CENTRAL RICE RESEARCH INSTITUTE
CUTTACK

केन्द्रीय धान अनुसंधान संस्थान
कटक

ANNUAL REPORT
1993-94

वार्षिक प्रतिवेदन

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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Annual Report of the year 1993-94

The Central Rice Research Institute, Cuttack, Orissa located in the heart land of the rice growing region of the eastern India, is a unit of the Indian Council of Agricultural Research, New Delhi.

Compiled and Edited by : K. V. S. R. K. Row
Santosh K. Mohanty
B.T.S. Moorthy
B.T. Rayudu

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FROM DIRECTOR'S DESK

The Institute continued its commitment to raise the productivity of rainfed rice lands with special emphasis to eastern Indian States. The research had to be more focussed to specific rainfed situtations in the uplands and lowlands. The cardinal issuses of hydrology and its diversity were examined in details to characterise the rice lands into mega, macro systems and farming situations with soil and biotic characteristics to focus research on each situation. The report embodies the results of research work organised by my colleague Dr. B. Venkateswarlu during his second year of stay at the Institute as the Director.

Six ecosystems viz. rainfed drylands, irrigated, shallow water (0-30 cm) intermediate lowlands (0-50cm) Semi deep, (0-100 cm) and deep water (above 100 cm) were finalised based on hydrology and Genetic Resources, Cropping systems and transfer of technology were indentified as special thrust areas. For each of these ecosystems and thrust areas research groups were identified alongwith a Ecosystem convenor.

Increased emphasis was provided for development for variety for semi-deep situations and work was also initiated in deep water situations for testing materials at Cuttack and undertaking crossing work so that seggregating materials are sent to different locations for assessment and selection.

Single factor demonstrations involving suitable rainfed lowland and upland varieties with high yield potential were conducted in Orissa State. Around 1400 demonstrations were organised in collaboration with the department of Agriculture, Orissa. The yields from these demonstrations ranged from 2 to 3.5 t/ha in rainfed drylands and 3.0 to 5.0 t/ha in shallow and intermediate lowlands. The demonstration amply proved that new materials for rainfed situation are now available which can raise productivity of these lands several fold just by

adoption of the variety. However, appropriate production technology can further help raise the productivity.

Considerable efforts were made to procure equipments and collection of material and samples for molecular characterisation of strains of blast and BLB and biotypes of gall midge.

The notable achievements during the period related to development of a rice-fish system for rainfed lowlands, which aims at conserving the environment as it encourages synergism between components and recycles the wastes of one another.

This report documents the endeavours of my colleagues made during the period between April 1993 to March, 1994. The findings are presented on an ecosystem basis, convering various aspects on crop improvement, crop management and crop protection.

K. C. Mathur

K. C. Mathur
Director (Acting)

MANAGEMENT COMMITTEE

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Central Rice Research Institute,
Cutttack, Orissa

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Sri B. Narendra Rao
Senior Administrative Officer
Central Rice Research Institute, Cuttack

WEATHER CONDITIONS

WEATHER CONDITIONS

CRRI, CUTTACK

The total rainfall during the year 1993 was 127 mm more than the average of previous 30 years (Table 1). Excepting June and August, the rainfall was below normal. Summer months (April and May) had a low relative humidity of 87 percent and high evaporation demand (7.3 and 7.5 mm/day) whereas rest of the year was characterised by a high relative humidity (89-93 percent) and low pan evaporation (2.7-5.9 mm/day) (Table 2).

A prolonged dry spell from May to mid-June followed by a sudden flooding immediately was the characteristic feature of the rainfall pattern during this year. The deficit rainfall 8-22 mm in the month of May resulted in inadequate land preparation and delayed sowings of rice in the rainfed areas. However, the crop sown between May 20-26 germinated well due to a light shower on May 26 but subsequently no rains occurred until June 15 resulting in the cracking of the soil crust, which was responsible for seedling emergence, and seedling mortality (locally called *Gajja marudi*).

Further, a total of 343 mm rainfall received with in 4 days during June 16-19 resulted in accumulation of water in lowland areas upto a depth 30 cm for more than 10 days. Such an aberrant condition of deficit moisture stress, immediately after germination and acute excess water stress at the early seedling stage (15 days after germination) led to a poor crop stand and significant losses in yield. Water level receded to below 15 cm by the end of June but rose abruptly again in the mid-July and first and third weeks of August. The crop transplanted in July-August was badly affected due to poor establishment and high seedling mortality because of higher water depth at planting. However, in some cases, the crop planted towards the end of August in deep water situation did show a better survival due to shallow water depth in the beginning of September.

The crop sown in the first fortnight of June generally failed completely as the land was flooded even before the seeds could germinate, although emergence of rice seedlings from the seeds sown in the first week of June was

Table 1. Rainfall (mm) for the year 1993, as compared to average rainfall of 30 years from 1963-1992

Period	Month	Average rainfall from 1963-1992	Rainfall during 1993	Deviation from normal
Winter	January	11	0	-11
	February	34	0	-34
	Total	45	0	-45
Pre-monsoon	March	39	10(2)	-29
	April	39	42(3)	+3
	May	73	49(5)	-24
	Total	151	101	-50
South-west monsoon	June	156	439(9)	+283
	July	352	324(10)	-28
	August	378	501 (15)	+123
	September	268	223 (15)	-45
	Total	1154	1487	+333
Post-monsoon	October	157	77(9)	-80
	November	33	7(1)	-26
	December	5	0	-5
	Total	195	84	-111
Grand Total		1545	1672	+127

Figures in parenthesis indicate number of rainy days.

Table -2 Weather data for Cuttack, 1993

Period	Month	Relative himidity (%)	Sunshine (hours/day)	Pan evaporation (mm)
Winter	January	90	8.0	3.3
	February	90	8.6	4.7
Pre-monsoon	March	89	8.1	5.9
	April	87	8.1	7.3
	May	87	8.5	7.5
South West monsoon	June	91	6.4	4.9
	July	92	3.1	2.9
	August	92	4.0	3.1
	September	93	4.2	3.8
Post monsoon	October	91	7.3	3.6
	November	89	7.3	3.1
	December	93	8.7	2.4

observed in some shallow lowland fields where water receded completely by the end of June. The popular lowland rice varieties, Gayatri, Panidhan and CR 260-77 showed 20-30 percent germination even when the seeds remained under the water for 10 days.

CRURRS, HAZARIBAG

The total rainfall during the year 1993 was 1347 mm (Table-3). No rainfall was recorded in the months of January, February and December. The maximum rainfall of 501.6 mm was recorded in the month of September and the minimum rainfall of 6 mm was recorded in the month of march. Maximum relative humidity of 78% was recorded in the month of August. Temperature reached maximum in the month of may (38.3°C) and minimum temperature was recorded in the month of January (6.0°C). The sunshine hours were recorded maximum (9.8 hrs.) in the month of May.

Table - 3 : Weather data for Hazaribag 1993

Month	Temperature		Humidity (%)	Sunshine hrs./day	Rainfall (mm)
	Max (°C)	Min (°C)			
January	22.2	6.0	73	9.3	0.0
February	28.1	10.8	56	9.5	0.0
March	30.5	13.8	43	8.3	6.0
April	36.4	18.8	38	9.2	15.8
May	38.3	22.4	27	9.8	49.0
June	34.5	23.0	55	7.0	232.8
July	30.9	23.2	69	6.3	206.7
August	29.9	22.5	78	4.3	132.4
September	28.4	21.7	77	4.0	501.6
October	29.5	18.0	51	9.0	33.6
November	26.4	11.1	37	8.8	15.8
December	22.4	6.1	32	8.7	0.0

INTRODUCTION

INTRODUCTION

Genesis

The Central Rice Research Institute was set up in 1946 at Cuttack with 60 hectares farm provided by the Government of Orissa with Dr. K. Ramiah as the first Director. The administrative control of the Institute was subsequently transferred to the Indian Council of Agricultural Research (ICAR) in 1966.

Location

The Central Rice Research Institute (CRRI) is located in Cuttack (20°N, 86°E) 23 m above mean sea level and about 410 km. south of Calcutta in the State of Orissa which is in the main rice growing tract of the country. The annual rainfall at Cuttack is about 1225-1575 mm and is mostly received during June to October from the south-west monsoon. The institute is situated 35 km from Bhubaneswar airport and 7 km from Cuttack railway station on Cuttack-Paradeep road.

Organisational Set Up

The Indian Council of Agricultural Research (ICAR) is headed by the Director General who is also the Secretary to the Department of Agricultural Research and Education of the Government of India. Crops Division of ICAR is headed by the Deputy Director General (Crops) who looks after crop institutes including the Central Rice Research Institute. CRRI has links with the Secretary, ICAR for the administrative purposes and the Agricultural Scientists Recruitment Board for the recruitment of scientific personnel.

The CRRI has been charged with the responsibility of conducting research on all aspects of rice and transfer of technology. The institute has a Management Committee for deciding the policies and administrative matters. The Institute is headed by the Director who is also the Chairman of the Management Committee. The Director executes the mandate of the institute through a fullfledged administrative set up and 12 divisions/ sections viz; Genetic Resources; Plant Breeding and Genetics; Agronomy; Physiology; Biochemistry; Soil Science and Microbiology; Plant Pathol-

ogy; Entomology; Agricultural Engineering; Extension,; Communication & Training; Agricultural Economics and Statistics and two sub-stations and 3 KVKs.

Sub Stations & KVKs

In order to involve directly in location specific research on rainfed rice, two sub-staitons, Central Rainfed Upland Rice Research Station at Hazaribag, Bihar in 1984 and Central Rainfed Lowland Rice Research Station at Kharagpur, West Bengal in 1986 have been established to tackle th problems of rainfed drylands and lowlands respectively. It is also proposed to establish a sub-station in Assam for catering to specific needs of rainfed rice. Further for self propelling the technology transfer the Krishi Vigyan Kendras function under this institute at Santhpur, Cuttack district. Angul district and Dhenkanal district have already been commissioned and work is in progress.

Sailent Achievements

The Institute has so far developed and released 48 high-yielding varieties of rice; of these, 22 are suitable for irrigated lands, 11 for rainfed drylands and 15 for rainfed lowlands. Amongst HYV's for irrigated lands, varieties viz, Ratna, Saket-4, Sarasa, Udaya and Moti are popularly grown by farmers and varieties viz, Heera, Kalinga-III, Neela, Vandana and Sneha are popularly grown in rainfed drylands. Varieties viz. Savitri, Gayatri, Dharitri, Tulasi, Panidhan and Lunisree are popular in rainfed lowlands. Varieties viz. Savitri and Dharitri possess very high yield potential up to 10 t/ha.

Present Status

Since the establishment of the Institute, field, laboratory, administrative and residential facilities have progressively increased. From a mere 60 ha land, the area of the experimental farm has increased to 102.20 ha, of which the cultivated area is 70.05 ha while roads, buildings, office and orchard occupy 26.56 ha area. The major source of irrigation for the farm is from a nearby Taladanda canal. For supplemental irrigation two tanks-Kanori and Patnayaka with an area of 5.60 ha and 8 tube wells are available in the farm. The tanks are also used for fish culture. The farm is divided into 15 blocks with well bunded and leveled plots. Field plots for the respective ecosystems were developed with suitable bunding as per the known heights.

Field experiments are conducted in these simulated plots representing irrigated, upland, shallow lowland and semi-deep water situations. Cemented tanks are constructed to simulate conditions of intermediate and semi-deep situations. A fish pond with a water area to two acres is developing in F block (F_5 and F_6) for studies on rice-cum-fish culture.

With the recruitment of scientific personnel, the demand for additional laboratory facilities grew, resulting in the addition of laboratory wing in 1958 and a new administrative and laboratory block in early 1980's. Simultaneously, the residential accommodation had also increased with the construction of staff quarters accommodating 300 families. The International Students Hostel was built in late 1950's to provide accommodation to research workers visiting this Institute on a short term basis.Later a Guest Hose, Scientists Home, Farmers Hostel were added during 1980s.

The green house facility for conducting experiments under controlled conditions was also expanded for all the disciplines. The number at present is twelve.

The institute had started functioning with few scientists and the strength of the scientific personnel gradually increased to 40 in 1960s and steeply to the present level of 170. The institute at present has principal scientists, senior scientists and scientists working on both fundamental of applied aspects of rice.

Our Mandate

* To increase productivity and sustainability of rice farmers by undertaking applied, strategic and basic research of rice ecosystems especially of eastern India

* To collect, preserve, evaluate and utilise the genetic resources for rice improvement

* To generate technology packages through interdisciplinary research and disseminate them

* To help, strengthen and intensity local/ regional rice research systems

* To work in collaboration with international programmes so as to accomplish the goals

Central Rice Research Institute, con-

sidering the cardinal issues of hydrology and its diversity, characterised the conditions into different ecologies and indicated the relevant mega, macro and micro farming situtions. Research programme is oriented suitably by addressing the sharp questions through multi-disciplinary teams consisting of 15 to 25 scientists called 'Ecosystem Groups' with Convenor for each. Thus, eight ecosystems are formed like dryland, irrigated, shallow water (0-30 cm), intermediate lowland (0-50 cm) semideep (0-100 cm) and deep water (> 100 cm). Genetic Resources, Rice based cropping systems and transfer of technology are added to support and strengthen them.

RICE GERMPLASM

RICE GERMPLASM

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- Screening of scented varieties against BPH, GM & YSB
- Screening of varieties against nematodes
- Screening of germplasm against RTV
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- Preliminary evaluation of fixed cultures for Boro rice
- Assessment of breeding materials received from different centres

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- Foundation seed
- Breeder seed
- Nucleus seed

EXPLORATION AND COLLECTION

An exploration and collection programme for primitive cultivars of Kalahandi district of Orissa was organised in collaboration with M.S.S. Research Foundation, Madras. A total of 45 samples were collected from mangrove areas of Rajnagar block and Kalahandi district. Some of the distinct cultivars are Raspanjari, SolaLeelabati, Bhundi, Haldigundi, Rangalata, Asamchudi, Kalama etc.

A special mission was made to collect wild rice, *Porteresia coarctata* from the estuarine tidal swamps of Bhitarkanika National Park. So far eight samples of *Porteresia coarctata* were collected and are being maintained in the net house.

Germplasm enrichment in the Gene bank was initiated through exchange programme with Directorate of Agriculture, Govt. of Orissa.

At the Institute an "Oryza Garden" has been developed and different wild species of Genus-Oryza are being maintained.

Seventeen land races were collected from 24-Paraganas district of West Bengal. These are Khejurchor, Lilabati, Patnai-23, Gopalbhog, Panikalas, Chutigeti, Sadamota, Kalomota, Bhudi, Nanki, Patnai, Sabita patnai, Dudhsar, Velki, Saruchini, Batasi and Baggi. Most of these could not be evaluated because these are too late ones wild rice yet to be identified has been collected from Balarampur farm are at Central Rainfed Lowland Rice Station at Kharagpur.

Forty new collections were added to the genetic stock in 1993, making a total of 665 rice collections.

Germplasm Collection

Forty new upland rice collections were added to the genetic stock of 625 accessions maintained at CRURRS, Hazaribag. (Table-1)

Table-1 : Upland rice germplasm collections at Central Rainfed Upland Rice Research Station, Hazaribagh

Collection	No.
Exotic collections	71
Indigenous collctions	554
(a) Uplands	354
Gora rices	151
Others	203
(b) Bunded uplands	200
Collections during 1993	40
Total	665

CHARACTERISATION AND EVALUATION

Yield Potential

Characterisation of 2000 accessions of scented and exotic rice germplasm was done in the field for their morpho-agronomic characters. Post harvest characterisation data were recorded in the laboratory. During rabi season only donors and high yielding varieties were grown for exhibition/demonstration purpose. Sixteen *japonica* varieties were grown to screen their yield potential. Two of them were found to yield 5 t/ha with 90 days duration.

Seed viability

The seeds of 3 rice varieties from 3 maturity groups viz. PTB 10 (early), T 141 (medium) and T 1242 (late) were preserved during wet season 1964 at 5°C and 40% R.H. They have been found to be viable for last 29 years. The experiment is in progress.

Screening of varieties against BPH

Five hundred eight varieties received from Genetic stock were screened against BPH under manual infestation, of these Shul, Bahalmali, Kendrapria china, Kandu phool, Basamata, Kakdi munj, ARC 15831, AC 1789, Kusuma, MNP 709 were found to be moderately resistant.

Sreening of scented varieties against BPH, GM and YSB

Two hundred scented varieties have been screened against BPH in the green house and 24 varieties were found to be resistant (0 to 9 grade) taking TN1 as susceptible and velluthicheera as resistant checks.

Screening of varieties against nematodes.

White-tip nematode *(Aphelenchoides besseyi)*

One hundred seeds of each of the 424 rice varieties collected from Genetic Resources were examined for the seed borne nematodes. The nemotade population ranged from 0 to 853 nemas/100 grains.

Basing on population level, 159 varieties were classified as resistant (less than 10 nemas), 137 varieties moderately susceptible (less than 50 nemas) and 128 susceptible (50 and above) to this nematode.

Root-knot nematode *(Meloidigyne graminicola)*

Four hundred and eleven rice varieties collected were screened against the root-knot nematode under artificial inoculation in net house. Among these 12 varieties SSM 630, SSM 735, SSM 766, SSM820, SSM 826, SSM 827, SSM 835, SSM 836, SSM 839, SSM 853 and SSM 977 were found resistant; 184 moderately susceptible and 215 highly susceptible based on root gall index.

Screening for rice-root nematode *(Hirschmaniella mucronata)*

Out of 347 rice varieties tested, only i.e. SSM 739 was found resistant, which 115 varieties were moderately susceptible and 231 highly susceptible based on the nematode population in roots.

Screening of rice germplasm against RTV

During Wet season RTV occured in the germplasm under natural conditions. Karnasail, Badshabhog, Katharibhog, Swarna, IET 9188, Bombaimugi, Khejurchor were found tolerant to RTV syndrome.

Generation of breeding materials and selections in segregating populations

During Wet season, Nine crosses were attempted involving parents CPK1 21, IR 36, IR 64, Salivahana, Mansarovar, Padmini and Khejurchor. Two hundred fixed cultures were advanced from the crosses attempted during previous years. The segregating lines were notified based on the duration for the season aman, boro etc. These will be tested for their suitability under such situations.

Preliminary evaluation of fixed cultures

Among the fourteen entries developed from the cross Pankaj/Kabirajsail (Table -2) CRK1 21, CRK1 19, CRK1 8, CRK1 18 were found better than their parents. The height was reduced enhancing lodging resistance at harvest. The duration ranged from 135 to 155 days.

Out of sixty one fixed cultures developed, 12 cultures yielded more than 4 t/ha. However many them were slitghtly late for land situations in Kharagpur region. The performance

Table 2 : Performance of some lines developed from Pankaj/ Kabirajsail crosses

Entries	Height (cm)	Duration (days)	Yield (t/ha)
CRK1-27	127	145	3.75
CRK1-21	125	150	4.00
CRK1 -23	125	140	3.50
CRK1 -22	125	140	3.50
CRK1 -19	125	140	4.23
CRK1 -18	130	145	2.36
CRK1 -8	122	145	4.75
CRK1 -1	130	135	4.76
CRK1 -13	125	145	2.06
CRK1 -92	145	160	3.60
CRK1 -47	140	150	3.35
CRK1 -18	130	150	4.90
Pankaj	120	140	4.00
Kabirajsail	140	150	1.80
C.D. (5 %)	-	-	0.83

of elite lines is given in Table-3. The yields ranged from 4 to 4.7 t/ha in all the cultures.

Preliminary evaluation of fixed cultures for *Boro* rice

Twenty three early cultures along-

Table-3 : Performance of elite cultures

Entry No.	Parentage	Height (cm)	Duration (days)	Yield (t/ha)
LT-29	Janaki	135	140	4.4
LT-41	Tilok-kachhari/CR1018	155	150	4.4
LT-II	IR 42/IR III414	10	150	4.6
LT-23	CR1002/IR 36	120	155	4.6
LT-19	IR 34/CR 149	120	150	4.1
LT-45	CTC Chandi/CR 1018	145	155	4.0
LT-10	HM/CR 1009	120	160	4.7
LT-64	HM/CR 1009	120	155	4.4
LT-54	Jaladhi/CR 1018	120	150	4.1
LT-74	Tilakkachhari/CR1018	120	160	4.2
S-214	Pankaj/Hathipanjara	150	175	4.1
CRK-3-P	HM/CR 1009	130	106	4.5

with IR-36 as check were evaluated for yield.

The cultures Sattari, IIR8, IR42 S, CR 380-22 performed well. However none of the entries had yield more than 3 t/ha. This is because the entries flowered at the time of rain during October.

Assessment of breeding materials received from CRRI and other centres

Forty elite entries identified during wet season 92 were evaluated. The yield of selected promising entries are given in Table - 4. The yields ranged from 2.9 to 5.0 t/ha. in these cultures.

Characterization and cataloguing of 131 gora rices for 60 agro-morphological characters have been completed. Two hundred and fifty breeding lines including 180 indica and 70 japonica types were evaluated under moisture stress; 55 promising lines were selected for further study. Japonicas generally had higher grain number and lower sterility under moisture stress.

MAINTENANCE AND MULTIPLICATION OF SEED

Seed rejuvenation, characterisation and evaluation

During wet season 1993, a total of 12,000 accessions of rice germplasm collections were grown in the field for

Table - 4 : The Yield of promising entries

Entry	Height (cm)	Duration (days)	Yield (t/ha)
BKS 64	130	150	4.21
CR 629-249	135	155	3.0
BKS 10	155	145	2.9
IET 9188	155	145	4.1
IET 11183	160	160	3.25
CN 845-125-1254	165	145	4.5
CN 977	140	160	3.4
CR 1006	100	160	5.0

maintenance, seed increase, seed supply and gene bank deposit at the National Active Collection Center. A total of 2586 accessions of rice germplasm were supplied to the researchers all over the country.

Foundation Seed

Under the National Seed Project, the national requirement of breeder seed of rice as scheduled by the council was produced and supplied to the National Seed Corporation, State Seed Corporations, State Farms Corporations and other seed agencies for production of foundation seed.

Breeder seed

A total of 5536 kg breeder seed of 30 improved rice varieties was produced in dry and wet seasons of 1993-94. The crops were certified by the National Seed Monitoring Team. (Table 5)

Table-5: Production of breeder seed of rice varieties, 1993-94.

Variety	Quantity(kg)
Annada	809
Basmati 385 *	26
Basmati Haryana *	11
Basmati Ranbir *	15
Basmati Pusa *++	10
CR 1002	42
CR 1006	77
CR 1010	108
CR 1011	110
CR 1014	14
Dharitri	188
Gaurav	28
Gayatri	217
Heera	284
IR 36	811
IR 64 ++	84
Kalinga III	562
Kasturi *++	28
Lunisri	288
Moti	70
Padmini	85
Panidhan	39
PR 106 ++	155
PR 109	58
Ratna	509
Savitri	80
Tulasi	37
Utkalprabha	481
Vanaprabha	224
Vandana	86
Total	5536

Scented rice, ++ Export quality rice, *++ Scented export quality rice.

A total of 5416 kg breeder seed of 24 varieties was supplied to the State Seed Corporations of Maharastra, Orissa, West Bengal and Bihar (Table-6)

Table-6 : Distribution of breeder's seed in 1993-94

Variety	Quantity (kg) supplied	Agencies
Annada	828	Orissa(OR) West Bengal (WB) Andhra Pradesh (A.P)
Basmati (Haryana)	11	OR
Basmati (Ranbir)	13	OR
Basmati (Pusa)	30	OR, Maharashtra (MR)
CR 1002	30	OR, WB
CR 1006	5	WB
CR 1010	5	WB
CR 1011	9	OR, WB
CR 1014	15	OR,WB
Dharitri	145	OR,WB
Gaurav	25	OR,WB
Gayatri	222	OR,WB
Heera	276	OR, WB, Bihar (BR)
IR 36	804	OR, WB, MR
IR 64	83	OR, MR
Kalinga-3	563	R, WB, MR, A.P
Kasturi	28	OR
Lunisri	280	OR
Moti	70	OR
Padmini	85	MR
Panidhan	28	OR
PR 106	69	OR
PR 109	45	OR
Ratna	302	OR, WB
Savitri	315	OR,WB,Tamil Nadu(TN)
Seema	42	OR
Tulasi	328	OR
Utkalprabha	489	OR
Vandana	71	OR
Total	5416 kg.	

Nucleus seed.

A totly 239 kg nucleus seed of 56 rice varieties (Table 7) was produced and 124 packets of nucleus seeds were distributed in Andhra Pradesh, Maharashtra and Orissa.

Traditional rice vareties of National Germplasm Collection were grown in the field under direct seeded condition in wet season 1993 for rejuvenation, verification of gentic purity and seed increase for supply to research workers. A duplicate set of these varieties has been conserved at long-term storage, NBPGR, New Delhi.

Table-7 : Production and distribution of nucleus seed of rice varieties in 1993-94.

Annada	Heera	Lunishri	Samlei
Basmati 370 *	Indira	Mahsuri	Sarasa
Basmati 385 *	IR 84	Moti	Sattari
Basmati (Haryana)*	IR 36	Neela	Savitri
Basmati (Pusa)*	IR 64	Padmini	Seema
Basmati (Ranbir)*	Jagannath	Pallavi	Supriya
CR 1002	Jaya	Panidhan	Swarnadhan
CR 1006	Kalasri	Pankaj	Swarnaprabha
CR 1010	Kalinga-1	PNR 546	Tulasi
CR 1011	Kalinga -2	PR 106	Tulsi
CR 1014	Kalinga -3	PR 109	Manjari*
Dharitri	Kalyani -II	Rasi	Udaya
Gaurav*	Kasturi*	Ratna	Utkalprabha
Gayatri	Kshira	Saket-4	Vanaprabha
			Vandana

* *Scented rice varieties*

DRYLAND ECOSYSTEM

DRYLAND ECOSYSTEM

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CROP IMPROVEMENT

Extra early cultures for bunded uplands

Two extra early lines viz. CR 544-1-3-4 and Heera Nx (82 days) were found suitable for normal and late sowing conditions, with an average yield of 4 t/ha each. The line CR 544-1-3-4 (Dhala Heera) was found resistant to gall midge, blast and RTV and is suitable for post flood conditions. A natural cross of Heera (Heera NX) having semi-tall stature (110-115 cm), high biomass production and long slender grains was identified suitable for bunded uplands.

Evaluation of advanced breeding cultures

Five upland rice cultures viz. RR 50-5, RR 51-1, RR 151-3, RR 165-1160 and RR 166-645 are in pipeline for release by State/Central Variety Release Committees (Table-1). These fulfill the needs of different toposequences with an advantage over local/improved check varieties in terms of grain yield and tolerance to biotic stresses. In addition three cultures RR 174-1, RR 222-1 and RR 218-68 were found to be most promising amongst the 24 advanced breeding lines in the observation nursery. The culture RR 226-49 was identified as the earliest amongst them with a total duration of 72 days.

Evaluation of fixed cultures and new selections

Two mutant lines of Kalinga III with high level of blast resistance and seven improved grain mutants of Brown gora and Annada were identified as promising in yields. Short statured mutants of Kalamadani recovered from M^2 generation of EMS-treated progenies, were purified and selections were made for earliness.

Breeding lines proposed for release

Three cultures viz. CR 314-5-10, CR 314-5-3 and RR 52-1 (Table-2) were proposed for release through Central Variety Release Committee for Punjab, Maharashtra and North-Eastern region. These cultures consistently exhibited their superiority over local/high yielding check varieties.

Among the advanced breeding lines the selection RR 139-1 (IET No 12518) had shown resistance to foliar blast consistently at Hazaribag and was reported resistant at more than 75%

Table - 2 : Varieties for proposed for release medium lands, 1993

Designation	Parentage	Plant type	Duration (days)	Grain type	Yield potential (t/ha)	Area of adaptability	Reaction to diseases and inseets
RR 52-1 (IET 9315)	CR 188-10/ Idira	SD	115-120	LB	4-4.5	North-Eastern hill region	MR to blast, BLB, Br.sp. of & Tungro; R to gall midge, MR to stemborer and whorl moggot
CR 314-5-10 (IET 8707)	IR 42/ IR 5853-118-5	SD	115-120	LS	4-5.0	Punjab & Blast endeimic areas of Maharashtra	R to blast, MR to BLB, B. spot, sheath rot; R to stem borer, WBPH, & rice hispa
CR 314-5-3	IR 42/	SD	115-120	LS	4-5.0	Punjab & Maharashtra	R to BLB, blast and MR to Br. spot, R to gall midge & WBPH

Table - 1 : Varieties proposed for release for rainfed uplands

Designation	Parentage	Plant type	Duration (days)	Grain type	Yield potential (t/ha)	Area of adaptability	Reaction to diseases and in
RR 50-5 IET 13627	IET 2232 CR 245-1	SD	80-85	MS	3.0-3.5	Uplands and medium lands of Orissa	MR to RTV, brown spot, Blast, BLS and sheath rot, MR to gall midge, WE, LF & termites R to BPH
RR 51-1 (IET 8675)	ARC 6650/T(N)1/ Mudgo/PTB	SD	95-100	LB	4.0	Maharashtra	R to Br. spot & MR to blast, R to stem borer rice hispa and caseworm
RR 151-3 (IET 13628)	C 22/N22	T	85-90	LB	2.5-3.5	Tarn lands of Chotanagpur	R to RTV, leaf blast, BLB, Br. spot, & sheath rot, MR to gall midge, WE, LF & termite
RR 165-1160 (IET 12305)	C 22/Annada	T	95-110	LB	2.5-4.0	Upper don lands of Chota nagpur.	R to Br. spot, R to Gundhi bug and MR to white ants.
RR 166-645 (IET 12696)	C 22/CR 289-1208	T	90-100	LS	2.5-3.5	-do-	HR to blast, br. spot, MR to sheath blight, & sheath rot. MR to BPH, WBPH, gall midge and WE

SD = Semi-dwarf
T = Tall
MS = Medium slender
LB = Long bold
LS = Long slender

BLB = Bacterial leaf blight
BLS = Bacterial leaf streak
RTV = Rice tangro virus
WE = White earhead
EF = Leaf folder
BPH = Brown slant hopper

WBPA = White backed plant hopper
LF = Leaf folder
R = Restitant
MR = Moderately resistant
HR = Highly resistant

locations in the national screening trials. In addition to NSN I the lines RR 19-2-2 and RR 36-141 (tall cultures) also were found resistant to blast, brown spot and gundhi bug.

The lines RR 203-16 (IET 13630) and RR 151-3 (IET 13628) were promoted to AYT (VE) based on their superior performance in IYT (VE) at several upland locations in coordinated trials of DRR. The entry RR 217-1 (IET No. 13697) was found resistant to blast, bacterial blight, gall midge biotype 1, stem borer and leaf folder and promoted to AYT-IME.

Genetics of resistance to brown spot

Genetics of resistance to brown spot was studied in six crosses involving RR 35-4-1, RR 20-5 and RR 36-141 as resistant parents and RR 159-90 as the susceptible parent. Resistance to brown spot is governed by two genes; RR 35-4-1, RR 20-5 and RR 36-141 each have single recessive gene governing resistance but the gene in RR 20-5 and RR 36-141 is different from the gene present in RR 35-4-1 (Table 3).

Genotypic variations for physiological traits

Genetic variability, heritability in the broad sense and expected genetic advance under selection for nine physiological traits were studied in 22 upland rice genotypes. Maximum genetic variability was recorded for crop growth rate and relative growth rate. Variations were large for most of the char-

Table - 3 : Genetics of resistance to brown spot in six crosses

Cross			F_1	F_2 ratio
RR 35-4-1	x	RR 159-90	S	3 (S) : 1 (R)
RR 20-5	x	RR 159-90	S	3 (S) : 1 (R)
RR 35-141	x	RR 159-90	S	3 (S) : 1 (R)
RR 25-4-1	x	RR 20-5	S	15 (S): 1 (R)
RR 20-5	x	RR 36-141	R	All resistant
RR 35-4-1	x	RR 36-141	S	15 (S) : 1 (R)

acters but the estimates were also affected by the growing seasons. Crop growth rate, relative growth rate, net assimilation rate, specific leaf weight and area were having high heritability values consistently (75%) whereas total dry matter, leaf area ratio, leaf area index and harvest index showed variable estimates. High heritability values were associated with high genetic advance for crop growth rate, relative growth rate, net assimilation rate, specific leaf area and weight indicating predominance of additive gene effects.

Pattern of variations for physiological growth parameters at different growth stages was also studied in seven improved cultivars and were compared with the traditional Brown gora. The variety Brown gora had the highest dry matter accumulation but the improved cultivars had higher harvest index. In another study, eleven upland rice genotypes of varying growth duration and plant stature were evaluated in two cropping systems viz., monocropping and intercropping with pigeonpea cv UPAS 120. Cropping system and cropping system x genotype interaction effects were significant for yield, panicle weight, panicles/m^2 and spikelet fertility.

Drought effects on different phases of crop growth

Seedlings : Eleven upland rice genotypes were evaluated for water loss during rolling in detached leaves under laboratory conditions. Varietal differences were observed for percent water loss during rolling, water loss per minute and time taken for the water loss. Highest (16%) and lowest (10.03%) percentage of water loss were observed during rolling in genotypes, Salumpikit and Dehula respectively. The culture CR 143-2-2 took maximum time (173 min.) in leaf rolling while leaves Dehula rolled quickly (92.6 min.). Percent loss of water per minute during rolling in variety showed a close association with scoring methods for drought tolerance in the field.

Flag leaf : Drought tolerant Moroberekan, CR 143-2-2 and Annada took more time for complete rolling as compared to the susceptible genotypes Cauvery and Brown gora but the quantity of water loss during rolling was higher in the other genotypes. The susceptible genotypes had a higher rate of transpiration after rolling. Delayed rolling was associated with quick unrolling in the tolerant genotypes.

Flowering : Moisture stress was induced at flowering in five genotypes (Lalnakanda 41, CO13, Salumpikit, Annada and Cauvery) and the factors responsible were found to be the genotypes and flowering periods. The leaves rolled at a soil moisture percentage of 6.33, 7.35, 7.79, 8.70 and 10.20 in Salumpikit, Lalnakanda 41, Cauvery Annada and CO 13 respectively. Spikelet opening was also inhibited at these respective moisture levels in these genotypes. Flowering 1-2 days prior to rolling induced high sterility in Lalnakanda 41, Salumpikit and CO 13 while Salumpikit, CO 13 and Cauvery showed high grain sterility when flowered immediately after redemption of stress. Lalnakanda 41 and Annada did not show any effect on grain fertility in those panicles which flowered six days after redemption of stess compared to CO 13 in which grain fertility was reduced to 50%.

Reproductive phase : Effect of moisture stress at reproductive phase was studied in five upland rice genotypes. Leaf rolling occurred when soil moisture ranged from 6.35 (Salumpikit) to 10.21% (Co 13). Spikelet opening was also inhibited at the same moisture levels in these varieties. Depending on whether stress occurred before or after flowering, reduction in grain fertility varied among the genotypes. Lalnakanda 41 did not show reduction in grain fertility when flowering occurred six days after relieving stress. Rate of water loss during rolling in detached seedlings was maximum in Cauvery and minimum in CR 143 2-2.

Root Zone : Relative contribution of roots to drought tolerance at specified depths was also studied at reproductive phase. Roots in the 0-30 cm zone contributed 76.7% of the total dry matter under stressed as well as non-stressed soils. Brown gora, Vandana and N 22 had slightly higher percent root dry matter in the deeper zone (75-90 cm). Drought also induced the production of thicker roots in this zone. Thick roots were mainly restricted to the 45 cm depth under non-stressed soils while under stress, thick roots were observed upto 75 cm depth in drought tolerant genotypes. However these effects were not observed on drought tolerant CR 143-2-2- but it recorded minimum soil moisture depletion under stress indicating that water economy in this variety is a consequence of shoot characteristics.

CROP MANAGEMENT

Soil fertility and tillage effect

Long term manurial and tillage effects revealed that a combination of inorganic and organic fertilizers (2.5 t/ha FYM + 40:30:20 NPK/ha) ever year and conventional tillage (summer ploughing with country plough and 2-3 preparatory tillage after pre-monsoon showers) was superior to inorganic fertilizers and deep or minimum tillage.

Returning the crop residue to soil alone increased upland rice yields singificantly and consistently. Optimization of pH through liming @ 0.5 t/ha, gave promising results. Application of N in conjunction with lime yielded similar to the application of N with P and K, and was significantly superior to application of N alone. Drilling phosphorus was superior to broadcast application or soil incorporation of Mussoorie Rock Phosphate was as good as SSP and had advantage over SSP in reducing weed growth in acidic spils.

Soil fertility management in acid soils

A long-term fixed plot experiment with Nitrogen (N), Phosphorus (P), Potash (K) and lime (L) was continued for the third year. Treatment combinations were N, NP, NK, NL, NPK and NPKL with two controls. All the combintatins along with one control received the entire crop residue of the previous year. N, P, K and L were used @ 60, 40, 30 and 1000 kg/ha, respectively.

Return of entire amount of crop residue to respective plots siginificantly increased the grain yields. Combination of NPKL recorded the highest (2.07 t/ha) grain yield, statistically at par with the combinations NK, NL and NPK (1.91 to 1.94 t/ha). All these tratments had significantly higher grain yield over N 91.75 t/ha) and NP (1.76 t/ha).

Effect of source and method of P application and P use efficiency

A fixed plot experiment in acidic soil (pH 5.5) was continued for the third consecutive year. Broadcast and drilled application of different sources of P were made. The treatments included single superphosphate (SSP), Mussoorie Rock Phosphate (MRP), mixture of SSP and MRP in 1:1 ratio, SSP 1.0 t/ha with lime, SSP with 2.5 t/ha FYM and residual effect of DAP applied in the first year with neces-

sary adjustment to supply 30 kg P_2O_5/ ha.

Drilling of P recorded higher grain yield over broadcast application but the difference was non-significant. Among different sources of phosphorus MRP recorded the highest grain yield. It was significantly higher than all other sources except SSP + FYM. Residual effect of DAP became incident in the second year. MRP not only gave higher grain yield but also reduced the growth of weeds as compared to SSP. Moreover, unit cost of P through MRP was 0.75 times the cost of SSP.

Effect of liming on upland rice productivity:

The experimental plots were limed @ 0, 500, 1000, 1500, 2000 and 2500 kg/ha, 15 days before seeding.Rice variety Vandana was the test crop. Nitrogen, Phosphorus and Potash were applied (as urea, SSP and MOP) @ 40, 30 and 20 kg/ha respectively. The increase in grain yield was significant only upto 500 kg lime/ha and upto 1000 kg/ha lime for straw yield.

Long term manurial trial

Sixteen combinations of FYM (2.5 and 5 t/ha) and NPK (40:30:20 and 20:15:10) along with control were tested a fixed plot for evaluating the effects of organic and inorganic manures alone and in combination with Vandana as the test variety. Grain and straw yield defferences were significant. Maximum grain yield was recorded when inorganic fertilizer was applied alongwith 2.5 t/ha FYM and maximum straw yield when 5 t/ha of FYM was applied.

Effect of tillage systems on rice productivity

Effect of tillage was evaluated in the third year in fixed field plots with minimum, conventional and deep tillage systems using Vandana as the test variety. Phosphorus @ 30 kg/ha was applied alone in the form of SSP or incubated with FYM (1:2 SSP: FYM and 1:4 SSP:FYM) for 72 hours and band-placed in seed furrows. Grain yield was maximum in conventional tillage with application of FYM incubated P (1:2) while maximum straw yield was recorded in deep tillage with the same phosphorus treatment.

Effective root depth was reduced from 30-35 cm (1993) to 15-20 cm (1992) as a consequence of drought/ rainless periods during growth. Moisture content of soil and bulk density measured after 1, 11 and 13 days after

precipitation showed that bulk density increased with increasing soil moisture content (Table 4).

Utilization of beneficial microflora (VAM) for upland rice improvement

Genotypic differences in colonizaion:

Native VAM colonization was estimate in (i) traditional rices including local land races, few other indigenous upland genotypes and (ii) improved

Table - 4 : Changes in soil moisutre content and bulk density in different tillage systems and moisture levels

Tillage methods	Depth (cm)					
	10	20	40	10	20	40
	(Moisture content) %			(Bulk density) g/cc		
				1 day after precipitation		
Minimum	16.8	-	-	1.69	-	-
Conventional	18.3	-	-	1.65	-	-
Deep	18.2	-	-	1.61	-	-
				11 days after prcipitation		
Minimum	9.9	19.5	21.0	1.37	1.42	1.50
Conventional	11.9	20.4	22.6	1.41	1.48	1.52
Deep	11.7	19.6	21.8	1.41	1.53	1.55
				13 days after precipitation		
Minimum	8.7	18.1	20.4	1.40	1.29	1.31
Conventional	10.5	17.8	22.1	1.37	1.48	1.43
Deep	10.5	18.5	21.1	1.31	1.44	1.54

upland rice varieties. Traditional rices had higher colonisation than improved types. The differences were statistically significant in case of local land races (Table 5). The specificity for gora rices (land races) might be the result of a long term, selective assso-ciation between the two symbionts.

Exploratory survey of VAM in the upland ecosystem

Glomus acoulospora were the predominant VAM genera identified in the upland ecosystem. Natural colonization of upland rice, pigeonpea and other legumes and several upland weeds have been documented. Leguminous crops had higher colonization; rice grown under intercropping also had higher colonization; than monocropped rice. VAM fungi were found to survive in the off-season colonizing roots of *Euphorbia hirta* and *Richhardia sp.*

Enhancement of VAM population

Intercropping rice with pigeonpea, sequence cropping of upland rice and oil seed crops and different schedules of summer ploughing were examined for their effects on changes in VAM colonization intensity. Sequence cropping had no advantage over monocropping of upland rice but intercropping sustained the colonization of VAM. (*Fig 1*).

Development of water management structure in uplands

A water harvesting structure of capacity 40 m^3 was constructed with LDPE film lining all along. The water was collected from 0.3 ha land. The collected water was utilised to produce a good tomato crop with yield (44 t/ha) in an area of 286 m^2. The percolation loss was nil. Evaporation varies from 1.5 mm/day to 12 mm/day.

Quality characteristics of upland rice varieties

Rice varieties Kalinga III, Sarasa and Ratna were grown in dry season 1993 at CRRI farm and the quality characteristics of these varities were studied. Among the varieties Kalinga III and Sarasa had a kernel length of 6.79 mm and 6.73 mm which were nearer to Ratna (6.71 mm). The head rice recovery in these varities was 43.0% and 49.5% respectively and was lower than those of Ratna. The cooking quality parameters such as alkali value, amylose content and other characters, are nearer to Ratna. All the varieties exhibited high amylose content. (Table 6).

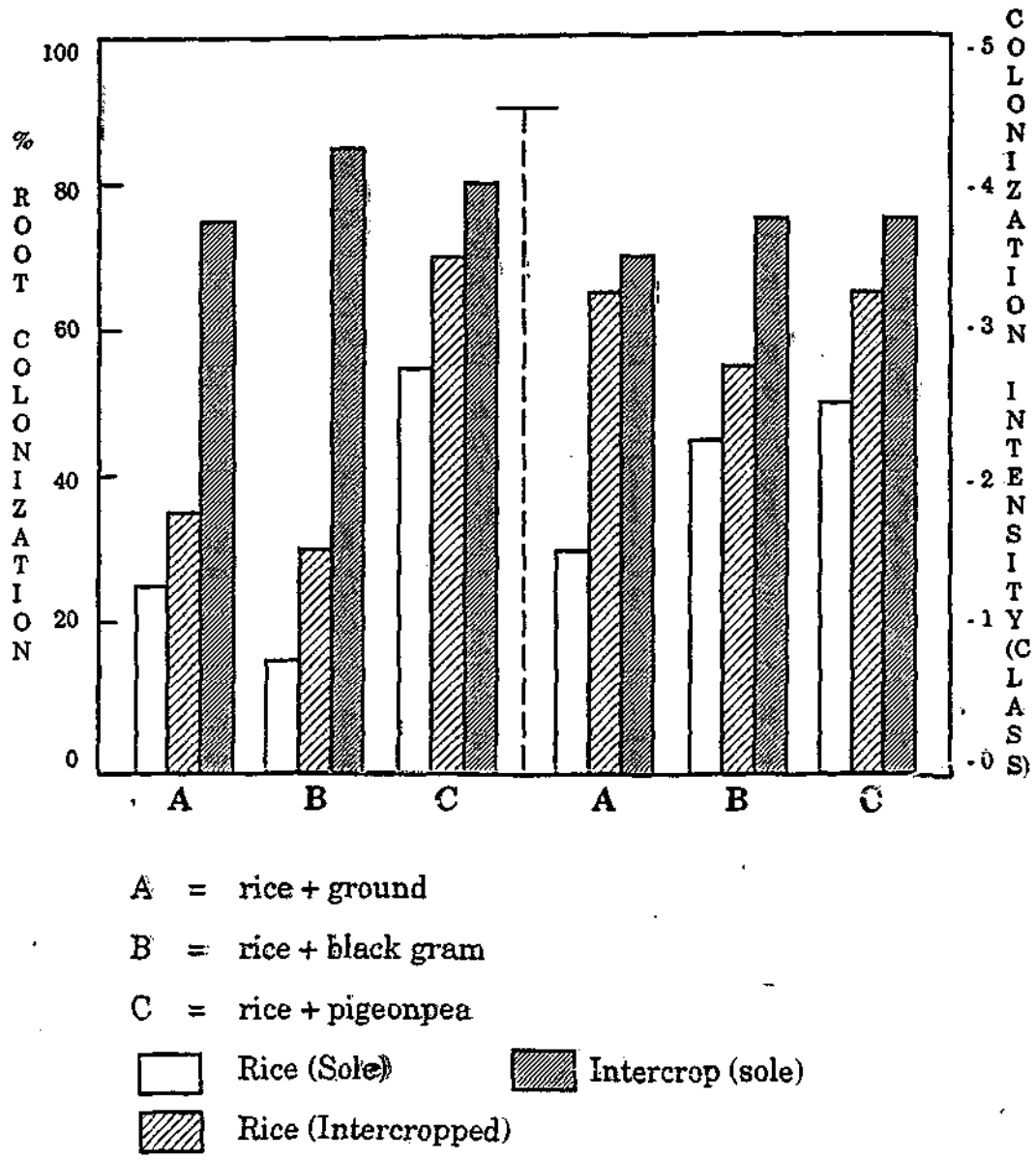

Fig. 1 : Incidence and intensity of colonization by native VAM in rice and legumes root under uplands

Table - 5 : Variation in colonization by native VAM in different rice varieties

Variety	Percent root[1] colonization (%)	Colonization[2] intensity (class value)
Local land races (upland)		
Brown gora	90.5 de	3.48 e
Black gora	97.8 e	4.37 f
White gora	87.5 cd	3.18 de
Other indigenous types/land races (medium land)		
N 22	80.4 bcd	2.30 bc
Kalakeri	83.4 bcd	2.01 ab
Jonga	83.8 bcd	2.70 cd
Improved/modern varities		
Vandana	45.9 a	1.59 a
RR 174-1	68.8 b	2.60 c
RR 20-5	66.7 ab	2.28 bc
Kalinga III	70.4 bc	2.43 bc
Sattari	63.8 ab	2.20 bc
Kalyani II	65.0 ab	2.56 bc

1 Mean of three replications

2 Scoring on 1-5 (1= 1-20%, 2=21-40%, 3=41-60%, 4=61-80%, 5 = 81-100%)

Mean as in a column followed by similar letters are statistically not significant at P = 0.05

Table 6. Quality characteristics of three promising upland varieties

Variety	Length (mm) (%)	Head rice (%)	Alkali value	Amylose (%)	Elongation ratio	Class
Kalinga III	6.794	49.0	6.5	25.70	1.68	LS
Sarasa	6.734	49.5	6.0	25.00	1.63	LB
Ratna	6.714	51.5	6.0*	25.70	1.64	LS

CROP PROTECTION

Weed Management

Crop-weed competition

A study was conducted at CRRI Cuttack (bunded uplands) during wet season to find out the effect of different periods of weed removal and weed competition on two upland rice varieties - Annada (semi-dwarf) and Heera (dwarf) under wet-sown condition. The loss in grain yield of Annada due to weed competition throughout crop growth and upto 60 and 30 days after sowing was 29.4, 26.3 and 16%, respectively. The grain yield of Heera in the corresponding treatments was reduced by 35.2, 31.7 and 22.9%, respectively. The increase in yield over unweeded control due to weed removal during the first 30 and 60 days and throughout the crop growth was 14.3, 29.8 and 41.7% in variety Annada and 33.2, 47.3 and 54.3% in the variety Heera, respectively.

Long term effect of weed control *treatments on shift of weed flora:*

The experiment was conducted at Hazaribag for the third year of succession in a fixed plot using no-weeding and twice hand-weeding as checks, butachlor (2.0 kg and 1.5 kg/ha), pretilachlor (1.0 kg/ha) and pendimethalin alone (2.0 kg and 1.5 kg/ha) as well as in combination with 2,4-D Na (@ 1.5 kg pendimethalin + 0.6 kg/ha of 2,4-D Na) were compared for their efficiancy.

Herbicides were effective against weeds and less toxic to crop when there was sufficient soil moisture at the time of spraying. Hand-weeding twice produced higher grain yield than the other treatments. Herbicide treatments

resulted in higher grain yields in the first year (1991) but in subsequent years yield were significantly reduced possibly due to weed build-up in subsequent years. Butachlor and pretilachlor treated plots had a build-up of *Echinochloa colona* whereas Pendimethalin treated plots had profuse growth of *Cyperus* sp. and *Ageratum conyzoides.*

Chemical weed control : New formulations

Liquid formulations of anilophos (0.4 and 0.6 kg/ha), butachlor (1.0 and 1.5 kg/ha) and pendimethalin (1.0 and 1.5 kg/ha) alone and their lower dose in combination with 2,4-D Na @ 0.6 kg/ha were compared with weed-free, twice-hand-weeding, stale seed bed and no-weeding treatment at Hazaribag. Early post emergence application of anilophos @ 0.6 kg/ha produced the highest grain yield and recorded lowest crop toxicity. Combining 2,4-D Na with the other herbicides did not give any yield advantage.

With a view to find out an effective weed management schedule for upland rice, a field experiment involving eight treatments comprising unweeded and hand-weeded checks, preemergence application of butachlor (1.0 kg/ha) and anilophos (0.6 kg/ha) in a single dose 6 days after sowing (DAS) or in two equal splits 6 and 20 DAS following a raking operation, raking once 20 DAS followed by hand weeding and raking twice 20 and 35 DAS followed by hand weeding was conducted using variety Annada at CRRI, Cuttack. Sprouted seeds were sown on the wet soil on 7 July as dry sowing in June was not possible due to continuous rains. *Cyperus iria* was found to be the most predominant weed. Results indicated that, in terms of weed control efficiency and grain yield, split application of butachlor coupled with raking operation was at par with hand-weeded check. For both the herbicides, split application was superior to a single application. However, application of anilophos in a single dose caused phytotoxicity and significantly reduced the crop stand and yield.

Phosphorus management in relation to weed growth

Broadcast application of Mussoorie Rock Phosphate (MRP) one month before seeding, at the time of seeding, drilling MRP in seed furrows, and drilling SSP in seed furrows were compared with control (no phosphorus) for their effect on weed growth in upland rice.

Echinochloa colona was the predominant weed in all the treatmets. Weed growth, measured in terms of height, root length, dry weight and number of branches, was higher in plots receiving MRP one month before seeding. Dry weight of weeds one month after sowing was also higher in phosphorus-applied plots indicating the role of phosphorus on weed growth to be positive. Drilled application of MRP at seeding, however, recorded the lowest dry weight of weeds.

Disease Management

Blast

Relationship between leaf and neck blast resistance

The resistance to leaf and neck blast in 34 upland rice breeding lines (mostly indica) was compared with six traditional upland rice cultivars (aus). Leaf and neck blast were evaluated simulatneously in adjacent plots where sowings were adjusted to synchronise with flowering in one set with maximum tillering in the other at peak blast period (September). Leaf blast intensity was correlated with panicle blast severity (PBS) in the susceptible lines; the leaf blast resistant lines exhibited a relatively higher PBS while in aus cultivars the PBS was lower. Black gora, Kalakeri and Brown gora (leaf blast susceptible) had PBS ranging between 5.6-11.7% which was on par with the PBS in highly resistant cultivars RR 222-1 (7.2), RR 265-184 (4.4) and RR 265-197 (4.4) and less than PBS in many promising, leaf-blast resistant lines indicating the adult plant resistance providing in the aus cultivars. (Fig 2).

Effect of drought on establishment and spread of blast

Interactive effect of drought on blast was evaluated in a field under three moisture regimes. The rol-stress was maintained below 0.03 MPa by garden sprinkler. Moisture levels were monitored using mercury manometers upto 0.08 MPa. Soil moisture tension exceeded 0.08 MPa (10 cm depth) for a period of three days between 12-15 August in the dry nursery.A prolonged drought spell was experienced during the vegetative phase when the soil moisture tension remained above 0.04 MPa.

Though blast established early in no-stres soil the rate of spread was higher in the stressed soils. Drought at vegetative stage accelerated disease spread on Brown gora and Vandana though the relativi rates were

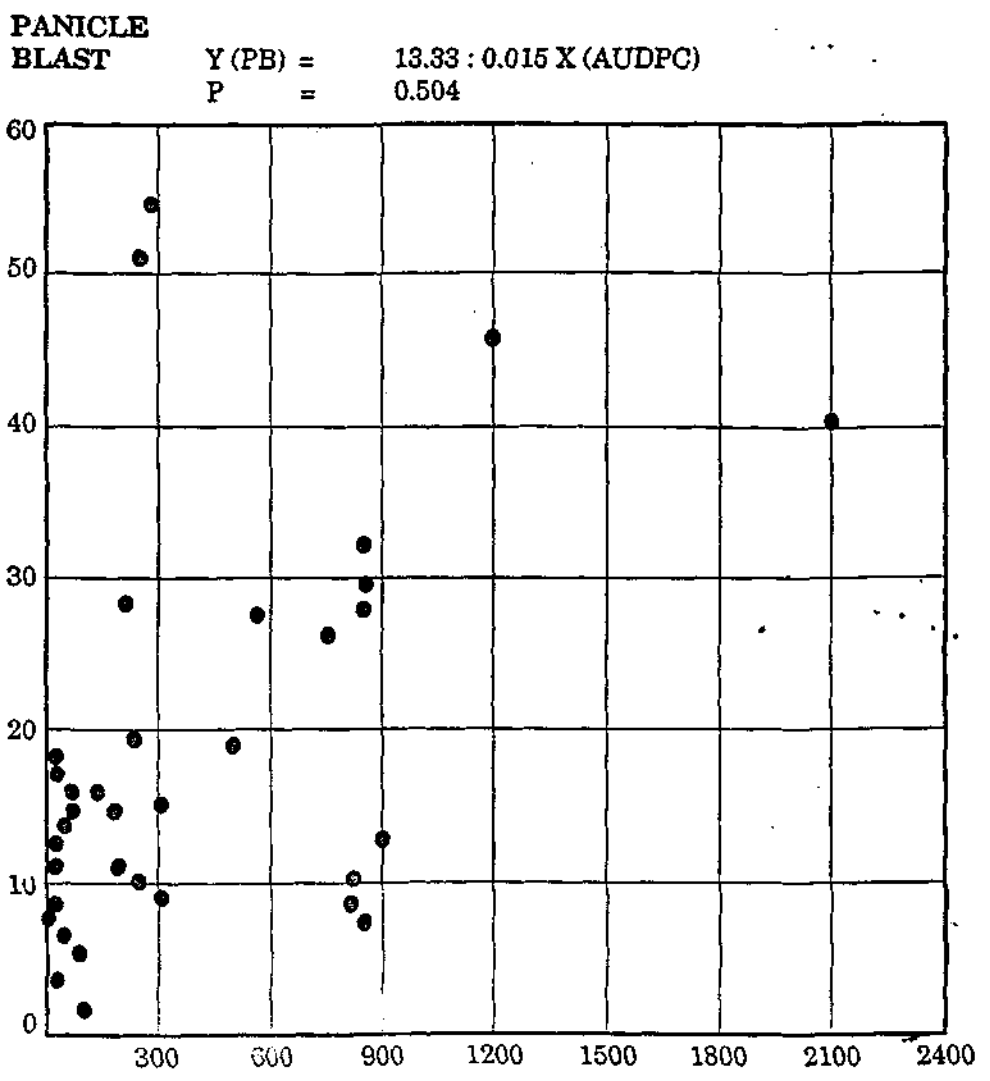

Fig. 2 : Relationship between Leaf and Panicle Blast (n = 40)

significantly higher for the Brown gora (Fig 3). Recovery after stress was evident in Brown gora whereas Vandana did not recover. Differences in neck blast under stressed and non-stressed soils were not significant for Vandana.

Leaf characteristics imparting tolerance to drought and blast

Epicuticular Wax (EW) content in selected upland rice genotypes was studied in relation to their resistance to leaf blast and tolerance to drought. EW content in leaves of similar phenological age were compared and correlated with resistance to blast reaction. Slow blasting resistance appeared to be related to drought tolerance.EW content was high in Moroberekan and moderate in CR 143-2-2. These known drought tolerant genotypes with high cuticular resistance had few and restricted blast lesions. However hypersensitive lesions of blast were not correlated with EW content. It was found that there is a possibility of simultaneously improving tolerance to drought and blast in the breeding programmes and selecting blast resistant lines with different mechanisms by manipulating leaf characters.

New blast resistant lines

A culture RR 222-1, developed from a cross between K 39 and IR 3237-339 was highly resistant to leaf and neck blast. It is a tall, high yielding culture with a duration of 95 days after RR 265-184 and RR 265-197 were two semi - dwarf cultures identified as highly resistant to leaf and neck blast during 1993. Two induced mutants of Kalinga III, 146-1 and 139-1, were identified to be moderately resistant to blast for two years in succession. Blast resistant lines identified from national and international coordinated nurseries are listed in (Table 7)

Parameters for evaluation of slow-blast resistance

Slow blasting resistance was evaluated in 25 rice genotypes through estimation of eight parameters like the final disease severity, SES scoring system, the area under disease progress curves (ADPC), the normalised area under disease progress curve (RDPC), the apparent infection rates estimated by logistic (r) and Gompertz (k) models and the time required for 50% severity by logistic as well as Gompertz models. The ADPC correctly

Table - 7 : Breeding lines resistant to blast (CRURRS, Hazaribag 1993)

Lines	Source
Fixed cultures and new donors	
AR 222-1	K 39 x IR 3273 - 335-2-5
RR 265-184	
RR 265-197	
146-1	Kalinga III mutant
149-1	Kalinga III mutant
National and International nurseries	
RR 36-141, RR 203-2, RR 203-16	NSN I
PNR 580-3, REWA 685-3, Rewa 14-174	
JR 82-5-195,	
RP 2033-7487-18, RP 2826-8118	NSN II
CL Selection 63, CL selection 72 B	IIRON
RANAU	IURON

reflected the disease development (Fig.1), did not involve complicated data transformations and computations like those of apparent infection rates as well as the L50 values, involved the most important element of the disease progress curves like the incubation period, the latent period, the entire infectious period, the number of lesions, the infection efficiency as well as the daily disease development measured as the total host tissue damaged and hence was considered to be most convenient and appropriate over other parameters. The only disadvantage of its not being estimated from a common time base, could be avoided by estimating the relative area under disease progress curve for easy comparison among disease progress curves developed under widely varied conditions of host, pathogen and environmental variations. (Fig. 4)

Evaluation of isogenic lines againt blast

The aim is to screen the isogenic lines in green house and uniform blast nurseries to record the patterm of

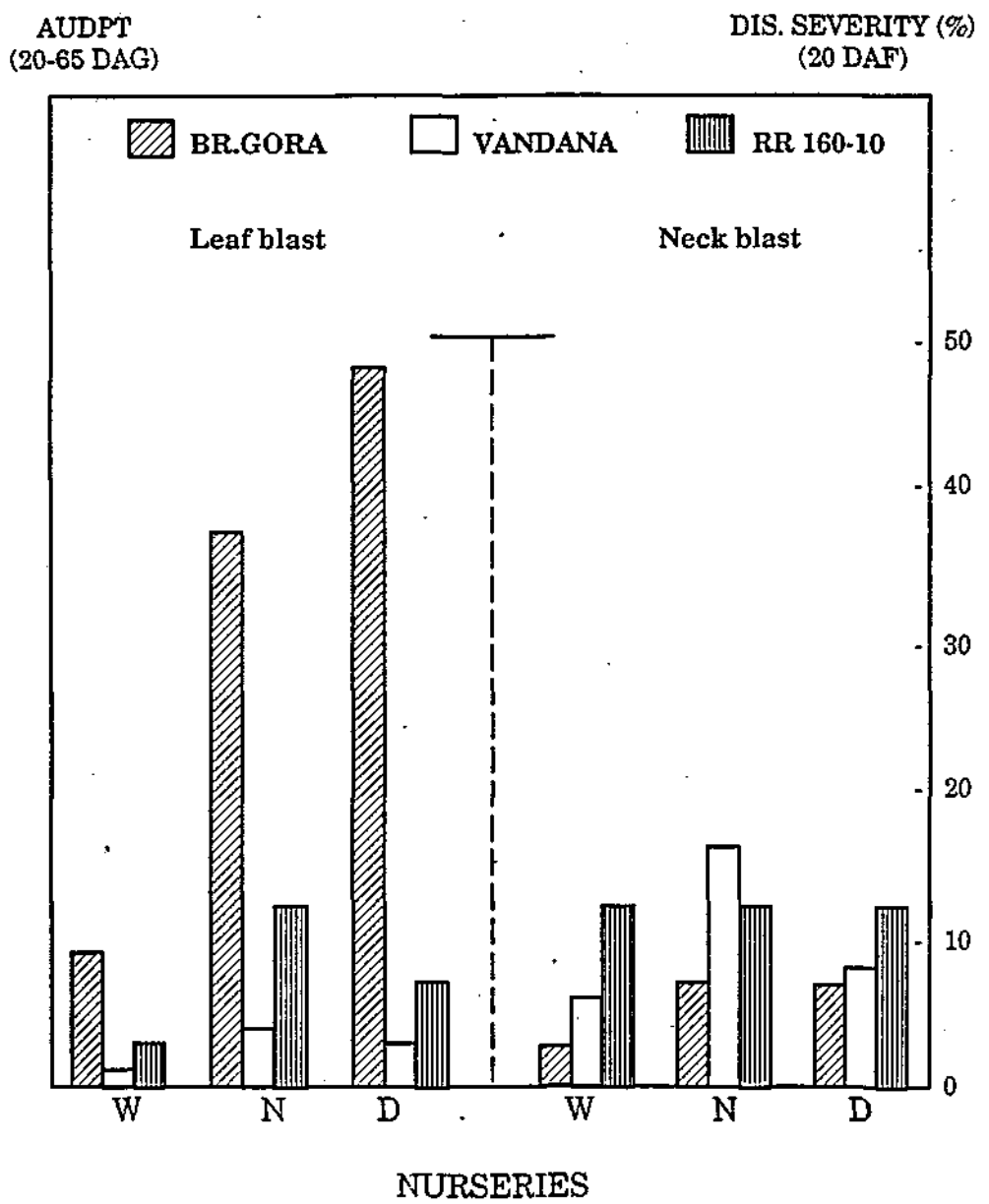

Fig. 3 : Disease progress in wet, Normal and Dry Nurseries Hazaribag (wet season 1993)

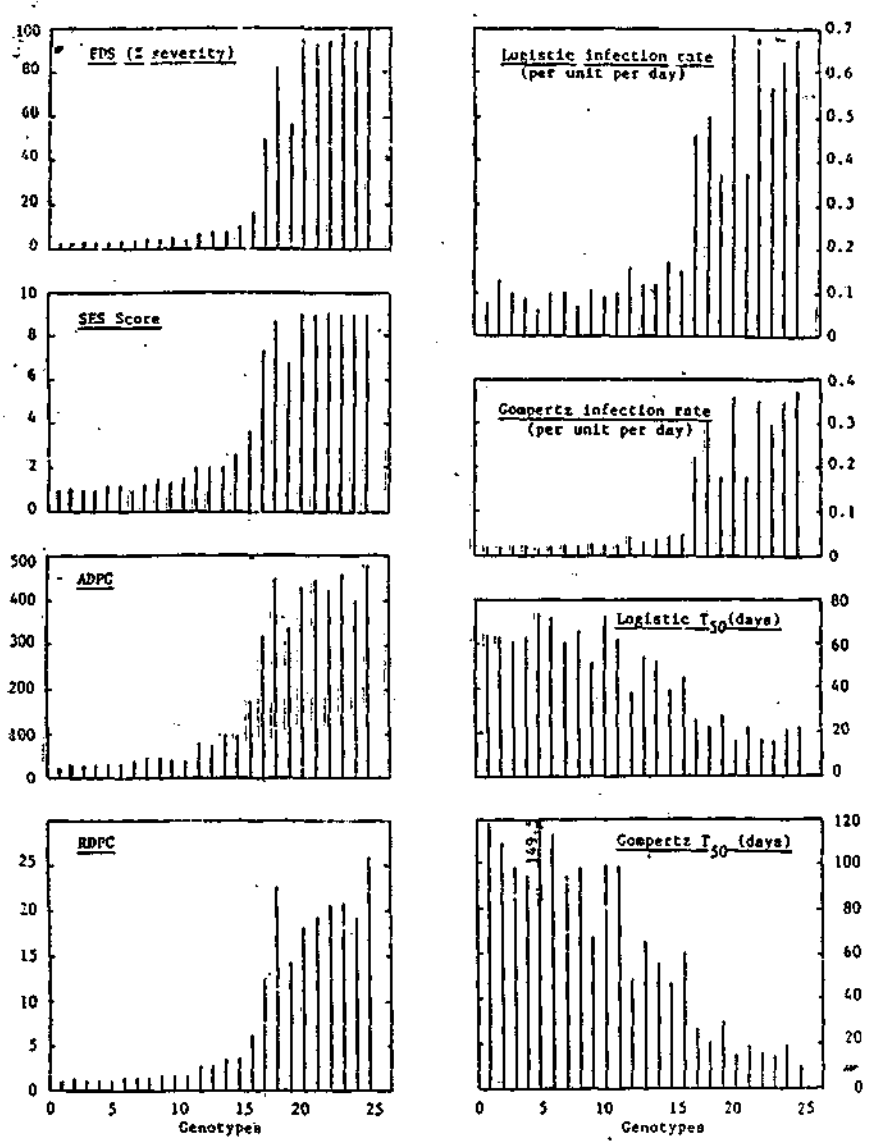

Fig. 4 - Parameters for evaluating slow blast resistance

disease reaction and monitor the changes in blast patnogen populations in nature. Out of 22 lines tested isogenic line C 102-A-51 was found resistant in earlier trials. In the year under study isogenic lines C 104-PKT and C 105-TTP-2-49 were found resistant which were susceptible in earlier testings.

This suggested that there is a change in rice blast pathogen populations in different seasons. These findings help in identifying cause of breakdown of blast resitance in varieties.

Effect of seed treatment on blast tolerant cultures

The objective is to assess the advantage gained in blast tolerant varieties through seed treatment by way of reduction in foliar blast.

Sixteen mutants derived from blast susceptible variety IR 50 were found tolerant to blast. The seeds were treated with Bavistin (carbendazim) @ 1 : 500 (seed : Chemical) and sown in trays. It was found that in all the varieties the foliar infection was lower than untreated check. Normal IR 50 has recorded a leaf area damage of 37 percent.

The study revealed that it is possible to check blast through tolerant varieties by supplementing seed treatment with fungicides.

Varietal screening against blast

a) NBPGR material (1780 nos.) were screened against blast. Out of which 115 were found to be resistant, 1623 as moderately resistant to susceptible and 42 as highly susceptible. In case of helminthosporise, 188 as resistant, and 1592 were observed to be moderately susceptible to susceptible.

b) Out of 369 varieties/cultures of NSN, 35 were seen to be moderately resistant, 112 as resistant and the rest 222 varieties as susceptible to blast. In case of *Helminthosporiose,* 75 were observed to be resistant and 294 as moderately susceptible to susceptible.

c) Out of 300 varieties/cultures of genepool materials, 115 found to be moderately resistant, 100 as susceptible and the rest 85 as resistant to blast.

d) From MRSN (85 Nos.) cultures, 12 found to be resistant 34 as susceptible and the rest 39 as moderately resistant to blast.

Races of rice blast fungus

a) Out of 250 cultures isolated from varieties HR 12, Karuna, NP 125, Dular, CI 8970 (S) 25 isolates could be maintained and identified as races, IC 17, IC 18, ID 1, ID 2, IE 2 and IE 5.

b) Material received from Shillong and Assam areas were isolated and identified as races : IC 1, ID 14, IE 1 and IE 2.

Periodical assessment of blast disease progress

It was noticed from the weekly sown susceptible varieties HR 12 and Karuna that both varieties showed their susceptibility from August onwards reaching its maximum in November 2nd week in wet season and from February on wards to April 1st week. After this period, the susceptibility decreased gradually with the onset of winter.

Evaluation and utilization of Indigenous natural plant products against blast.

Although the three extracts of aqueous, ethanolic and essential oil of either *A. marmelos* of *O. sanctum* reduced collar rot and yellow root diseases effectively both in green house and in the field, but the extract prepared in the organic solvent proved superior in green house.

Control of foliar blast of rice was also observed most effectively in field due to ethanolic extract treatment of *A. marmelos* and essential oil of *O. sanctum*.

An attempt was made for purification of the active principle through column chromatography. The hexane fraction from the crude ethanolic extract and the Methanol fraction through the column fraction of essential oil when tested against blast pathogen *P. grisea* displayed no fungitoxicity, indicating that active ingredients might have mobilized in other solvents scheduled to be examined in the next phase of study.

Amongst the *O. sanctum* preparations when mixed with carbendazim, the essential oil combinations was found to be the best in reducing *P. grisea* conidial germination.

The excised sheath treated with the *O. sanctum* preaparations indicated the potential of *O. sanctum* to control rice blast. However, the ethanolic extract and essential oil prepara-

tions were found superior to the steamed aqueous extracts.

The extracts from *O. sanctum* largely proved stable when heated, exposed under sunlight and autoclaved. However, essential oil was more sensitive comapared to any other extracts.

Brown spot

Effect of macro- and micronutrients on brown spot

Potash

Six levels of potash, ranging from 0.50 kg/ha were evaluated at two locations using Kalinga III and Brown gora as test varieties. Nitrogen (20+20) kg/ha and Phosphorus (20 kg/ha) were applied uniformly.

Potash level upto 30 kg/ha reduced brown spot intensity; and beyond this level (40 and 50 kg/ha) disease intensity was enhanced. Maximum rice grain yields were obtained in plots receiving 20 and 10 kg/ha of potash in case of Kalinga III and Brown gora respectively. Grain yield and disease intensity were negatively correlated.

Lime and phosphorus

Six levels of phosphorus and 3 levels of lime were evaluated in a fixed plot study using Brown gora, Kalinga III at two locations. Lime was applied in 1992 and the residual effect was studied in 1993. Nitrogen and potash were applied at the time of sowing @20:30 kg/ha and 20 kg N/ha was topdressed 30 days after sowing.

It was found that increased levels of phosphorus and lime upto 1.5 t/ha reduced brown spot intensity in both the cultivars. Brown spot intensity was higher at 3 t/ha of lime application. Differential effects of varieties, phosphate and lime levels on disease intensity were more pronounced at seedling stage, and less at tillering stage. (Fig 5).

Micronutrients

Nitrogen, phosphorus, potash and seven micronutrients were added to typical upland soil in a one-nutrient-less series in a pot experiment. Brown spot intensity ranged from 25.47% in pots receiving all nutrients to 60.26% in the control plots receiving no added nutrients. Potash, magnesium and phophorus had the maximum influence on disease intensity, followed by Fe, N and Zn. (Fig 5). Disease intensity was negatively correlated with plant height, number of grains, panicle weight and pot yield.

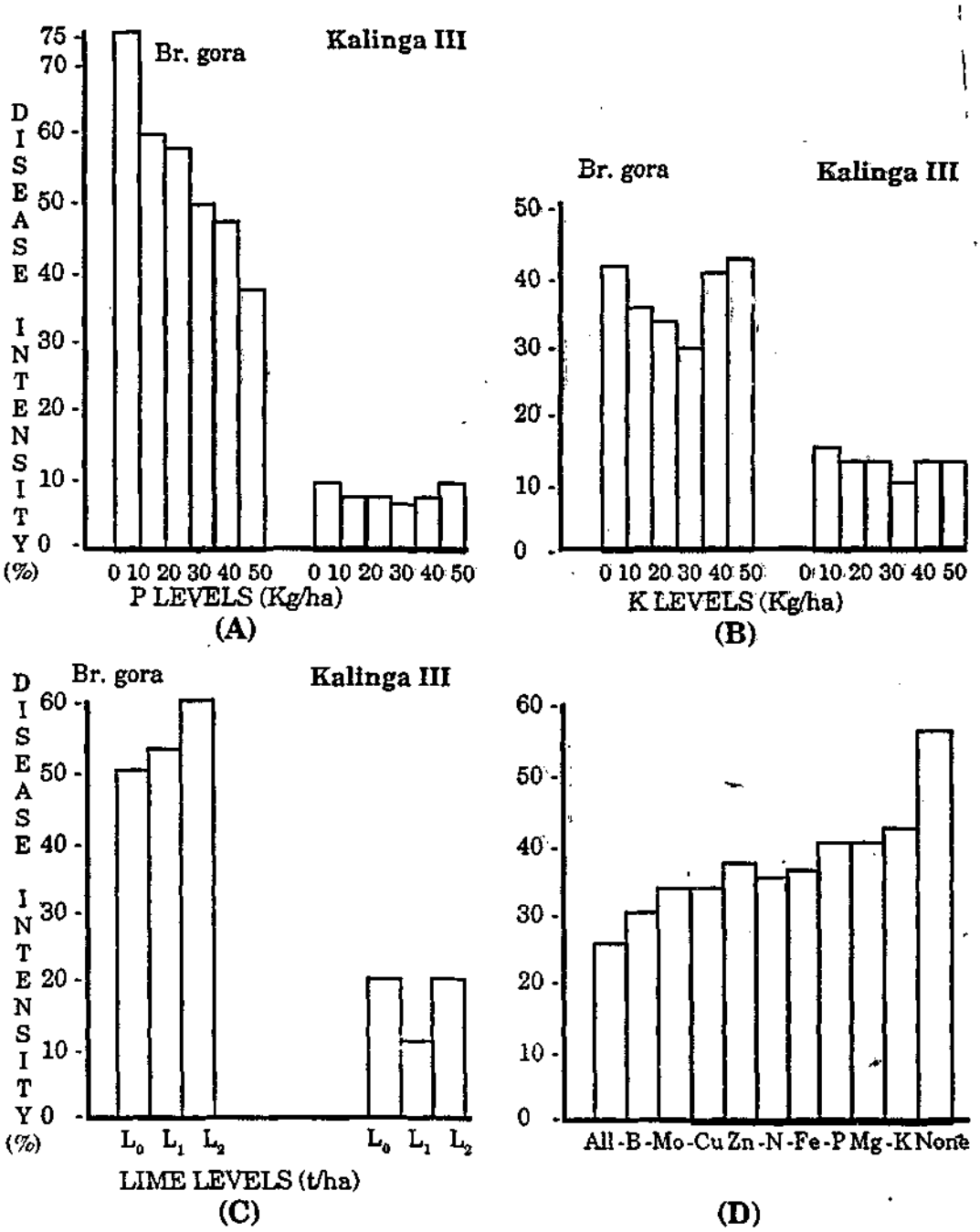

Fig. 5 Effect of P(A), K(B), Lime (C), Micronutrients(D) on brown spot intensity of upland rice

Evaluation for varietal resistance

One hundred sixty five traditional medium/lowland rice germplasm of Santhal Paraganas, Dumka, Gumla and Hazaribag, 160 breeding lines and 220 lines of NSN were evaluated for their resistance to brown spot. Among the traditional genotypes 42-43 (HRC 702), Jhillidhan (HRC 703) and Chapasair (HRC 712) exhibited resistance in the screening nursery. Breeding lines derived from the crosses 83 K 39 x BG 367-4, Bala x IR 3237, RR 18-3 x RR 6-1, RR 18-3 x RR 20-2-10 x RR 158-327 had complete resistance. Among the advanced breeding lines, RR 203-16, RR 174-1 and RR 151-4 were resistant. Fifteen lines of NSN had scores of 0-1 while 72 were moderately resistant with scores of 2 and 3.

Sheath blight

Chemical control

Increased virulance of sheath blight pathogen (*Rhizoctoni solani*) was noticed when the fungus was grown on pesticides (Saturn and Carbofuran) amended media. Mycelial growth and sclerotia formation was uneffected at lower concentration (1 and 2.5 ppm) of these pesticides.

In another study, although fungal biomass remained unaffected by Validacin (1 and 2.5 ppm) treatment, but reduced virulence of the pathogen was recorded when mycelia growth on pesticide amended media was tested on the host.

Bacterial blight

Evaluation for varietal resistance

One hundred and sixtyfive traditional varieties and 72 breeding lines were evaluated for their resistance to bacterial blight in bunded uplands. Kalmdani (HRC 711), Nanhia (HRC 726), Jhillidhan (HRC 703) and Judagi (HRC 733) among the traditional genotypes; and breeding lines derived from the cross CR 149-3244 x Mahsuri and derivatives of the natural outcross of the open floret mutant CR 314-5-10 were found resistant.

Integrated disease management

Disease Management through seed treatment with fungicides, insecticides and herbicides

The aim of this experiment was to find out the combined effect of fungicides, insecticides and herbicides in control of rice diseases.

The experiment was conducted with two blast susceptible varieties HR 12 and IR 50. The seeds were treated with two fungicides carbendazim and coratop, two insecticides chloropyrighos and fufadon and two herbicides, butachlor and thiobencarb @ 1 : 500 (seed : chemical) in various combinations.

It was found that foliar blast was reduced by combinations of carbendazim + thiobencarb by 75% over control. The control recorded a leaf area damage of 64 due to blast. This experiment is being modified to assess the overall effect on pests, diseases/weeds.

Disease Management under Intercropping

Upland rice was intercropped with pigeonpea in two row ratios with different crop protection schedules including the use of host plant resistance (blast), mechanical seed separation (for sheath rot) and need based spray for brown spot and blast. Incidence neck blast and sheath rot was seen under the intercropping system compared to the sole crop. Mechanical seed separation was effective in reducing sheath rot in mono-as well as intercropping But only blast indence was reduced in intercropping.

Pest Management

Gundhibug and termites

Varietal performance

Of the 28 varieties tested against gundhi bug, the varieties Black gora, Brown gora, Sneha, RR 165-1160 were less susceptible recording less than 10 percent grain damage. The varieties like Dhala Heera, CR 666-100, CR 160-42, Heera, IR 42 (SS) were highly susceptible with 45% grain damage.

None of the test varieties showed tolerance to termite attack.

Chemical control

On farm trials under FSR/E project were conducted at Bhogra and Khuntuni to evaluate the effectiveness of insecticides including plant products against termite and gundhi bug. Amongst the test chemicals chlorpyrifos (1.0 kg ai/100 kg.) and imidocloprid (0.5 kg ai/100 kg seed) rcorded nil damage of termite followed by carbosulfan (1.0 kg ai/100 kg seed) with 2 to 3% plant damage against 22.4% plant damage in control. Neem kernel, neem cake and neem oil among the plant poducts were also pomising in checking termite damage.

Yield increase in the case of insecticides ranged between 1.2 and 1.9 t/ha whereas the increase with plant product was from 0.5 to 0.9 t/ha over control which recorded an yield of 2.5 t/ha.

Monocrotophos followed by chloropyrifos and ethofenprox were superior in checking gundhi bug damage and recording higher yield (3.9 to 4.7 t/ha) over the other insecticides and untreated control (2.6 t/ha).

IRRIGATED RICE

IRRIGATED RICE

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CROP IMPROVEMENT

Breeding for photo-insensitive rice varieties

Twentyfive photo-insensitive varieties were grown in dry and wet seasons for purification and evaluation. Varieties, IR 64, Ratna, IET 8585, Swarnaprabha, PR 106, PR 109, Lalat and CR 691-253 were found promising in both seasons and are being utilized in crossing programme to develop high yielding genotypes.

Evaluation of breeding material

Two hundred single plant progenies of advanced generation from the crosses Sattari / CTG. Sattari / NDR 97, Sattari / IR 36, C 1064-5/Dular and Sattari / White gora were evaluated during dry season 1993. All the uniform progenies were bulked and selections were made in segregating lines. The yields ranged from 3.0-4.5 t/ha with a duration of 100-130 days.

Fifteen fixed lines were evaluated during dry and wet seasons and the cultures, CR 691-61, CR 691-248, CR 691-253 and CR 773-1 were found promising. These lines were entered into the coordinated trials.

Another set or 20 promising lines of 90-110 days duration were grown under direct seeded condition during wet season.The cultures, CR 693-18, CR 691-73, CR 691-56 and CR 773-1 performed better than the check varieties, Annada and Kalinga-III in yield and other characters.

Evaluation of early advanced lines under transplanted condition

Twenty five advanced lines of early duration (90-115 days) along with 3 check varieties viz. Annada, IR 36 and CR 628-2 were tested in replicated trial during dry season under transplanted condition. Three cultures, CR 679-1, CR 679-2, (CR 628-2/ IR 36) and CR 678-3-23 (CR 628-2/Swarnaprabha) recorded yields of 5.0, 4.6 and 4.5 t/ha, respectively and were superior to IR 36 (4.2 t/ha).

Selection in segregating material

During wet season, 264 F_6 single plant progenies from 8 cross comginations wert grown under irrigated condition. At the time of harvest, 70 uniform lines were bulked for further evaluation. Besides, 80 single plant selections were made on the basis of grain type and tolerance to pests and diseases.

Selection in segregating population

The F_2 population from HPU 823/ Ratna, HPU 823/Gaurav and Gaurav/Ratna were grown in dry season and 300 single plant selections were carried forward to wet season as F_3 generation. Selections were made on the basis of flowering duration and grain type.

Population of F_7 generation from CR 555/Basmati was direct seeded and selection was undertaken. The uniform lines were bulked based on grain type (LS) and duration. The maturity duration however ranged between 70-80 days.

The population from F_5 generation from two crosses, CR 260-72/Pusa 33 and CR 689-3/Vanaprabha were grown and selection of more than 100 single plant progenies was made based on grain type (LS) and duration. The duration ranged from 120 to 145 days.

Three hundred F_4 progenies from Katarni / Basmati 370. EC 205265/ Katarni, Basmati 370/EC 205265 and Tulasimanjari / Basmati 370 were grown and selections were made based on grain type, single plant yield and height. Since all the parents involved were scented, there was no difficulty in recovering scented types from the segregating population.

The F_2 population from Pakistan Basmati/Prasadbhog, Pakistan Basmati/Tulasimanjari, Pakistan Basmati/ Pusa 33, Karnal local/CR 726, CK 726/ Pakistan Basmati and Karnal local/ Pusa 33 were grown and observations on single plant basis were recorded for flowering date, plant height, aroma, grain length, breadth, Yield, number of grains and chaff per plant. Based on these characters, single plant progenies were selected which will be carried forward for F_3 and genetical studies.

The Plants from M_4 generation from EMS treated Karnal local, Ranbir Basmati and M_3 generation and EMS treated Basmati 370 and Karnal local were grown and selections were made based on grain type, height and aroma.

The M_4 generation plants from gamma treated Pusa Basmati and Pakistan Basmati were grown and selections were made based on grain type, height and scent.

Yield maximization through agronomic management

A field experiment with 9 treatments comprising different combinations of normal plant stand (spacing 15 cm x 15 cm), 33% extra plant stand (spacing 20 cm x 20 cm), optimum fertilizer (90 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha), 33% extra fertilizer (120 kg N, 53 kh P_2O_5 and 53 kg K_2O/ha), green manuring *in situ* and insecticide-treated robust seedlings was conducted with variety Gayatri. The highest grain yield of 6.9 t/ha was recorded in treatment where insecticide-treated seedlings were transplanted using 33% extra plant stand following green manuring and crop was given 33% extra fertilizer. A combination of green manuring + 33% extra plant population + 33% extra fertilizer also produced similar grain yield. The grain yield in these treatments was 21.7 to 22.6% higher than that of treatment with normal plant population and optimum fertilizer application. Inadequate plant stand seem to be the key factor limiting productivity of rice. The grain yield could be maximized by increasing the plant population and conjunctive use of organic and inorganic fertilizers.

Identification of superior genotypes having excellent technological, biochemical, cooking and eating qualities of Basmati cultures

Twenty scented rice Basmati cultures were grown under wet season in All-India co-ordinated trials conducted at CRRI. These cultures were analysed for quality attributes. Among these advance cultures, IET 13548, IET 13554 and IET 13553 were promising and comparable to kernel local and Pusa Basmati (Table 1).

CROP MANAGEMENT

Integrated management of organic nitrogen sources and urea to increase their efficiency

Application of 50% N through Azolla and the rest 50% N as urea in two equal splits at active tillering and panicle initiation stages proved to be the best among all the nitrogen treatments. Delaying the basal dose by 10 days or conditioning the applied urea with P and K did not give additional advantage over the nitrogen application through urea in splits (50+25+25). Application of formalin (140 ppm) along with FYM increased

Table 1. Evaluation of long slender grain Basmati derivatives from advance yield trial for quality characteristics

Variety	Head rice recovery (%)	Length (mm)	L/B	Alkali value	Water uptake (ml)	Kervel length (mm)	Volume expanstion after cooking (mm)	Elongation ratio	Amylose (%)
IET 13548	55.1	6.73	3.89	6.0	295	11.20	4.0	1.66	20.44
IET 13158	50.4	6.92	3.92	6.0	305	10.80	4.0	1.56	15.30
IET 13554	57.8	7.04	4.27	7.0	330	10.60	4.0	1.50	18.14
IET 13553	35.1	6.71	4.04	7.0	335	10.40	4.0	1.55	15.81
Kernal local	44.8	6.91	3.73	6.0	295	10.60	4.0	1.53	17.91
Pusa Basmati.I	42.6	7.23	4.28	7.0	345	12.80	4.0	1.77	22.11

the grain yield significantly over the treatment receiving FYM alone. Similarly, substituting 50% of the FYM nitrogen with chemical nitrogen increased significantly the grain yield over the treatment receiving the entire N through FYM but could not compete with the treatment receiving chemical nitrogen in splits. The straw yield followed more or less similar trend as that of the grain yield excepting the treatment receiving urea conditioned with P and K, which showed a significantly higher straw yield over the urea application in splits and was comparable to the treatments receiving full *Azolla* or 50% N through *Azolla* as basal and the rest N as urea in two equal splits.

The uptake of nitrogen was highest in the treatment of receiving *Azolla* either in full or supplemented with urea N - Uptake from full FYM treatment was significantly more than control but interior to all other nitrogen treatments. FYM blended with formalin proved better than simple FYM application, in N uptake.

Integrated use of organic and inorganic nitrogen fertilizers

This multi-locational IRRI-collaborative trial initiated during the wet season of 1987 was continued during the wet season of 1993. The effect of *Azolla* compost, water hyacinth compost, farm-yard manure and green manures (*Sesbania aculeta* and *S. rostrata)* applied in conjunction with inorganic N fertilizer (urea) on grain yield of rice and sustainability of rice production over the years was examined. All the tested organic sources in combination with prilled urea, each source providing 37.5 kg N/ha, gave significantly higher grain yield (5.6 to 5.8 t/ha) than that of 57 kg N/ha applied as inorganic N alone (4.7 t/ha). However, the yield in these treatments was comparable to that with placement of urea super granules (5.4 t/ha). However the decline in grain yield over the base year (1987) was maximum (25.2%) in the treatment receiving inorganic N alone.

Optimum time of planting for scented Basmati rices

Four scented Basmati rice varieties, HKR 228, Pusa Basmati - I, Kasturi and Basmati-370, were transplanted on 5 July, 15 July, 25 July and 4 August. Irrespective of varieties, planting on 25 July gave higher grain yield (2.4 t/ha) than that under remaining dates. The reduction (%) in yield over 25 July planting was worked out at

30.8, 10.8 and 27.9 under 5 July, 15 July and 4 August planting, respectively. Variety Kasturi recorded significantly higher grain yield of 2.3 t/ha as compared to HKR 228 (1.86 t/ha), Pusa Basmati-I (1.6 t/ha) and Basmati-370 (2.1 t/ha) irrespective of dates of planting. However, variety Kasturi recorded maximum grain yield (2.70 t/ha) under 15 July planting while Basmati 370 (2.59 t/ha) and HKR 228 gave the highest yield (2.56 t/ha) under 25 July planting.

Modelling the effects of nitrogen application on growth and yield of rice - (A simulation model)

As a first step towards modelling nitrogen distribution in the plant and its uptake from the root zone, a field experiment was conducted during the dry season to study the effect of time of nitrogen application on growth and yield of rice. Nitrogen at 200 kg N/ha was applied in varying splits at different growth stages. Altogether there were 11 treatments and the maximum number of splits used was 7 - at transplanting, seedling establishment, active tillering, maximum tillering, panicle initiation (PI), between PI and flowering and at flowering. The highest grain yield of 7.5 t/ha was obtained when N was applied in five or more splits, skipping a basal application or application between PI and flowering and at flowering.

Application of N beyond active tillering stage reduced the grain yield by reducing the number of panicles, whereas withdrawal of N application after the active tillering reduced the grain yield by reducing the harvest index as a result of increased number and percentage of unfilled grains.

Effort to increase the efficiency of Indian phosphate rocks

The P availabilty in soil and P utilisation by rice from the thermal products prepared with the phosphate rocks from Kasipatnam, Purulia, Mussorie (all from India) and Jordan were studied in a pot experiment. Only the products of the phosphate rocks and Na_2CO_3 mixture in different proportions heated at 900°C were evaluated in two P-deficient soils from Khuntuni and Choudwar. The results indicated that the agronomic efficiency of thes thermal products of Indian phosphate rocks and Na_2C0_3 mixture in the ratio 1:0.5 heated at 900°C was comparable to superphosphate. The residual effect of these thermal products was also comparable to the residual effect of superphosphate. However P supply-

ing power of similar thermal product of Jordan phosphate rock was very poor. The behaviour of thermal products of Indian phosphate rocks and Na_2C0_3 mixture in the weight ratios 1:0.25 and 1:0.15 were superior to no P (control) or raw phosphate rock but was still inferior to superphosphate.

The chemical nature of the thermal products prepared with phosphate rocks-Na_2CO_3 mixture in the ratio 1:0.5 heated at 900°C was also investigated from their X-ray diffraction analysis (XRD). Powder XRD analysis of raw phosphate rocks were also undertaken for comparison. It could be seen that these products primarily contained a water soluble phosphate phase in the form of Na_3PO_4 and citrate soluble phosphate phases like $CaNaPO_4$, $NaCaPO_4$ and $Ca_7(PO_4)_2$ (SiO4)2. In addition, the presence of $FeNaPO_4$ is also indicated in the thermal product of purulia phosphate rock. The presence of free Na_2CO_3 and carbonate apatite is indicated in the thermal product of Jordan phosphate rock only. So, Na_2CO_3 has not been fully utilised by Jordan phosphate rock during the thermal transformation of apatite. The inherent silica content of Jordan phosphate rock was insufficient to promote the apatite Na_2CO_3-sillica reaction at 900°C towards completion; thus leading to a thermal product which was found inferior to superphosphate in the pot experiment with rice as the test crop.

Effects of amendments and zinc on growth, yield and nutrients contents of rice in a problem soil

A pot experiment was initiated during January - May, 1993 with the treatments of NPK, NPK+organic matter, NPK+lime, and NPK+ lime+organic matter, each supplied with and without Zn. Fertilizers were added at 200 ppm N as urea, 100 ppm P, and 126.7 ppm K both as KH2 PO4: and 5 ppm Zn as ZnSO4. Organic matter at 2% as compost and lime at 1 t/ha as Ca (OH)2 were mixed with the soil. Rice varieties viz. Parijat, Saket 4 and Pusa 33, all susceptible to Fe toxicity were grown. The soil was inceptisol, loamy sand from Ranital, in Bhadrak district of Orissa, with the history of Fe toxicity and low in plant nutrients.

The treatments significantly affected the height, tiller, dry matter at maximum tillering; and yields of grain and straw. Zinc significantly increased the grain yield by 30, 12, 15 and 11%, respectively in NPK, organic matter, lime, and organic matter + lime. Or-

ganic matter increased (15%) and lime decreased (17%) grain yield significantly over NPK. Organic matter improved straw yield (31%) significantly. Plant contents of Ca, Fe, Mn, Zn and Ck were significantly altered by different treatments. Similarly, treatments showed significant influence of total uptake of P,S, Mg, Fe, Mn, Zn, and Cu.

The Ca content in plant was significantly raised by 24, 52 and 48 % of NPK in organic matter, lime, and organic matter+lime, respectively. Lime and lime+organic matter significantly reduced the contents and total uptake of Fe, Mn, Zn and Cu in plant. Organic matter, on one hand, reduced the contents of Fe, Zn and Cu; and on the other, increased that of Mn, significantly. Organic matter also enhanced Mn (27%) and lowered Cu (20%) uptake in plant significantly. The Mg uptake was significantly decreased (27%) by organic matter+lime.

The Zn content increased significantly in + Zn treatments. But total uptake of Zn was significantly enhanced (55%) by NPK+Zn.

Cadmium-sulphur interaction studies in rice

A pot experiment was conducted to study the interaction effect of Cd (O, 10, 25, 50 and 100 ppm) and S (O, 10, 25 and 50 ppm) on the rice variety IR 36.

The grain yield decreased from 36.6 to 25.3 g/pot at 0 and 100 ppm Cd levels, respectively. However, S addition had no significant effect on grain yield. The interaction effect showed that at 50 and 100 ppm Cd levels, S addition significantly increased grain yield. The interactions had no significant effect on straw yield.

The grain Cd content decreased from 12.5 ppm at Cd 100 + So to 6.0 ppm at Cd 100 + S 50 treatment combination. The highest S content of 0.58 ppm was recorded in grain at Cd 100 + S 10 combination. The straw Cd content was 75.0 ppm in Cd 100 + S 0 treatment, as against 35.7 ppm in Cd 100+S50 combination. The S content of straw increased with levels of both Cd and S.

The study indicated that Cd toxicity in rice could be checked by S fertilization.

Response of rice to graded levels of Zn

A pot experiment was condutcted

using three rice growing soils of Bhubaneswar, Maitapur and Jagtial to study the reponse of rice to the application of graded levels of Zn (0, 10, 20, 50, 80, 100 ppm).

The grain yield varied from 33.7 to 39.2, 26.4 to 29.1 and 26.9 to 33.4 g/pot in Bhubaneswar, Maitapur and Jagtial soils, respectively. There was a significant response to Zn upto 50 ppm in Jagtial soil, while only a slight response was observed in the other two soils.

The straw yield ranged from 28.5 to 38.5, 18.7 to 22.0 and 18.1 to 23.2 g/pot in Bhubaneswar, Maitapur and Jagtial soils, respectively. Significant increase in straw yield was noticed in Bhubaneswar soil to the application of 50 ppm Zn beyond which the yield was inconsistant. In respect of other two soils, only a marginal response was observed.

There was a significant difference in Zn content in straw due to Zn application in all the three soils, the range being 64.2 to 192, 73.3 to 95.0 and 53.3 to 65.8 ppm in Bhubaneswar, Maitapur and Jagtial soil respectively. The grain Zn content was in the range of 20.0 to 29.5 ppm in Maitapur and 46.6 to 53.3 ppm in Jagtial soils. No definite trend was noticed in the crop grown in Bhubaneswar soil. The post-harvest soil will be analysed for different forms of soil Zn.

Response of phosphorus-enriched Azolla to nitrogen fertilizer application

The experiment was conducted during the wet season using three levels of urea-N application (0, 30 and 60 kg/ha). Unenriched and P-enriched *Azolla (A. caroliniana)* were grown at 1.0 t/ha without further application of phosphorus or with 10 kg P_2O_5/ha 10 days after transplanting of IR 36 seedlings. Fresh weight and N-yield of *Azolla* in different treatments ranged from 3.7 to 13.1 t/ha and 7.1 to 28.2 kg N/ha, respectively. Application of urea at 60 kg N/ha significantly inhibited the growth and N_2-fixation of Azolla phosphorus-enriched *Azolla* produced higher fresh weight and N-yield than unenriched *Azolla* at all the urea-N levels. The differences between two *Azolla* were much larger when no P was applied during dual cropping. At different urea-N levels, P-enriched *Azolla* grown without phosphorus application produced as much biomass and N-yield as unenriched Azolla grown with application of 10 kg P_2O_5/ha. Grain and straw yields of rice were

significantly increased by both P-enrichment of the *Azolla* inoculum and application of phosphorus during dual cropping.

Herbicide and insecticide interactions in Azolla

The experiment was conducted during the wet season with two pre-emergence herbicides (butachlor and thiobencarb) and three insecticides (furadan, thimet and metacid) which were applied at their recommended doses 3 and 15 days after transplanting of IR 36 seedlings, respectively. *Azolla caroliniana* was grown at 1.0 t/ha a week after application of the herbicide and phosphorus at 10 kg P_2O_5/ha was applied. Urea at 30 kg N/ha was uniformly applied to all the treatments. Fresh weight and N-yield of *Azolla* in different treatments ranged from 7.2 to 12.3 t/ha and 13.3 to 25.8 kg N/ha, respectively. Application of any of the herbicides significantly decreased the fresh weight and N-yield. Thiobencarb was comparatively more effective than butachlor. Fresh weight and N-yield of *Azolla* in untreated, butachlor-treated and thiobencarb-treated plots were increased due to application of different insecticides by 17.8-24.6, 24.3-32.4 and 13.5-33.1% respectively. Interactions between the herbicide and insecticide were not significant. Application of the insecticides also increased the grain and straw yields of rice which were lower in thiobencarb-treated plots than in untreated plots.

Characterisation of *Anabaena*-free Azolla

Growth of Anabaena-free (+N medium) and Anabaena-containing (-N medium) *A. filiculoides* and *A. pinnata* was compared at varying levels of phosphorus (0-25 ppm) and potassium (0-37.5 ppm). Fresh weight, dry weight and chlorophyll content of *Anabaena* free *Azolla* were maximum with 5 ppm P in case of *A. filiculoides* and 10 ppm P in case of *A. pinnata*. These attributes of Anabaena-containing *Azolla* increased further with increasing P levels upto 15 and 20 ppm in case of *A. filiculoides* and *A. pinnata*, respectively. Similarly, Anabaena-free *A. filiculoides* and *A. pinnata* recorded maximum fresh weight, dry weight and chlorophyll content with 15 and 7.5 ppm K, respectively. These attributes of Anabaena-containing Azolla increased further with increasing K levels upto 22.5 ppm in case of *A. filiculoides* and 15 ppm in case of *A. pinnata*. The results indicated a higher requirement of both P and K for *Anabaena*-containing than

for *Anabaena*-free *Azolla*. *A. filiculoides* required less P but more K than *A. Pinnata* regardless of the presence of absence of *Anabaena*.

Studies on sporulation in *Fischerella* species

Effects of different pH, heavy metals, antimicrobial agents and a metabolic inhibitor (thiourea) on sporulation in the bluegreen alga, *Fischerella* sp., were studied in the culture room at 25±2°C under 2 K lux light (10th light/15h dark).

Effect of pH : sporulation was generally better in acidic than in alkaline pH, although the alga showed poor growth in acidic pH and could not survive at pH 4. The number of akinetes was highest at pH 5 and gradully declined there after with an increase of pH upto 7.6, after which it again increased upto pH 8.6. However, further increase in pH decreased their number again.

Effect of heavy metals : Among the different heavy metals tested, Zinc (0.1-1.0 ppm) was the most toxic at all the concentrations. It killed the alga by 6th day after incubation. However number of akinetes on 3rd day with different zinc levels was 7.8-12.9% higher than with control. Cadmium at 0.8 and 1.0 ppm siginificantly increased sporulation on 3rd day but killed the alga by 6th day after incubation. Its lower concentrations either had no effect or decreased sporulation. Lead at 0.1-1.0 ppm showed significantly higher (3.2-37.1%) number of akinetis than the control on 3rd and 6th days, whereas on 9th day increased sporulation was observed only at 0.1 and 0.2 ppm chromium at 5-25 ppm also significantly increased sporulation over the control on 3rd and 6th days, whereas on 9th day increased sporulation was observed only at / upto 15 ppm concentrations. Chromium and lead were more effective than cadmium and zinc in stimulating sporulation.

Effect of antimicrobial agents : Copper sulphate was highly toxic to this alga which was killed within 3 days at concentrations above 2.0 ppm and within 6 days at concentrations upto 2.0 ppm. Potassium permanganate (0.2-0.8 ppm) and hydrogen peroxide (0.2-1.0 ppm) showed no toxicity. At different dates after incubation these two chemicals recorded 7.2-50.6 and 2.7-35.8% more akinetes than the control, respectively. Their increasing concentrations generally increased sporulation.

Effect of thiourea : Sporulation on different dates after incubation was siginificantly increased by 3.6-35.1% over the control due to addition of thiourea from 20 to 80 ppm. The number of akinetes was highest at 40 ppm concentration and declined gradually afterwards.

Herbicide and phosphorus interaction in BGA

The experiment was conducted during wet (cv. Gayatri) and dry (cv. IR 36) seasons using two pre-emergence herbicides (thiobencarb and anilophos) and four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5/ha). The herbicides were applied at their recommended field doses within 3-5 days after transplanting and fresh BGA mixture at 100 kg/ha was inoculated a week after herbicide application. Phosphorus was applied in four equal splits at weekly intervals after BGA inoculation. Application of either of the herbicides significantly decreased, the fresh and dry weights, ARA and N-yield of BGA during both the seasons. However, anilophos was more effective than thiobencarb. Increasing the level of phosphorus application increased the bio-mass and N-yield of BGA in both untreated and herbicide-treated plots, where response to phosphorus application was comparatively better, Phosphorus application also increased the grain and straw yields of rice in both the seasons.

Effect of various organic manures and urea on BGA

Azolla, *Sesbania*, FYM, cattle slurry and urea were incorporated into the soil on equal N basis at 30 kg N/ha before transplanting of Gayatri (wet season) or IR 36 (dry season) seedlings. Fresh BGA mixture at 100 kg/ha was inoculated in one set of the plots a week after transplanting. In the other set growth of native BGA was allowed. Phosphorus at 20 kg P_2O_5/ ha was applied in all the plots. Fresh and dry weights, ARA and N-yield of both native and inoculated BGA were the highest with FYM incorporation followed by that with cattle slurry, *Azolla* and *Sesbania* incorporations. Urea incorporation was significantly inferior to the other treatments, indicating that for algalization application of organic manures was better than that of chemical N fertilizer. *Azolla* incorporation treatment produced highest grain yield of rice in both the season, whereas FYM incorporation treatment recorded the lowest grain yield. Inoculated plots showed significantly higher

growth and N2-fixation of BGA and the grain yield of rice than uninoculated plots.

Biological N fixation by free-living bacteria in rice soils

Nitrogenase activity associated with the basal and terminal portions of the roots of several rice cultivars and the different groups of nitrogen fixing bacteria, *Azospirillum* so associated with root base and tip was studid using gas-chromatographic acetylene reduction assay and microbial populations were enumerated by conventional serial dilution technique. Results indicated a definite partitioning of the nitrogenase activity within the root and a plant growth dependent shifted in the activity associated with basal and terminal portion of the roots. Nitrogenase activity associated with root base among the two rice varieties IR-36 and Annapurna steadily declined with plant growth. On the other hand, the activity associated with root tip showed a sharp increase by 55 days in IR-36 while in Annapurna the increase was noticed only after 75 days.

Further, basal portion had higher nitrogenase activity in the pre-reproductive phase while the root tip had higher activity during reproductive and maturity stages of the plant.

Alteration in the distribution pattern of the populations of *Azospirillium* sp., *Azotobacter* sp. and anaerobic nitrogen-fixing bacteria associated with root base and root tip in the plant samples collected at 70 days after planting were investigated. Root base harboured higher populations of *Azospirillum* sp. and *Azotobacter* sp., while the root tips had higher populations of facultative anaerobic bacteria. Results suggested qualitative and quantitative differences in the nitrogenase activity and the association of various groups of bacteria with the basal and terminal parts of the root might be responsible for the ultimate variation noticed among the rice cultivars and at different stages of plant growth.

Simulation of growth and performance of rice under water limited conditions in a puddled rice system

Pre flowering contribution of photosynthates towards the grain yield was increased under stress by 3.6 % in a tolerant cultivar Annada, whereas the sensitive cultivar showed a decreased contribution to a tune of 7.6

percent over the control. In Annada the yield reduction was not significant, whereas the sensitive cultivar Cauvery showed a yield reduction of 22.4 %. This aspect of dry-matter partitioning is to be incorporated in the model. Ground water table progressively decreased after the intiation of stress and went below the subsurface zone in 4 days. There after the depth to water table increased slowly upto 60cm by 17 days but the depth to water table increased swiftly afterwards. But this ensured water availability to the root zone below compact zone through capillary rise, even at a point when the surface layers were cracking and soil moisture was only 11 percent of the field capacity. The model is sensitive to this as the water table depth is and input. The modified tensiometers fabricated and tested in the laboratory last year were installed the field along with the conventional tensiometers. The modified tensiometers worked satisfactorily upto 0.54 bars of soil moiture tension. The gravimetric moisture content at 20-30 cm depth decreased to a minimum of 16.4% which was better than the overlaying compacted zone.

Irrigation scheduling in rice

Irrigation scheduling at 80% probability of rainfall occurence gave higher yield of Annada variety. Sowing by manual seed drill yielded 15% more than the manual sowing. In case of bullock drawn seed drill seed rate is higher by 20%. In case of Annada ratooning gave an extra yield of 1.0 ton/ha. without any management and fertilizer. (Table - 2)

Effect of nitrogenous fertilizer on quality attributes of long slender rice

Four long slender (Sabita, CRM 30, Hatipanjari, CR 662-2318) and one long bold (Amulya) were grown under three fertilizer doses (N_0,N_{30},N_{60} and N_{90}). These five varieties possesses high head rice recovery, translucent kernels, high amylose content, intermediate gelatinization-temperature, good elongation ratio and confirm with the quality requirement of established varieties. Application of 60kg N increased head rice recovery without effecting any quality characters.

Physiological studies on scented rice

Spikelet sterility was assessed in six rice varieties having long slender grains during wet season. More than 50% sterility was observed in photo-

Table 2 : Scheduling of irrigation and its effect on yield of rice

Variety	Scheduling of irrigation of different probability (%) of rainfall.					
	70%		80%		90%	
	I.R. (cm)	Yield (t/ha)	I.R. (cm)	Yield (t/ha)	I.R. (cm)	Yield (t/ha)
Vanaprabha	30	4.2	6.54	4.3	27.4	4.2
Kalinga III	35	4.1	31.5	4.7	32.3	4.5
Annada	25	4.8	20	5.1	22.0	5.0

IR = Irrigation requirement

insensitive varieties flowering in September. However, sterility reduced to 50% in photosensitive varieties flowering between 15th to 30th October.

Dubraj, a scented variety recorded the highest grain yield of 391g m^{-2} followed by other scented varieties. Among the other non-scented long slender rice varieties, highest grain yield was obtained from Hatipanjari (591g m^{-2}), followed by Lunishree (534g m-2), Kalma (484g m^{-2}). In photoinsensitive varieties grain yield was less than 200g m-2 (Table 3).

Effect of Nitrogen levels on the pattern of biomass partitioning in rice

Changes in dry weight of each aerial component and partitioning of new incremental biomass were investigated for two rice varieties Swarnaprabha (semitall) and IR 36 (semi dwarf) at different levels of nitrogen, 30, 60, 90, 120 and 150 kg ha^{-1}. Incremental biomass of leaf, stem and panicle was assessed at ten day intervals from samples drawn at different growth stages.

Varietal differences in distribution of new incremental biomass were observed. There was no increase in leaf partitioning co-efficient after vegetative stage where as stem partitioning co-efficient attained a maximum at panicle initiation stage. In general, the distribution of new incremental biomass during flowering was found to be least to the leaves followed by

Table - 3 : Grain yield and yield attributes in scented and non-scented quality rice

	Name	Chalf (%)	Single panicle weight (g)	Panicle (No./m²)	Grain yield/m² (g)
A.	**Scented**				
	Basmati 370	85	0.6	380	78
	Kasturi	83	0.5	333	105
	Ranbir Basmati	57	0.9	280	155
	Basmati Kaputhala	72	0.9	303	173
	Pusa Basmati 1	53	0.8	343	192
	Dubraj	24	1.7	307	391
B.	**Non.scented**				
	Ratna	78	0.8	320	112
	IR 36	50	0.7	323	135
	* Kalma (Hoogly)	36	1.4	360	360
	* Kalma (West Dinajpur)	20	2.1	272	484
	* Lunishree	27	2.0	307	534
	* Hatipanjari	18	2.4	320	591

* *Photosensitive*

stem and thereafter it started declining with concomitant increase in the panicle. At milk stage the panicle partition co-efficient was 1.

Biomass distribution pattern indicated that allocation was more to stem than to leaves at lower levels of N (30 kg N ha -1). However, at higher levels of N (150 kg ha-1), contribution to leaves was more than to stem. The relatively high N responsive variety IR 36 had a larger investment of new biomass in leaves than in stems. However, the reverse was true with low N responsive variety, Swarnaprabha (Table 4 and 5).

Table - 4 : Harvest index at differrent nitrogen levels

Variety	N150	N120	N90	N60	N30
Swarnaprabha	55.7	57.0	57.6	51.1	40.6
IR 36	58.7	63.3	61.6	55.0	44.6
Mean	57.2	60.1	59.6	53.1	42.6

CD	1%	5%
Variety	3.93	2.77
Nitrogen	6.25	4.39
V*N	ns	ns

Diurnal variation in maintenance respiration at different growth stages.

Maintenance respiration was assessed for two rice varieties viz; Swarnaprabha and Ratna at vegetative (45 days after planting) and flowering stages. Leaf samples drawn at 2 hour interval from a field experiment were processed in the laboratory and the estimation was done by Differential Respirometer (Gilson, USA). The study indicated that although pattern of diurnal variation was similar, the rate of maintenance respiration was higher at flowering than at vegetative stage for both varieties (Fig 1). Peaks were observed at 6.00 a.m. and 6.00 p.m. whereas a depression was evident during mid-day, indicating an apparent direct relationship with photosynthetic activity. As the photosynthetic activity declined during morning and evening due to non availability of solar radiation, the respiration activity increased conocomitantly. However maintenance respiratory activity in Swarnaprabha was found to be lower than in Ratna inspite of its higher biomass production.

Variation in maintenance respiration at different growth stages of rice as influenced by nitrogen

Maintenance respiration was estimated in two rice varieties viz; Ratna and Swarnaprabha at maximum tillering, primordial initiation, flowering and 10 days after flowering under 4 nitrogen levels, 30, 60, 90 and 120 kg ha-1. Irrespective of growth stages, maintenance respiration rate increased

Table - 5 : Nitrogen uptake by leaf (mg/pot) of rice varieties at different nitrogen levels and growth periods

Variety/DAT		N levels (kg/ha)				
		150	120	90	60	30
Swarnaprabha	12	135.04	94.36	82.37	79.49	36.46
	22	212.26	152.88	135.19	94.08	42.12
	32	335.71	243.98	198.02	144.77	69.15
	42	544.01	399.02	320.03	195.54	108.22
	52	500.76	365.92	297.72	188.28	99.96
	62	863.24	594.76	424.04	278.88	135.92
	F	1310.76	829.59	544.25	373.12	159.21
	F+10	709.48	497.72	329.92	194.56	94.88
	F+20	328.96	237.36	184.08	122.39	61.44
	F+30	204.96	116.64	92.68	61.72	28.01
	Mean	514.52	317.22	261.83	173.26	83.53
IR 36	12	235.41	198.81	146.16	126.82	52.69
	22	254.52	208.12	179.04	156.84	50.54
	32	430.84	368.46	305.42	261.97	52.99
	42	764.21	578.12	464.01	367.59	73.54
	52	797.16	576.29	437.46	351.36	105.25
	62	1339.71	956.07	710.24	542.12	150.89
	F	2044.99	1311.02	1012.68	753.45	96.22
	F+10	909.47	723.04	411.26	272.57	82.54
	F+20	472.68	352.81	231.57	173.38	49.05
	F+30	219.22	182.61	151.19	96.74	33.68
	Mean	746.82	545.55	404.89	310.39	86.74
Treatment mean		630.67	431.39	333.37	241.83	84.64

DAT = Days after transplanting

F = Flowering, F+10 = 10 days after flowering

C.D. (0.05)

Vareity	114.44
Nitrogen	180.95
Variety x Nitrogen	ns

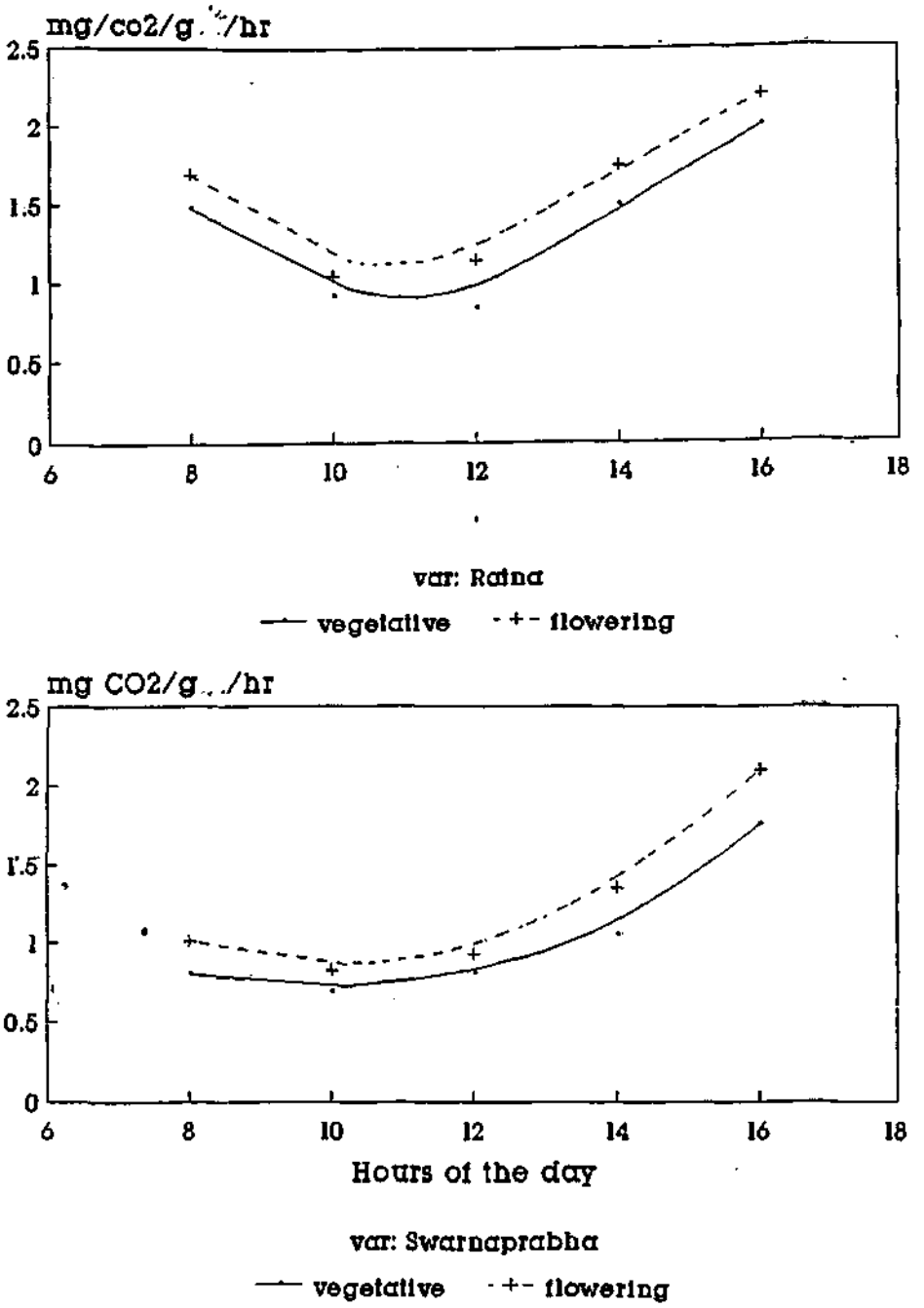

Fig. 1 - Diurnal Variation in Respiration

with increasing levels of nitrogen. Further the rate also increased with growth stages from maximum tillering to flowering and 10 days after flowering (Fig.2).

The variety, Swarnaprabha exhibited lower respiration rate than in Ratna at lower N levels (30 and 60 kg N ha-1). But at 120 kg N ha-1 Swarnaprabha was respiring more than Ratna, indicating its poor response to higher N dosage but also it increased the respiratory activity at the cost of biomass production.

Effect of exogenous application of kinetin on spikelet degeneration in rice

The effect of foliar application of kinetin at 100 ppm on spikelet degeneration was assessed in two high yielding rice varieties, Ratna and Swarnaprabha grown in field. The spray was made at 34 days after transplanting. Under untreated condition Swarnaprabha exhibited 18% spikelet degeneration from panicle initiation to flowering followed by further reduction of 48% during ripening and finally grain recovery was 41%. Application of kinetin improved grain recovery to 43%.In case of Ratna it was 26%, 51%, 38% and 41% respectively. Thus, kinetin spray had a beneficial effect in minimising spikelet degeneration.

Crop modelling studies on simulation of BPH damage to host plant

The earlier model on BPH population dynamics is now converted to a subroutine and successfully coupled to a plant growth model (L1D. CSM). In proportion to the BPH population every day, the subroutine quantifies the amount of stem reserve consumed and the same is computed as a loss to the plant. The loss is integrated over the growth period of the crop and thus the damage is reflected in terms of depletion in stem reserve and subsequently yield loss. The model however needs to be reinforced with actual data of feeding rate of BPH for further improvement.

Pesticide metabolsm in rice soils

Fenitrothion (O,O-dimthyl-O- (3-methyl-p- nitrophenyl phosphorothioate) is being increasingly used for insect control in agriculture. There is no evidence yet on the accelerated hydrolysis of fenitrothion in fenitrothion-acclimatized soils. Attempts have been made to induce the accelerated hydrolysis of fenitrothion through

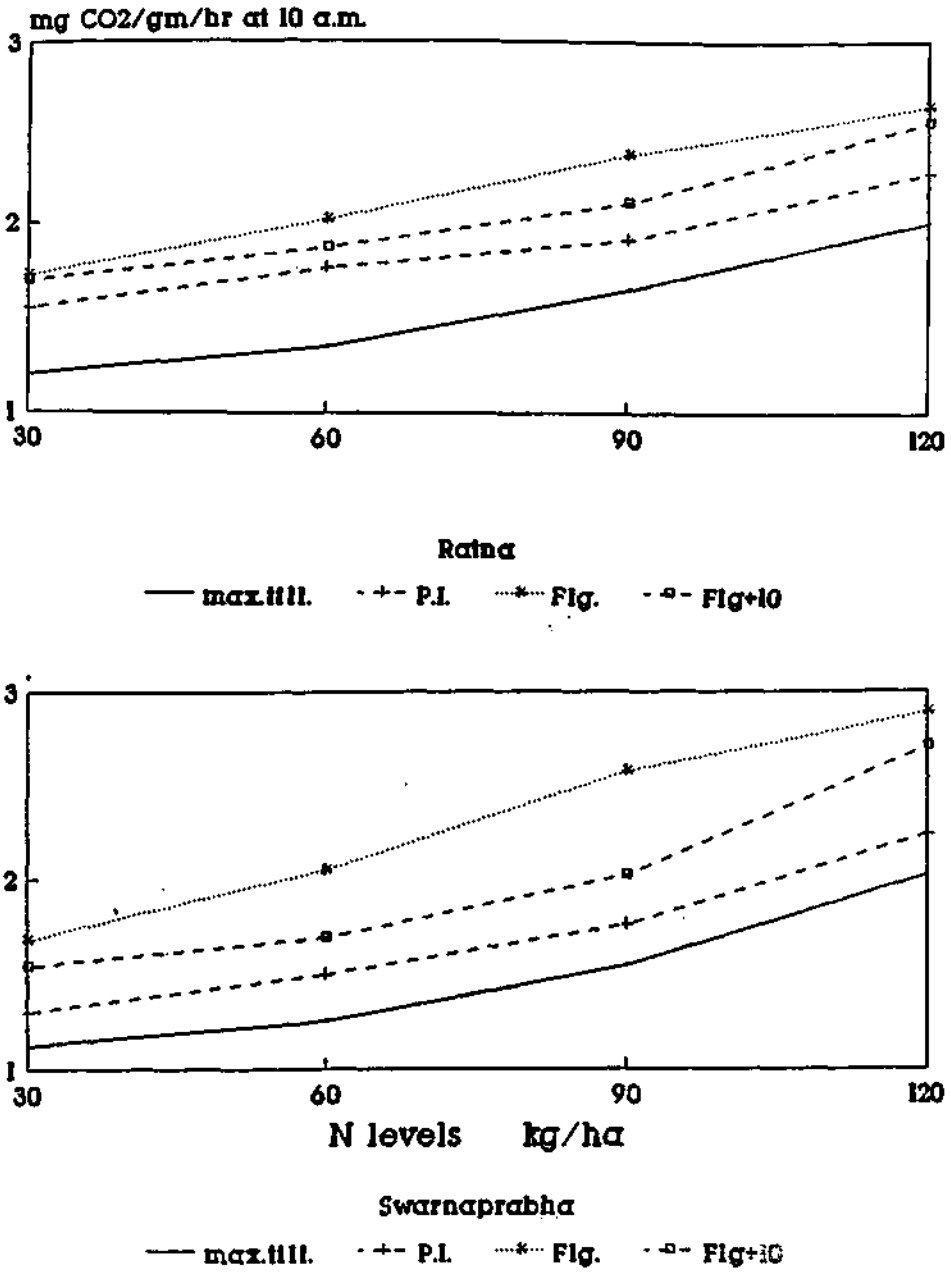

Fig. 2 - Effect of N levels on respiration rate at different growth stages

repeated additions of fenitrothion or its hydrolysis product, 3-methyl-4-nitrophenol to flooded or non flooded soils. Results indicated that repeated additions of fenitrothion or its hydrolysis product could induce accelerated hydrolysis of fenitrothion in acclimtized soil suspensions depending upon the soil type, moisture regime (flooded or nonflooded) and the substrate (fenitrothion or 3-methyl-4-nitrophenol) applied. Although, accelerated hydrolysis of fenitrothion was noticed in all the three (CRRI, Bhubaneswar and Kalahandi)soils, occurence of this phenomenon was not uniform and no generali sation on the factors promoting accelerated degradation of fenitrothion could be made. It appears from the present study that fenitrothion is not affected by accelerated biodegradation in acclimatized soils to the same extent as methyl parathion or parathion.

In a follow-up study, the relative susceptibility of p-nitrophenol and 3-methyl-4-nitrophenol to degradation by soil suspension (enrichment culture) from fenitrothion-or 3 methyl-4-nitrophenol-treated soils was examined. p-Nitrophenol, was readily metabolised by enrichment cultures from fenitrothion amended flooded Kalahandi soil and 3-methyl-4-nitrophenol-treated nonflooded Bhubaneswar soil. None of these enrichment cultures could metabolise 3-methyl-4-nitrophenol indicating that 3-methyl-4-nitrophenol indicating that 3-methyl-4-nitrophenol was resistant to degradation even by 3-methyl-4-nitrophenol-acclimatized enrichment cultures. Fenitrothion-acclaimatized soil, upon sterilization by auto claving lost its capacity to hydrolying fenitrothion indicating microbial involvement.

Methane emission in tropical rice soils

In studies on methane emission from flooded rice fields under irrigated conditions, fields planted to rice emitted more methane than unplanted fields. At the seedling (nursery, 30-day old) stage of the rice plant, methane emission was low and the oxidation power of rice roots, in terms of naphtylamine oxidation was high. A reverse trend was noticed at the reproductive stage of the rice plant of methane emission and root exidase activity. In studies on diurnal variation in methane efflux at panicle intiation stage, methane emission reoched maximum during mid-day and declined to minimum level at mid-night, irrespective of the rice variety. Diurnal variation of methane efflux at

seedling (nursery) stage was negligible.

In another study ont the effect of source and form of nitrogenous fertilizer on methane emission, urea supergranule (USG) or prilled urea effected two-fold increase in methane emission over that of control, while prilled urea in combination with *Azolla* increased methane emission by four-fold. Studies indicated that substantial amount of methane was evolved by tropical rice under flooded condition and this could be further influenced by different cultural practices associated with rice growing.

Development and testing of puddle seeder for rice

A manual six row drum type pregerminated puddle seeder for rice has been designed and fabricated (Fig.3). The machine consists of frame made of M.S. pipes, one handle, three cylindrical seed boxes with circular holes on two edges, two ground wheels, two float shoes, one axle and one central float leveller. The seed drums are mounted directly on the axle of the ground wheel. The seeds fall through the circular holes at both edges of the seed drum by gravity. There are two sets of holes for 15 cm and 20 cm row spacing. There are metallic strip belts to cover the circular holes of any row not in use. The same strips can also be used to vary the opening size in order to vary the seed rate. Two float shoes help the machine to float above mud without much sinkage. The central float leveller levels the foot holes of the operator so that seeds do not fall inside the mud. For filling seed inside the cylindrical seed boxes there is one hinged door plate in each seed box which can be opened of closed by a altrap. As the seed boxes rotate with the axle of ground wheel, there is no need of separate agitator for free flow of seed. The laboratory testing of the seed drill has been completed.

Specifications

Type	Manual
No.of seed box	3
No. of rows	3
Row spacing	15 or 20cm.
Hill spacing	continuous
Seed metering	Gravity flow through circular holes in seed box.
Power requirement	One person.

The seed flow rate with different rice varieties and with varying amount

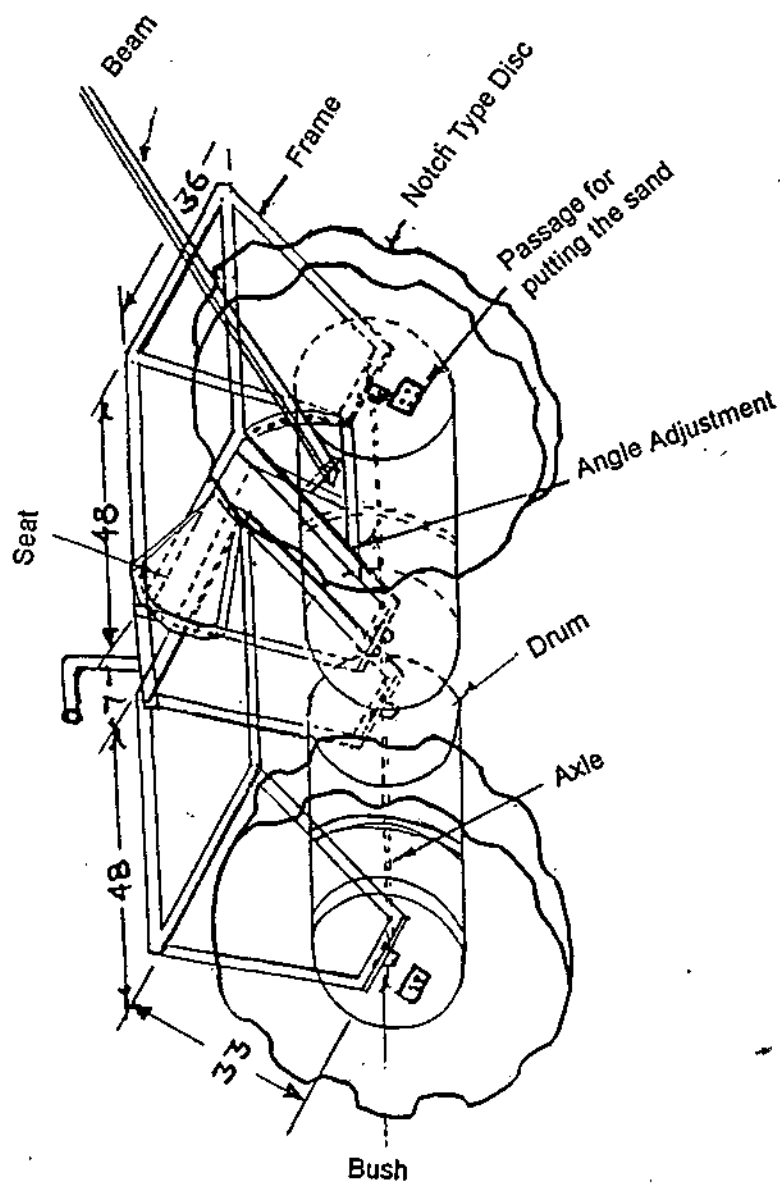

Fig. 3 - Puddle Seeder (Notch Type Disc) developed at CRRI

of seed in the seed boxes are as follows.

When the quantity of seed box is between 2 to 3 kg, there is no much variation in seed rate of long slender and small slender varieties. In case of medium bold grain the seed rate is more.

Evaluation of manual operated 4-row rice transplanter using mat type seedlings in a modified tray with different aged seedlings

Transplanting is a very labourious and time consuming operation. With the help of mat type seedlings ore 4-row transplanter has been modified and developed at the Institute. (Fig.4) On trial it was found that the tray movement is not perfected due to the friction of the loaded tray in the iron bar provided at the base of the frame. Hence it was replaced by the four small roller in order to reduce the friction. The testing is under progress.

Specifications

No. of rows	4
Width of the machine(cm)	76
Length of the machine(cm)	75
Weight of the machine(kg)	22
Tray displacement per stroke(mm)	6
Power required for operation	One person.

Design and fabrication of a two gang and notch type disc harrow for secondary tillage equipment

One notch type disc harrow operated by a pair of bullocks has been fabricated for secondary tillage operation. Four notch type discs with 3 cm concavity have been mounted over two 25 cm diameter empty drums. These drums have provision for putting the sand to increase the load for operation in the heavy soil. The two gangs are coupled in such way that it can be pulled by a pair of bullock. This is the only equipment which can be used in light as well as heavy soils by increasing and decreasing the weight.

Specifications

Dia of notch disc	60 cm
Diametre of drum	25 cm
Width of the implement	110 cm.
Angle for adjustment	23 - 35°
Weight of the implement	82 kg.
Power required for operation	One pair of bullocks.

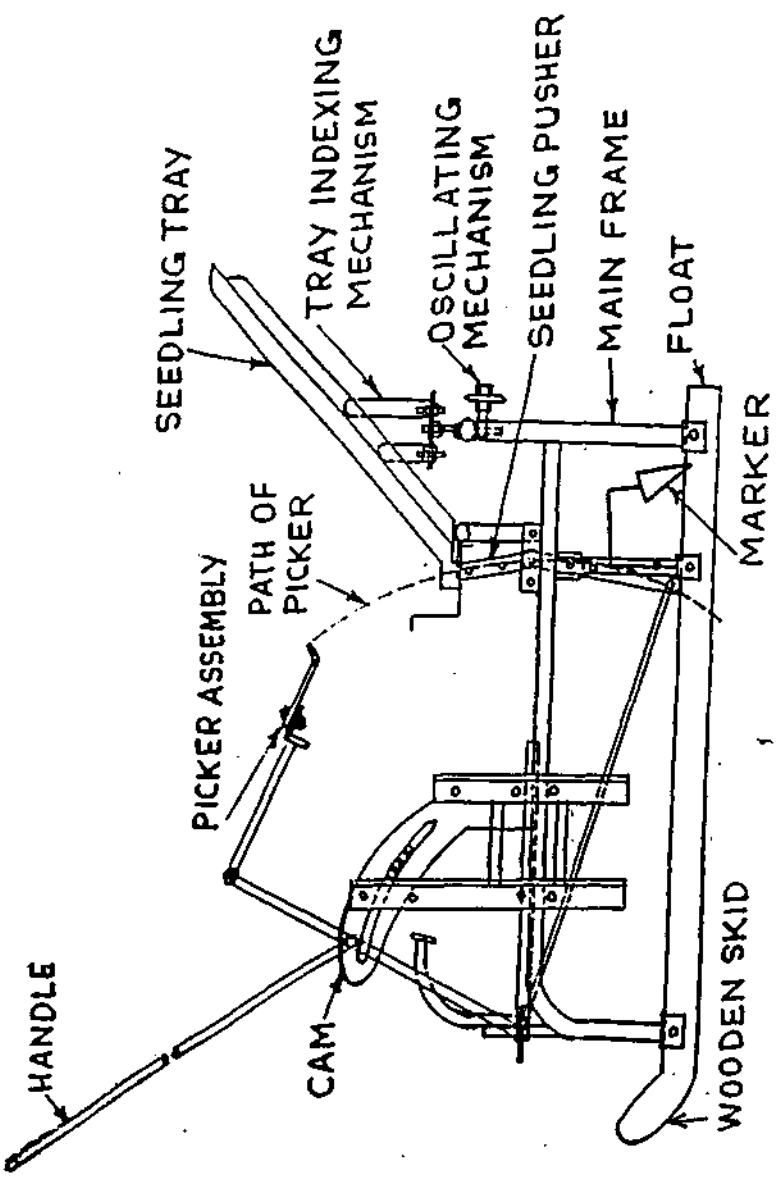

Fig. 4 -Manual Rice Transplanter (4 Row)

Testing and evaluation of different types of harvester for rice

A tractor mounted harvester was procured in the previous year and was also tested for harvesting rice. The tractor harvester (Sherpur model) and a power tiller mounted harvester (National Power Tiller) were tested in the field this year for their performance. The data shows their performance is similar to that obtained in the previous years.

The reapers were used for nonlodging high yielding type rice variety and the soil condition was appropriate for the movement of tractor as well as power tiller. The tractor operated harvester harvested about 0.32 ha/hr including the idle and breakdown timings. The cost of operation is about Rs. 473 per ha. There is a saving of labour and time using this harvester (Table 6). This may find popularity with rice growing farmers.

A power tiller operated harvester (National Power Tiller) was also tested for its performance. Its field capacity was 0.17 ha/hr. It can harvest about more than a hectare per day (Table 7). Cost of operation is about Rs. 411/- per hectare and there is a labour saving of Rs. 260/- per hectare and also the harvesting is quick. However there was little bit mixing of the earhead portion with the rootside of the straw and the windrows are not neat. A self propelled reaper is to be tested and compared with the other reapers in the coming season.

Crop parameters studied during the test

Average height of plants	114 cm.
No. of tillers	6 to 11
Average number of hills/m^2	36
Moisture content of grain	21%
Variety	Dharitri

Cost of operation (Rs./ha) of tractor front mounted rice harvester:

Fixed cost	340
Fuel cost	90
Labour cost	143
Cost of harvesting	573
Cost of sickle harvesting	675

Cost of operation (Rs/ha) of power tiller mounted rice harvester

Fixed cost	204
Fuel cost	42
Labour cost	165
Cost of harvesting	411
Cost of sikkle harvesting	675

Table 6 : Field performance results of tractor drawn rice harvester

Date of test.	Field capacity (ha/hr)	Field efficiency (%)	Skilled labourer (hrs/ha)	Harvest Loss (%)
13.12.93	0.32	82.54	3.1	0.3
14.12.93	0.29	77.64	3.4	0.2
30.12.93	0.31	79.44	3.2	0.4
31.12.93	0.30	78.24	3.3	0.3
06.01.94	0.344	85.64	2.9	0.4

The dryer has been tested with freshly harvested rough rice during 1993. The summary of the test results is given below.

Parameters of Paddy dryers

Parameters	Observations
Average ambient air temp.	26°C.
Drying air temp.	42 ± 2°C.
Maximum grain temp.	40°C
Initial m.c.of rough rice	24%
Final m.c. of rough rice	14.2%
Total drying time	7 hrs.
Tempering time (After 3 hrs. of initial drying).	1 hr.
Head rice recovery	62%
Fuel consumption	15 kg. of coal
Drying cost	Rs. 52/- per ton.

Table 7 : Field performance results of power tiller mounted harvester

Date of test.	Field capacity (ha/hr)	Field efficiency (%)	Skilled Labourer (hr/ha)	Harvest Loss (%)
28.12.93	0.174	82	6.0	0.2
30.12.93	0.154	73	6.6	0.4
05.01.94	0.184	88	5.6	0.2
06.01.94	0.164	76	6.2	0.3

Development of a rice winnower

Based on the conceptual design, a winnower has been developed particularly for winnowing rough rice just after threshing. The objective is to separate the light materials such as, straw, stalks, chaff, immature grains dust etc. from the heavy grains in a single pass. At present farmers do this operation by hand which is time consuming, laborious and therefore expensive. The mechanical winnower, developed for this purpose consists of a blower and grain feeding mechanism such that the light and heavy materials are moved in different directions to make the separation effective. The unit is now under trial to undertake necessary modifications for giving it a final shape.

Development of a dryer suitable for rice farmers

A dryer of 500 kg. holding capacity, suitable for rice farmers has been developed. The unit comprises of the following main components : (i) Drying chambers, (ii) Blower with motor and (iii) solid fuel fired furnace with heat exchanger. The furnace is placed in between the drying chambers and the blower. The detailed specifications of the dryer is as follows.

A. Schematic diagram of the dryer is shown in Fig.5. It is simple in construction and easy to operate. Both raw and parboiled rice can be dried with this urit. Because of the heat exchanger, the air does not get contaminated with smoke. This helps to get quality rice after drying.

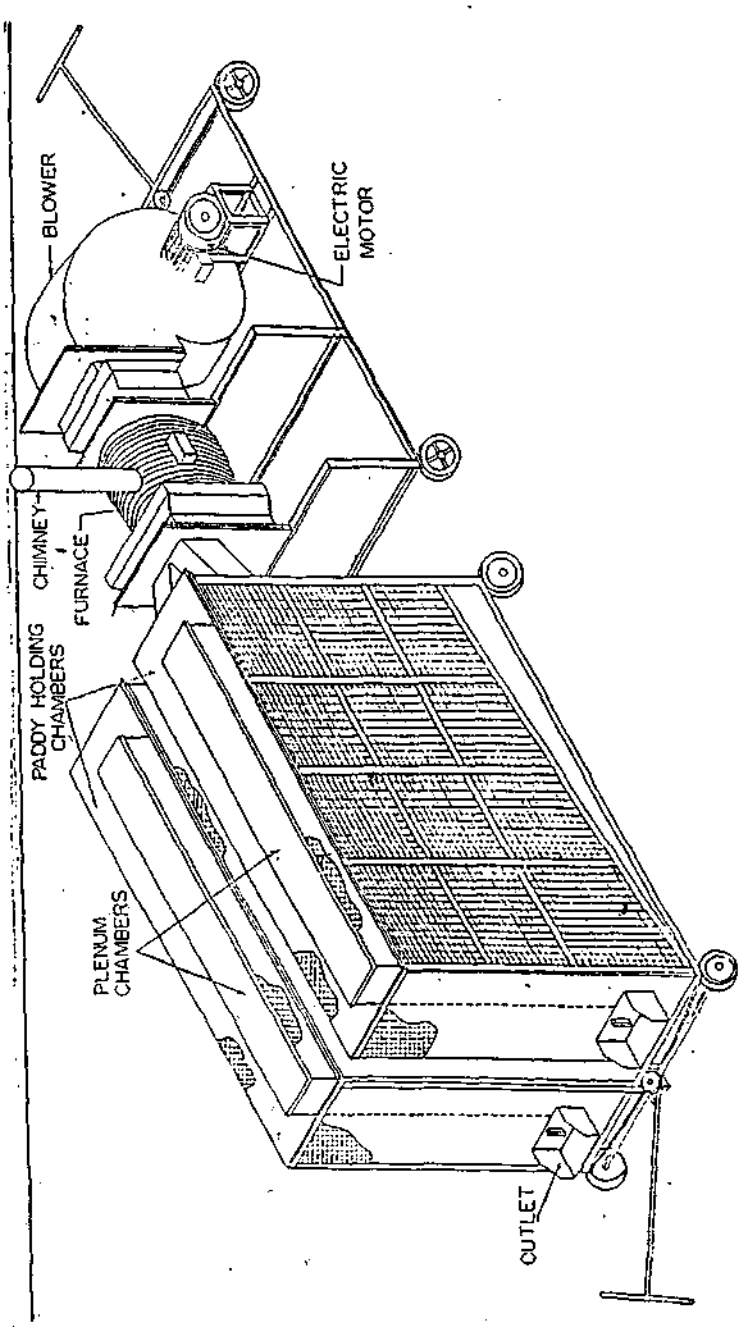

Fig. 5- Complete View of Paddy Dryer (Capacity 500 Kg)

Specifications

Type of the dryer	Batch
Holding Capacity	500 kg(rough rice)
Drying principle	Thin layer (12mm)
Over all dimensions (LxBxH)	356 cm x 97cm x 140cm.
Fuel used	Solid fuels like coal, wood or briquets.
Blower type	Centrifugal (3000 cfm)
Motor	Induction, 3 phase, 3.25A, 1.5/2 (KW/HP0.
Permanent/Movable	Movable.
Cost of the dryer	Rs. 25,000/- (approx.) (1993)

CROP PROTECTION

Chemical weed control in puddle-seeded rice

To find out an effective herbicide for puddle-seeded rice during the dry season, a herbicide screening trial was conducted in a field infested with *Cyperus difformis, Fimbristylis miliacea* (sedges) and *Sphenochlea zelanica, Marsilea quadrifolia* and *Ludwigia parviflora* (dicots). There were 18 treatments including unweeded and weed-free (3 hand weedings) checks, hand weeding twice and different herbicides/herbicide combinations anilofos (EC and granules), anilofos + 2, 4-DEE, butachlor, pretilachlor, thiobencarb and cinmethylin - at varying rates of their application. Rice variety Annada was sown on February 5 and the herbicides were applied 7 days latter. The dry weight of weeds 60 days after sowing in herbicide treatments anilofos (EC, 0.6 kg/ha), butachlor (1.0 and 1.5 kg/ha), pretilachlor (0.45 and 0.6 kg/ha), thiobencarb (1.0 kg/ha), pretilachlor plus safener (Sofit, 0.6 kg/ha), cinmethylin (0.05 and 0.10 kg/ha) and anilofos (granules, 0.6 kg/ha) was comparable to that in weed-free and hand weeding twice treatments. Forty days after sowing, the herbicide treatments anilofos (EC, 0.4 and 0.6 kg/ha), anilofos (0.3 and 0.4 kg/ha) + 2,4-DEE (0.4 and 0.53 kg/ha), butachlor (1.0 and 1.5 kg/ha), pretilachlor (0.45 and 0.6 kg/ha) and cinmethylin (0.05 and 0.1 kg/ha) showed moderate to high toxicity to rice. The highest grain yield of 5.7 t/ha was recorded in weed-free check, which was comparable to hand weeded twice, anilofos

(granules, 0.6 kg/ha), pretilachlor puls safener (Sofit, 0.45 and 0.6 kg/ha) and thiobencarb (1.0 kg/ha).

Crop-weed competition in puddle-seeded rice

A field experiment was conducted to find out the critical period of crop-weed competition in puddle-seeded rice (CV. RR 50-5 of 85 days duration) during the dry season. The crop was subjected to varying periods of weed competition and weed removal at different growth stages. The loss in grain yield due to weed competition throughout the crop growth was worked out as 23.1%. Weed competition during the first 20, 40 and 60 days after sowing reduced the grain yield by 7.6, 15.2 and 19.2%, respectively. Removal of weeds during these periods increased the grain yield over that of unweeded check by 12.6, 24.9 and 27.6%, respectively.

Physiology of disease resistance

Toxin production by brown spot pathogen : With a view to examine the posibility of utilizing the toxin produced by *Dreschslera oryzae* in culture for in-vitro screening of rice seeding and to direct somaclonal variant tolerant to brown spot in callus tissues, a crude preparation (partially purified) of the toxin was prepared. Preliminary studies revealed that the toxin is a low molecular weight compound.

A seedling bioassay technique was developed to assess the toxicity of the toxin extract. The sensitivity of five rice cultivars (Benibhog, Jaya, Karuna, Annada and Minri), susceptible to the disease, to the toxin preparation were coleoptile and radicle growth in the assay and the inhibitory activity was dependent on the concentration used. This suggests the possibility of utilizing this toxin preparation for experimenting with the rice callus tissue.

Asian Rice Biotechnology Network Programme on bacterial blight

A total of 213 isolates of bacterial blight pathogen and 139 isolates of blast pathogens has been collected by the ARBN team and maintained in the laboratory.

Efficacy of fungicides by seed treatment for the control of rice tungro

The following fungicides namely Imadachloprid, Bavistin, Topsin, Coratop, Kitazin, Hinosan, Dithane

M-45, oryzemate, Fungorene, Beam 75 etc. were used as seed treatment and the seedlings were inoculated with viruliferous leaf hoppers to see the efficacy of these fungicides for control of tungro. Only one chemical, Imidachloprid recorded 0% disease wheras others recorded 70-80% disease on par with control. Percentage reduction in height and number of tillers in these different treatments were taken and these data also are on par with healthy plants incase of Imidachloprid and on par with diseased in case of others. This indicates that Imidachloprid is only effective as seed treatment for control of tungro Conatop and oryzemate which were effective as spray application in previous years also failed to be effective as seed treatment.

Screening of released high yielding/ varieties for tungro resistance

One hundred twenty five recently released high yielding/popular varieties of India were screened for tungro resistance under field epiphytotic conditions. Only one variety Athikaraya recorded high degree of tolerance (score I) to tungro. Only 4 varieties Hatangi, Biraj, Sabita and Y-4 showed tolerance score of 3.

Testing of wild rices for tungro resistance

Twenty accessions of wild rice species were tested for tungro under green house conditions by inoculating with 10 viruliferous leaf hoppers per seedling. The following accessions viz. *Oryza nivara* (RN 1054), *O. rufipogon* (SD 1001),*O. officinalis* (SD 1024) and *O. latifolia* (SD 1001) were found to be resistant to tungro since no didsease appeared on these wild rice accessions.

Determination of the stability analysis of tungro resistant varieties

Thirty five tungro resistant varieties (tolerance score 1-3) were tested under field conditions in 3 replications to see their stability analysis over a period of 5 years. Due to severe disease pressure, five varieties - Saket-4, Gillawan, Utrirajapan, Virippu and Pankaj showed higher levels of disease (tolerance score 4-6). The reaction of these varieties is to be ovserved over the period of remaining 4 years.

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SHALLOW ECOSYSTEM

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CROP IMPROVEMENT

Evaluation of breeding material for shallow submergence (10-30 cm) (All India Co-ordinated Trials)

Six advanced cultures viz. CR 626-256 (IET 12241), CR 659-380 (IET 12545), CR 724-241 (IET 12549), CR 728-57-4-2 (IET 13364), CR 702-53 (IET 13368) and CR 410-6018 (IET 13369) were included in Advanced Variety Trial-shallow water (AVT-SHW) Zone II for testing all over the country. The entry, CR 629-256, having semi-tall stature, medium slender grains, good cooking quality and flowering duration of 125 days was ranked second and was recommended for minikit trials.

Another set of 15 cultures viz. CR 581-9-1 (IET 13507), CR 661-179 (IET 13508), CR 661-236 (IET 13509), CR 683-195 (IET 13510), CR 757-179 (IET 135-11), CR 751-235 (IET 13512), CR 662-221 (IET 14106), CR 683-18 (IET 14107), CR 626-7-3 (IET 14108), CR 766-1 (IET 14109), CR 673-431-92 (IET 14110), CR 673-475-91 (IET 14111), CR 767-1 (IET 14112), CR 768-1 (IET 14113), CR 768-2 (IET 14114) were entered in Initial Variety Trial-Shallow water (IVT-SHW) Zone II. Based on their performance in 7 locations, the cultures, CR 661-236, CR 661-179 and CR 662-2211 were ranked second, fourth and fifth, respectively, with an average yield range of 4.4-4.7 t/ha. The flowering duration of these cultures ranged from 119 to 123 days.

Elite cultures

Fifteen cultures were grown in 100 m^2 plots to assess their yield potential. The promising cultures were CR 664-132-600 (5.2 t/ha), CR 661-236 (5.1 t/ha), CR 662-2211 4.9 t/ha) and CR 680-103-981 (4.7 t/ha) compared with checks Savitri (3.1 t/ha), Mahsuri (2.0 t/ha) and Pankaj (1.7 t/ha). All these lines matured in 145-150 days.

Elite cultures under normal and late planted conditions

Twenty elite cultures were tested for their suitability under normal and late planted conditions. Thirty day-old seedlings were transplanted by first week of July for normal planting and fifty day-old seedlings were transplanted in the first week of September for late planting. The rice lines, CR 683-123, CR 683-115, CR 683-195 and CR 682-162 were found promising with usual yield and the characters under both normal and late planted condi-

tions. However, the semi-tall lines, CR 683-310 and CR 758-113 performed better under normal than under late planting. Height reduction was seen under late planted condition. Semi-tall varieties performed better under late planted condition.

Fixed cultures

Fifty two fixed cultures from 20 cross combinations were grown in three replications and observations on tillering, sterility percent, effective ear bearing tillers, single plant weight, 1000 grain weight and plot yields were recorded. The cultures, CR 661-102-235 and CR 782-113-90-1465 gave yields of more than 7 t/ha. The other promising cultures were CR 783-789-180, CR 165-787-178, CR 662-1133, CR 778-631, CR 780-2-2318, CR 780-79-982 and CR 780-956 (6.0-6.8 t/ha) as compared to checks, Jagannath (5.8 t/ha), Savitri (5.5 t/ha), Pankaj (4.0 t/ha) and Mahsuri (3.7 t/ha).

Evaluation of fixed cultures

Twenty three varieties viz., Gayatri, C-8, Padmini, Jagannath, Sh 59, DR 1006, IET 2254, SM 147, C 6, Utkalprabha, Sm 50, SM 55, HM x CR 1009, Salivagana, Santri, C 10, CR 1016, Manasarovar, S 57, SM 3, Biraj and IET 2254 were tested with local check Pankaj under moderate application of fertilizer viz., 60 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha.

The cultivars CR 1006, Salivahana and Manasarovar performed better yielding more than 6.5 t/ha. Gayatri and C 10 gave an yield of more than 5 t/ha. The other prominent cultures giving more than 5 t/ha were SM 3, SM 79, SH 59, HM x CR 1009, C 8 and Pankaj.

Identification of varieties with built-in-resistance to biotic stresses

From a replicated trial of 40 fixed cultures under unprotected conditions in shallow lowlands, CR 402-1-2, CR 403-2-2, CR 405-8, CR 580-17-2 were found to possess tolerance to gallmidge brown plant hopper, green leaf hopper, blast, bacterial leafblight and tungro. (Table 1)

Selection in segregating population

Two hundred advanced generation rice lines from the crosses of Jagannath/Padmini, Jagannath/Mahsuri and Moti/Mahipal were grown. Uniform lines were bulked and selection was

Table - 1 Promising cultures from CRRI for shallow lowlands

Culture No.	Duration (days)	Yield potential (t/ha)	Built-in-tolerance for
CR 402-1-2	135	5.0	GM, GLH, BL, RTV
CR 403-2-2	135	5.5	GM, BPH, BL,RTV
CR 405-8	130	4.5	GM, RTV
CR 580-17-2	155	4.0	GM, GLH, RTV

GM : Gall midge, GLH : Green leaf hopper,
BL : Blast BPH : Brown plant hopper,
RTV : Rice tungro virus

made in the segregating lines. Further, M_4 generation of gamma irradiated CR 256-35 population was grown and selections were made. In order to increase the yield potential of the well adapted but low yielding traditional rice varieties, crosses were made between local varieties (Boita, Sagari, Mayurakanta and Sita) and elite lines and released varieties. F_1s of the crosses Boita/CR 662-2211. Sagari/CR 660-947, Mayurakantha/CR 661-236 and Sita/Vanaprabha were made. Selection will be made based on plant height, grain type and single plant yield in the F_2 generation. (Table-2)

Rice varieties for late planted situations

Five rice varieties, Manasarovar, IGT-7251, IET-9757, Salivahana and S57 were tested under four dates of planting at fortnightly intervals starting from 16 July until 27 August. Manasarovar, Sawlivahana and IET-9757 recorded the best performance at 16th July planting with mean grain yield of 6.33, 3.97 and 6.27 t/ha respectively. Subsequent delay in planting by a fortnight registered drastic reduction in grain yield of these varieties (3.12, 3.52 and 3.72 t/ha respectively). However Salivahana produced consistently reasonable grain-yields even upto August 27 planting.

HYBRID RICE

Source nursery

Forty two CMS lines including 13

Table - 2 : Number of pedigree lines evaluated under shallow low lands

Cross	No. of progenies grown	No. of selections made	Generation
Jagannath/Padmini	100	75	F_7
Jagannath/Mahsuri	25	15	F_7
Moti/Mahipal	75	50	F_4
CR 256-35 Mutant	100	40	M_4

developed at CRRI, Cuttack 175 identified as maintainers, 300 restorers, about 200 *indicas* (improved elite lines), 20 *japonicas*, 214 promising lowland varieties, 36 primitive cultivars including *O. glaberrima* and 35 wild rices *(O. rufipogon, O. nivara* and *O. sativa f. spontanea)* were grown in the source nursery for purification, seed multiplication and utilization in test and back-crosses for identification/ development of CMS, maintainers and restorer lines. Agronomic characters and flowering behaviour of all these lines were recorded. Of the 42 CMS lines, only six lines viz. Pragati A, Deepa A, Pusa 33 A, Sarasa A, PMS 3A and PMS 10 A were found to be suitable for shallow lowland conditions.

Test crosses

A total of 350 test crosses were made involving 15 CMS lines. [Krishna A (Kalinga-I), Krishna A(WA), Annada A (WA), IR 64 A *(O. perennis),* Kiran A, Pusa 33 A, Sarasa A, IR 58025 A, Pusa 4-1-11A, PMS 10 A, PMS 3 A, Deepa A Pragati A, Madhuri A, CRMS 2 A], and 80 tester parents to identify effective maintainers and restorers suitable for shallow lowland ecosystem. The maintainers thus identified will be subsequently used for development of CMS lines through conversion.

Twenty eight crosses in the conversion programme of different CMS lines were back-crossed with their respective *indica* pollen parents for further back-cross generations at different stages to develop new CMS lines (Table 3).

A number of inter-varietal crosses between *indica* (land races) and *indica* (varieties) were made to identify

Table - 3 : Backcrosses made for developing new CMS lines

Combinations	BC Generation
LOWLANDS	
(CR 21 A/Anamica)/Anamica$_5$	BC_5
(V 20 A/IET 10158)/IET 10158$_5$	BC_5
(V 20 20 A/Padmini)/Padmini$_4$	BC_4
(V 20 A/IET 10435)/IET 10435$_4$	BC_4
(V 20 A/IET 10983)/IET 10983$_4$	BC_4
(V 20 A/IET 11350)/IET 11350$_4$	BC_4
(V 20 A/IET 10849)/IET 10349$_4$	BC_4
(V 20 A/BKS 64)/BKS 64$_4$	BC_4
(V 20 A/Moti)/Moti$_3$	BC_3
(V 20 A/Kalashree)/Kalashree$_3$	BC_3
(IR 64 A/CRM 35)/CRM 35$_3$	BC_3
(IR 64 A/Panidhan)/Panidha$_3$	BC_3
(IR 64 A/PN 56-65)/PN 56-64$_2$	BC_2
(PMS 10 A/CR 682-166)/CR 682-166$_2$	BC_2
(CR 21 A/CR 580-17-3)/CR 580-17-3$_2$	BC_2
(IR 58025 A/ARC 10339)/ARC 10339$_2$	BC_2
(PMS 10 A/Tulasi)/Tulasi$_2$	BC_2
(IR 58025 A/Panidhan)/Panidhan$_2$	BC_2
(IR 62829 A/Khadikasali)/Khadikasali$_2$	BC_2
(IR 64 A/Miz.61)/Miz.61$_3$	BC_3
(CR 8 A/Miz.24) Miz.24$_3$	BC_3
(CR 21 A/Miz.24)/Miz.24$_3$	BC_3
(IR 64 A?miz.35)Miz.35$_2$	BC_2
(CR 2 A/CR 1016)/CR 1016	BC_1
IRRIGATED CONDITION	
(V 20 A/Daya)/Daya$_5$	BC_5
(IR 64 A/Krishna)/Krishna$_4$	BC_4
(CR 21 A/Suweon 310)/Suweon 310$_3$	BC_3
(IR 64 A/Vijaya)/Vijaya$_1$	BC_1

new male sterile cytoplasm, of which only ten were found to be completely sterile. These were back-crossed with their respective pollen parents advanced back-cross generation. The cytoplasm sources were from Miz.21, Miz.4, Miz.24 and HWR 85. The pollen parents were Padmini PN 56-65, Saruchina, Krishna, Moti, CR 1006, Kalashri and Mizoram 41.

Identification of maintainers and restorers

Test cross results involving different CMS lines and tester parents which were found useful in identifying a number of effective maintainer and restorer lines (Table 4).

Identification of promising heterotic combinations

Twenty hybrids along with their respective parents 4 checks and 70 hybrids along with 7 checks were assessed for their yield performance in a single row with 20 plants/row. Twenty five hybrids yielded more than the checks (Table 5).

Evaluation of checks in National Hybrid Rice Trial

Five replicated trials (2 during dry season and 3 during wet season 1993) involving 113 hybrids and 5 checks were conducted. Promising hybrid combinations are as follows.

IHRT-1 (29 Hybrids + 5 checks) - Dry season : Two hybrids, IR 62829 A/IR 11757 R and IR 62829 A/IR 40750 out yielded the best check Jaya (8.12 t/ha), by 0.74 and 0.56 t/ha respectively.

AHRT-1 : (24 hybrids + 5 checks) Dry season : Three hybrids, IR 58025 A/IR 29723 (6.18 t/ha), IR 62829 A/IR 54742 (6.13 t/ha) and IR 62829 A/ Swarna (6.13 t/ha) were found superior to Jaya (5.61 t/ha).

IHRT-1 : (22 hybrids + 3 checks) Wet season : Two hybrids, IR 58025 A/IR 13419 and IR 58025 A/IR 32809 gave an yield advantage of 1.44 and 0.71 t/ha over the best check IR 36 (2.01 t/ha).

IHRT-2 : (22 hybrids + 3 checks) wet season : Three hybrids, PMS 3 A/ PR 103 (4.03 t/ha), IR 64608 A/IR 53970 (3.99 t/ha) and IR 62829 A/IR 29723 (3.85 t/ha) have given increased yields better than the check., Ratna (1.86 t/ha).

AHRT-1 : (16 hybrids + 3 checks) wet season : Twelve hybrids out

Table - 4 : Test results for different CMS lines (wet season)

CMS lines	M	R	WM/PR	Total
Krishna A (Kal.I)	14	15	19	48
Krishna A (WA)	8	14	16	38
Annada A (WA)	3	11	13	27
IR 64 A *(O.Perennis)*	16	2	5	23
Kiran A (WA)	4	10	17	31
Pusa 33 A (WA)	7	10	5	22
Sarasa A (WA)	6	6	13	25
IR 58025 A (WA)	3	0	12	15
Pusa 4-1-11 A (WA)	0	1	2	3
PMS 10 A (WA)	2	4	21	27
PMS 3 A (WA)	3	2	18	23
Deepa (WA)	3	5	18	26
Pragati A (WA)	0	5	6	11
Madhuri A (WA)	3	5	13	21
CRMS 2 A	1	4	5	10
TOTAL	73	94	183	350

Table - 5 : Yield performance of hybrids developed at CRRI (wet season)

Hybrids	Flowering duration (days)	Yield g/m²	Standard heterosis (%)
Sarasa A/IR 85311-25-2-1-3	82	802	49.6
Pusa 83 A/Gaurab	90	81.9	52.8
Krishna A (WA)/IR21820-38-2	92	817	54.3
Pusa 33 A/IR 35366-28-3-1-2-2	92	853	59.1
Krishna A (Kal.I)/IR 48725-B-B120-1	92	643	19.9
Annada A/IR 48725-B-B29-1	93	819	52.8
Pusa 33 A/BR 1870-88-11	93	771	43.8
IR 64 A/IR 21820-38-2	94	767	43.1
Krishna A (Kal.I)/Mahsuri	95	668	24.6
Kiran A/RP 1860-303-2-1-3	96	911	69.9
Check - IR 36	90	536	--
Pusa 33 A/IR 48725-B-B-129-1	93	1100	83.0,17.4*
Krishna A (Kal.I)Nang Nhuan	97	674	11.2
Krishna A (Kal.I)/IR 4127-F-KN-91	97	743	22.6
Pusa 33 A/IR 35311-25-2-1-3	98	819	25.1
Krishna A (WA)/SPR 7210-1-3	98	998	64.7
Kiran A (WA)/BR 1870-88-11	98	832	37.3
Krian A/IR 48725-B-B-120-1	99	718	18.5
Krishna A (WA)/IR 48225-B-B-48-1	100	741	22.3
Krishna A (WA)/Mahsuri	101	731	20.6
Pusa 33 A/IR 51139-42-1-2-3	102	857	41.4
Annada A/IR 35311-25-2-1-2	102	767	26.6
Annada A/IR 49689-84-2-1-2	104	1100	81.5
Krishna A(WA)/RP 1860-303-2-1-3	104	903	49.0
Annada A/Swarnaprabha	106	802	32.3
Deepa A/IR 4131-16-2-2-2	111	767	26.6
Checks - Vajram	105	606	-
Gayatri	130	945	-

yielded the best check Jaya (3.38 t/ha). The top three high yielding hybrids were IR 58025 A/IR 54742 (5.60 t/ha), ORI 161 (5.47 t/ha), and IR 58025 A/ IR 297-23 (5.15 t/ha).

Seed multiplication

Bulk multiplication and maintenance of purity of CMS lines, v. 20 A, IR 46829 A., IR 46830 A, IR 58025 A, IR 62829 A, Annada A, Pragati A, Krishna A (WA) and Krishna A (Kalinga-I) were done both in the field and through hand pollination. The CMS line IR 62829 A showed a maximum seed set of 28.7% in wet season with supplementary pollination techniques (rope pulling and flag leaf clipping only without GA_3 application). Seed/ stubbles of various CMS, maintainers and restorer lines were supplied to IRRI, DRR and other experimental stations. (Table-5)

Evaluation of factors contributing to heterotic vigour of hybrid rice

Three hybrids with two checks Jaya and Rasi were grown in field to evaluate factors associated with heterotic vigour. Leaf area index and total dry matter were recorded at ten day interval from transplanting to flowering. The crop IR 58025 A x Swarna exhibited highest leaf area and total dry matter until flowering and produced maximum panicles m^{-2} (306) and spikelets m^{-2} (41000). However, IR 58025 A x IR 29723-143-3-1 showed highest grains m^{-2} (20900) and grain yield (4 t ha-1). Total biomass at maturity was also highest in IR 58025A x IR 29723-143-3-1 (1321 g m^{-2}) followed by IR 58025 A x Swarna and IR 62829 A x IR 10198-66-2R.

CROP MANAGEMENT

Improvement on traditional practice of beaushening

The effect of different cultural practices (broadcast seeding, broadcast seeding + *beaushening* without gap filling, broad cast seeding + *beaushening* with gap filling + 30 kg N/ha applied at the time of *beaushening*, broadcast seeding + *beaushening* with gap filling + green manuring with *Sesbania aculeata*, line seeding + interculture with cono-weeder + 30 kg N/ha applied at the time of interculture and transplanting with 45-day old seedlings) on rice was evaluated under shallow-submerged lowland situation. Seedlings for gap filling during *beaushening* were obtained from a field sown with three times normal seed rate. *Beaushening* coupled with

adequate gap filling increased the grain yield by 15.6 % over unbeaushened crop and 12.4 % over traditionally beaushened crop (*beaushening* without gap filling). *Beaushened* and gap-filled crop grown with 30 kg N/ha applied through inorganic fertilizer or green manuring produced 8.3 to 11.4% higher yield than *beaushened* and gap-filled crop raised without nitrogen application. Line seeding followed by interculture with cono-weeder and application of 30 kg N/ha at the time of interculture produced a grain yield of 5.9 t/ha and was comparable to *beaushening* coupled with gap filling and nitrogen application through inorganic fertilizer or green manuring, which yielded 5.9 to 6.0 t/ha. Transplanted crop gave the lowest yield (4.2 t/ha) because of poor tillering due to submergence.

Evaluation of coated urea materials for higher grain yield and N use efficiency

The efficacy of gypsum coated urea (GCU) and nimin coated urea (NCU) for improving the growth and grain yield of transplanted rice (cv. CR 1002) was compared with that of prilled urea (PU), when they were applied at 60 kg N/ha in a single dose at planting or in two splits-two-third at planting one-third at panicle initiation (PI). The highest grain yield of 5.1 t/ha was obtained with GCU and NCU applied in a single dose or in two splits. These treatments were comparable with application of PU in three splits (half at planting, one-fourth at active tillering and the rest at PI) and produced 24.3 kg grain /kg N added. Application of PU in a single dose and in two splits produced 11.0 and 18.7kg grain/kg added N, respectively. Prilled urea applied in two splits recorded a mean grain yield of 4.7 t/ha.

Evaluation of varieties for post-flood conditions

To identify a suitable variety and appropriate spacing for late-planted rice under the post-flood situations five rice cultures (CR 673-475, CR 683-123, IET 6080, IET 5914 and IET 7251) along with variety Gayatri were grown under 10 cm x 15 cm, 15 cm x 15 cm and 20 cm x 15 cm spacings. The crop was planted on 9 September using 50-day-old seedlings. The culture CR 683-123 recorded a maximum grain yield of 4.4 t/ha followed by IET 6080 which yielded 4.3 t/ha. Their grain yields were significantly higher than those of CR 673-475, Gayatri, IET 5914 and IET 7251 (2.0-3.9 t/ha). The spacing did not have

a significant effect on the yield of these varieties

Response of rice to drainage at different growth stages

Seedlings (45 days old) of rice variety Gayatri were transplanted on 13 July at a spacing of 15 cm x 20 cm and the crop was fertilized with 40 kg each on N, P_2O_5 and K_2O/ha. The water depth during the crop growth was 15-20 cm. Drainage for 7 days was imposed in different combinations at early tillering (43 DAT), late tillering (60 DAT) and panicle initiation (85 DAT) stages. An additional treatment of sub-surface drainage, wherein water table was lowered to a depth of 15-20 cm, was kept for comparison. Drainage at early tillering and panicle initiation stages gave the highest grain yield of 6.2 t/ha as against 4.9 t/ha in control (without drainage). However, other treatments of drainage at 3 stages (early tillering, late tillering and PI) or 2 stages (early tillering and late tillering) produced comparable yields as that of the highest treatment. The sub-surface drainage was not of advantage as it was on par with control.

Plant population and nitrogen requirement of rice under transplanted conditions

A promising elite rice cultivar CR 260-77, was transplanted at 15 cm x 15 cm spacing using 2,4,6 and 8 seedlings/ hill (88, 176, 264 and 352 seedlings/m^2) under four levels of nitrogen application (0, 30, 60 and 90 kg/ha). The highest grain yield of 5.6 t/ha was obtained under 2 seedlings/hill which was, however, comparable to that under 4 and 6 seedlings/ hill. There was a significant yield reduction under 8 seedlings/ hill (5.2 t/ha) compared with 2 seedlings/hill. Interaction between number of seedlings/hill and N levels indicated that the highest grain yield was observed in no-nitrogen and 30 kg N/ha treatments under 4 seedlings/ hill and in 60 kg N/ha treatment under 2 seedlings/hill.

Effect of intensive rice cropping on the changes in soil properties and productivity

A long term experiment was initiated in the wet season of 1969 in order to find out the effect of intensive rice cropping on the changes in soil properties and productivity. The treatment combinations are control (CK), N, NP, NK and NPK with or without compost at the rate of 5 t/ha applied annually during May-June every year.

During the year 1993, only one crop was taken during the wet season. Dry season crop could not be taken due to unavailability of water in the irrigation canal.

There was significant response to application of compost and nitrogen in terms of both grain and straw yields, whereas, significant response to application of phosphorus was noticed only for grain yield. Application of potassium did not show any significant response either in terms of grain or straw yields.

Averaged over compost, grain yields ranged from 3.48 t/ha in control to 4.19 t/ha with the treatment receiving NPK Maximum grain yield 4.35 t/ha was obtained with treatment receiving NPK blended with compost. Averaged over fertilizer treatments application of compost gave 0.2 t/ha more grain yield over no compost treatment which was significantly superior.

Averaged over compost straw yields ranged from 5.85 t/ha with control to 8.8 t/ha with NPK blended with compost. Averaged over compost, there was significant response to application of nitrogen alone. Averaged over treatments, application of compost gave 2.54 t/ha more straw yield and was significantly superior to no compost treatment.

Management of a low level N for increasing nitrogen use efficiency

A significant progressive increase in the grain and straw yield was observed with increase in the rates of N application. The grain and straw yields were 2.1 and 2.6 t/ha with no nitrogen treatment, 2.9 and 3.6 t/ha with 30 kg N/ha in 3 splits, 3.5 and 4.4 t/ha with 60 kg N/ha in 3 splits respectively. Single application of 30 kg N/ha at 30 days after transplanting (DAT) or at 60 DAT produced similar grain yields in the range of 3.5 to 3.6 t/ha and were comparable to three splits application of 60 kg N/ha. These treatments proved to be superior to the remaining treatments in terms of their grain yields. The grain yield data also suggested that application of 30 kg N/ha in three splits, 50% at planting and 25 percent each at tillering and panicle initiation stages was inferior to application of the same 25 percent at planting, 50 percent at tillering and the remaining 25 percent at panicle initiation stage. There was no significant difference among both the treatments in terms of their straw yields.

Nitrogen use efficiency in general

was in the range of 24.2 to 51.7 kg grain/kg N applied. A decline in the nitrogen use efficiency was observed with increase in N application rate. The highest nitrogen use efficiency (51.7 kg grain/kg N applied) was achieved in the treatment receiving 30 kg N at 30 DAT.

Effect of silver-ethylene diguanide nitrate on rice growth and yield

A field experiment was conducted with two rice varieties viz. IR 36 and T 141 and with three levels of N (0, 30 and 60 kg N/ha) over a basal dose of 30 kg each of P_2O_5 and K_2O to study the effect of silver ethylene diguanide nitrate. The seeds of both the varieties were soaked in 1 percent solution of the chemical and the nursery raised along with untreated control. One month old seedlings were transplanted.

In both the varieties the yields were low ranging from 1.60 to 2.03 t/ha for IR 36 and 1.93 to 2.51 t/ha for T 141. The straw yields were 2.77 to 3.64 and 4.17 to 5.39 t/ha for IR 36 and T 141, respectively. Although the chemical treatment gave slightly higher grain and straw yields in both the varieties, which was not significant. However, significant varietal differences could be noticed for both the grain and straw yields while the interaction between variety and treatment was not significant. The drastic reduction in yield in both the varieties could be attributed to the total submergence of the crop due to heavy rain during pre-tillering stage of the crop.

Rate of decomposition of rice stubbles under varying moisture regime as influenced by different amendments

A pot culture experiment was conducted during rabi season with the objective of studying rate of mineralization of rice stubbles applied either as powdered, burnt or as such with or without single superphosphate and muriate of potash either alone or in combination under aerobic and anaerobic soil environments. The treatments were mixed with soil in porcele in pots and were maintained either moist or water logged. During the succeeding wet season 35 day old seedlings of rice cv. Savitri were transplanted without any fertilizer.

Results indicated that the soil that was maintained under anaerobic condition during the entire rabi season and there after showed a significant improvement in the crop perform-

ance as compared to aerobic soil. However effect of the amendments was marginal.

Nitrogen response and N-use efficiency of long duration rice varieties under direct sown condition

In sandy clay loam soils of Kharagpur, where the crop was direct sown by drilling, Prilled urea(PU) and large granulated urea (LGU) of 6 mm diameter were compared at three levels of nitrogen (20, 40 and 60 kg/ha) using six varieties of rice viz., IET-5914, IET-7251, Manasarovar, Gayatri, Kabirajsal and Salivahana under rainfed lowland (0 to 30 cm) condition. Grain yield increased significantly with PU at 60 kg N/ha as compared to 20 kg N/ha while LGU at 60 kg N/ha gave significantly superior grain yield to 20 and 40 kg N/ha. LGU was better than PU in grain yield (2.47 t/ha), while all the other test varieties did not perform well. Salivahana was next only to Gayatri giving an yield of 1.60 t/ha. The low yield was due to excessive flooding and poor stand establishment.

Stand establishment methods for optimum production

Four methods of stand establishment i.e. direct seeded broadcast, dircet seeded drilling, transplanted random and panting in rows were compared in eight varieties. Transplanting was found significantly better than direct sowing. Direct seeded broadcast and direct seeded drilled were at par. Similarly random planting as well as planting in rows were significantly at par. However, the varietal differences were there. Irrespective of methods of stand establishment, Gayatri and Manasrovar gave the highest yield, of 3219 and 3207 kg/ha respectively followed by Utkalprabha (2597 kg/ha). Next in order were Tulasi, Kabirajsal, Pankaj and Biraj which were at par amongst themselves.

Response of newly-developed long duration rice cultures to nitrogen

Five long duration rice cultures newly-developed at CRRI, BKS-1, BK 7-309, BKR 368, BKR 296 and BKS 10 were compared with Gayatri (local check) under graded levels of nitrogen (0, 30, 60 and 90 kg N/ha). Thirty-day-old seedlings were planted on 26 July and the crop was uniformly fertilized with 30 kg each of P_2O_5 and K_2O/ha. The cultures flowered between October 25 and November 12. The highest grain yield of 4.6 t/ha was recorded by variety Gayatri, which

was closely followed by BK 7-309, with an yield of 4.5 t/ha. All the cultures responded to nitrogen application up to 60 kg N/ha whereas variety Gayatri responded up to 90 kg N/ha.

Response of long slender grain non-scented rice varieties to nitrogen

Five non-scented, long slender grain, long duration varieties viz. CR 662-2318, Haathipanjara, Sabitha, Lunishri and Amulya was evaluated under four levels of nitrogen (0, 30, 60 and 90 kg N/ha). The crop was planted on 26 July. The highest grain yield of 4.1 t/ha was recorded in variety Sabita, which was closely followed by Haathipanjara (4.0 t/ha). All the varieties responded up to 60 kg N/ha.

Integrated management of organic and inorganic nitrogen for rice

The combinations of green manure and farmyard manure in different proportions without chemical nitrogen applied basally gave significantly more grain yield over control but they could not compare with the chemical nitrogen applied in three splits, full green manure and also with 50% N as green manure and the rest in two equal splits at active tillering and panicle initiation. The last three treatments however, were comparable. All the nitrogen treatments excepting the treatment receiving 50 percent N as green manure and the remaining N as urea in two equal splits gave comparable straw yields.

The nitrogen uptake also followed almost similar trend. All the nitrogen treatments excepting the treatments receiving either full N as green manure or 50% N as green manure & the rest 50% as chemical N in two equal splits gave comparable nitrogen uptake. The last two treatments, however showed comparable N uptake and were significantly superior to the treatment receiving chemical nitrogen applied in three splits. (50%+25%+25%).

In general, the treatment receiving 50% N through green manure and the remaining as chemical nitrogen in two equal splits at active tillering and panicle initiation, was the best among all the nitrogen treatments in terms of the grain and straw yields and N uptake.

Effect of application of nitrogen through farmyard manure and urea

The application of FYM alone could

not increase the grain and straw yields significantly over control. The results showed that the application of 66% N as basal, out of which 33% was supplied through FYM and the rest 33% N as urea applied either at active tillering or at PI stage gave comparable grain yield to that of chemical nitrogen applied in splits (50+25+25). The grain yield obtained by the application (25 percent N (FYM) + 25 percent N (urea) as basal and the rest 50 percent N as urea in two equal splits at AT and PI was also comparable to that of the best split. The grain yield obtained with the treatment., where 50 percent of the FYM nitrogen was substituted with chemical nitrogen was found to be inferior to the treatments receiving either chemical nitrogen in splits or the treatment where 66-75 percent of FYM nitrogen was substituted with chemical nitrogen.

The straw yield followed almost similar trend as that of the grain yield. Maximum straw yield was obtained with the treatment receiving (33 percent N (FYM) + 33 percent N (urea)) as basal and the rest 33 percent N as urea at PI stage and was significantly superior to the treatment receiving chemical N in three splits.

The nitrogen uptake also followed similar trend as that of the grain and straw yields. Maximum N uptake was observed when 66% of the FYM nitrogen was substituted with chemical nitrogen and was comparable to the treatment where 75 percent of the FYM was substituted with chemical nitrogen.

Effect of nursery management techniques on phosphorus nutrition of rice in main field

Six nursery treatments viz., no fertilizer (control), diammonium phosphate (DAP) 2 kg/40 m^2, Superphosphate plus urea (SSP + U) to supply N and P_2O_5 equivalent to that supplied by 2 kg DAP, root dipping of seedlings in superphosphate slurry 20 kg P_2O_5/ ha, Farm Yard manure (FYM) and calyricidia leaves each 50 kg/40m^2 on dry wt. basis and three levels of phosphorus application to the main-field viz., no phosphorus (control) and 20 an 40 kg P_2O_5/ha were tested on the variety Manasarovar.

Application of DAP, SSP + U and root dipping of seedlings with phosphate slurry (20 kg P_2O_5/ha) greatly influenced seedling characters and recorded higher grain yield in the main

field. Application of either FYM or *Glyricidia* leaves had no beneficial effect. Main field phosphorus fertilization had no significant influence in increasing the grain yield.

Sulphur nutrition in rice

The soil content of sulphur of Kharagpur (CRLRRS) was observed to be below critical level (10 ppm). NPK + elemental sulphur 20 kg S/ha recorded the best results at Khargpur with a mean grain yield of 5.40 t/ha, as compared to 4.65 t/ha in NPK (no sulphur) treatments. The response to sulphur in this case was almost 0.75 t/ha which was a significant gain in grain yield. Pyrites and gypsum were also equally effective as sources of sulphur. The data on ancillary characters also revealed a similar trend and the contribution from sulphur appeared to be more in the form of an increased panicle weight.

Response of selected minikit rice cultures to nitrogen

Long duration group : Crop growth, grain yield and N-use efficiency of three long duration rice cultures from minikits (IET 5914, IET 5760 and IET 8002) were compared with that of Pankaj (standard check) and Gayatri (local check) at different levels of nitrogen application (0 to 120 kg N/ha) during wet season. The variety Gayatri, with a grain yield of 4.9 t/ha, outyielded all the test cultures. It produced more number of panicles (316/m^2) having intermediate panicle weight. The entries IET 8002 and Pankaj gave grain yields of 4.3 and 4.1 t/ha, respectively. The percentage increase in the grain yield of all the varieties at 40,80 and 120 kg N/ha over the control was 26.4, 45.9 and 36.0. The N-use efficiency in the corresponding treatments was 20.8, 18.0 and 9.4 kg grain/kg applied N, respectively. The interaction between variety and nitrogen was significant. In terms of grain yield, IET 5914 responded to nitrogen application up to 40 kg N/ha only while IET 5760, IET 8002, Gayatri and Pankaj responded up to 80 kg N/ha.

Medium duration group : Three rice cultures of medium duration from minikits viz., IET 8585, IET 8682 and IET 9691 were compared with Jaya (standard check) and IR 36 (local check) at four levels of nitrogen (0, 40, 80 and 120 kg N/ha) in wet season. The entry IET 8585 produced the highest grain yield of 4.5 t/ha and was followed by IR 36 which yielded grain yield of 4.0 t/ha. The number of panicles was the highest in IR 36 (360/

m^2) whereas panicle weight was maximum in IET 8585 (2.3 g).Increasing levels of nitrogen up to 80 kg N/ha significantly increased the grain yield of all the cultures. However the yields were reduced at 120 kg N/ha. The N-use efficiency at 40,80 and 120 kg N/ ha was 14.5, 9.0 and 3.0 kg grain/kg applied N, respectively.

Fish and prawn seed raising in shallow lowlands

Rice-fish seed system

Effect of different organic N inputs-FYM, *Azolla* compost and fish feed (oil cake + rice polish in ratio of 1:1.5)-on yield of common carp fingerlings cultured at 9,000 fry/ha for 82 days was examined in a rice-fish seed system. The organic materials were used at the rate of 30 kg N/ha. Application of FYM increased the fish yield by 56.2% over that of Azolla compost and 71.1 per cent over control without organic N, which recorded an yield of 74.5kg/ha. More than two-fold higher plankton biomass (0.99 ml/55 1) in the case of FYM compared with the other two treatments contributed to higher fish yield. However, supplementary feeding two times to the total biomass at the time of stocking produced more fish seed (166.2 kg/ha). Whereas the yield in the case of mrigal seed was 156.2 kg/ha with four times higher stocking density than that of common carp species. The grain yield of rice ranged between 3.0 to 5.5 t/ha. The protein content in the fish flesh on dry weight basis was highest with fish feed (72.5 to 74.8 percent) followed by that in treatments without organic N (69.5 percent), FYM (71.6 percent) and *Azolla* compost (65.2 percent).

Rice-prawn seed system

Raising of freshwater giant prawn *(Macrobrachium rosenbergii)* seed at 10,000 juveniles/ha for a period of 60 days along with rainfed shallow lowland rice (cv. Sabita) was attempted for the first time. The practice was found successful in view of the recovery (45.6 percent), growth (9.6 cm/7.9 g) and yield (40.2 kg/ha) of prawn. Grain yield of rice was 2.5 t/ha.

Adaptability of AYT shallow lowland rice cultures to low light stress conditions

Forty AYT shallow lowland rice cultures from All India Coordinated programme and two checks Swarnaprabha and Ptb 10 were screened in field for physiological traits associated with

adaptability to low light conditions. Low light treatment (50% normal light) was given at 30 days after transplanting. Plant samples were drawn at flowering, 10 days and 20 days after flowering and at harvest. In general, total dry matter and stem weight ratio at flowering were reduced under shade by 28 and 12%, while leaf area index increased marginally by 3% At harvest, grain yield, total dry matter, panicle m^{-2} spikelet m^{-2} and grains m^{-2} were reduced by 62, 44, 21, 41, and 65% respectively while sterility increased by 38% compared with normal conditions (Fig.1). Pre-flowering dry matter contribution to panicle development was 40% while post-flowering remobilisation through current photosynthesis was 60% under normal light whereas in shaded condition it was 44 and 56% respectively. Rice cultures viz. IET12067, IET 12545, IET 12549, IET 13364 and Ptb 10 recorded higher grain yield over others under shaded condition giving more than 1.5 t/ha.

Design and development and testing of green manure incorporation in dry seeded rice

After preliminary testing of the two row animal drawn green manure incorporator fabricated during the year 1992-93, the following modifications have been made.

Concrete rollers have been attached behind the incorporating ground wheel to press the plant in the mud. Upper cover has been provided above the incorporating wheel for avoiding splash of mud upwards and for safety of operator when sitting over the implement. A seat above the cover for the operator has been provided for giving additional load for better incorporation.

Energy requirement for the cultivation of direct sown rice

A study was underaken during wet season to find out the energy requirements for the cultivation of direct sown rice under different tillage and planting implements/methods using tractor as the main source of power. Different tillage implements treatments used were T_1- One M.B. ploughing + two passes of cultivator T_2 - one M.B . ploughing + two passes of disc harrow. T_3 - Two passes of cultivator + two passes of disc harrow and T_4 - One passes of rotovator. Different planting implements/ methods sub-treatments used were S_1 - Broadcasting and covering by cultivator, S_2 - Sowing by bullock drawn seed drill and S_3 -

Fig.1 : Sink Formation from Pre and Post flowering dry matter contribution

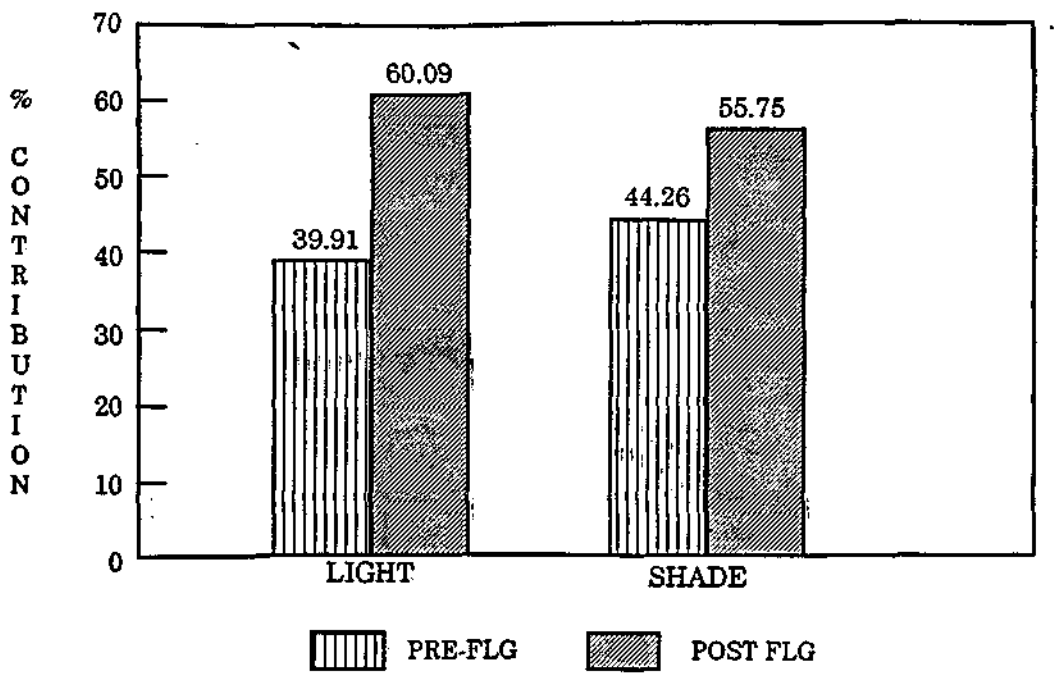
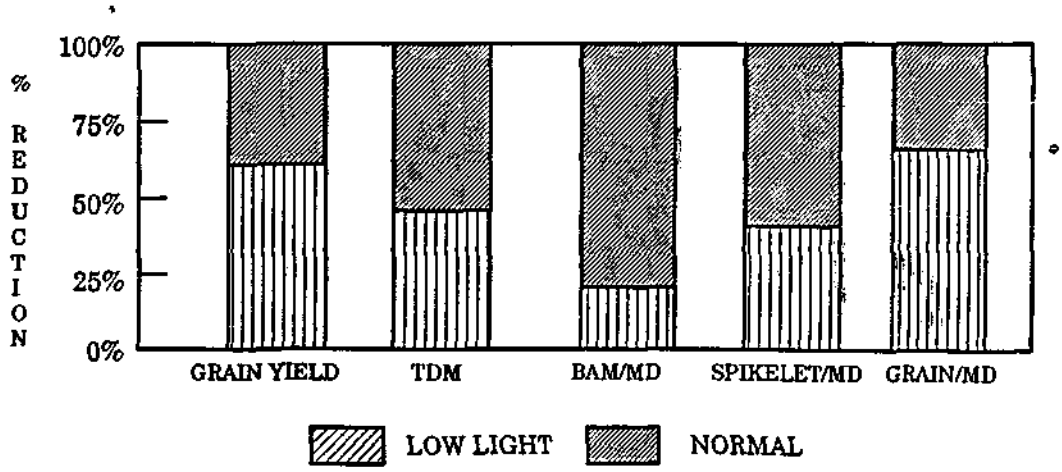


Fig.1 : Sink Formation from Pre and Post flowering dry matter contribution



Sowing by tractor drawn seed drill.

Among different tillage treatments energy required for tillage in treatment T_3 (1829 MJ/ha) was found to be significantly lower than other treatments T_1 (2723.5 MJ/ha), T_2 (2533 MJ/ha) and T_4 (2371 MJ/ha). There was no significant difference in yield obtained among different tillage treatments. The yield obtained in different treatments T_1,T_2,T_3 and T_4 was 4.06, 4.11, 3.70 and 3.87 t/ha respectively. So tillage treatment T_1 is recommended for field preparation for direct sown rice as it saves energy.

Among different methods of planting rice, operational energy required for planting was found to be significantly less in planting treatments S_2(115.5 MJ/ha) in comparision to other planting treatments S_1(388.9 MJ/ha) and S_3(424.8 MJ/ha).

Energy required for weeding in planting treatments S_1, S_2 and S_3 was found to be 2296, 1850 and 1673 MJ/ha. There is greater saving of energy in line sown plot. No significant difference in yield of rice was found due to different methods of planting of directown rice. The yield obtained in planting implements treatments S_1, S_2 and S_3 were 3.80, 3.95 and 4.03 t/ha respectively.

Evaluation of quality traits of varieties/cultures

Twenty seven long slender cultures/varieties grown at CRRI during wet season, 1993 and were analysed for quality characters. Among these cultures/varieties : OR 1143-230, OR 362-SP-15, R 321-71, R 2434-9-5-4, RP 2633-29-5-5, RP 253-7122-9, RP 2533-7487-15 were formed better than Samalei (checkl). Specially the quality features of the grain such as length, breadth and thickness of the kernel after cooking are compared that of Samalei. Physical characters of cooked kernels are addtive quality for consumers' preference (Table 6).

Evaluation of long bold cultures/varieties for quality characteristics

Eighteen non-scented long bold (LB) cultures/varieties grown in CRRI during wet season, 1993 were analysed for quality characters. Among these cultures/varieties : NDR 330, RP 2468-6071-3, Pusa NR 570-17, CN 776-46-34, CR 544-1-1 were promising and comparable to Sarasa. The cooking characteristics of the LB grain were better than Sarasa in respect of thick-

Table - 6 : Evaluation of rice cultures for quality traits

Culture/Variety	Head rice (%)	Length (mm)	Breadth (mm)	Thick-ness (mm)	Amylose (%)	Alkali value	Kernel after cooking		
							Length (mm)	Breadth (mm)	Thickness (mm)
OR 1143-230	59.5	6.5	2.1	1.8	22.5	6.0	11.4	2.8	2.0
OR 362SP-15	55.5	6.3	2.1	1.7	21.8	6.3	10.6	3.0	2.0
R 321-71	61.0	6.8	2.2	1.7	21.8	6.0	10.7	2.8	2.0
R 2434-9-5-4	50.5	6.2	2.0	1.7	23.1	7.0	11.4	3.0	2.0
RP 2633-29-5-5	68.0	6.5	2.0	1.7	22.5	5.0	10.0	3.0	2.0
RP 253-7122-9	37.5	6.6	2.0	1.7	21.8	5.0	10.6	2.9	2.0
RP 2533-7487-15	35.0	6.3	2.1	1.0	22.5	5.8	11.0	2.6	2.0
Samalei (Check)	66.0	6.5	2.2	1.7	21.3	6.0	10.4	3.3	2.2

ness of the kernel after cooking in length, breadth and thickness-wise (Table 7).

Identification of varieties/cultures with less cooking time

Twelve cultures/varieties were cooked under identical conditions in laboratory and it was observed that certain variation exists in cooking time. Cooking time ranged from 22 to 26 min in rice varieties which were stored (old) for one year. (Table 8).

CROP PROTECTION

Insect Management

Evaluation of pheromones for monitoring and mass trapping of yellow stem borer and leaf folder

Sex pheromone septa impregnated with 2, 13-Octadeceny 1 acetate and 2-11, Hexadeceny1 acetate in 10:1 ratio were used in dry furnel traps to monitor *Cnaphalocrosis medinalis* population in CRRI farm. The traps showed the presence of *Marasmia exiqua* population along with *C. medinalis* population. The population of *M. exiqua* was more during the later part of wet season. They started appearing in the middle of November and reached a peak during last week of December. The presence of sexpheromone activity in *M. exiqua* is being reported for the first time.

The population of *C. medinalis* was high till the last week of November (23/4 traps) and started dwindling in the month of December and January.

Sex pheromone septa impregnated with 2.9 Hexadecenol and 2,11-Hexadecenol in 1:3 ratio were used in dry funnel traps to monitor *Scirpophaga incertulas* population in CRRI farm during wet season. Stem borer moths started appearing from the second week of October and reached its peak in second week of November and gradually declined towards the last week of November.

Disease Management

Sheath Blight

Physiology of sheath blight-pathogen

The influence of 11 different phenolic compounds (at 5 x 10-4M) believed to confer general resistance in rice to diseases on the virulence of *Rhizoctonia solani* was tested using two different rice cultivars (Karuna and Mahsuri). The mycelium and sclerotia

Table - 7 :

Table - 7 : Evaluation of long bold cultures/varieties for quality characters

Culture/Variety	Head rice (%)	Length (mm)	Breadth (mm)	Thick-ness (mm)	Amylose (%)	Alkali value	Kernel after cooking		
							Length (mm)	Breadth (mm)	Thickness (mm)
NDR 330	69.0	6.1	2.6	1.7	20.0	7.0	9.4	3.4	2.0
RP 2468-6071-3	22.5	6.2	2.7	1.9	20.1	7.0	11.0	2.9	2.0
Pusa NR 570-17	47.5	6.0	2.1	1.7	21.8	5.5	10.0	2.9	2.0
CN 776-46-34	21.0	6.1	2.2	1.7	22.5	7.0	10.0	2.9	2.0
CR 544-1-1	50.0	6.1	2.4	1.7	20.7	7.0	10.6	3.0	2.0
Sarasa (Check)	46.0	6.3	2.4	1.9	21.3	5.0	10.6	3.5	2.8

Table - 8 : Determination of cooking time

Variety	Cooking time (in minutes)
NDR 4105	26
NDR 4107	22
R 302-45	26
CR 95-181-2	24
Samalai	24
CR 603-1-14-1	24
RF 2436-909-2-1	24
Raupt-100-97-2	22
Pranava	24
NDR 330	26
CR 1018	24

obtained from media supplemented with these compounds was used to inoculate Karuna and Mahsuri.

With very few exceptions (Vanillin, benzoic acid and cinnamic acid), these compounds reduced the virulence of *R. solani*. The reduction in the disease severity was more distinct in less susceptible cultivar. Mahsuri than in highly susceptible Karuna. In contrast to this observation, when the mycelium and sclerotia obtained from normal medium were treated for 6 or 12 hr individually with the phenolic compounds, and used for inoculation, the disease intensity was rather enhanced. This suggests that the metabolic products of these defence compounds formed during the growth and development of the pathogen is of significance in influencing the disease development than the compounds per se.

Method for the mass production of inoculum of *Rhizoctonia solani* for sheath blight screening

Bulk multiplication of *R. solani* inoculum in the field. *R. solani* inoculum could be prepared by growing the causal fungus in Polypropalene bags of 29.5 cm x 17.5 cm size. PVC tube of 3 cm

length was placed in the centre of the open end of the bag and closely tied with a rubber band to firm a neck for plugging it with cotton. By this method, a large amount of inoculum could be prepared in less time with less cost. It is also very handy to carry the inoculum unexposed directly to the field.

Factors influencing the sclerotial production of *Rhizoctonia solani* on rice plants

The information on the indicate mechanics of host, pathogen ineration that influence the sclerotial production on plants infected with sheath blight is on a great epidemiological significance. Among the host factors, the degree of susceptibility of the rice cultivar and the age of the plant greatly influenced the sclerotial production. Tolerant cultivars showed less sclerotia than highly susceptible cultivars. They were produced more on plants at flowering - grain filling stage than at maximum tillering and early tillering stages. The aggressive isolate resulted more sclerotia than the less aggressive one, on any given cultivar. The most critical factor for the sclerotial production seemed to be the environment. Maximum sclerotial production was observed in wet season during the month of September while no sclerotia were produced in dry season during the month of April eventhough the plants showed 7-9 disease score.

False Smut

Effect of false Smut disease on yield of mutant rice

The yield obtained under different sowing dates D1 (25.5.93), D2 (7.6.93) and D4 (7.7.93) was not significantly different but yield in these three sowings was significantly more than D3 (24.6.93) which had maximum number of false smut balls. D4 had low EBT (about 1/3 of EBT of D3) but it produced more yield than D3 because it had low false smut incidence.

Relation between date of flowering of cultivated rice and flase smut development

The area under disease progress curve (AUDPC) for false smut development in populations of rice var. CR 1014 (mutan) was calculated by Simpson rule (Table 10). It was found to be better than trapezoidal integration. The disease progress curve was

Table - 9 : Cross protection of false smut inoculated seedlings against RTV infection

	Average plant height (cm)	EBT	Total tiller plant	Leaf width (cm)	Leaf length (cm)	Spikelets per panicle	Yield (t/ha)
Inoculated with flase smut (escaped tungro)	100.8	12.70	19.2	1.40	43.1	55	1.90
Uninoculated (Heavy tungro incidence)	83.3	8.66	27.3	0.93	41.0	22	0.63

divided into equal number of strips.

AUDPC = 1/3 (strip width) [(first + last ordinate) + 2(sum of intervening even ordinate) + 4(sum of odd ordinates)].

Flowering during first week of October, 1993 was found to be favourable for false smut whereas environmental conditions during November were not so much congenial and hence AUDPC was very low in November flowering.

Table - 10 : Relation between date of sowing, yield, EBT and false smut disease

Date of sowing	Yield g/m²	EBT	No. of false smut balls per 100 plants	AUDPC
25.5.93	399	11.8	714	7450
7.6.93	432	25	952	
24.6.93	351	18	1159	10231
7.7.93	400	6.5	140	336
17.7.93	335	6	no disease	nil

Monitoring of flase smut on crosses of wild rices

The maximum incidence of flase smut on wild rice crosses involving O. minute was observed during September and October. Sterile panicles of these crosses and sterile lines of hybrid rice were also found to be infected.

Relation between water depth and false smut incidence in rice cum fish culture

A severe false smut incidence was observed in saturated soil without standing water as compared to soil with standing water during the end of November (Table 11).

Cross protection of false smut inoculated seedlings against tungro infection

False smut balls were sown alongwith seeds of rice variety HR.12. Later on leaf hoppers were found to be feeding on inoculated and uninoculated

Table - 11 : Rice cum fish culture : Relation between water depth and flase smut incidence

Variety	Water depth	Balls/panicle	Balls/100 plants
CR 1014	+	0.6	700
	++	0.2	173.2
Panidhan	+	0.448	373
	++	0.011	31.3
Lunishree	+	0.945	
	++	0.318	
Utkal Prabha	+	2.32	2669
	++	0.45	393

\+ = Saturated soil but no standing water on 25.11.93

++ = Standing water on 25.11.93

seedlings but false smut inoculated seedlings escaped tungro infection (Table 12).

Blast

Effect of seedling blast on yield

The effect of seedling blast on yield may be represented by the following equation

where, X = Disease severity index of seedlings

and Y = Yield of rice variety Karuna in t/ha.

Seedling blast is negatively corrected with yield. Heavy infection of seedlings affected roots and plants could not pick up after was resulting in poor yields.

Effect of Pesticides on false smut

Carbofuran enhanced the false smut incidence whereas phorate, Cartap, Monocrotophos were effective against it. Phorate treatment increased the yield significantly at 1% level of probability.

$Y = 273.5 / X$

Association of antagonistic bacteria with blast lesions

It was found that a bacterium *Pseudomonas* spp. was actively associated with blast lesions at 20 to 26°C temperature. The bacterium checked the growth of a few isolates of blast fungus and could kill most of the blast isolates *in-vitro*.

Table - 12 : Effect of pesticides on false smut disease of rice

Treatment	Average yield per plant (gm)	Average number of balls per 1000 plants
Phorate	824	496
Carbofuron	577	1539
Cartap	568	284
Monocrotophos	576	366
Control	655	793

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INTERMEDIATE LOWLAND ECOSYSTEM

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CROP IMPROVEMENT

Elite lines for pre-release multiplication

The elite line CR 644 (IET 11385) was recommended for pre-release multiplication and is eligible for Variety Identification Committee for consideration of suitability for coastal/inland saline areas.

Evaluation of advanced lines

Nine lowland advanced lines from six cross combinations were tested in a replicated trial with Gayatri as a check. CR 672-5 gave the highest yield of 5.8 t/ha as against 5.2 t/ha recorded by Gayatri (Table 1).

Selection in segregating populations

One hundred two F_3 lines of six crosses and 2 F_2s were grown and selection for panicle weight types was made.

Eastern India Rainfed Lowland Shuttle Breeding Programme

Eastern India Rainfed Lowland Shuttle Breeding Programme is being

Table 1. Evaluation of promising cultures for intermediate water depth.

Designation	Cross combination	Grain yield (t/ha)	Date of 50% flowering
CR 672-5	CR 1009 x MR 87	5.81	13 November
CR 674-534	CR 1018 x CR 1014	5.61	10 November
CR 673-431	CR 1018 x MR 87	5.55	15 November
CR 674-470	CR 1018 x CR 1014	5.54	13 November
CR 671-194	CR 1018 x NC 1281	5.45	5 November
CR 673-420	CR 1018 x MR 87	5.09	13 November
CR 740-1-9-1	CR 1009 x AC 3370	5.04	30 October
CR 673-475	CR 1018 x MR 87	4.86	7 November
CR 676-614-2	Cuttack Chandi x CR 1009	4.46	23 October
Gayatri(Check)	--	5.26	2 November
	C.D 5%	0.49	

coordinated by CRRI in collaboration with IRRI. This programme is operatative in six centres - Titabar (Assam), Pusa (Bihar), Raipur (M.P), Masodha (U.P), Chinsurah (West Bengal) and CRRI (Orissa). The programme was initiated to improve germplasm for rainfed lowlands of eastern India and a programme is developed for multilocational testing of elite lines for yield and adaptability, exchange of breeding lines for location specific selection, and screening of elite cultures and donors, for submergence tolerance.

Delayed planting experiment

An experiment was conducted with 22 test entries and 4 checks with two dates of planting. Normal planting was done with 30 day-old seedings and delayed planting with 60 day-old seedings. Moratality of seedings was higher in normal than in late planted crop due to early flooding in July. It was observed that under the stress of initial submergence, no entry was better than check variety, Sabita. Under late planting, however, most of the CR cultures performed well. (Table-2)

Screening for submergence tolerance

A set of 42 entries was screened for submergence tolerance and 30 day old plants were submerged for 14 days upto a depth of 80 cm. The released lowland varieties viz., Pankaj, Jagannath and Panidhan perished completely, whereas FR 13 A and FR 43 B exhilated a high degree of tolerance to submergence with non-elongation habit.

Shuttle breeding

Four hundred fifty nine advanced rice lines, segregating population consisting of 125 F_2 s, 166 F_3 s and 350 F4s were grown and selections were made. Some of the advanced lines viz. IR 55040-B. 2.5.3.3.2, IR 57474-55-2-3-1-1 and IR 57479-35-2-1-2-1 were bulked on the basis of their uniformity and yield potential.

Genetic variability in lowland rice

Genetic variability, correlation and path analysis were studied in 36 lowland genotypes fore grain yield and its components. Among the different characters studied, grain yield/hill showed the highest coefficient of variability for genotypic (31.1%) and phenotypic (34.3%) characters. The heritability ranged from 43.36 percent for number of EBT/hill to 95.0 percent for grain length. Grain yield/

Table 2. Performance of entries under normal and delayed planted condition

Culture	Yield (t/ha)		50% Flowering (days)	
	Normal planting	Late Planting	Normal Planting	Late Planting
Sabita (Check)	2.9 (1)	2.3	120	122
TCA 48	2.2 (2)	3.0 (6)	112	114
BKP 242	2.1 (3)	2.6	120	120
TCA 88-69	1.6 (4)	2.7 (8)	119	117
CR 673-475	1.6 (5)	3.3 (4)	123	126
R 371-1	1.5 (6)	2.2	119	122
CR 629-249	0.7	3.9 (1)	118	124
Mahsuri (Check)	0.8	2.0	117	117
Rajashree (Check)	0.9	2.6	116	116
Gayatri(Local Check)	0.8	3.0	131	134

Figures in parenthesis indicate ranking.

hill, number of grains panicle and panicle weight recorded higher values of genetic advance as percentage mean (58.13, 50.34 and 48.43 respectively). The correlation studies revealed a significant positive association of grain yield with panicle weight and number of grains/panicle. Path coefficient analysis also indicated that panicle weight was the most important character for increasing grain yield under intermediate water depth situation.

Screening of rice germplasm under 0-50 cm water depth.

The rice genotypes tested for complete submergence were also subjected to partial submergence by

impounding water upto a depth of 45 to 55 cm from 60 days after germination to dough stage. Only 13 genotypes showed superiority in respect of chaff%, panicle number m^{-2}, panicle weight, 1000 grain weight and harvest index compared with checks.

Genotype AC No. 1020 (T 535) was tolerant to submergence and produced higher grain yield of 420gm m-2 as compared to checks FR 13 A (230g m-2), Hatipanjari (370g m^{-2}) and Jagnnath (184g m^{-2}). However highest grain yield was found in AC No. 2386 (679g m^{-2}) followed by AC No. 1922 (577g m^{-2}) (Table 3).

Studies on carbohydrate content and its association with submergence tolerance

Varied carbohydrate content was created in two rice varieties viz. Hatipanjari and Jagannath by subjecting plants to varying periods of darkness from 0 to 8 days.

Hatipanjari survived by more than 80% even after 10 days of submergence at a pre-submergence carbohydrate level being depleted to 8% of initial level (counterpart under normal condition). Likewise, the susceptible variety Jagannath could survive submergence up to 6 days (survival 78% at carbohydrate level being 32%), but it could not sustain for even 3 days when its pre-submergence carbohydrate level was depleted to 9% of its initial value. Thus, pre-submergence carbohydrate level played an important role in withstanding the adverse effects of complete submergence (Table 4, 5 and 6).

Screening of rice varieties against submergence tolerance :

Twelve advance selections viz. JNR-1, JNR-2, JNR-6, JNR-7, JNR-9, JNR-10, JNR-12, JNR-14, JNR-16, JNR-17, JNR-19, JNR-21 were tested for submergence tolerance alongwith two popular varieties viz. Jangali-jata and Biraj. The rice selections, JNR-6, JNR-12, JNR-16 and variety Biraj were found tolerant to submergence for about a week at initial stages i.e. 10 days after sowing recording 15.7, 20.2, 13.8 and 14.3 t/ha grain yield respectively under intermediate depth (0 to 50 cm) of standing water.

CROP MANAGEMENT

Effect of seedling vigour on crop performance

Three rice varieties, Gayatri (semi-

Table-3 : Effect of partial submergence on grain yield and yield attributes of different rice genotypes

Genotypes	Grain yield (g/m^2)	Spikelet fertility* (%)	Panicles/m^2	Panicle weight (g)	Harvest index (%)
FR 13A	230	3	133	2.1	22.0
Hatipanjari	370	2	159	3.3	22.4
Jagannath	184	3	139	1.9	21.6
AC. (Nos)					
19 (CH 19)	525	3	145	3.9	23.0
231 (CD 15)	362	2	105	3.0	26.2
878 (T 343)	358	3	140	2.0	19.7
1020 (T 535)	420	3	145	2.5	23.1
1604 (T 1437)	414	2	290	1.6	17.1
1728 (T 1651/1)	447	3	265	2.1	19.2
1784 (T 1734)	489	3	260	2.3	17.0
1824 (T 1299)	390	3	270	1.6	21.8
1919 (T 1925)	405	2	215	2.2	29.1
1922 (T 1931)	577	1	170	3.9	31.5
2296 (Doc Phung 3470)	478	3	180	3.2	18.5
2386 (Kattuvaman)	679	2	240	3.3	24.8
3260 (Karang Serang 55)	401	2	185	2.1	17.9

* 1 = > 80% fertility, 9 = < 10% fertility

dwarf), Utkalprabha (semi-tall) and Matangini (tall) were planted with seedlings raised in the nursery seedbeds with or without application of 100 kg N/ha and with clonal tillers uprooted from the previously established direct-sown crop on equivalent area basis. Seeds were sown both in

Table - 4 : Effect of dark treatment on submergence tolerance of seedlings of rice (variety Hathipanjari)

Dark treatment (days)	Dry weight (mg/plant)			Plant height (cm)			Carbohydate content (pre-submergence) (%)	Survival (%)
	BS	5 DAS	10 DAS	BS	5 DAS	10 DAS		
0	340	157	258	44	85	112	36.4	100
2	257	137	204	45	73	111	26.5	100
4	180	90	170	47	70	110	15.5	80
6	133	53	46	45	59	70	8.8	12
8	110	50	30	38	39	39	6.9	0

BS = Before submergence, DAS = Days after submergence

Table - 5 : Changes in plant characteristics as affected by 8 days dark treatment in variety-Jagannath (susceptible)

	Plant height (cm)	Dry weight (mg/plant	Carbohydrate content (%)
Control	35	270	32.1
Dark treated	24	137	8.6

the nursery seed-bed (60 g/m²) and field (400 seeds/m²) on 25 May and the crop was planted at a spacing of 20 cm x 15 cm on 28 July under 8 cm water depth.

The crop experienced acute excess water stress up to a depth of more than 50 cm at four days after transplanting. The seedlings of Gayatri were almost completely submerged inside the water for more than a week, whereas the leaf tips of those of Utkalprabha and Matangini remained above the water surface. Unfertilized seedlings which were shorter having

Table - 6 : Effect of different periods of submergence on survival of rice (variety Jagannath)

Period of submergence (days)	Survival (%)	
	Untreated	Dark treatment for 8 days
2	100	97
4	100	38
6	78	0
8	47	0
10	8	0

less dry weight than the fertilized seedlings suffered more. On the other hand, clonal tillers whose height and dry weight were the maximum and which had been previously growing in a flooded environment, showed better establishment and faster recovery from excess water stress. The crop raised from clonal tillers gave the highest grain yield followed by that from fertilized and unfertilized nursery seedlings. All the varieties produced similar grain yields (4.1-4.3 t/ha) when clonal tillers were planted, whereas Matangini gave significantly higher grain yield (0.7-1.3 t/ha) than Utkalprabha (0.4-0.7 t/ha) and Gayatri (0.2-0.9 t/ha) when nursery seedlings were planted. Higher yield in the clonally-prpagated crop was associated with taller plants and more number and weight of the panicles. The grain yield of direct-sown crop from which the clonal tillers were removed for planting was not decreased because the reduction in panicle number was compensated for by increased panicle weight.

Effect of combined application of organic manure and inorganic nitrogen fertilizer on growth and yield of rice

This experiment with 12 treatments consisting of two levels of organic manuring (0 and 10 t FYM/ha) and six levels of rate/time of nitrogen fertilizer application (0, 20 and 40 kg N/ha applied as basal and/or top dressing) was repeated during 1993 using rice variety Gayatri grown under direct-sown condition. Farm-yard manure (50% moisture) and basal dose

of nitrogen through prilled urea were incorporated before sowing, whereas top dressing of nitrogen through urea supergranule placement was done at 40 days after germination. The crop experienced drought immediately after germination and excess water stress at early seedling stage, which resulted in a high seedling mortality and poor crop stand. However, the plants raised in FYM-treated plots grew more vigorously and tolerated the abiotic stresses better than those raised without FYM or with nitrogen fertilizer only.

The grain yield increased with application of both FYM and inorganic nitrogen fertilizer but the increase was greater with FYM and nitrogen fertilizer was more effective whern the crop was grown without FYM. Application of nitrogen fertilizer increased the grain yield in FYM-treated plots also, indicating the scope for supplementing nitrogen fertilizer with the organic manure, but different rates and/or time of its application had similar effects. However, the grain yield of the crop grown without FYM increased significantly with increasing levels of nitrogen fertilizer up to 40 kg N/ha and its basal application was more effective than the top dressing. Further, 40 kg N/ha applied in two equal splits before sowing and 40 days after germination gave higher grain yield (3.0 t/ha) than that applied in a single basal dose (2.7 t/ha). Nonetheless, the yield in these treatments was lower compared with that obtained by application of FYM alone (3.8-4.0 t/ha). Application of FYM along with nitrogen fertilizer at 20 kg N/ha gave the maximum grain yield.

Effect of different methods of stand establishment on growth and yield of rice

Rice varieties, Gayatri (dwarf) and Matangini (tall) were established either through direct sowing on 26 May using 400 (normal) and 600 seeds/m^2 or through transplanting on 29 July and 23 August using clonal tillers (110-120/m^2) uprooted the direct-sown crop at 50 and 75 days after germination as well as the nursery-grown seedlings of the same age. In the direct-sown crop, seedling emergence was low (30-35%) due to light shower (21 mm) just after sowing followed by a prolonged spell of drought, although the emergence was better at higher seed rate. Further, the excess water stress at early seedling stage (15 days after germination) increased the seedling mortality, particularly in variety Gayatri. However, the crop

recovered partially due to lowering of water depth at the later growth stages. Plants of Matangini which elongated with the fluctuating water depth lodged prematurely before flowering (mid-September) when the water level started receding, as a result of which, its grain yield (3.0 t/ha) was significantly lower than that of non-elongating Gayatri (4.1 t/ha). Removal of clonal tillers decreased the number of panicles/m^2 in both the varieties but their yields were not affected due to increased panicle weight.

The performance of transplanted crop was variable, depending on the time of planting, type of seedlings used and variety. The crop planted under 16 cm water depth on 29 July experienced excess water stagnation up to 58 cm depth for 7 days from 4th day after transplanting which caused nearly complete mortality of the nursery-grown seedlings, particularly in the variety Gayatri. However, the crop planted on 23 August establishment well due to a favourable water regime (16-20 cm) after planting and attained the optimum stand with both nursery-grown seedlings and clonal tillers. Planting with clonal tillers gave significantly more grain yield (2.3-2.7 t/ha) than that with nursery-grown seedlings (0.4-1.8 t/ha), irrespective of the time of planting and variety. This was due to better survival and establishment of the clonal tillers which were taller, having more dry weight and were growing previously in a similar flooded condition, unlike the nursery-grown seedlings, which were transferred from the upland situation to the excess water regime. The yield of Gayatri (2.4 t/ha) was more than that of Matangini (1.7 t/ha) under late planting but the reverse was true under early planting. Nonetheless, the yield of transplanted crop (1.9 t/ha) was lower than that of direct-sown crop (3.6 t/ha).

Screening of rice cultures/cultivars for nitrogen use efficiency.

A preliminary field experiment conducted during the wet season indicated that there was a great deal of difference in nitrogen absorbing ability of rice cultures both from soil and fertilizer source. While the rice culture, BK-7-275 absorbed 80.5 kg N from soil source alone giving grain yield of 4.4 t/ha, the culture, BKS-13 absorbed only 24.8 kg N from soil producing a poor grain yield of 1.5 t/ha at zero level of N application intermediate lowland ecosystem. Response of rice to increasing levels on N was observed in all the cultures/cultivars

only up to 60 kg N/ha except in case of 3 cultures/cultivars viz. MJ 27g, Sabita and CR 683-123 which responded upto 90 kg N/ha. The culture, BK-7-275 utilized fertilizer-nitrogen more efficiently, gave a grain yield of 6.2 t/ha and absorbed 116 kg N/ha at N level of 60kg/ha. The study indicated the possibillity of evolving a variety with better N utilization efficiency through appropriate donor selection and breeding strategy.

Contribution of nitrogen from soil, fertilizer and green manure towards productivity and nitrogen nutrition

The experiment was conducted during wet season in a typical lowland site. Because of heavy rainfall received during mid June, the freshly germinated Dhaincha seeds were totally damaged but rice seedlings survived. Consequently post-flood N fertilizer management treatments were imposed. The results obtained from the experiment are presented hereunder. Unlike in medium land in lowland ecosystem depth of standing water does not reach a level, where normal N fertilizer management is possible even if the flash flood totally recedes.

Broadcasting of prilled urea after flash flood and after total crop submergence was as good as not applying the fertilizer, the grain yield with these two treatments being 2.87 and 2.70 t/ha, respectively. On the other hand, when urea supergranules or urea mud lumps were placed at a spacing of 40cm x 20 cm, grain yield as high as 4.7-4.9 t/ha was obtained even in a broadcast sown rice crop. These reduced zone-N-placement treatments also registered higher levels of N uptake (66-74 kg N/ha), N use efficiency (33-38 kg grain/kg N added) and apparent utilization of applied N (60-72 %). The line planting or line sowing was not a prerequisite for point placement of urea supergranules or urea mud lumps, provided a spacing of 40 cm x 20 cm between placement points was roughly maintained in randomly planted/sown fields.

Stand establishment under rainfed lowland

The yield performance of direct sown and transplanted crops was compared under intermediate lowland condition. Direct sowing was done on 3rd June in plough furrows at 20 cm spacing whereas transplanting with nursery grown seedlings was done on 18 July at 20 x 15 cm spacing. There was excess water stress at the time of

transplanting (25 cm water depth). A common basal dose of 40 kg N, 20 kg each of P_2O_5 and K_2O/ha was applied. Direct sown crop gave significantly higher grain yield (2.03 t/ha) than transplanted crop (1.19 t/ha).

Rice-fish Prawn system

A study on the integrated farming system involving rice - fish / prawn - vegetable and horticultural crops was taken up for the first time on about 1 ha area under the rainfed intermediate lowland ecosystem. A pond refuge with two gently sloped trenches on opposite sides and strong wide bunds all around was constructed. The refuge and trenches accounted for 10% of the total area while bunds occupied 18%.

Rice : Among the six promising lowland cultivars tested, CR 260-77 recorded the highest grain yield of 2.6 t/ha followed by Panidhan (2.4 t/ha), Lunishree (2.3 t/ha), Utkalprabha (2.2 t/ha), CR 1014 and CR 383-10 (each 2.1 t/ha). However, the yields were generally low due to poor crop stand (60 to 104 panicles/m^2) caused by more than 10 days flooding at the initial stage and high yellow stem borer incidence (15 to 36%) at the heading stage.

Fish and prawn : The freshwater Indian major carps, common carp and two prawn species *(Macrobrachium rosenbergii* and *M. malcolmsonii)* were reared at a stocking density of 10,000 fry, 1,500 fingerlings and 4,500 prawn juveniles (4000 from reverline source)/ ha, respectively. The combined yield of fish and prawn was 220 kg/ha/7 months. The reasons for low yield were the entry of predatory fish (cat fish and murrels) as a result of flooding and outbreak of Epijutis ulurative syndrama disease during December. Among the four fish species tested, common carp attained the maximum size (390 g) followed by catla (180 g), mrigal (171 g) and rohu (148 g), The size of *M, rosenbergii* and *M. malcolm* sonii prawns was 57 and 45g. respectively.

Crops after rice : Water melon (cv. Sugar Baby) and pumpkin were grown after rice under four irrigations from the refuge/trenches. The yield of water melon was 3.0 t/ha (average weight 2.5 kg) and that of pumpkin 5.0 t/ha (average weight 3.0 kg).

Crops on bunds : Different winter vegetables - tomato, bean, radish, cauliflower, cabbage, pumpkin, beet, carrot, bitter gourd and some leafy

vegetables - were raised on the bunds with pot irrigation using the rain water stored in the trenches. Among them, the productivity of radish was the highest (151.4 t/ha) followed by that of tomato (93.6 t/ha), beet (56.8 t/ha), leafy vegetables (40.7 t/ha), carrot (36.4 t/ha), pumpkin (31.9 t.ha), bean (28.6 t/ha), cauliflower (21.0t/ha) and cabbage (20.0 t/ha). The vegetable farming on the bunds gave a total productivity of 41.2 t/ha.

Dwarf papaya (C_1 hybrid) and five improved varieties of coconut were also planted on the bunds. Papaya started fruiting after four months and the average weight of the fruit was 690 g.

The vegetables, horticultural crops and other crops grown after rice altogether consumed only 27,000 litres of water out of more than 4,00,000 litres available in the refuge and trenches during the crop growing period.

CROP PROTECTION

Evaluation of chemicals against *Nymphula depunctalis.*

Five chemicals including three neem based products such as chlorpyrifos, quinalphos, Sukrina, Neemox and Greenmark were evaluated against rice case worm *Nymphula depunctalis* during wet season. 15 to 20% leaves were damaged by the case worm showing typical papery leaf symptoms. Due to stagnant water the damaged plants completely died. Thus nearly 10% hills were missing under untreated control. Only chloropyrifos and quinalphos prevented the damage with 2 and 3.3% leaf damage.

SEMI DEEP WATER ECOSYSTEM

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CROP IMPROVEMENT

Promising Cultures

The culture, CR 581-9 (IET 11189) selected from ARC 6650 / Jaya / Sudrusambha was recommended for pre-release multiplication by Variety Identification Committee (VIC) for its superior performance under semi-deep water condition. It is semi-tall in stature with short bold grains, built-in-resistance against gall midge and WBPH, with an yield potential of 4.5 t/ha.

From a replicated yield trial with 15 cultures, the cultures CR 580-17-1, CR 768-1, CR 766-1-2 and CR 771-1 with an yield potential of 3.0-4.0 t/ha were identified to be promising. The check variety, Sabita recorded an yield of 2.8 t/ha. The cultures matured in 160-170 days with medium tall habit of 122.0-133.0 cm height.

CROP MANAGEMENT

Response of rice varieties to nitrogen application and foliage pruning

This experiment with two rice varieties, Panidhan (180 days) and Amulya (170 days), and three levels of nitrogen (0, 30 and 60 kg N/ha) was repeated during 1993 under direct-sown conditions. The crop was sown on May 25 using 400 seeds/m^2 and foliage pruning at the junction of leaf sheath and leaf blade of the topmost leaf was done at 90 or 120 days of growth.

The crop germinated well (40-45% emergence) but experienced drought as well as flooding at the early seedling stage. Although the water level fluctuated widely during the early stages, plants elongated with the rising water and grew luxuriantly. The foliage yield was more in the taller variety Amulya than in Panidhan, and it increased with nitrogen application and delayed pruning. The plant height at harvest decreased due to foliage pruning but the reduction was less in Amulya than in Panidhan. The number of panicles/m^2 and grain yield remained unaffected by foliage pruning, although panicle weight was slightly lowered when foliage pruning was done at a later stage. However, the straw yield was significantly lowered due to foliage pruning. It seems that accumulation of more dry matter is not essentially associated with production of more grain, rather an efficient translocation of carbohydrates from the source to the sink during

reproductive stage might result in increased harvest index. The grain yield and response to nitrogen application were less in Amulya than in Panidhan. Both the varieties responded up to 30 kg N/ha, irrespective of foliage pruning. The results of two years did not show any beneficial effect of foliage pruning on the grain yield. However, the green foliage so obtained could be used for feeding the cattle at the time of fodder scarcity.

Effect of varying seed rates and nitrogen application schedules on growth and yield of rice

With the objective of obtaining a better crop stand and vigour, a tall elongating rice variety, Nalini, was direct-sown on May 24 using 200,400, 600, 800 and 1000 seeds/m^2 and fertilized with 60kg N/ha either in a single basal dose at sowing through prilled urea or in two splits - two-third through prilled urea at sowing and one-third through urea supergranule placement at 35 or 73 days after germination (DAG).

The crop germinated well (45-50%) and there was a progressive increase in seedling emergence with an increase in the seed rate. Nitrogen fertilization improved the initial crop vigour and produced taller plants with more tillers. A rapid increase in the water depth during early seedling and vegetative growth stages resulted in a quick elongation and increased the plant height. The crop started lodging by mid-September (105 DAG) and use of higher seed rate and nitrogen application increased the lodging. Although the plant height at early growth stages increased with increasing seed rates, the final height at harvest was not affected. The nitrogen application schedules had no effect on the plant height. The use of higher seed rate increased the number of panicles/m^2, despite an increase in the number of unproductive tillers, but decreased the panicle weight. The grain yield of rice was significantly more with sowing at 400 seeds/m^2 (2.9 t/ha) than at 200 seeds/m^2 (2.5 t/ha), but further increase in the seed rate did not increase the grain yield. Irrespective of the seed rate, the grain yield increased with nitrogen application but the different application schedules had similar effects. The results indicated that sowing at 400 seeds/m^2 and basal application of 60 kg N/ha were adequate for the optimum productivity of rice under semi-deepwater condition.

Transformation and efficient utilization of prilled urea in rainfed lowland rice.

Results from a field experiment conducted during the wet season revealed that single basal application of urea at the time of sowing, preferably as band placement of prilled urea in solid or in solution form in seed furrows was significantly better than broadcasting of prilled urea @ 60kg N/ha at active tillering. The grain yield of rice cv. Gayatri obtained with basal treatments was in the range of 4.95 to 5.4 t/ha as against the yield of only 4.21 t/ha recorded with the application at tillering stage when depth of standing water was about 25 cm. The lowest grain yield of 3.05 t/ha was however obtained with zero nitrogen control, which was significantly inferior to all the N application treatments.

Further, if no application of N is made at the time of sowing, then urea should be point placed in reduced zone of soil i.e., at 5 cm depth as urea supergranules or alternately as urea mud lumps at active tillering stage.These two treatments gave grain yield in the range of 5.32-5.37 t/ha as against 4.21 t/ha obtained with broadcast application of prilled urea at tillering. The data on percentage nitrogen in grain and straw, nitrogen uptake, N use efficiency and recovery of applied N exhibited a similar trend as that of grain yield. As much as 77-78% of applied N was recovered by rice crop and as high as 38 to 40 kg of grain per kg of applied N was harvested with treatments such as basal band placement of urea solution or point placement of urea supergranules or urea mudlumps at tillering stage of the crop.

Among the basal application of urea, band placement showed larger concentrations of unhydrolysed urea-N (109-292 ppm at 2 days after sowing seeds (DAS) than broadcast dressings (17-25 ppm). Presence of unhydrolysed urea was detected upto 7 DAS in basal dressings. Among the urea applications made at active tillering when water depth was around 25 cm, surface broadcast application exhibited 79% recovery of urea in flood water indicating the possibility of larger run-off loss. On the contrary, only 8-12% of urea was recovered in flood water immediately after sub-surface placement. The data on NH_4-N and NO_3-N contents of soil measured at different time intervals throughout the growth period of rice crop indicated prolonged availability of applied N in sub-surface placement treatments of

urea. In surface broadcast applications especially that made to submerged soil at tillering the N availability was short lived. Thus it was inferior to band or point placement methods.

Screening of rice germplasm for submergence tolerance

Two hundred and seventy photosensitive rice germplasm lines were tested for submergence tolerance along with three checks viz., FR 13A, Hatipanjari and Jagannath. The plants were submerged at 25 days after germination for 12 days by maintaining 75 cm water depth, after which only 10 cm water depth was maintained. Survival count was taken 15 days after termination of submergence. The cultivars exhibiting more than 80% survival were AC Nos. 841, 2221, 2336, 1830, 1020, Sarubhujni, FR 13A and Hatipanjari. Jagannath (susceptible check) completely succumbed to mortality (Table 1).

Table 1. Effect of complete submergence on plant height and survival percentage of different rice genotypes

Genotype	Plant height (cm)		Survival (%)
	BS	AS	
Ac. No. 841 (T 300)	47	81	95
Ac. No.2221 (B 24-92)	47	68	90
Ac. No. 2336 (Fukoku)	46	63	81
Ac. No. 1830 (T 1808)	40	60	85
Ac. No. 1020 (T 535)	51	96	88
Sarubhujini	39	82	84
FR 13A	35	59	95
Hatipanjari	47	93	80
Jagannath (check)	35	55	0

BS - Before submergence, AS- After submergence

Effect of submergence on seedling quality in rice

Initial seedling weight plays an important role in tolerance to submergence. An experiment was conducted with two low land rice varieties viz. Panidhan and Tulasi. Twenty five days old seedlings were transplanted and 15 days after transplanting they were subjected to 12 days of submergence. It was revealed that seedling vigour (plant height and dry matter) with N application of 15 kg N ha^{-1} in the seedbed at 15 days after sowing was more compared with seedlings without N application (Table 2).

The carbohydrate content increase with increasing seedling

Table - 2 : Effect of nitrogen application in the seed-bed on seedling vigour

Variety/N level		Seedling grade (cm)	Plant height (g/10 plants)	Total dry matter (%)	Nitrogen content (%)	Carbohydrate content (%)
Panidhan	N0	1	38.2	0.81	2.02	22.5
		2	35.5	0.48	1.47	12.6
		3	32.1	0.36	1.65	9.2
	N1	1	52.4	0.90	4.15	22.2
		2	51.5	0.60	4.20	14.5
		3	43.9	0.51	3.38	13.8
Tulasi	N0	1	30.3	0.58	1.74	20.9
		2	26.2	0.33	1.80	9.1
		3	23.2	0.24	1.53	5.9
	N1	1	42.8	0.97	5.00	23.5
		2	36.5	0.56	4.83	12.0
		3	29.7	0.34	3.88	5.9

1 = 1.0 g. = 0.81 g/10 Plants; 2 = 0.6 g = 0.48 g/10 plants; 3 = 0.3 g = 0.36 g / 10 plants

weight. Seedlings raised wit N application in the seed bed were found to survive better and exhibited higher grain weight than those having less initial weight.

All India Coordinated trial for rapid screening of AYT rice cultures for semideep water and evaluation of tolerance to water logged conditions

a) Evaluation for seedling survival

Twenty five days old seedlings of 18 rice cultures including 2 checks raised in plastic trays were submerged up to a water level of 25 cm above the leaf tips. The treatment was given for a period of 12 days and the seedling survival was recorded 5 days after termination of submergence.

Survival of IET 11189 and IET 13119 was 32 and 31 % compared with check varieties Sabita and Utkalprabha which recorded 12 and 15% survival respectively (Table 3).

b) Evaluation of yield and yield attributes of AYT cultures

Under intermediate deep water ecosystem the AYT cultures exhibiting higher grain number, test weight and rice total dry matter were IET 13119, IET 11901 and IET 11283 respectively (Table 3).

A study on flood and stagnant water environments in eastern India (semi-deep) (Rainfed Lowland Rice Research Consortium)

Dissolved oxygen content of flood water with fully or partially submerged rice plants was lower 0.13 moles m^3 in the morning than at noon (0.21 moles m^3). However, opposite trend was noticed with dissolved carbon dioxide levels. Low oxygen level in flood water in the farmers fields contrasted with the observations obtained at CRRI farm where water was found to be supersaturated with oxygen up to 0.59 moles m^3 (equivalent to 50% v/v oxygen).

Root growth pattern of groundnut as influenced by seed-bed tillage and depth to water table

Ten representative fully grown groundnut plants were selected in the experimental field for the study of their root system. Soil columns with the selected plant at the center was excavated after enclosing it in a cylindrical iron frame (20 cm diameter and 50 cm length). The roots were exposed by

Table - 3 : Yield and other parameters of rice varieties under intermediate water depth

Culture/ Variety	Grain/m^{-2} (x1000 m^{-2})	Test weight (g)	Grain yield (g^{-2})	Total dry matter (g^{-2})	Harvest index (%)	Seedling survival (%)
IET 10543	11,443	20.1	232	1653	14.0	21
(nos) 11187	11,680	23.6	283	1447	19.5	23
11188	15,023	21.1	315	1453	21.6	15
11189	12,998	25.3	222	1575	14.1	32
11195	10159	27.2	285	1435	19.8	19
11271	13,455	20.8	278	1677	16.5	12
11272	10,767	23.3	251	1310	19.1	18
11283	15,881	22.0	354	1692	20.9	20
11893	7,601	28.0	235	1765	13.3	23
11896	13,779	25.2	346	1870	18.5	16
11893	9,446	17.6	173	1301	13.3	14
11901	15.069	24.4	372	1711	21.7	06
11904	14,969	20.2	292	1438	20.3	19
11910	17,574	18.0	316	1579	20.0	24
13119	19,959	20.2	383	1828	20.9	31
13120	9,967	18.9	215	1259	17.0	08
Sabita(C)	13,496	21.6	292	1667	17.5	15
Utkal Prabha(c)	16,085	17.4	277	1755	15.5	12
C.D. (0.05)	2,561	1.8	51	--	--	4

washing with waterjet. The rooting depth (vertical distance from the base to the tip of the root system) and the distribution of secondary roots along the vertical length of the main root were measured.

For no-tillage, sowing (tilled after establishment of seedlings), on an average, 1%, 44.3% and 54.7% of the total number of secondary roots originated from 0-2 cm, 2-6 cm and > 6 cm depth interval respectively. The corresponding values of shallow tillage-sowing were 9.5%, 34.2% and 56.4%. It indicates that under no-tillate sowing, which is preferred for ensured germination on residual soil moisture, the root proliferation starts from a slightly deeper depth. At about 50 cm depth to water table only 2.1% of the total number of secondary roots originated below 12 cm depth whereas it was 21.7% in case of 100 cm depth to water table. The results again indicated that proliferation of roots growing in a soil underlain by a light textured one (poor nutrient status) need not go deeper if water is available at the surface. In fact, the rooting depth observed ranged from 15 to 35 cm only.

CROP PROTECTION

Effectiveness of insecticides and their method of application against yellow stem borer

Stem borer at heading stage causes heavy damage. Three granular insecticides namely cartap, carbofuran and phorate @ 1.0 kg a.i./ha given once and monocrotophos spray @ 0.5 kg a.i./ha applied twice were evaluated at the heading stage of the crop with the variety CR 260-171 in the water depth of 10 cm at the time of insecticidal application. Monocrotophos spray reduced the infestation of stem borer to 16.7% while rest of the insecticides and control recorded 23.6 to 28.3 and 27.6% respectively. Occurrence of false smut interfered at the grain filling stage and affected the yield.

Interestingly granular cartap prevented the false smut while carbofuran enhanced the incidence. The highest grain yield of 3.9 t/ha was obtained it the cartap treatment followed by 3.6 t/ha in the monocrotophos when compared to 3.3 t/ha in the control.

DEEP WATER ECOSYSTEM

DEEP WATER ECOSYSTEM

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CROP IMPROVEMENT

Screening for stem elongation

Forty deep water rice varieties/cultures collected from North Laxmipur Station, Assam, Pusa, Bihar, Ghaghraghat, U.P. and Bhubaneswar were screened for stem elongation ability under 2 m water depth. Eleven surviving varieties/cultures were used as pollen parents for making 40 crosses involving traditional tall indica varieties. The female parents used included Basmati 802, Basmati 6141, Taitung 16, Deep straw 24-500, TK Deep straw 34-774, KDML 65-G-V-45, Daeng Laem, Samson Polo, Y.Doun, Khao Ykhad, Khao Khai and Kawn-Fu-1. The F_1s were grown in the greenhouse in the dry season and the F_2 seeds were harvested.

Crossing programme for development of YSB and Ufra tolerant cultures

Since CRRI is an ideal location for making crosses, breeding material are being developed for the deep water flood prone areas of Assam, Bihar and Uttar Pradesh; The following crosses were made with the parents selected at target environments.

CROSSES

Rayagada 16-06 x NDGR 410	:	Brajil 65 x TCA 4
Rayagada 16-06 x TCA 88-82	:	Brajil 65 x NDGR 421
Rayagada 16-06 x NDGR 421	:	Brajil 65 x TCA 88-82
Rayagada 16-06 x LPR-14	:	Brajil 65 x NDGR 428
Rayagada 16-06 x NDGR 429	:	Brajil 65 x NDGR 410
Rayagada 16-06 x Jalanidhi	:	Brajil 65 x Jalanidhi
Rayagada 16-06 x LPR 56-49	:	

CROP MANAGEMENT

Response of deep water rice to fertilizers under conditions of varying soil fertility and stagnant deep water

A pot culture experiment was carried out using soils differing widely in their fertility. Jalanidhi, a deep water variety was grown under conditions of *stagnant deep water.*

Dissolved oxygen concentration in the standing water under highly fertile soil condition was low ranging from 2.0 to 2.5 ppm as compared to soils with low fertility where it ranged from 5.8 to 8.0 ppm. Canopy Oxygen content was generally higher in the morning than in the afternoon. Dissolved O2 concentration in water was lower at various depths under fertile soil condition possibly due to more of foliage remaining under water. The pH of water was up by about 0.5 units in the afernoon as compared to the forenoon. Affternoon temperature of water also was higher by about 2°C.

The highest response was associated with application of PK in the most fertile soil. Other soils gave high response to application N/NP/NPK.

Studies on the importance of nodal roots in the nutrition of deep water/floating rice

Nodal roots in deep water/floating rice start appearing within 10 days accumulation. In fertile soils where plants are healthier, nodal roots appear early. If the plants are detached from soil surface and are allowed to float nodal roots come up even *within 24* hours. These roots were found to be functional in providing nutrition from water. Often deep water rice plants get deteached from soil in the vegetative stage due to damage by crabs etc. It was observed that such plants could successfully complete their life cycle (including grain filling and ripening) withour anchorage and nutrition from the soil.

Deep water rice plants having nodal roots only were floated in water to which application of various fertilizers and green manuring was done to study their nutritional behaviour through nodal roots.

Temperature, pH and dissolved Oxygen of water were examined in the forenoon and afternoon. Temperature was about 29°C in the forenoon and 31°C in the afternoon.

pH of water went up by 0.5 to 1.0 units in the afternoon. With application of feritlizers (NP/NPK) pH or water went up due to algal growth and was in the range of 9.3 to 9.7. Buried green manure *(Sesbania aculeata)* docomposition, however, lowered down water pH which was found to be in the range of 7.2 to 8.2. In general dissolved Oxygen concentration in water was higher in the afternoon as compared with the forenoon while reverse trend was observed in the crop canopy. A relatively lower dissolved oxygen in water was associated with the application of NP, NPK fertilizer and green manure. In presence of decomposing *Sesbania aculeata* green manure dissolved Oxygen concentration in water was in the range of 0 to 0.2 ppm in the forenoon while it went up to 1.0 to 6.6 ppm by the afternoon.

There was a positive response to applied nutrients which were absorbed through nodal a roots in this study. Application of NP and NPK were on par and were superior to application of N content upto 20 ppm in water was observed to produce maximum nodal rooting and thereby higher yield.

Feasibility of growing Sesbania species under stagnant deep water conditions

Both *Sesbania aculeata* and *Sesbania rostrata* could grow since accumulation of water was gradual. Water depth in the field went upto 2.75 m. Initially *Sesbania aculeata* had put up better growth while *Sesbania rostrata* had an edge over *Sesbania aculeata* in the later stage. Both the species were compared for their morphological characteristics as they were adopted to such higher water depth.

Sesbania aculeata : The plant height at flowering was 4.25 m above soil surface. Roots inside soil were black and were a few. Root nodules were present which were masked by corky tissues. Profuse aerial rooting was observed inside water (at the surface of water) within 200 to 2.75 m from soil surface.Corky tissues also covered these aerial roots. Avove 3 m from soil surface plant parts were studted.

Sesbania rostrata : The plant height at flowering was 5.8 m. Roots inside soil were black. No corking nor nodulation was seen. Stem nodules possibly got decomposed inside water since the phloem tissues were almost decomposed upto 2.75 m from soil surface. Few roots were seen from stem within water. At a height of 2.75 m to 3.75 m

above soil surface, stem nodules were visible which were again covered by a type of corky tissues. Above 3.75 m from soil surface twigs with stem nodules were almost normal. Flowering and fruiting took place with production of wrinkled seeds.

Evaluation of deep water rice varieties for quality characteristics

Twenty three deep water culture/ varieties were collected from different loactions viz., Ghagraghat, Bhubaneswar and Lakhmipur. Their quality attributes were determined. Among these cultures/varieties viz., TCA, CRS,NDGR 410, NDGR 413, NDGR 421, NDGR 417, NDGR 429, DWR (Rambha), Kalashree, LPR 246, and LPR 14 are promising and comparable to Jalamagna (control). However, the Kalashree has the distinct edge over the rest by showing better quality attributes. As a matter of fact, it is a medium slender gram variety having 70% head rice recovery, whereas all the varieties studied belong to bold types and lesser head rice percentage (Table 1).

CROP PROTECTION

Monitoring the Populations of YSB in deep water rice

The deep water areas in Pattamundai were surveyed for pest incidence. Local varieties *Dalua* and *Hadagada* were grown in village *Osengera* and the water height was nearly 1.2m at the time of observation. It was seen that *S. incertulas* and *S. Innonata* moths in good numbers were sitting in a local variety Dalua. which was direct sown as well as transplanted in different farms.

Seven villages near Paradip were surveyed which were growing *Debashish, Rahasapanjara, Katakichandi, Kalasebati* and *Panidhan* under 1.5m water height during rainy season. The YSB incidence ranged from 19 to 74% in then varieties.

Incidence of Ufra in Assam

Plant samples collected from deep water rice growing area of north Lakhimpur (Assam) were exmined for ufra nematode. (*Ditylenchus angustus).* These plants were found to contain large number of nematodes and showed typical symptoms of ufra disease.

Occurrence of diseases at CRRI farm in DWR Ecosystem

Bacterial leafblight was found to be

Table - 1 : Evaluation of rice varieties for grain quality (deep water ecosystem)

Culture/ Variety	Hulling (%)	Head rice (%)	Length (mm)	L/B (mm)	Class	Amylose (%)	Alkali value	Water uptake (ml)	Volume expan-sion	Length of the kernel after cooking	Elonga-tion ratio
TCA CRS	76.0	66.0	4.86	1.96	SB	21.8	6.0	230	2.8	9.4	1.9
NDGR 410	78.0	59.0	5.47	1.84	SB	21.8	5.9	315	2.8	8.2	1.5
NDGR 413	76.0	65.0	5.31	2.00	SB	21.2	6.9	265	3.0	10.8	2.0
NDGR 421	76.0	65.0	5.31	2.03	SB	21.8	7.0	335	2.8	9.1	1.7
NDGR 417	76.0	64.0	5.22	1.92	SB	21.2	7.0	250	2.9	9.5	1.8
NDGR 429	76.0	62.0	5.21	1.99	SB	19.0	7.0	270	2.9	9.2	1.8
DWR (Rambha) BBSR	78.0	58.0	5.50	2.13	SB	21.8	5.6	270	3.5	9.3	1.7
Kalashree BBSR	78.0	70.0	5.63	2.90	ms	20.7	6.0	250	3.5	9.7	1.7
lpr 246	78.0	55.0	5.70	2.01	sb	19.0	7.0	275	3.7	9.4	1.7
lpr 14	76.0	62.0	6.77	2.84	lb	19.0	6.8	250	3.7	10.6	1.6
Jalamagna (Control)	72.0	62.0	5.14	1.92	SB	21.2	6.5	245	2.8	8.5	1.7

the predominating disease in DWR ecosystem followed by sheath blight, sheath rot, false smut, and blast.

The varieties Dalbao, Kalasebati, hathipanjari, CR 683-123, CR 1020, Chamnpaisali, Jalapriya, Nalini, Jaladhi-I, IET 1002, NDGR 402 and NC 491 were found resistant to blast with low degree of infection. The rest of varieties showed varying levels of infection.

Almost all the varieties observed under this ecosystem were infected by BLB. Amongst them the varieties - Lunishree, CR 1006, Hatipanjari and Cr 683-123 were infcted severely, the percentage of leaf area damaged being 55.0, 66.0, 48.0 and 35.0, respectively. However, low degree of infection was observed in the cultivars Champaisali (15.5%), BAM 6 (10.5%), NC 491 (13.5%) which the rest of varieties exhibited varying levels of infection.

High degree of sheath blight infection was recorded in varieties - kalasebati (20%), Panidhan (35%) While it was low in BAM 6 (2%).

Sheath rot infection was found to be higher (20%) in the variety Dalbao and it was less in madhukar (1%). Lunishree was found to be highly susceptible to false smut (65%) infection. (Table - 2)

Table - 2 Monitoring diseases under DWB ecosystm at CRRI, Cuttack, 1993 Wet season

Variety	BLB		Sheath blight		Blast		Sheath rot		False smut	
	Mean% LAD	SES	Mean% LAD	SES	Mean % LAD	SES	Mean % LAD	SES	Mean %	LAD SES
BKP-246	30.6	7	--	--	10.0	5	2.0	3		
BKP-242	25.6	7	15.0	5	5.0	5	10.0	5	15.0	5
BAM 6	10.5	5	2.0	3	2.0	3	15.0	5	15.0	5
CRM 30	55.0	9	--	--	5.0	5	--	--	4.0	3
Champaisali	15.5	5	5.0	3	--	--	10.0	5	5.0	3
CR 1016	60.0	9	20.0	5	5.0	5	5.0	5	--	--
Dalbau	23.0	5	15.0	5	--	--	20.0	5	--	--
Gayatri	32.0	7	5.0	3	4.0	3	--	--	15.0	5
Hathipanjari	48.0	9	15.0	5	--	--	5.0	5	15.0	5
IET 10020	34.0	7	10.0	5	--	--	5.0	5	25.0	5
IET 1002	50.5	5	5.0	5	--	--	5.0	5	5.0	5
Jaladhi	32.5	7	--	---	10.0	5	15.0	5	15.0	5
janaki	15.5	5	--	--	--	--	5.0	5	15.0	5
Jalamagna	12.0	5	--	--	--	--	5.0	5	--	--
Kalasevati	16.5	5	20.0	5	--	--	2.0	3	5.0	5
IPR 312	23.5	5	--	--	--	---	1.0	3	5.0	5
Madhukar	25.6	7	20.0	5	5.0	5	1.0	3	15.0	5
Mashuri	28.0	7	--	--	1.0	3	1.0	3	2.0	3
Nalini	20.5	5	10.0	5	--	--	--	--	5.0	5
NDGR 402	34.0	7	10.0	5	--	--	15.0	5	15.0	5
NC 491	13.5	5	--	--	--	--	1.0	3	--	--
Panidhan	32.8	7	35.0	7	6.0	5	15.0	5	10.0	5
Paniola	28.2	5	5.0	5	2.0	3	5.0	5	20.0	5
Utkal prabha	10.6	5	--	--	2.0	3	--	--	65.0	9
Utkal Kacheri	28.0	7	20.0	5	3.0	3	--	--	15.0	5
CR 728-6-7	30.5	7	15.0	5	2.0	3	5.0	5	53.0	9
CR 683-123	44.0	9	--	--	---	---	10.0	5	5.0	5
CR 626-20-14-7	18.2	5	5.0	5	--	--	2.0	3	5.0	5
CR 575-369-3-1	23.5	5	5.0	5	--	--	--	--	15.0	5

SUPPORTIVE PROGRAMMES

SUPPORTIVE PROGRAMMES

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Inheritance of multi-pistillate character

The F_1, F_2 and F_3 generations from the crosses between multi-pistillate and multi-grain rice variety JMGR-1 and single pistillate varieties like Neela, Savitri and Mahsuri with reciprocal crosses were studied to know the mode of inheritance pattern of multipistillate character. All F_1s were single pistillate In F_2, all the crosses and reciprocals showed a rate of 3 (single) vs 1 multipistil which was further confirmed in F_3 suggesting that multipistillate character is governed by a single recessive gene.

Assessment of breeding material received from DRR

During wet season, 4 coordinated trials were conducted to assess the yield potential and adaptability of elite cultures developed at different parts of the country. The details of the promising cultures identified at CRRI are given in Table 1.

Determination of water-stable aggregates in rice soil

The aggregates in rice soil are very weak. The finer aggregates also tend to stick together. These make the determination of aggregate size distribution in rice soil very difficult. An attempt was made to separate the aggregate fractions by a wet sieving procedure that involves minimum agitation of soil aggregates. Preliminary results indicate that the method is sensitive enough to differentiate the favourable effect of compost and NPK and the unfavourable effect of puddling at 10 to 20 cm soil depths.

Identification of non-scented rice cultures for export purposes

A study was initiated to identify long and medium grain varieties with medium amylose content, intermediate GT, soft to medium gel constituency flaky and soft cooked rice.

Sixty six released varieties were received from DRR and were analysed for quality characteristics. Among them 24 were long slender (LS) having a length of 6.06 to 6.72 mm. and breadth 1.93 to 2.36 mm.

Among LS grains, Ambica, PR 110, PAU 1106-6-2, Saket-4, Tella Hamsa, IR 22 were found promising. Among long bold grain variety Intan, PR 103, Puskhala were promising.

Among medium slender grain, PLG-

Table 1. Performance of promising cultures of the coordinated programme at CRRI, Cuttack

Ecosystem/Trial	Culture	Total duration (days)	Yield kg/ha
Rainfed shallow lowland	CR 768-1	157	6764
(AVT/IVT-SHW)	CR 1128-7-71	148	6079
	Gayatri (ckeck)	160	4876
Semi-deep lowland	CN 578-190-7-4	175	2229
(AVT-SDW)	CR 683-123	173	2016
	CR 581-9	167	1740
	Panidhan	170	530
Aromatic grains	Pusa Basmati	138	2839
(AVT-BT)	Karnal local	133	2444
	HKR 86-402	131	2345

1, Sona Mahsuri, Samba Mahsuri were promising.

Analysis of samples from different parts of the country

Besides these, quality attributes of promising cultures evolved by different institutes in the country were analysed.

1) Twenty three short grain local scented cultures were analysed for Bidhan Chandra Krishi Bishwa Bidyalaya and the data was transmitted to them.

2) Nine samples were analysed for Kerala Agril. University, Mon Compu.

3) Eight cultures were analysed for Assoc. Director, Kerala Agril. University, Pattambi.

4) JJ-92, a variety from Tamil Nadu was analysed and data was sent to the Director, TNAU, Aduthurai.

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CROPPING SYSTEMS

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- Response of mustard to nitrogen and potassium
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- Response of wheat varieties grown in rice fallows to nitrogen.
- Effect of irrigation methods on water requirement and yield of tomato after rice
- Irrigation scheduling for groundnut

INTER CROPPING

Rice-pigeon-pea

Five rice varieties of varying plant type and duration were grown in both sole and intercropping systems with pigeonpea cv BR 65 In intercropping, different combinations of two rice varieties were tested in 2:2:1 row ratio.

Maximum rice equivalent yield was obtained when two rows of Sneha (75 days, semi-dwarf) were grown alongwith two rows of Vandana and single row of pigeonpea cv BR 65. All the other combinations produced significantly lower rice equivalent yield than the above combnation.

Optimizing population in rice-pigeonpea intercropping system

Broadcasting rice seeds at the normal seed rate in the interspace (75 cm) between two rows of pigeonpea (BR 65) or sowing rice seeds in 4:1 row ratio either at 80% or 120% seed rate with pigeonpea having plant to plant spacing of 20 and 30 cm, respectively produced higher LER and monetary return than monocrop of respective crops or other combinations.

Broadcasting of rice seed in the interspace between two rows of pigoenpea appeared to be farmers' friendly technology because most of the farmers practise broadcast method for sowing rice.

Effect of simultaneous/deferred planting of upland rice and groundnut

Goundnut cv AK 12-24 sown in rice field 30 days after rice emergence produced maximum gross return and recorded highest LER value. When sowing of groundnut was delayed further for next 10 days, yield of groundnut declined. Rice yield was lowest when rice and groundnut were planted simultaneously.

Groundnut genotypes for intercropping with rice

Highest rice equivalant yield LER was recorded in the intercropping system involving rice cv Vandana and groundnut cv BG 3 followed by Vandana + Kissan and Vandana + AK 12-24 in 4:2 row ratio. The 2:1 row ratio was inferior. Rice + BAU 6, however gave similar rice equivalant yield and LER in both the row ratios.

Incidence of tikka disease was generally less in BG 3 and BAU 6 compared to other groundnut varieties. Disease incidence was lowered in 4:2 row ratio. Other varieties did not show much change in disease incidence due to intercropping.

Comparision of relay, sequence and intercropping system

Rice cv Vandana produced highest yield in both pure and intercropping systems during wet season. Grain yield of pigeonpea was higher when grown with short duration rice variety Sneha. Grain yields of rabi crops were low when relayed in standing crop of Vandana.

Intercropping of Vandana with pigeonpea cv BR 65 proved most advantageous as evident from gross returns, relay cropping proved inferior to intercropping.

SEQUENCE CROPPING

Performance of sesamum varieties in rice fallows

To identify a sesamum variety suitable for rice fallows, six varieties - Kalika. kanak, Uma, Usha, OMT 10 and Vinayak were evaluated during the dry season. The crop was sown on January 18 and fertilized with 60 kg N and 30 kg each of P_2O_5 and K_2O/ha. Four irrigations were given. The highest yield of 505 kg/ha was recorded in the variety Kalika and the yields of Kanak (486 kg/ha) and Vinayak (468 kg/ha) were comparable to it. These 3 varieties matured in 93 days and produced more branches and pods/ plant as compared to others.

Response of mustard to irrigation and nitrogen

Two mustard varieties, Pusa Bold and Pusa Bahar, were grown in uplands during winter season under three levels of nitrogen (0, 30 and 60 kg N/ ha) and four irrigation treatments (no irrigation, one irrigation at branching, two irrigations at branching and flowering, and three irrigations at branching, flowering and siliqua development stages). The highest seed yield of 1.1 t/ha was obtained with three irrigations, which was 23.6% higher than that of treatment receiving no-irrigation. One and two irrigations increased the yield by 46 and 172% over no-irrigation treatment, respectively. The yields of both the varieties under all the irrigation treatments increased significantly with nitrogen application up to 60 kg/ha.

Pusa Bold and Pusa Bahar gave similar seed yields in all the treatments

Response of mustard to nitrogen and potassium

A newly developed mustard variety, RH-30, of 115 days duration was grown under five levels of nitrogen (0, 30, 60, 90 and 120 kg N/ha) and three levels of potassium (0, 30 and 60 kg K_2O/ha). The crop responded to application of nitrogen up to 60 kg/ha (seed yield 1.4 t/ha) and potassium up to 60 kg K_2O/ha (seed yield 1.5 t/ha), beyond which the yield did not increase siginificantly. The nitrogen and potassium interaction was not significant.

Evaluation of mustard/toria varieties in rice fallows

To identify mustard/toria varieties suitable for cultivation after the harvest of early rice in irrigated uplands, 8 varieties of mustard (Krishna, Vandana, Varuna, Pusa Bold, Pusa Bahar, Pusa Barani, Pusa Basant and Gujarat M_1) and 4 of toria (M-27, Toria Bhawani, T-9 and TLC-1) were evaluated. Among the mustard varieties, Pusa Bold and Pusa Basant with a seed yield of 1.6 t/ha were the most promising. The yields of other varieties ranged between 1.2 and 1.5 t/ha. Among the toria varieties, the highest yield of 0.79 t/ha was obtained in Toria Bhawani followed by M-27 and T-9 with an yield of 0.7 t/ha.

In another experiment, four newly developed mustard hybrids were tested for their yield potential. Among them, Mustard Hybrid-2 with a seed yield of 2.1 t/ha and a duration of 112 days and Mustard Hybrid-1 with a seed yield of 1.7 t/ha and duration of 110 days were found promising.

Performance of linseed and mungbean varieties in rice fallows

Five linseed varieties - Garima, Subra, Sweta, Laxmi-27 and Neelam and three mungbean varieties - Samrat (PDM 84-139), Basanti (PDM 84-143) and Kanchan (PDM 116) - were evaluated for their suitability for cultivation in the post-rice season and yield potential. Among the linseed varieties, Laxmi-27 flowered at the earliest (45 days after seeding) and produced the highest yield of 1.2 t/ha. Variety Sweta also gave a similar yield. Among the mungbean varieties, Samrat produced the highest yield of 0.8 t/ha.

Response of wheat varieties grown in rice fallows to nitrogen

The performance of three wheat varieties (DL 802-3, DL 803-3 and DL 784-3) grown in rice fallows was assessed under different levels of nitrogen (40, 80 and 120 kg N/ha). The crop was sown on December 9 in rows 30 cm apart and nitrogen was applied in two equal splits at and 20 days after sowing. Forty kg. each of P_2O_5 and K_2O/ha were applied at sowing. Three irrigations at crown root initiation (20 DAS), maximum tillering (50 DAS) and milk (80 DAS) stages were given.

The overall growth of the crop was not satisfactory because of less cold, particularly during folwering and milk stages. Among the varieties tested, DL 803-3 gave the highest grain yield of 3.2 t/ha, followed by DL 784-3 (2.7 t/ha)and DL 802-3 (2.3 t/ha). Higher grain yield in the variety DL 803-3 resulted from more number of panicles/m^2 with a higher panicle weight. There was a progressive increase in the grain yield with increasing levels of nitrogen up to 80 kg N/ha. The average N response (kg grain/kg N applied) was 7.5, 21.0 and 10.3 at 40, 80 and 120 kg N/ha, respectively.

Effect of irrigation methods on water requirement and yield of tomato after rice

After rice crop is harvested, tomato was a users on 19 December (one month old seedling) to estimate the water requirement and to compare different irrigation methods for optimum water use efficiency and ultimately the yield. Four methods namely all furrow, alternate furrow, skip furrow and flooding were compared with control, where irrigation was not applied. Three irrigations were given, each at flowering ruiting and at 50% harvesting stages. It was seen that there was no yield difference between all furrow, alternate furrow and skip furrow whereas water requirement in first case was two times more than the other two cases. In control plot the yield was 20% less than the other treatments. The yield of tomato varied from 46.3 t to 44.3 t/ha (Table - 1).

Irrigation scheduling for groundnut

After kharif short duration rice crop, groundnut (variety JL5) was taken in dry season 94 and was sown on December 27. The experiment was carried out to determine water requirement and optimum scheduling of irrigation. Irrigation was applied at 4

Table - 1 : Effect of irrigation methods on irrigation requirement and yield of tomato

Method of Irrigation	Irrigation requirement (mm)	Yield (t./ha)	Water use efficiency (cm/t/.ha)
All furrow	180	46.3	2.57
Alternate furrow	90	46.3	5.14
Skip furrow	90	44.3	4.92
Flooding	240	40.8	1.70
Control	0	38.9	--

growth stages of groundnut namely seedling to flowering, flowering to pegging, pegging to pod formation and pod foration to maturing. 3 treatments i.e. 9 irrigation (1+3+3+2) 6 irrigations (1+2+2+1), 4 irrigations (1+1+1+1) were compared with control where no irrigation was applied. It was confirmed that the 1st treatment i.e. 9 irrigations one irrigation at 1st stage, 3 irrigations at 2nd stage, 3 irrigations at 3rd stage and 2 irrigations at last stage gave highest yield 2.88 t/ha and its water use efficiency was 44 cm./kg/ha (Table-2).

Table - 2 : Effect of irrigation scheduling on yield and water requirement of groundnut

Treatment	Yield (t/ha)	Water requirement (mm)	Water use efficiency (cm/kg/ha)
T_1 (1+3+3+2)	2.88	540	44.0
T_2 (1+2+2+1)	1.87	360	51.9
T_3 (1+1+1+1)	1.04	240	43.3
T_4 Control	0.62	0	--

TRANSFER OF TECHNOLOGY PROGRAMME

TRANSFER OF TECHNOLOGY PROGRAMME

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- Varietal evaluation in bunded uplands
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- Soil amelioration
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- Celebration of Birth Centenary of Dr. K. Ramiah (Founder Director of CRRI)

ON-FARM RESEARCH

On-farm trials were conducted during 1993-94 in 8 villages like Khuntuni, Bhogra, Mathurapur, Champia, Totapada, Radhadamodarpur, Ragidipada and Patharkata of Cuttack district. Work was undertaken with active participation of the farmers under all the ecosystems in order to generate location specific agricultural technology. Trials were conducted on the aspects like soil amelioration, varietal screening, methods of stand establishment, soil amelioration, time of sowing, response to N, P and K fertilizers, control of termite and gundhi bug, crop substitution and cropping patterns.

Varietal evaluation for unbunded upland

Under rainfed lateritic unbunded uplands promising varieties/cultures were screened for tolerance to in-season drought, blast disease, termite and gundhibug insects which were the serious problems under those situations. The rice variety "Vandana" (duration 90 days) gave the highest yield (3.54 t/ha) followed by "RR 203-16" (90 days), "RR 203-2 (88 days), "Vanaprabha" (90 days) and "Sneha" (82 days) in that order.

Insect-pest management

Termite was the major insect pest infesting the upland crop especially under prolonged dry periods. Among the different insecticides tested seed treatment with chloropyrifos @ 1.0 kg a.i./100 kg seed provided effective control against termite damage. Gundhi bug was another major insect causing considerable damage especially in upland rice. Among the different insecticides tested spraying of monocrotophos @ 0.5 kg a.i./ha was most effective to control the damage by this insect. However, plant products like neem leaf extract and neem oil also were effective in checking the gundhi bug.

Methods of stand establishment

Among different methods of stand establishment tested, seedling (dibble) behind country plough gave highest grain yield (3.35 t/ha) being more than two times higher than the broadcast method of seeding.

Soil amelioration

Lateritic soils are acidic, hence, to ameliorate such soils liming trials were conducted and locally available paper mill sludge was used as liming

material. It was found that the addition of lime @ 1/4 LR was sufficient to get the good yields of rice crop.

Response to fertilizer application

In lateritic soils, from the fertilizer trials it was found that the basal application of phosphorus @ 30 kg P_2O_5/ha was essential to get optimum crop yield. However, crops responded upto the application of 45 kg P_2O_5/ha. Besides this, a dose of 45 kg N/ha and 30 kg K_2O/ha were optimum for upland rice crops.

Improved vs Traditional management

Different varieties were tested under improved as well as traditional management systems. Improved varieties especially semi-talls gave much higher yield as compared to local variety under both the management systems.

Varietal evaluation in bunded uplands

Under bunded upland situations culture "CR 749-20-2" (115 days gave the highest grain yield (5.18 t/ha) followed by "CR 750-48-2" (4.98t/ha), "Sarasa" (4.77 t/ha), Lalata' (4.71 t/ha) and 'Gaurav' (4.31 t/ha).

Varietal evaluation in mid/lowlands

Under shallow lowlands 'Tulasi' (170 days) gave the highest grain yield (6.68 t/ha) followed by 'CR 260-77' (6.60 t/ha), 'Gayatri' (6.40 t/ha) and 'Utkalprabha' (5.78 t/ha) in that order while in deeper lowlands 'Panidhan' was highest yielder (5.25 t/ha) followed by 'CR 580-5' (4.90 t/ha).

Different cropping systems and their economics

Different crop sequences were tested after early rice crop in uplands. It was found that on provision of limited irrigation also, rice-tomato was most remunerative. Only tomato crop gave a net return of Rs. 55.000/ha. This sequence was followed by rice-brinjal, rice-beans, rice-chillies, rice-potato, rice-maize and rice-mustard in their remunerative returns.

Farming System

Study on energy utilization for the cultivation of fish under a village survey study (1993-94) in Cuttack.

Energy survey in village Khentalo, Cuttack was carried out to investigate the energy utilization for the cul-

tivation of fish on small ponds (0.05 acre to 0.3 acre) of small farmers and on large ponds (more than 1 acre). Data on energy utilization for all operations were recorded. Salient finding of the study are as follows :

Total operational energy utilization for the cultivation of fish on small ponds was found to be 1809 MJ/ha out of which harvesting (netting) consumed (1082 MJ/ha) highest operational energy. Harvesting in ponds is done throughout the year for self consumption as well as for selling purpose. No separate exercise netting is done. Operational energy for fingerling collection was found to be 248 MJ/ha. Fingerling collection was done from river bed. About half the quantity of fingerling used were purchased from market.

Total operational energy requirements for the cultivation of fish by farmers having big size ponds (more than 1 acre) was found to be 23910 MJ/ha. Operationwise energy utilization by large size pond farmers was found to be much higher than small ponds. Small ponds farmers gives very negligible feeds and they do not do any pumping of water in the pond to maintain the constant level of water whereas farmers having large ponds run pump to maintain a constant level of water in the pond.

Operational energy utilization on small ponds and big size ponds farmers are given below.

Varietal demonstrations and on-farm trials

During 1993 wet season, 143 farmers in 13 villages of Hazaribag district were selected for varietal demonstrations using Vandana, Kalinga III and RR 151-3 in approximately 13 ha. These varieties were grown with farmers practice and improved practice along with the local check Brown gora. The crop suffered due to drought at vegetative growth phase. Vandana was less affected by moisture stress as well as blast and brown spot which was aggravated by the moisture stress in several villages. Poor land preparation and weed management reduced yields in some villages. RR 151-3 and Vandana recorded the highest yields of 2.8 and 2.5 t/ha at poraiya, Barhi. The farmers appreciated the performance CR the improved varieties which showed tolerance to stresses and better yielding ability compared to Brown gora.

familiar with the varieties. About

Table 1 : Operation-wise energy utilization for the cultivation of fish in a village survey study in the Dist. of Cuttack.

Sl.No.	Operation	Operational energy (MJ/ha)	
		Big size pond	Small pond
1.	Fingerling collection leaving in the ponds.	31.34	248.0
2.	Renovation of ponds and removal of acquatic ponds.	588.0	372.0
3.	Fertilizer application	78.44	23.5
4.	F.Y.M.	176.4	66.2
5.	Calcium Carbonate application	156.8	7.8
6.	Fee application	176.0	9.8
7.	Exercise netting	940.8	Nil
8.	Diseases control	—	Nil
9.	Oxygenation	—	Nil
10.	Harvesting	1791.0	1082.0
11.	Pumping	19973.0	Nil
	Total	23910	1809

two quintals of seeds of high yielding varieties were distributed free of cost to the farmers. Mr. Kiranmoy Nanda Hon'ble Minister of Fisheries, Govt of West Bengal visited CRLRRs stall along with other state officials on 6/2/94. Dr. OMAR Ali, Minister of Minor Irrigation and planning, Govt. of west Bengal. Visited CRLRRS stall along with other state officials on 7/2/94.

Seed supply :- A total of 80, 592 kgs.

of quality seeds of different rice varieties/promising cultures was supplied to various Government and Private agencies viz. National seeds Corporation, State Agricultural Departments, Research Institutes and progressive farmers.

Single factor demonstration

Suitable rainfed lowland and upland varieties with high yield potential submergence tolerance etc. were used for single factor demonstration in Orissa state. Around 1400 such demonstrations were organised in collaboration with department of Agriculture, Orissa. Four districts of Orissa were taken up for this programme and the number of demonstrations sites in different districts of Cuttack, Dhenkanal, Jaipur and Kalahandi were 1058, 150, 20, and 161 respectively with a total of 1389. Each variety was evaluated by 90-100 farmers. Total area covered under this programme was 153.85 ha and the seeds suplied was 11,275 kg.

The yields from these demonstrations ranged from 2.0 to 3.5 t/ha in rainfed drylands (varieties Annada and Vandana) and 3.0 to 5.0 t/ha in shallow and intermediate lowlands.

It was observed that flood water had flown in some lowland areas to the level of 2 feet above the crop, but the varieties like Tulsi, Panidhan and Lunishree did not lodge and gave yields upto 5 t/ha.

These demonstrations had attracted large number of farmers, state officials and other enterpreneurs and received greater appreciation. There is need for large scale cultivation of these varieties.

EXTENSION ACTIVITIES

Extension Communication and Training Division has modes programme of dissemination of modern technology which includes advisory services, publication of extension bulletins personal communication to extension personnel of State govt. farmers, village agricultural workers and students through training and visit programme (T&V).

Publications

Few useful publications of this Institute were brought out during this year (1993-94).

Those are :

Table - 2 : Visit of Farmers, Extension workers and Students to CRRI (April 1993- March 1994)

State	No. of Farmers	VAWS	AEOS/Other Officers	Students	Total
Assam	169	--	--	--	169
Bihar	200	--	--	--	200
Madhya pradesh	48	--	--	---	48
Orissa	57	222	127	--	406
Pondicherry	18	--	--	--	18
Tamilnadu	--	---	--	56	56
West Bengal	--	--	--	53	53
Total	492	222	127	109	950

1. Transfer of rice technology through CRRI in Orissa (Kharif - 1993)
2. Annual Report of CRRI (1992-93)
3. Four issues of CRRI Newsletter.

Training & Visit Programme

A total of 950 visitors including 492 farmers, 222 Village Agricultural Workers (VAWS), 127 State Government Officers and 109 students visited CRRI during this period. Most of the farmers and VAWS were from Bihar and Orissa respectively. (Table - 2) At the outset of the programme they were briefed about the mandate and ongoing research activities of the Institute through audio visual system and then they were taken around experimental fields, net houses and display hall appraising them new rice production technology developed by this Institute. At the end of thhe programme they were called for a group discussion with scientists of the Institute.

Participation of CRRI in Exhibitions

This Institute actively participated in 21st Farm and Home Anversary organised by All India Radio, Cuttack at Satyabhamapur, Cuttack from November 19-20, 1993. The Institure had opened a stall in the exhibition which

was inaugurated by Revenue Divisional Commissioner of Central Zone of Orissa. A large number of farmers, VAWs visited the stall and they were appraised of the Technologies developed by CRRI for increasing rice yields in different ecosystems.

This Institue actively participated in the Agrobased Industrial Exhibition held at Telengapenth, Cuttack from 30th January to 2nd February 1994. A stall was opened by this Institute in the exhibition to display various components of modern method of rice cultivation. This exhibition was inaugurated by Hon'blle Governor of Orissa Sri B. Satyanarayana Reddy. Some dignitories of the State including Hon'bles Panchayatiraj and Revenue Ministers of Orissa.

Farmers' Day

During this period two farmers' days were organised by Central Rainfed Lowlad Rie Research Station, Kharagpur on December 10, 1993 at Debra, West Bengal and at I.I.T. Kharagpur, West Bengal on February 6-8, 1994 respectively. About 2 quintals of seeds of high yielding varieties of rice suitable for low land areas of West Bengal were distributed to farmers on free of cost.

Celebrations of Birth Centenary of Dr. Ramiah

The birth Centenary of Dr. Krishna Swamy Ramiah affectionately remembered as "**Rice Ramiah**" the doyen of rice research in the country nd founder Director of CRRI was commemorated during April 1-2, 1993 with much enthusiasm and gaiety. Several eminent Scientists ffrom India and abroad involved with rice research and development participated in this celebrations. The function was inaugurated by prof. V. L. Chopra, Director-General, ICAR and Secretary to Govt. of India, DARE. Ramiah exhibition hall consisting of great scientific contribution of the Institue and photographs on the life of Ramiah was opened by Dr. Zakhariev, F.A.O. representative in India. One monograph as 'Miracle rice varieties of India' and a brochure entitled 'CRRI at a glance' were released by Prof. V.L.Chopra and Dr. G. S. Khush respectively.

The transactions of the National symposium on 'Advances in Rice Genetics and breeding'began in the afternoon of the first day of celebration. The entire celebration functin was highly appreciated by dignitaries and participants.

TRAINING, CONFERENCES SYMPOSIA AND WORKSHOPS

LIST OF TRAININGS, CONFERENCES SYMPOSIA AND WORKSHOPS ATTENDED BY SCIENTISTS FROM APRIL, 1993 TO MARCH, 1994

1.	Annual Rice Research Workshop	April, 6-8,1993	Directorate of Rice Research,Hyderabad	Dr. J.S. Chauhan Dr. P.K. Singh Mr. M. Variar Mr. S.K. Singh
2.	Training programme on "Conservation and Management of plant genatic Resources"	June 11-July 2,1993	N.B.P.G.R., New Delhi	Mr. S.S.C Patnaik
3.	State Level Workshop-cum-Training on Faerm implemetns and machinery	July, 29-30' 93	OUAT, Bhubaneswar	Mr. F.C. Das Mr. A.K. Choudhry Mr. B.C. Parida
4.	Research Training & Planning Workshop	Sept. 11-Oct. 11 1993.	IRRI, Philippines	Dr. R. Sridhar Dr. (Mrs) A. P. Dath Dr. J.N. Reddy
5.	Weed Management in Upland rice	Sept. 26-Oct.23, 1993.	IRRI, Philippines	Dr. G.N. Mishra
6.	National Group discussion on rice germplasm	Oct.4-5, 1993	Indira Gandhi Krishi Viswa Vidyalaya, Raipur	Dr. S.D. Sharma & Dr. S. Dhua
7.	International Training Conf. on "Current Status and future directions of rice related group training programme in Asia"	Nov. 1-4, 1993	Kasetsart University, Bangkok,Thailand	Dr. Santosh K. Mohanty
8.	International Symposium on "integrated weed management for sustainable Agriculture	Nov. 10-11, 1993	Haryana Agrl.Univ. Hissar	Mr. S.K. Singh

9.	Annual meeting of the Zonal Chapter of Indian Phytopathological Society..	Dec. 10-11, 1993	T.M. Bhagalpur Univ.	Dr. Dipankar Maiti
10.	National Seminar on "Impact of plant physiology on Indian Agriculture"	Jan 27-29, 1994	Agricultural College, Baptatla A.P.	Dr. G. Ramakrishnayya. Dr. R.K. Sarkar
11.	National Workshop on "Use of Pheromone in integrated pest Management" organised on behalf of Plant Protection Association of India.	Feb. 8-9,1994	D.R.R, Hyderabad	Mr. R.C. Dani
12.	"Rainfed Lowland Rice Research Consortium Workshop and Themati conference on stress physiology"	Feb. 28- March 5,1994	Lucknow	Dr. B. Venkateswarlu Dr. J.K. Roy Dr. K. Prasad Dr. G. Ramkrishnayya
13.	International Symposium on climate on stress physiology"	March 14-18, 1994	IRRI,Philippines	Dr. N. Sethunathan
14.	29th Annual Rice group meeting	March 19-22, 1994	I.G. Viswa Vidyalya Raipur	Dr. B. Venkateswarlu Dr. K. C. Mathur Dr. S.B. Lodh Dr. J.K. Roy Mr. P.J. Jachuck Dr. S. Devadutta Dr. K.V.S.R.K. Row Dr. S.K. Mohanty Dr. S.N. Shukla Mr. S.K. Singh Dr. K. Prasad Dr. G.N. Misra Dr. V.D. Shukla Dr. R.K. Singh

PUBLICATIONS

PUBLICATIONS

AGRONOMY

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DISTINGUISHED VISITORS

DISTINGUISHED VISITORS

Col. K. P. Singh Deo	Hon'ble Minister of State for Information and Broadcasting, Govt. of India.
Dr. V. L. Chopra	Director General ICAR & Secretary, DARE, Govt. of India
Sri Chattra Pal Singh	Hon'ble Member of Parliament
Sri Manmohan Mathur	Hon'ble Member of Parliament
Sri Basant Kumar Das	Hon'ble Member of Parliament
Sri Satyadeb Singh	Hon'ble Member of Parliament
Sri Bhupinder Singh mann	Hon'ble Member of Parliament
Dr. U. Venkateswarlu	Hon'ble Member of Parliament
Dr. D. P. Sisra	Director of Agriculture, Orissa
Mrs. Lian Heg.	Agril. Attachee, U. S. Embassay, new Delhi.
Dr. Zakhariev	F. A. O. Representative in India
Dr. H. K. Panda	Former Dirctor, CRRI
Dr. R. Seetharaman	Former Director, CRRI
Dr. S. Patnaik	Former Director, CRRI
Dr. I. C. Mahapatra	Vice Chancellor, OUAT
Dr. A. Appa Rao	Vice Chancellor, APAU
Dr. D. K. Dasgupta	Vice Chancellor, BCKVV
Dr. R. Subramaniam	Son of Late Dr. K. Ramiah
Dr. T. Venkataswamy	Former F.A.O. Expert
Dr. G. S. Khush	IRRI, Philipines
Dr. J. Bennett	IRRI, Philipines
Dr. J. Chandramohan	Retd. Prof. T.N.A.U., Combatore.
Dr. K. K. Jena	Associate Prof. Deptt. of PL. Genetics, Osmania University, Hyderabad.

Dr. O. P. Makhija	ADG (FC), ICAR, New Delhi
Dr. Mahatim Singh	Director, Patash Research Institute, Haryana.
Dr. H.R. Kalia	Former Vice Chancellor, Krishi Viswavidyalaya, Himachal Pradesh.
Dr. J. Venkateswarlu	Director, CAZRI, Jodhpur
Dr. K. L. Chadha	D.D.G. (Crops), TCAR, New Delhi
Dr. K. L. Bokolia	D.D.(P), ICAR, New Delhi
Mr. Bahadur Singh	Former M.L.A., Rajasthan
Dr. Timothy L. Setter	Pl. Physiologist, IRRI, Philippines
Mr. Marco Wopereis	SARP Theme Coordinator, IRRI, Philippines
Dr. Anne Eligs	SARP Corrdinator, IRRI, Philippines
Dr. Elsa Rubia	IRRI, Philippines
Mrs. N. Narayanswamy, IAS	Agrl. Production, Commissioner, Govt. of Orissa
Mr. P. K. Pattnaik, IAS	Development Commissioner, Govt. of Orissa
Dr. M. Kazim	Head, Germplasm Exchange, Divn. NBPGR, New Delhi.
Prof. Prabhas Podiker	Chairman, Legistrature, West Bengal
Shri Amal Dutta	Hon'ble Member of Parliament
Shri Gumanmal Lodha	Hon'ble Member of Parliament
Shri Rajendra Kumar Sharma	Hon'ble Member of Parliament
Shri K. G. Shivappa	Hon'ble Member of Parliament
Shri Mohan Singh Deoria	Hon'ble Member of Parliament
Mr. Bruno Janin	Official in the Ministry of Youth Affairs and Sports, Govt. of France.
Dr. S. I. Bhuyan	Head, Engineering, IRRI, Philippines.

FINANCES

FINANCES

CRRI BUGET FOR (1993-94)

(Actual Rs. in lakhs)

Head	Plan	Non plan
Pav & allowences	35.00	320.07
T.A	1.20	2.80
Recurring & Non-recurring Contigency	39.00	37.13
Total	**75.20**	**360.00**
Non-recurring contingency		
Works	44.30	
Equipments	-	-
Vechile	-	-
Library & live Stock	0.50	-
Others (Furnitures)		
Total	44.80	-
Grand total	120.00	360.00

Inclusive of CRLRRS, Kharagpur and CRURRS, Hazaribag.

PERSONNEL

PERSONNEL

OFFICE OF THE DIRECTOR

B. Venkateswarlu, Ph.D. Director
K. C. Mathur, Ph.D. Joint Director [1]

ADMINISTRATIVE STAFF

B. Narendra Rao, M.Sc. Senior Administrative Officer [1]
G. P. Sharma, M.Com. Finance & Accounts Officer [5]
T. Sarangi, Asst. Administrative Officer
K. Satpathy, B.A. Asst. Administrative Officer

RESEARCH STAFF

AGRICULTURAL ECONOMICS

Salik Ram, *Ph.D. Senior Scientist*
P. Samal, *M. Sc. Ag. Scientist*

AGRICULTURAL ENGINEERING

A K Choudhury, *M.Tech., Senior scientist (Head)*
F C Das, *M.Tech., Senior scientist*
B N Mohapatra, *M.Sc., Senior scientist*
P C Mohapatra, *M.Tech., Senior scientist*
P N Mishra, *M.Tech., Senior scientist*
B C Parida, *M.Tech., Senior scientist*
S P Patel, *M.Tech., Senior scientist*
N Sahoo, *M.Tech., Senior scientist*
A. K. Behera, *M.Tech., Senior scientist*
D K Jaiswal, *M.Tech., Senior scientist*

AGRICULTURAL STATISTICS

S. Rawlo, MA, *Principal scientist (Head)*
A V Suriya Rao, *M.Sc. Senior scientist*
N K Mahana, *M.Sc, scientist*

AGRONOMY

C R Padalia, *M.Sc Ag. prrincipal scientist (Head)*
K C Das, *Ph.D, principal scientist*
K P Jha, *Ph.D, principal secientist*
Dinesh Chandra, *Ph.D, senior scientist*
D P Sinhababu *Ph.D, senior scientist*
B T S Moorthy, *Ph.D, senior scientist*
K S Rao, *Ph.D, senior scientist*
A R Sharma, *Ph.D, scientist*
A Ghosh *M.sc, scientists*

BIOCHEMISTRY AND RICE TECHNOLOGY

S B Lodh, *D.Phil, principal scientist*
B B Nanda, *M.Sc, scientist*
Bhaskar Das, *M.Sc Ag., scientist*

ENTOMOLOGY

K C Mathur, *Ph.D, principal scientist (Head) from 4.1.94*
B C Misra, *Ph.D, principal scientist (Head) upto 3.1.94*
YRVJ Rao, *Ph.D, principal scientist*
VN Rao, *M.Sc, senior scientist*
S Rajamani, *Ph.D, senior scientist*
Gouri Padhi, *Ph.D, senior scientist*
Prabhati Samal, *Ph.D, senior scientist*
A Prakash, *Ph.D, senior scientist*
R C Dani, *M.Sc, senior scientist*

S Sasmal *Ph.D, senior scientist*
P K Das, *M.Sc. senior scientist*
Jagadiswari Rao, *Ph.D, senior scientist*
S C Sahu, *Ph.D, senior scientist*
KS Behera, *M.Sc, scientist (Sr. Scale)*
C D Misra, *M.Sc. Ag. Scientist (Sr. Scale)*
T K Dangar, *Ph.D, scientists (Sr. Scale)*
M S Panwar, *M Sc, Ag. scientist*
Mayabini Jena, *Ph.D, scientist*

EXPERIMENTAL FARM

C R Patnaik, *BVSc, Senior Farm Manager*
J Teram, *M.Sc., Ag. Farm Superintendentt*

EXTENSION, COMMUNICATION AND TRAINING

S K Mohanty, *Ph.D, senior scientist (acting Head)*

GENETIC RESOURCES

S D Sharma, *Ph.D, principal scientist (Head)*
D P Ghorai, *Ph.D, senior scientist*
S R Dhua, *M.Sc, senior scientist*
A R Panda, *M.Sc, Ag. senior scientist*
B C Patra, *Ph.D, scientist*
S S C Patnaik, *M.Sc., scientist*

PLANT BREEDING AND GENETICS

P J Jachuck, *M.Sc, principal scientist (Head)*
R N Misra, Ph.D, principal scientist
MJ Balakrishna Rao, *M.Sc, principal scientist* [2]
J K Roy, *ph.D, principal scientist*
D Chaudhury, *Ph.D, senior scientist*

S N Ratho, *Ph.D, senior scientist*
R N De, *Ph.D, senior scientist*
GJN Rao, *Ph.D, senior scientist*
M Nagaraju, *M.Sc, senior scientist*
R N Rao, *Ph.D, senior scientist*
JN Reddy, *Ph.D, scientist*
PK Agrawal, *M.Sc, scientist* [1]

PLANT PATHOLOGY

S Devadath, Ph.D, *principal scientist (Head)*
KVSR Kameswar Row, *Ph.D, principal scientist*
A Premalatha Dath, *Ph.D, principal scientist*
A Anjaneyulu, *Ph.D, principal scientist*
P Ranga Reddy, *Ph.D, principal scientist*
R Sridhar, *Ph.D, senior scientist*
B Padhi, *Ph.D, senior scientist*
S K Mohanty, *Ph.D, senior scientist*
Urmila Dhua, *Msc, senior scientist*
S N Tewari, *Ph.D, senior scientist*
UD singh, *Msc, Ag. senior scientist*
G Bhaktavaslam, *Ph.D, senior scientist*
SK Singh, *M.Sc, scientist*

PLANT PHYSIOLOGY

S K Nayak, *Msc, senior scientist (acting Head)*
Ch. N Rao, *Ph.D, principal scientist*
G Rama Krishnaya, *Ph.D, senior scientist*
S R Voleti, *Msc, scientist*
Padmini Swain, *Ph.D, scientist*
RK Sarkar, *Ph.D, scientist*
Prameela Ramkrishnan, *M.sc, scientist* [1]
I Ravi *Msc.scientist* [1]

SOIL SCIENCED AND MICROBIOLOGY

SK Mohanty, *Ph.D, principal scientist (head)*
N Sethunathan, *Ph.D, principal scientist*
AR Mohapatra, *Ph.D, senior scientist*
A Bhadrachalam, *MS, senior scientist*
VR Rao, *Ph.D, senior scientist*
AK Misra, *Ph.D, senior scientist*
RN Dash, *Ph.D, senior scientist*
V Sarkunan, *Ph.D, senior scientist*
SP Chakraborti, *PhD, senior scientist*
RN Samantaray, *Ph.D, senior scientist*
D Panda, *Ph.D, senior scientist*
SK Pradhan, *Ph.D, senior scientist*
KR Mahata, *Ph.D, senior scientist*
TK Adhya, *Ph.D, senior scientist*
DP Singh, *Ph.D, senior scientist*
MM Panda, *Ph.D, senior scientist*
MVR Murty, *Ph.D, scientist*
B. Ramakrishnan, *Ph.D, scientist* [1]

CENTRAL RAINFED LOWLAND RICE RESEARCH STATION

SN Shukla, *Ph.D, senior sceintist (officer-in-charge)*
K Pande, *Ph.D, senior sceintist (plant breeding)*
SK singh, *M.Sc., Ag. Sientist (agronomy)*
NC Pande, *M.Sc., Ag. scientist (soil science)*

CENTRAL RAINFED UPLAND RICE RESEARCH STATION

VS Chauhan, *Ph.D, senior scientist (Officer-in-charge)*
DK Paul, *MTech, senior scientist (agril engineering)*
K Prasad, *MSc., principal scientist (Officer-in-charge)*
GN Mishra, *MSc, Ag. senior scientist (agronomy)*
VD Shukla, *MSc, Ag. scientist (Plant pathology)*

JS Chauhan, *Ph.D, scientist (plant breeding)*
RK Singh, *Ph.D, scientist (soil science)*
M Variar, *M.Sc, scientist (Plant pathology)*
D Maiti, *M.Sc Ag. scientist (Plant pathology)*
CV Singh, *M.Sc, scientist (agronomy)*

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1 Joined during the year

2 Retired during the year

3 Died during the year

4 On deputation

5 Transferred