Florida AgriGator Agriculture and Related Information.
- INFOMINE A long listing of sites including many international sites.
- Mother of all BBS Agriculture
- National Agricultural Pest Information System (NAPIS)
- National Biological Control Institute
- National Integrated Pest Management Network An Expanding Network of IPM Information.
- National IPM Materials Database
- Not Just Cows: A guide to Internet/Bitnet Resources in Agriculture
- Plant and Insect Parasitic Nematodes
- The Plant Pathology Internet Guide Book, a resource guide for phytopathology and related fields
- Science and Agriculture from Yahoo
- Soil Micromorphology
- Vet/Med Links from Auburn University - College of Veterinary Science

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Horticultural Information

- AGROPOLIS. Non-technical Texas A&M information on gardening, agriculture, environment, and home and family living
- G and G WWW Page - A Good Resource for Botanical Gardens and Gardening

Resources.

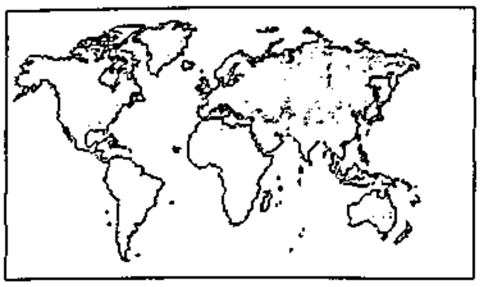
- **American Bamboo Society**
- **Florida Plants Online**
- **Glossary of Botanical Terms**
- **Horticulture and Home Pest News from Iowa State University**
- **Horticulture in Virtual Perspective**
- Texas A&M University - Dept of Horticultural Science
- ***Horticulture and Molecular Biology***
- **INFOMINE Biological, Agricultural and Medical Resources**
- Northwest Berry & Grape InfoNet
- **Pukeiti Rhododendron Trust (New Zealand)**
- **Rhododendron Page**
- Royal Botanic Gardens <li **Tyler Arboretum**
- UKEXNET *Horticultural Index*
- USDA/ARS Vegetable Lab

Do you have any questions/ Please write: raviviswom@hotmail.com

Ravi Home

The web counter says you are visitor:

Back to top



IPMnet
Agricultural Servers Worldwide

Click on the map for specific regions.

| Africa | Asia/Pacific | Australia/NZ | Europe | Latin America | Middle Asia | US/Canada | Multinational |

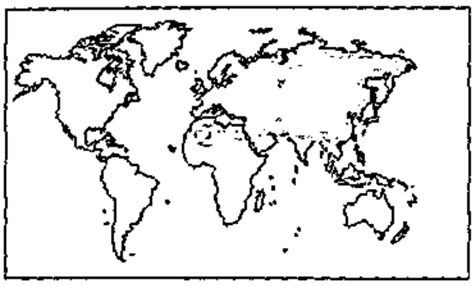
If you have a site you would like to add, please contact CICP.

Multinational

- AgNIC - Agriculture Network Information Center, from the U.S. Department of Aghriculture
- Alert-Pest.net Pest Information links
- CAB InternationalAgricultural information and databases
- Global Crop Protection Federation
- Inter-American Institute for Cooperation on Agriculture - IICA
- PEST CABWeb from CAB INTERNATIONAL.
- CLIMA - Centre for Legumes in Mediterranean Agriculture
- Center for Tropical Pest Management
- CGIAR Consultative Group on International Agricultural Research
  - CGIAR System-Wide Programme on IPM (SP-IPM)
- Organisation for Economic Co-operation and Development
- Food and Agriculture Organization of the United Nations
  - FAOSTAT - FAO multilingual agricultural statistics database
  - Sustainable Development Dimensions from the FAO Sustainable Development Department
- Global Crop Protection Federation
- International Fund of Agricultural Development
- IPM Bulletins of the European IPM Working Group This is a WEB posting of IPM information for and involving developing nations.
- IPMnet a WWW site with IPM information and services for developing countries
- Organization for Economic Cooperation and Development
- Third World Academy of Sciences
  TWAS supports research and technologists in developing countries and development international collaborative initiatives to enhance the science base for sustainable development.
- United Nations Food and Agriculture Organization
- USAID IPM CSRP
- USDA Foreign Agricultural Service
- World Bank
- World Health Organization

International Agricultural Research Centers

- CATIE *Centro Agronómico* Tropical de Investigación y Enseñanza (en Espanol)
- CIMMYT - Centro International de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center
- International Centre for Insect Physiology and Ecology (ICIPE)



IPMnet
Asia and Pacific Islands

Click on map for another specific region, or here to world organizations

| Africa | Asia/Pacific | Australia/NZ | Europe | Latin America | Middle Asia | US/Canada | Multinational |

If you have a site you would like to add, please contact CICP.

Pan-Asian

Asia-Pacific Crop Protection Association

Asian Vegetable Research and Development Center

"China Agriculture/Food - From Hong Kong Small Trader's View

South East Asian Ministers of Education Organization's Regional Center for Graduate Study and Research in Agriculture

Food and Fertilizer Technology Center - An information Center for small-scale farmers in Asia. Collects and disseminates technical information on new low-cost technology to help improve yields and farmers' incomes. Southasia.net - Agriculture - links to southasia ag and commodity information

Bangladesh

AgriNet Bangladesh

China

Beijing Agricultural University
China Agricultural Weekly from ChinaWeb
IPM China from the Institute of Plant Protection, Chinese Academy of Agricultural Sciences

India

pioneer enterprise eco-friendly and safer alternatives (Bombay)

Indonesia

Sustainable Development Networking Programme

Japan

Japanese Dairy Cattle Improvement Program
National Institute AgroEnvironmental Science of Japan Satellite Image Catalog and Lotus Flower Image Index
National Institutes of Ministry of Agriculture, Forest

AgriNet Bangladesh

Your Online Guide to Bangladesh Agriculture

Welcome to Bangladesh Agriculture. This site is devoted to understanding and promoting knowledge about agricultural and rural development process in Bangladesh. Everybody is welcome to contribute ideas, thoughts, news, and views related to the agricultural and rural development in Bangladesh. This site is updated every Sunday.

BAU Alumni Registry

BRRI develops 8 new HYV rice

BAUNET Discussion Forum

- Introduction
- Research Institutes
- Journals
- Meet the Press
- Experts' Directory
- Links to Other Pages
- BAUNET News
- Educational Institutes
- Dear Policy Makers!
- Agri. News
- Open Forum
- Features
- South Asian Agriculture
- Uttam's Homepage

Fellowships, Jobs, Grants and Conferences for Agriculturists

Bengali Calendar for 1405 (Bangabada)

Thank you for visiting us. Your suggestions and comments are appreciated. Please submit your suggestions and comments about the AgriNet Bangladesh to the Webmaster.

LinkExchange Member

AgriNet Bangladesh

Introduction to Bangladesh Agriculture

Bangladesh is one of the South Asian countries. It is located in the north eastern part of the South Asia between 20 degree 34" and 26 degree 38" north latitude and 88 degree 01" and 92 degree 41" east longtitude. You can see from the map of Bangladesh that the country is bordered by India in the north and west, by India and Myanmar in the east and by the Bay of Bengal in the South. Dhaka is the capital of Bangladesh. To see the map of Dhaka City click here. You may be interested to see today's weather in Dhaka. Total population of the country in 1995 was about 128 million.

The Bangladesh economy largely depends on agriculture. About 40 percent of the gross domestic product (GDP) of Bangladesh comes from agriculture which employs 60 percent of the labor force and contributes about 60 percent of the total export earnings of the country.

A substantial amount of internet resources about the general features of Bangladesh are now available. You can use these resources free. World Bank has a page entitled Bangladesh . The Fourth World Documentation Project contains information on development aspects. The development information services online *(DEVLINE)* from the Institute of Development Studies and the British Library for Development Studies, Sussex, UK contains some information (studies) on Bangladesh. CIA has its own view about Bangladesh which can be seen in The World Fact Book Page on Bangladesh mantained by CIA. Library of congress has very informative Bangladesh--A Case Study . If you are interested about the flooding of Bangladesh then you can read The Flooding of Bangladesh maintained by the Earthbase. The Waikato University of New Zealand is conducting reasearch on The Green House Effect and Climate Change: The Implications for Bangladesh .

There are several news papers in the internet which provides daily news from Bangladesh. The Daily Star is the first daily newspaper in the internet from Bangladesh. Another daily newspaper from Bangladesh is The Independent. You can see also News From Bangladesh which provides daily internet news. Dhaka-Bangladesh Web's News can also meet your demand to provide the news about recent events. Bengali news papers and magazines like Daily Ittefaq and Jai Jai Din have their own web page. You can also read Some Poems in Bengali Script(!) or listen some Bangla music. available in the web.

To have a FREE online tour to Bangladesh agriculture, you must seeAgriNet Bangladesh . You can also read Introduction to Bangladesh and its Agriculture provided by ICPPGR of the FAO.

If you are intersted to know about the liberation war of Bangladesh then visit Bangladesh Liberation War Museum maintained by Shamim Chowdhury from USA.

You must see Dhaka '71 to have an understanding of the cruelty of the Pak Army and their collaborators in 1971. Kathan's Homepage has also a collection of Holocaust'71 moving pictures and a comprehensive page on culture and tradition of Bangladesh.

Cyber Bangladesh is another nice informative website maintained by Ishtiaque Ahmed. Moreover, you can visit Bangladesh Online for many other things in Bangladesh.

Have a look at Bangladesh from agroclimatological point of view--provided by Earthrise:

- Brahmaputra River Valley, CL (50580 bytes).
- Mouth of Ganges, CL (59508 bytes).
- Mouth of Ganges, CL (72830 bytes).
- Pan-Mizo Hills, Ganges Delta (27442 bytes).
- Pan-Mizo Hills, Ganges Delta (29170 bytes).
- Pan-Mouth of the Ganges (32942 bytes).
- Pan-Mouth of the Ganges (40089 bytes).
- Brahmaputra River Plain (35153 bytes).
- Brahmaputra River Plain (37165 bytes).
- Brahmaputra River Plain (39835 bytes).
- Ganges River Delta (37231 bytes).
- Ganges River Delta (32148 bytes).
- Megna River Mouth (38216 bytes).
- Mouth of Ganges, Haze (27722 bytes).
- Mouth of Ganges, Sediment (55052 bytes).
- Mouth of Ganges, Sediment (53235 bytes).
- Ganges River (65423 bytes).
- Ganges River (65778 bytes).
- Bay of Bengal, Sediment (49773 bytes).

| Back to Main Page |

Agrinet Bangladesh

News About Bangladesh Agriculture

BRRI develops 8 more HYV of rice

Bangladesh Rice Research Institute (BRRI) has developed eightmore high-yielding varieties of rice. six of them are expected to be released for commercial cultivation by the next year. The other two fine quality of aromatic rice are new awaiting the concerned authorities' approval to go for cultivation at field level.

Director General of BRRI Dr. Hamid Mia disclosed this to a group of journalists who went to visit the BRRI at Gazipur on Friday.

Dr. Hamid Mia said BRRI has so far released thirty-one high-yielding Modern Varieties (MVs) of rice, twenty-one of these are suitable for cultivation in the aus and boro seasons and ten in the transplant aman season.

The scientists at the BRRI opposed the idea of some imported hybrid varieties of rice for massive cultivation's at field level because the experimental cultivation of those varieties at BRRI's different stations has failed to give optimum results. The country needs hybrid varieties to come with the increasing demand of food-grains but such varieties would not be suitable unless those are developed on the basis of local agro-ecological and climatic situation, they observed.

It is learnt that recently the government had allowed some private firms to import hybrid varieties of rice seeds for field cultivation but without a proper laboratory test it would be risky to release those varieties for massive field cultivation. Some hybrid varieties were examined by BRRI, but only a single variety (CNSGC 6) was found suitable for cultivation.

When asked BRRI DG Dr. Hamid Mia said the success of hybrid varieties depends on their yielding, capacity in comparison with the local popular ones, quality of rice and the benefit of peasants. It should be wise to take into account of these issues before release of those hybrid varieties for massive cultivation's a field level.

He informed the journalists that BRRI was continuing its research activities to develop hybrid varieties and hoped that BRRI scientists would be able to release hybrid varieties suitable to local agro- ecological and climatic situations.

The BRRI is continuing its research to reach the target of producing 2.50 crore metric tons of crops across the country by the year 2002, BRRI sources said adding that some 1.86 lakh tons of paddy had been produced in 1997-98 fiscal by using its 35 varieties of high yielding seeds.

According to sources, the BRRI has developed 101 paddy related technology including 35 varieties of high yielding paddy by conducting massive research programmes from its inception in 1970, sources said. The RBBI has been able to reduce about 50 per cent wastage of paddy from harvesting to stockpiling every year after introducing the developed technology, BRRI officials said.

The sources said, BRRI entomologists have identified 175 species of rice insect pests, 99 species of parasites and 88 species of predators. Besides, thirty-one diseases have been identified.

The BRRI plant pathologists have developed screening methods for major diseases and have identified over 9,000 spruces of resistance, over 7,000 germplasms, of which about 5,000 are local, have been collected and preserved by BRRI plant breeders, BRRI sources said. (Courtesy: Dhaka-Bangladesh News).

Four-day BRRI internal meet begins

Four-day BRRI internal meet begins Farmers get much less yield from modern varieties of rice A four-day annual internal review meeting of the Bangladesh Rice Research Institute (BRRI) began in the city at the BRRI auditorium yesterday (27 April), reports BSS. Dr M A Hamid Miah, Director General, BRRI inaugurated the view meeting as the chief guest, a BRRI press release said. Some 150 scientists and specialists from different research institutes, universities, government and non-government organisations including BRRI are participating in the review meeting. In his opening comments, Dr M A Hamid Miah stressed the need for renewing agricultural research management and pursuing integrated approach to develop sustainable rice-based food production technologies and strengthening their rapid extension to ensure balance food security for the people. He said, "our farmers get much less yield from the modern varieties of rice than their actual yield potential and we should work relentlessly at the grass-roots to reduce this gap." He also stressed the need for introducing appropriate farm machinery to meet the shortage of agricultural labour force. Among others, Dr S M Hasanuzzaman, former member, the Planning Commission and former Director General (DG), BRRI, Dr A J M Azizul Islam, former DG, BRRI, Dr M A Majed, DG, the Bangladesh Agricultural Research Institute (BARI), Dr S I Bhuiyan, IRRI representative in Bangladesh, Dr Isuyomi Mizuochi, representative, the Japan International Cooperation Agency (JICA), and Zhou Kunlu and Wu Xiaojin, hybrid rice specialists from China attended the session. In total 26 reports on last year's research activities of 17 research divisions and nine regional stations will be presented for discussion and recommendations. (The Daily Star).

'Civilisation can't survive if agriculture collapses'

MYMENSINGH. Apr 18: Bangladesh Agricultural University today conferred honorary DSc Degree on the world renowned agriculture scientist and Nobel laureate Dr Norman Ernest Borlaug, reports UNB. Prime Minister Sheikh Hasina handed over the certificate of the degree to Dr Borlaug at a function at the Shilpacharya Zainul Abedin auditorium of BAU this morning. The conferment of the degree was arranged through the first special convocation of BAU. Earlier, the Prime Minister led the convocation procession joined by 384 BAU teachers, including the Vice-Chancellor. Recalling the contribution of Dr Borlaug, the Prime Minister felicitated the Nobel laureate for his lifelong service for the cause of world peace and human welfare. "Bangladesh owes in particular among the beneficiaries to your genius in respect of HYV wheat cultivation," she said adding that "Bangladesh aspires to attain the goal of self-sufficiency in food". Dr Borlaug thanked the Prime Minister for giving him the honour and said civilisation of a country cannot be sustained if its agriculture collapses. Dr Borlaug is called the pioneer of 'Green Revolution' for developing HYV wheat. In her address Hasina also called upon the agricultural scientists to pay more attention in innovative work to bring the crop production system and management into a modern standard keeping pace with the changeable climate and weather. "Any technology we develop must be compatible with the agro-ecological and socio-economic factors of our country," she told the agri scientists. The Prime Minister said agriculture, which accounts for about one-third of the GDP and employs about two-thirds of the labour force, has been playing a dominant role in the process of economic growth of the country and this trend will continue in the foreseeable future. Referring to country's rich natural resources, like fertile soil, rich water bodies, abundant sunshine and moderate temperature and rainfall, Sheikh Hasina said it is unfortunate that we have not yet reached the desired level of development even after having phenomenal success in boosting cereal production like paddy through adopting HYV technology. Sheikh Hasina said an Agricultural Commission has been working for the formulation of an agricultural policy encompassing crops, fisheries, livestock and forestry sub-sectors adding that the implementation work of the already announced new Agricultural Extension Policy has started functioning. Referring to the 30-year Ganges Water Sharing Treaty, the Prime Minister said it has created immense potentialities to develop and manage water resources for rapid improvement of irrigation, inland navigation, fisheries, afforestation and the ecology. The Prime Minister also lauded the role of the BAU in the development, propagation and transfer of appropriate agro-technologies in the country and hoped that the university will take more and more research activities in order to innovate and improve the species of economically important crops following the deals of Dr Borlaug. (The Daily Star)

Agri-scientists urged to devote themselves in cereals' research

Nobel laureate agronomist Dr Norman Ernest Borlaugh has urged agricultural scientists to devote themselves in research work on cereals in the wake of population boom in various countries of the world. Dr Borlaugh, who has been confered with honorary D.Sc. degree by Bangladesh Agriculture University, was addressing a gathering of 500 scientists at Bangladesh Agricultural Research Institute (BARI) at Gazipur recently, says a press release. Agriculture and food advisor to the Prime Minister, AM Anisuzzaman, attended the function as chief guest. Besides, executive chairman of Bangladesh Agriculture Research Centre (BARC), Dr Z Karim, DG of BARI, Dr MA Majed, DG of Bangladesh Rice Research Institute, Dr M A Hamid Mia, director and advisor of Wheat Research Centre Dr MA Razzak and Dr Craig A Meisner also spoke at the function. (The Daily Star)

Hilsha exports drop by 50 pc
By Govinda Shil

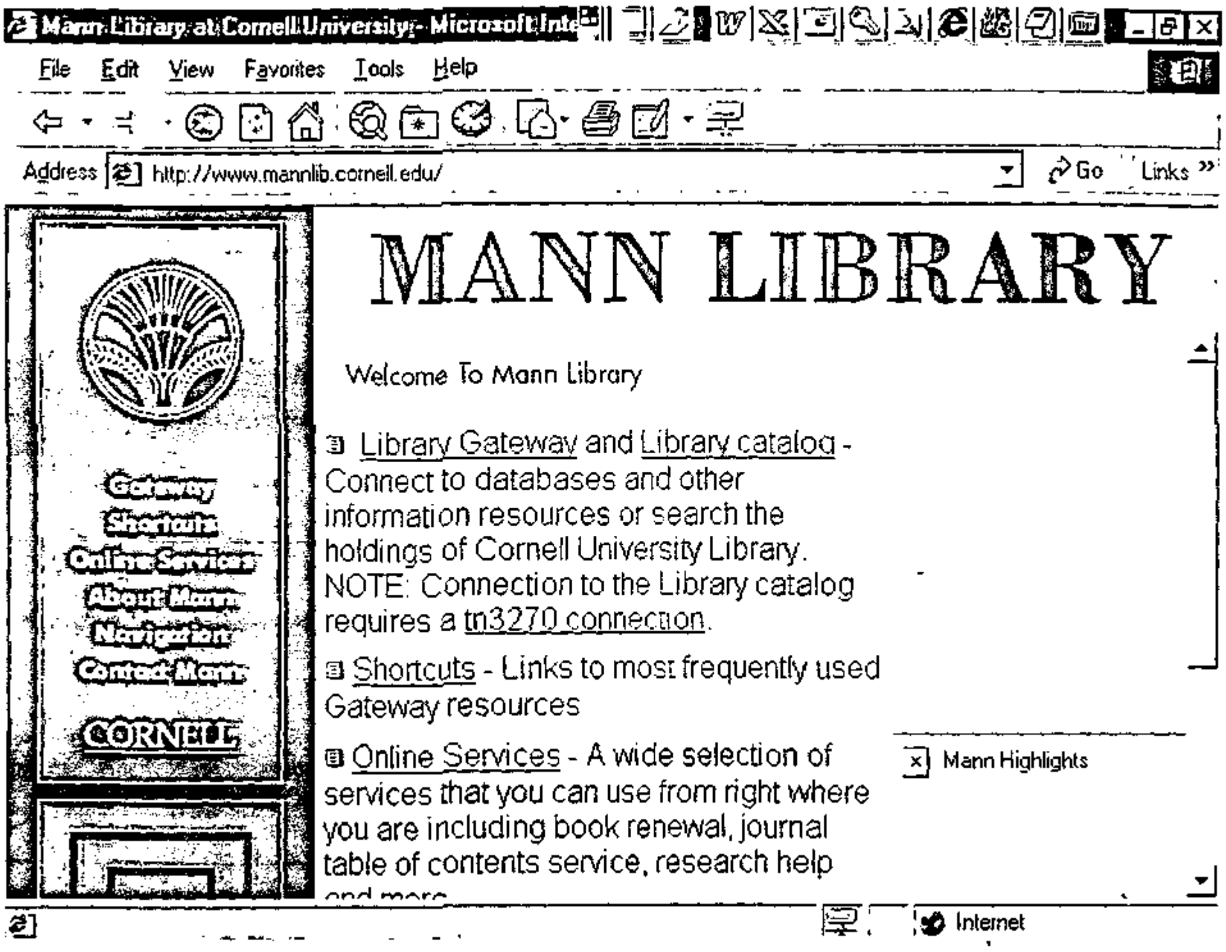
Export of hilsa fish would decline significantly this year as its major international buyers have shifted from Bangladesh to other Asian countries. Exporters might lose Tk 150 crore as hilsa trading would decline by about 50 per cent, to 5,000 tonnes, exporters said. According to Bangladesh Frozen Foods Exporters Association, some 2,000 metric tonnes of hilsa remained unsold for one year which had been kept in different cold storages. Prices of hilsa in some countries were low when harvests from the Bay of Bengal declined making it costlier, exporters explained. Revenue from Bangladesh's export of hilsa. the most popular fish among the Bangalis abroad, has been recorded at Tk 300 to Tk 350 crore annually in recent years. Malaysia was the top buyer, fish followed by the UK, the Middle East and EU countries and the US. Malaysia bought 2,000 tonnes of hilsa last year. "Malaysians have stopped buying our hilsa, because of their recent financial turmoil that made US dollar costlier for them," said Maqsudur Rahman, a top hilsa exporter. Traders also said hilsa catch declined due to water pollution in Karnafuli estuary in the Bay. Karnafuli Urea Fertiliser and Chittagong Urea Fertiliser were causing the pollution, they alleged. According to them, the water pollution has driven much of the hilsha population to neighbouring Naf river. As a result, the Myanmar fishermen are reaping the benefits and, naturally, offering low prices. (The Daily Star)

Jute production to fall by 30 pc next season

The overall jute production of the country was reviewed at a meeting of the Jute Advisory Committee here yesterday with the State Minister for jute, A K Faezul Huq in the chair, reports BSS. An official handout said the meeting was informed that the jute production will be 30 per cent less during the forthcoming season compared to the last season. About 64 lakh bales were produced in the country during the last season. The country will produce about 45 lakh bales of raw jute during the forthcoming season against its normal demand of about 50 lakh bale, the meeting was further informed. The State Minister who is also the Chairman of the Jute Advisory Committee said, the government will continue its efforts to protect the interest of the jute growers. He sought allout cooperation of all concerned to ensure fair price of raw jute and keep the price stable. The private jute traders have demanded to bring the Bangladesh Jute Research

Institute (BJRI) under the Ministry of Jute for better coordination. They appealed to the government to sanction working capital in the jute sector on time and reduce the rate of bank interest in other sectors like frozen food, garments and leather goods. The meeting was attended, among others, by the Secretary of the Ministry of Jute Mahfuzul Islam, Chairman of BJMC Abu Osman Chowdhury, Chairman of Bangladesh Jute Association (BJA) Abdur Razzak Akhand and its Vice Chairman Rezaul Karim, Chairman of Bangladesh Jute Exporters Association (BJEA) Giasuddin Ahmed, Chairman of Bangladesh Jute Spinners Association (BJSA) Nazmul Huq, Chairman of Bangladesh Jute Goods Association (BJGA) Mohammad Ali, former president of FBCCI Abdul Wahab and representatives of concerned ministries, banks and trade bodies. (The Daily Star)

Agrinet Bangladesh


Mann Library at Cornell University - Microsoft Inte
File Edit View Favorites Tools Help
Address http://www.mannlib.cornell.edu/
Go
Links
MANN LIBRARY
Welcome To Mann Library
Library Gateway and Library catalog - Connect to databases and other information resources or search the holdings of Cornell University Library. NOTE: Connection to the Library catalog requires a tn3270 connection.
Shortcuts - Links to most frequently used Gateway resources
Online Services - A wide selection of services that you can use from right where you are including book renewal, journal table of contents service, research help
Gateway
Shortcuts
Online Services
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Mann Highlights
Internet

Cornell International Institute for Food, Agriculture and Development

GLOBAL CROP PESTS

Identification and Information

Developed by Alfredo Rueda and Anthony M. Shelton

ENGLISH

The Cornell International Institute for Food, Agriculture and Development (CIIFAD) and collaborators welcome you to the prototype of the **Global Crop Pest Identification and Information Services in Integrated Pest Management (IPM)** on the World Wide Web.

Please select below the language you prefer to continue your exploration of our prototype site. In this prototype, only a few language sections are available:

- English
- Español
- Français
- Indonesian

Unsolicited proposal for crop pest identification and information services in integrated pest management (IPM) on the World Wide Web.

If you have questions or comments about this site, please send e-mail to Alfredo Rueda (aar4@cornell.edu).

ESPAÑOL

El Instituto Internacional de Cornell para la Alimentacion, Agricultura y Desarrollo (CIIFAD) y colaboradores le dan la bienvenida al prototipo de la guia electronica **Servicio de Informacion Global para la Identificacion de Plagas de Cultivos y Manejo Integrado de Plagas (MIP)** en el World Wide Web.

Por favor seleccione abajo el leguage de su preferencia para seguir explorando nuestro prototipo. En este prototipo las seleciones son limitadas:

- English
- Español
- Français
- Indonesian

Si Ud. tiene preguntas o comentarios sobre esta pagina o el projecto favor envie un e-mail a Alfredo Rueda (aar4@cornell.edu).

UNIVERSITY OF MINNESOTA
Extension
SERVICE

...connecting community needs and University resources

Welcome. This site features instant access to the most recent Extension publications, newsletters, audio scripts, news releases and programs.

Topics of interest

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Communities & Tourism
Crops
Environment & Natural Resources
Family Development
Financial & Business
Food & Health
Gardening & Horticulture
Housing & Clothing
Leadership & Civics
Livestock
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including Citizen's Forums

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This Week's Features

Tuesday Aug. 03, 1999

Get a free Sun Safe hat at Farm Fest!

to the Social and Economic Crisis in Rural Minnesota

Look for Rural Response at FarmFest.

Minnesota Citizen Forums

Next Forum - August 5, 1999

Programs

Find educational offerings near you

News and information

New Rural Response website available

Statewide Citizens forum at FarmFest

New study, more farmland is being lost to urban uses

More . . .

4-H - Extension's Youth Program

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Extension helps to educate people on the appropriate use of **Communications and Information Technology** in order to promote both personal growth and community economic development. In this area, we feature information on traditional communications such as writing and photography as well as the new electronic-based technologies including the World Wide Web and the Internet.

Topics materials in this area

Arts & Photography
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What's New on the Web

- How Do I Get on the Internet?

Related Extension Web Sites

- A*DEC Program Database System
- Access Minnesota - Internet Public Access Project
- Access Minnesota Main Street - E-Commerce & Small Businesses
- Master Internet Volunteer Program
- The Year 2000 Computer Problem

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- AGRICOLA/NAL-Melvyl ® System
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USDA Vegetable Laboratory

Beltsville Agricultural Research Center, Beltsville, Maryland

The mission of the Vegetable Lab is to genetically improve the quality and pest resistance of vegetables and develop more efficient production practices. Through traditional breeding and use of biotechnology, scientists develop potatoes, tomatoes, and other vegetables with *superior nutritional quality, disease and insect pest resistance and high consumer acceptability.* Scientists also develop production systems that reduce inputs of farm chemicals and lower production costs.

From the field to the greenhouse to the laboratory, with tractors, microscopes and pipettors, the staff of the Vegetable Lab conducts research aimed at improving vegetables. Please spend a few minutes exploring our web site.

ars USDA

This page last updated on April 14, 1999

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UPI NEWS

Glickman praying for rain
EPA limits two pesticides
Brits celebrate end of beef ban
Protests against Yugo ag head
Russian official calls for food aid
Report: CME to link with LIFFE
Record CA tomato crop expected
Researchers fight eucalyptus bug
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[details]

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ROYAL BOTANIC GARDENS KEW

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Local time is: Tuesday August 03 17:59 BST

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The mission of the Royal Botanic Gardens, Kew is to enable better management of the Earth's environment by increasing knowledge and and understanding of the plant and fungal kingdoms - the basis of life on Earth.

Visit our exhibition of photographs of more than 60 posters, on show in Kew Gardens Gallery

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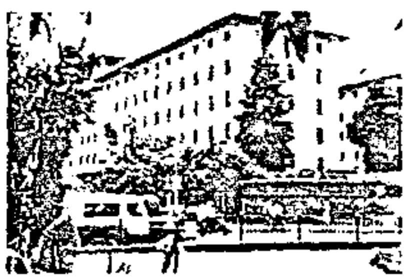
ICAR

Indian Council of Agricultural Research

The ICAR is an autonomous apex *national* organisation registered as a society which plans, conducts and promotes research, education, training and transfer of technology for advancement of agriculture and allied sciences.



The ICAR was set up on 16 July 1929 on the recommendations of the Royal Commission on Agriculture. It was re-organised in 1965, and again in 1973. Over the years it has developed a large research and training infrastructure to work on the production and other emerging problems confronted in agriculture to meet the growing demands for food, fodder, fibre and fuel. It operates through 45 Central Research Institutes, 4 National Bureaux, 10 Project Directorates, 30 National Research Centres, 90 All India Co-ordinated Research Projects, 261 Krishi Vigyan Kendras and 8 Trainers Training Centres.

- Organization
- Activities
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- Agricultural Research Information System
- International Linkages
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- Subordinate Offices
- UPDATED NATP Project Summary
- State Agricultural Universities
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- Natural Resource Management

International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century

NEW **Result of Fourth All India Entrance Examination for U.G. Programme**

NEW **Results of All India combined Exam for ICAR's JRF for Academic Session 1999-2000**

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khoj Daily
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Thought For The Day
In this world there are only two tragedies. One is not getting what one wants, and the other is getting it.
-Oscar Wilde

Link Of The Day
Rajshri: Real Audio - - Pehla Din Hai College Ka

Recipe Of The day
Handi Sabzi Mixed by Saroj at Bawarchi.

India Fact
Maruti's sales at 15-year high.
Maruti Udyog Ltd

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DIVISION OF EXTENSION,COMMUNICATION AND TRAINING
CENTRAL RICE RESEARCH INSTITUTE
CUTTACK 753 006

NATIONAL TRAINING PROGRAMME ON RICE BASED CROPPING SYSTEMS
(02-09 August,1999)

DAY-TO-DAY SCHEDULE

Day/Date/ Time	Topic	Resource Scientist (S)	Mode of Presentation
Monday (02.08.1999)			
10.00	Registration and pre-knowledge test	Shri A.K.Mohanty and Dr. B.T. Rayudu	
10.30	Inauguration	Director of Agril. Govt. of Orissa	
11.00	Rice and rice based crops in different ecologies	Dr. K.C. Mathur/ Dr.P.R.Reddy	Theory-cum-discussion
12.00	Lunch Break		
14.00	Identified cropping and farming systems in eastern India and their suitability to different ecologies	Dr. K.P. Jha	Theory-cum-discussion
15.15	Tea Break		
15.30	Visit of display hall	Dr.B.T.Rayudu	Visit
Tuesday (03.08.1999)			
09.00	Integrated nutrient management of rice	Dr. D. Panda	Theory-cum-discussion
10.15	Tea Break		
10.30	Effect of soil physical environments in rice based cropping systems	Dr. K. R. Mahato	Theory-cum-discussion
12.00	Lunch Break		
14.00	Role of green mannuring in rice based cropping system	Dr. S.P. Chakravarthy	Theory-cum-discussion
15.15	Tea Break		
15.30	Bio-fertilizers in rice cultivation-problems and perspectives	Dr. D.P. Singh	Theory-cum-nethouse visit
Wednesday (04.08.1999)			
09.00	Integrated weed management in rice based cropping systems	Dr. B.T.S. Moorthy	Theory-cum-discussion
10.15	Tea Break		
10.30	Integrated disease management in rice	Dr. Santosh K. Mohanty	Theory-cum-discussion
12.00	Lunch Break		
14.00	Skills in integrated rice insects pest management	Mr. R.C. Dani	Theory-cum-discussion
15.15	Tea Break		
15.30	Integrated pest management in rice based cropping systems	Dr. K.S. Behera	Theory-cum-discussion

Thursday (05.08.1999)			
09.00	Agronomic management of hybrid rice	Dr. K.S. Rao	Theory-cum-discussion
10.15	Tea Break		
10.30	Hybrid rice technology-problems and perspectives	Dr. S.N. Ratho	Theory-cum-discussion
12.00	Lunch Break		
14.00	Rice technologies for rainfed ecosystems-problems and perspectives	Dr. J.N.Reddy	Theory-cum-discussion
15.15	Tea Break		
15.30	Water management practices of rice and rice based crops	Dr. P.C.Mohapatra	Theory-cum-discussion
Friday (06.08.1999)			
09.00	Rice-fish system in rainfed lowlands	Dr. D.P. Sinhababu	Theory-cum-discussion
10.15	Tea Break		
10.30	Rice-fish system in rainfed lowlands	Dr. D.P. Sinhababu	Field visit
12.00	Lunch Break		
14.00	Feasibility of farm mechanisation for RBCS	Dr. R.S. Devnani	Theory-cum-discussion
15.15	Tea Break		
15.30	Visit to Engineering workshop	Mr. A.K. Choudhury /Dr. P.N. Mishra	Practicals
Saturday (07.08.1999)			
09.00	Utilisation of residual mositure for rice based crops	Dr.Amal Ghosh	Theory-cum-discussion
10.15	Tea Break		
10.30	Role of motivation in human life	Dr. M. Venugopalan	Theory-cum-discussion
12.00	Lunch Break		
14.00	Computer systems for information retrieval and exchange, and the WWW	Mr.Ravi Viswanathan	Theory-cum-discussion
15.15	Tea Break		
15.30	Computer systems for information retrieval and exchange, and the WWW	Mr.Ravi Viswanathan	Practicals
Sunday (08.08.1999)			
08.00 - 17.00	Visit to farmers fields to identify rice based cropping systems	Mr.A.K.Mohanty, Mr.A.C.Hota and Mr.J.Nayak	Practicals
Monday (09.08.1999)			
09.00	Visit to laboratories and nethouses	Mr.A.K.Mohanty	
10.15	Tea Break		
10.30	Post evaluation	Dr. B.T. Rayudu	
11.00	Valedictory	Director, CRRI	

The Joint Director, all Heads of divisions and resource scientists of this course are cordially invited for inauguration and valedictory functions.

(M. Venugopalan)
Course Co-ordinator

Copy to:

Joint Director

All heads of divisions and resource scientists

National Training Programme on
'Rice-based cropping system'
02-09 August, 1999

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