50 Years of AICRIP... Way Forward

Annam Bahu Kurvita
(multiply food production many-fold)
Upanishad

V Ravindra Babu, Ch Padmavathi, CN Neeraja, D Krishnaveni, Divya Balakrishnan, LV Subba Rao, P Raghuveer Rao, GSV Prasad, Gururaja Katti, T Ram, D Subrahmanyam, RM Kumar, AS Hari Prasad, K Surekha, MS Prasad and U Chaitanya

ICAR- Indian Institute of Rice Research
Rajendranagar, Hyderabad-30, Telangana State, India

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एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

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MESSAGE

Rice is the staple food crop of the country. A significant development in the recent years is the production of more than 100 million tonnes of rice. This has transformed the country from shortage to surplus, making the country a major rice exporter. Systematic rice research has played a key role in this regard. After the establishment of Central Rice Research Institute at Cuttack, Odisha in the pre independent India, rice research in the country got a boost. It was amply supported by the All India Coordinated Rice Improvement Project (AICRIP) at Hyderabad, which started in the year 1965 for coordinating multi-location trials essential for selection of the best lines for release as new varieties. The AICRIP Coordinating Unit was named as Directorate of Rice Research (recently renamed as Indian Institute of Rice Research - IIRR) is continued with 45 funded centres and more than 100 voluntary centres spread across diverse rice ecosystems of India. The foresight and vision of ICAR supplemented with research efforts of rice scientists has enabled successful completion of 50 years of AICRIP culminating in social and economic benefits for the rice farmers of the country.

The present publication brought out by the IIRR, 'Fifty years of AICRIP – A Way Forward' coinciding with the completion of Golden Jubilee celebrations of the Institute in 2015, is a much needed and welcome step as it details the R&D efforts and achievements thereof under AICRIP in the past 50 years. This is a testimony to the outcome of strenuous efforts of all the stakeholders involved in rice research for enhanced production in the country. On this occasion, I urge all the rice scientists under AICRIP to rededicate and continue with the agricultural R&D for enhancement of rice productivity in different agro-climatic conditions.

(T. Mohapatra)

Dated the 1st April, 2016
New Delhi

डॉ. जीत सिंह सन्धू
उपमहानिदेशक (फसल विज्ञान)
Dr. Jeet Singh Sandhu
Deputy Director General
(Crop Science)

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Foreword

In India, rice ecosystems are highly diverse and pose varied challenges to the rice farmers in terms of abiotic and biotic stresses of rice in India. Realizing the ecosystem complexities, destabilizing pest problems as well as grain quality requirements of different rices consumed, Indian Council of Agricultural Research (ICAR) had the foresight to come up with the concept of All India Coordinated Rice Improvement Project(AICRIP) way back in 1965. Through a nation-wide network of rice researchers actively supported by progressive rice farmers, suitable high yielding varieties along with suitable crop production and protection technologies have been developed for the rice farming community.

Under AICRIP, the initial efforts catered to the crop durational requirements, while in 80s high yielding varieties possessing major biotic stress tolerance and prototype of Basmati rice varieties in semi-dwarf background were developed. In nineties, suitable hybrid rice technology, non basmati quality trials targeting exports, hill trials for cold tolerance, trials for problem soil areas and aerobic trials for water limited environments were emphasized. In the last decade the focus has been on development of biotic stress tolerance through conventional and advanced biotechnology tools. In near future, the research direction is heading towards meeting the food and nutritional security needs of the country. India has now been elevated to the status of leading producer and exporter of rice in the world with export of Basmati rice worth about 40000 crores in foreign exchange. In view of the fast paced developments in rice research and technology advances in the country, I am confident that AICRIP scientists will redouble their team efforts to further contribute to the overall growth of rice economy of the country.

The present publication brought out by the Indian Institute of Rice Research (ICAR-IIRR) as a leading institute under AICRIP in commemoration of the completion of 50 golden years of rice research is a very good initiative in providing a sound futuristic direction to the organisation of rice research in the country. It is evident that AICRIP with its established strength and backed up by perseverance of all the stakeholders involved in rice production and technology will contribute towards attainment of food and nutritional security in India. I congratulate and compliment all those involved for their efforts in bringing out this publication.

March 23, 2016
New Delhi

(J.S. Sandhu)

Ph. : (Off.) 23382545 Fax : 23097003 E-mail : ddgcs.icar.nic.in

Dedicated

to

AICRIP Rice Researchers

CONTENTS

I. Genesis of AICRIP

The paradigm shift from subsistence agriculture to technology driven intensive farming has taken the country from the days of food deficit to an era of self sufficiency which is a golden chapter in the history of India. The year 2015 being the Golden jubilee year of the All India Coordinated Rice Improvement Project (AICRIP), is the time to celebrate, reflect and introspect to take stock of the achievements to plan ahead for facing new challenges with new initiatives.

Systematic rice breeding efforts in India date back to the early years of 20th century. More or less during the same period, erstwhile provinces of Bengal and Madras established research stations, mainly dedicated for rice research. Rice improvement in the country received much needed impetus with the appointment of Economic Botanist in Dhaka (now in Bangladesh) in 1911 and first crop specialist for rice in 1912 in Madras. Subsequently, research efforts were strengthened with the establishment of Indian Council of Agricultural Research (ICAR) in 1929. A national institute for rice research was subsequently established as Central Rice Research Institute (CRRI) at Cuttack in 1946. By 1950, there were 82 rice research stations in the country and breeding efforts to increase yields were confined to pure line selections.

Coinciding with the establishment of CRRI, FAO of the United Nations, through International Rice Commission (IRC), launched a large scale hybridization programme between the fertilizer responsive japonica and indica varieties to address the problem of improving rice production. CRRI implemented this programme for South East Asian countries on behalf of IRC and for Indian states with support from ICAR.

The opportunity of elevating yield potential of rice by utilizing the semi-dwarf varieties, highlighted by International Rice Research Institute (IRRI), Philippines during mid 1960s, emerged as a strong 'plant type' breeding objective approach in entire Asia. The rice breeding programmes in India were accelerated with the introduction of semi-dwarf and non-lodging plant type, Taichung Native 1 – T(N)1 developed in Taiwan from a cross between semi-dwarf mutant Dee-geo-woo-gen and Tsai-yuang-chung. The semi-dwarf plant type with fertilizer responsiveness, erect leaves to utilize maximum solar energy achieved much higher yields than the traditional varieties.

The concept of regional approach to solve the rice production problems like tall plant stature, lodging, photoperiod sensitivity, late maturity, narrow adaptability, non- responsiveness to fertilizers led to the formation of a nation-wide cooperation and was a prelude to the establishment of the All India Coordinated Rice Improvement Project.

The All India Coordinated Rice Improvement Project (AICRIP) was established at Hyderabad by ICAR in 1965 with the mandate of development of an integrated national network of cooperative experimentation on all aspects of rice production to accelerate breeding efforts with semi dwarf varieties. The Rockefeller Foundation, IRRI and US Agency for International Development (USAID) extended personnel and financial support to AICRIP to enhance the pace of rice research in the country. With the responsibility to organize multi-disciplinary, multi-location testing and develop suitable varietal and production technologies, AICRIP capitalized upon the available research infrastructure in different states of India and successfully introduced a national perspective to rice research.

The pre-AICRIP Indian rice research system was isolated in some research establishments and Universities. The varied difference of opnion regarding the testing of first semi-dwarf variety, TN(1) in every major rice growing areas of India led to the establishment of first nationally co-ordinated Rice Improvement Project (AICRIP) with a full time co-ordinator.

II. Evolution of ICAR-IIRR & its structure

In 1965, AICRIP was started with its headquarters at Rajendranagar, Hyderabad. The core staff at the headquarters and participating centers was provided by ICAR. Since inception until seventies, AICRIP was supported by the Rockefeller Foundation, the USAID and the Ford Foundation by way of financial assistance and technical support through strengthening of the research activities and by providing scientists in specific disciplines on a complimentary basis. The construction of green houses through financial support from the Ford foundation provided facilities for year round screening for resistance to insect pests and diseases under controlled conditions. In course of time, the foreign assistance was gradually phased out.

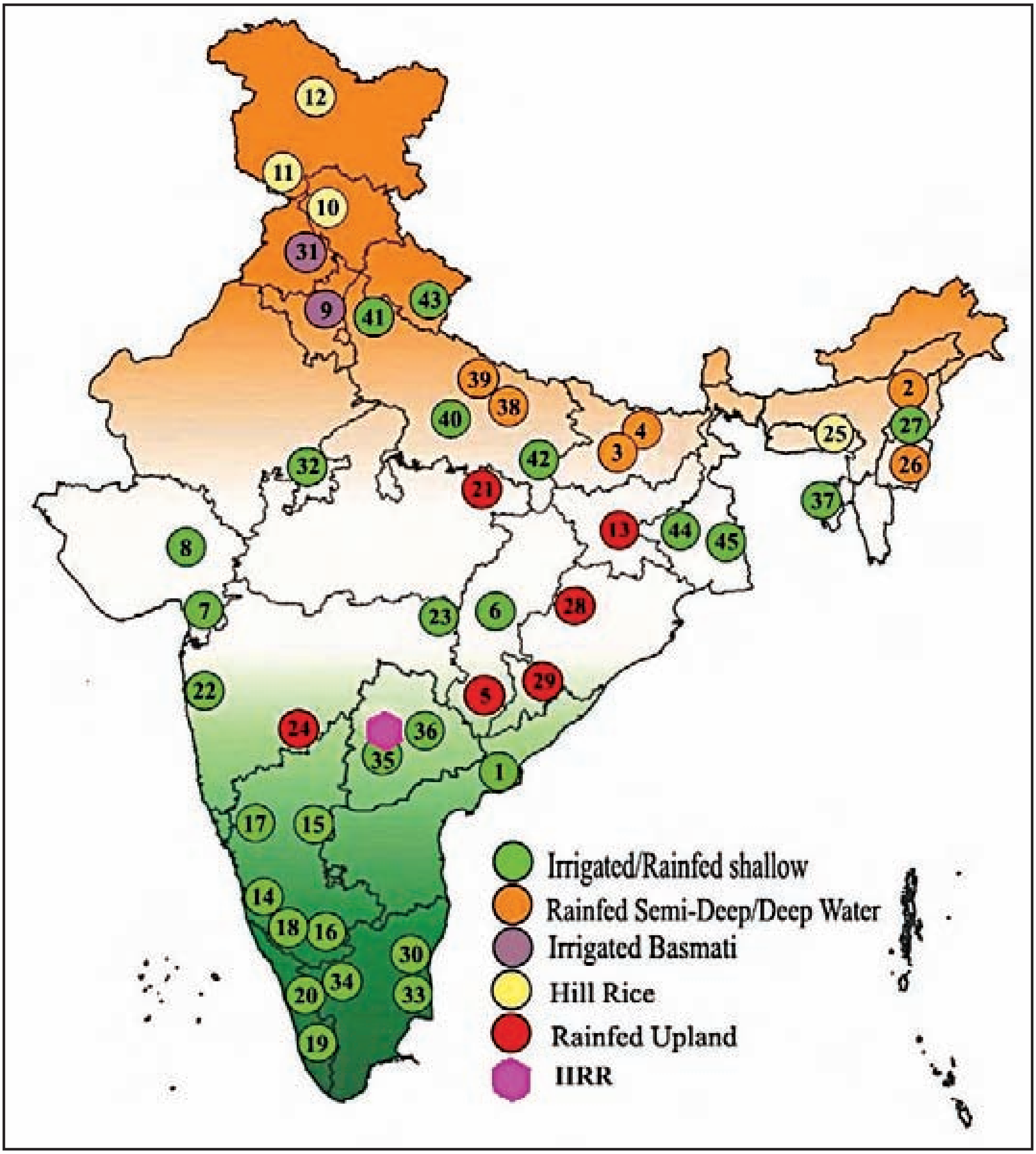
AICRIP placed utmost faith in the testing programme and adopted a set of objective criteria such as the low coefficient of variation and high mean yield of the trials, as indicators to grade the trials, while not being too restrictive on the choice of trial sites. In AICRIP, all the cooperators contributed to testing the breeding material and every one had equal opportunity, to contribute materials for testing. AICRIP's practice of reporting the results from all the locations in one common data table fostered a healthy spirit of competition among cooperators. Another conviction for AICRIP was that the multi-locational experience from a season is a more valid substitute for the multi seasonal experience from a single research station. Due to these advantages, the states progressively looked upon AICRIP playing a service role to their own breeding programmes. A research station operating on its own, would have taken several years to come up with a definitive position on a breeding line whereas it took much less time when the same line was put through AICRIP tests. This realisataion encouraged the state experiment stations to nominate more and more breeding material to AICRIP trials.

Release of a miracle variety, IR 8, from Peta and Dee-geo-woo-gen in 1966 from IRRI revolutionized the rice yields. At the same time, semi-dwarf high yielding variety 'Jaya' was released by AICRIP in 1968 ushering in green revolution. This transformed the country into a state of self-sufficiency by mid-eighties and stalled rice imports, while beginning an era of exporting rice, earning high foreign exchange for the country by early nineties.

To begin with, AICRIP work was carried out in 7 zones each under the responsibility of a Zonal Coordinator. The zonal headquarters were Khudwani, Jorhat, Faizabad, Patna, Hyderabad, Cuttack and Coimbatore. Twelve regional stations viz, Palampur, Pantnagar, Kapurthala, Chinsurah, Sambalpur, Raipur, Maruteru, Karjat, Nawagam, Mandya, Aduthurai and Pattambi were established in the major rice growing states of the Country. Upper shilling, Kalimpong and Imphal were identified as testing centers. Thus, there were 22 centers.

Considering the progress and future challenges, during fifth five year plan (1974-79), ICAR provided 23 additional centers, thus raising the number to 45. These centers were classified into single cropped (24) and double cropped units (21). Centers at Imphal, Upper shilling, Agartala, Pondicherry, Kohima and Varanasi were fully financed by ICAR. Cuttack center was a part of Central Rice Research Institute (CRRI). The rest were financed on a 75:25 with State Agricultural Universities (SAUs – 25%) or 50:50 per cent basis with State Departments of Agriculture (SDAs – 50%). In August 1975, AICRIP was elevated to the status of Directorate of Rice Research (DRR), headed by Project Director (PD), wherein lead research targeting mainly the irrigated ecosystem was included. During VI plan period (1980-85), 8 more sub centers were sanctioned raising the total to 53. There were a total of 61 centers including 8 subject related special centers. In the VII plan period (1985-86 to 1989-90) the number of centers was reduced to 50 (18 main and 32 sub centers). During the VIII plan (1992-97), there were 51 approved centers of which six centers were withdrawn and Karnal center was merged with Kaul in the IX plan period (1997-2002). The total number of centers during X plan (2002-2007) increased to 46 with the approval of Kanpur and Nagina centers and to 47 during XI plan (2007-2012) with addition of Navsari in southern Gujarat in western India. During the ongoing XII plan (2012 – 2017), two centers viz., Karimganj and Sabour have been withdrawn. So, currently there are 45 funded centers under AICRIP. In addition to these funded centers, there are more than 100 voluntary centers where trials were conducted on voluntary basis in each discipline.

DRR was elevated to national institute status and renamed as 'Indian Institute of Rice Research (IIRR)' during the golden jubilee year, from 15th December 2014. The positioin of Project Director was redesignated as Director. Over the years, the institute has strengthened its infrastructure and human resources and is well prepared to face the domestic and global challenges. It is committed to maintain its leadership and is responsive to the needs of its stakeholders. The institute activities are aimed at accomplishing the vision, mission and mtandate of IIRR keeping in view the "Farmer First" motive of ICAR. A novel feature of this programme is that ICAR research institutes including IIRR as well as state agricultural universities, state departments of agriculture and private seed industry work together as a team to resolve research problems of rice cultivation at national level.



Funded centers of AICRIP in India under different rice ecologies

List of AICRIP funded centers

S.No	State	Center	Latitude	Longitude
1	Andhra Pradesh	Maruteru	16.63	81.73
2	Assam	Titabar	26.60	94.20
3	Bihar	Patna	25.6	85.12
4		Pusa	25.88	85.68
5	Chattisgarh	Jagdalpur	19.07	82.03
6		Raipur	21.24	81.64
7	Gujarat	Navasari	20.95	72.92
8		Nawagam	22.80	72.58
9	Haryana	Kaul	29.84	76.66
10	Himachal Pradesh	Malan	32.12	76.53
11	Jammu & Kashmir	Chatha	32.61	74.79
12		Khudwani	33.74	75.06
13	Jharkhand	Ranchi	23.35	85.33
14	Karnataka	Brahmavar	13.43	74.75
15		Gangavathi	15.43	76.53
16		Mandya	12.52	76.90
17		Mugad	15.44	74.91
18		Ponnampet	12.15	75.93
19	Kerala	Moncompu	9.44	76.43
20		Pattambi	10.82	76.20
21	Madhya Pradesh	Rewa	24.53	81.30
22	Maharashtra	Karjat	18.92	73.33
23		Sakoli	21.08	79.98
24		Tuljapur	18.01	76.07
25	Manipur	Upper shillong	25.57	91.88
26		Wangbal	24.60	94.02
27	Nagaland	Kohima	25.67	94.12
28	Odisha	Chiplima	21.34	83.94
29		Jeypore	18.85	82.58
30	Puducherry	Puducherry	11.93	79.83
31	Punjab	Ludhiana	30.9	75.85
32	Rajasthan	Kota	25.17	75.85
33	Tamil Nadu	Aduthurai	11.02	79.48
34		Coimbatore	11.00	76.97
35	Telangana	Rajendranagar	17.32	78.40
36		Warangal	18.00	79.58
37	Tripura	Agarthala	23.83	91.29
38	**Uttar Pradesh**	**Faizabad**	**26.78**	**82.13**
39		**Ghaghraghat**	**27.12**	**81.53**
40		**Kanpur**	**26.47**	**80.35**
41		**Nagina**	**29.45**	**78.44**
42		**Varanasi**	**25.33**	**82.97**
43	**Uttaranchal**	**Pantnagar**	**29.05**	**79.52**
44	**West Bengal**	**Bankura**	**23.25**	**87.07**
45		**Chinsurah**	**22.88**	**88.39**

VISION

Welfare of the present and future generations of Indian rice farmers and consumers by ensuring food, nutritional and livelihood security

MISSION

Develop technologies to enhance rice productivity, resource and input use efficiency and profitability of rice cultivation without adverse affect on the environment

MANDATE

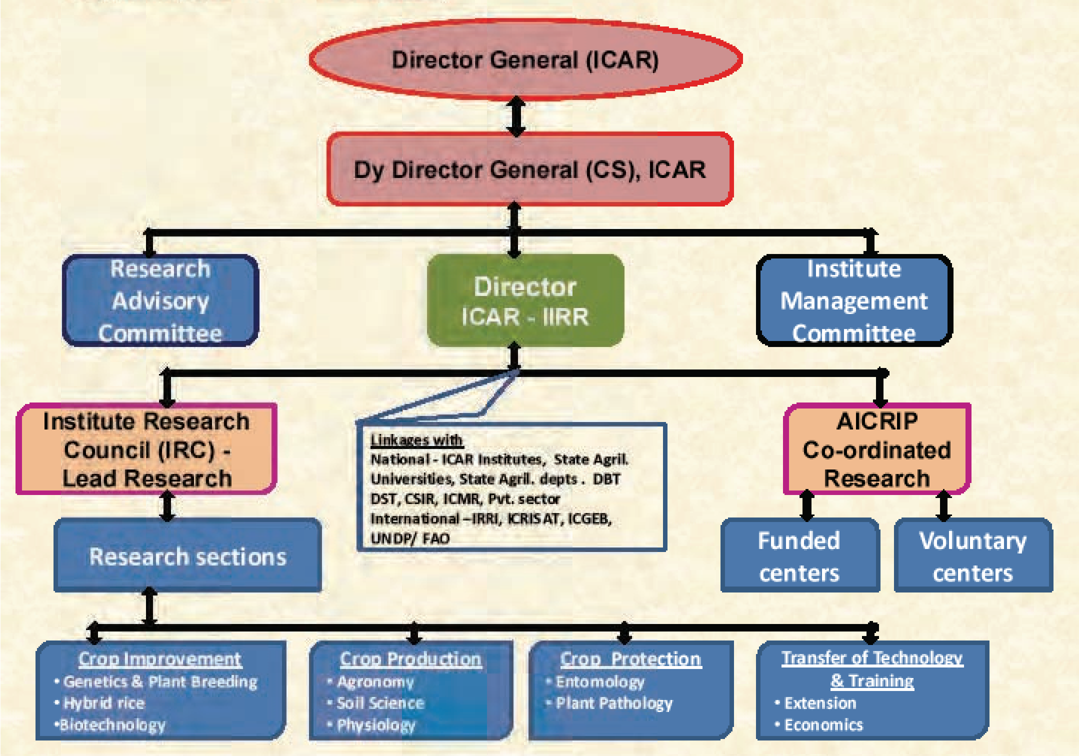
- To organize, coordinate and monitor multi-location testing at national level to identify appropriate varietal and management technologies for all the rice ecosystems.
- To conduct basic, strategic and anticipatory research in the major thrust areas of irrigated rice aimed at enhancement of production, productivity and profitability while preserving environmental quality.
- To develop, organize, coordinate and monitor research networks relating to problems of national and regional importance.
- To serve as major centre for exchange of research material and information.
- To accelerate the pace of technology transfer through development and adoption of innovative extension training models, self-learning modules and through organizing formal training courses, frontline demonstrations, exhibitions, farmers' day etc.
- To develop linkages with national, international and private organizations for collaborative research programmes.
- To provide consultancy services and undertake contractual research.

Organogram of IIRR-AICRIP

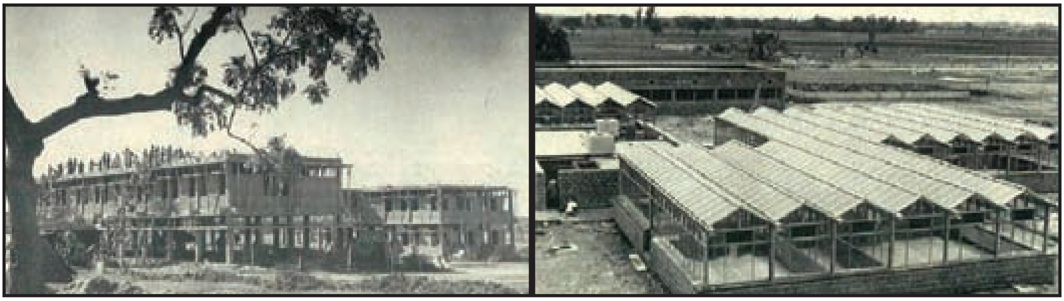
On the occasion of Golden jubilee year, IIRR takes highest pride for successful conduct and coordination of 50 years of AICRIP in India. AICRIP is the largest research network on a single crop comprising of 45 funded and over 100 voluntary centers covering all the rice growing states in the country. At present, more than 300 scientists of the State Agricultural Universities (SAU's), State Departments of Agriculture and ICAR institutes carry out planned experiments/ trials of breeding, agronomy, soil science, plant physiology, entomology and pathology at various locations.

ICAR- IIRR is one of the crop based institutes of ICAR under direct supervision of the Deputy Director General, Crop Sciences. Director, IIRR is also the National Coordinator of AICRIP and its activities are integrated into the mandate with senior most scientists of each discipline acting as the Principal Investigators (PIs) of the programme. Research and Institutional activities are planned and guided by Research Advisory Committee (RAC) and Institute Management Committee (IMC) while the progress is critically evaluated by the Quinquennial Review Committees (QRT). This institute has well equipped laboratories with state of the art equipments, centrally air cooled greenhouses, biosafe transgenic greenhouses, growth chambers, well laid out experimental farms at Rajendranagar, IIRR campus and Ramachandrapuram farm, ICRISAT campus.

Linkages: IIRR has the largest network of linkages and collaborations with organizations both in India and abroad. Under AICRIP, it has 45 funded and more than 100 voluntary centers affiliated to state agricultural universities and state departments of agriculture besides five ICAR institutes and International Rice Research Institute (IRRI). It has research linkages with national institutes like State Agricultural Universities (SAUs), State Agricultural Departments, ICAR Institutes, DBT, DST, CSIR, ICMR and Private sector. Internationally, it has strong collaboration with CGIAR institutes such as IRRI, International Crop Research Institute for Semi Arid Tropics (ICRISAT) and International center for Genetic Engineering and Biotechnology (ICGEB). IIRR also has a strong mode of operational linkage with the private sector, especially related to hybrid rice technology and fertilizer and chemical companies through testing new molecules of pesticides and herbicides related to entomology, pathology and agronomy sections.



Organogram of IIRR– AICRIP

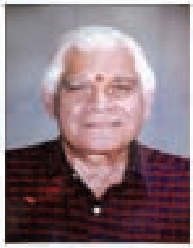


Old

New

AICRIP Leaders (1965 - 2015)

Dr MS Pawar, Project Coordinator
All India Coordinated Rice Improvement Project
April1965 – Mar 1966



Dr SVS Shastry, Project Coordinator
All India Coordinated Rice Improvement Project
Apr 1966 – Jan 1975

Dr R Seetharaman, Project Director
Directorate of Rice Research
Aug 1975 – Sep 1985

Dr EA Siddiq, Project Director
Directorate of Rice Research
Nov 1987 – Jun 1994

Dr K Krishnaiah, Project Director
Directorate of Rice Research
Dec 1995 – Feb 2000

Dr B Mishra, Project Director
Directorate of Rice Research
Jul 2000 – Aug 2005

Dr BC Viraktamath, Project Director
Directorate of Rice Research
Jun 2006 – May 2014

Dr V Ravindra Babu, Director
ICAR – Indian Institute of Rice Research
Nov 2015– till date

III. AICRIP Testing Mechanisms

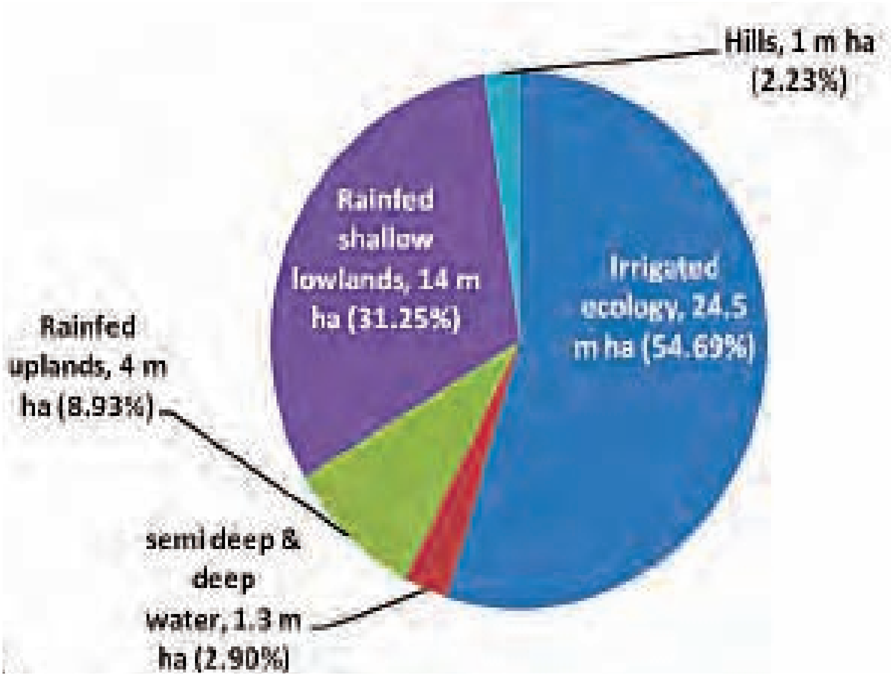
Rice Ecosystems

In India rice is grown in highly diverse conditions. Primarily it is grown under five different ecologies, with irrigated ecology accounting for the largest area (24.5 m ha) and highest production (70.5 mt) and productivity of 2.87 t/ha followed by rainfed shallow low lands. It is cultivated as a rainfed crop in areas with precarious monsoon distribution. It is also cultivated in areas where water level reaches 5 meters or more. The rice cultivation in Kuttanad district of Kerala is below the sea level, while in the states of Jammu & Kashmir, it is grown almost up to an altitude of 2000 msl. The wide rainfall distribution pattern (drought, submergence, deep water) and distinct differences in soils (coastal and inland salinity, alkalinity, acidity), agro-climatic situations (high humidity) and overlapping seasons with their specific duration requirements has resulted in the cultivation of thousands of varieties and this ecological diversity is also one of the causes for low productivity of rice in India. Rice is the only cereal that is consumed as whole grain; hence the quality preferences too are diverse. Further, rice crop is prone to the attack of weeds, several insect pests and diseases causing crop losses to the extent of 30 – 40% which further adds to the complexity to achieve high yield potential.

Realizing the limitations imposed by the ecosystem complexities, destabilizing insect pests and disease problems as well as grain quality requirements of different rices consumed, AICRIP evolved need based programmes / trials over the years to identify suitable genotypes of high yield potential along with appropriate crop management practices. During the initial phase i.e., in the first decade, emphasis was given to achieve higher yields through improved plant type largely for irrigated areas. This led to the development of short statured high yielding varieties (HYVs), which heralded the process of "Green Revolution" in India. During 80s, yield stability and quality improvement received major attention. This led to the development of varieties possessing major biotic stress tolerance and desirable quality to develop prototype of semi-dwarf basmati rice varieties. Nineties witnessed efforts in developing suitable hybrid rice technology and multi location testing to validate their superiority over varietal checks at least by 10%, non basmati quality trials targeting the export markets. During 2000s emphasis was on soil stress trials for problem soil areas, aerobic trials laying emphasis on developing genotypes for water limited environments and hill trials for incorporating cold tolerance. In recent times, emphasis has been on the near isogenic line development for quick evaluation of marker assisted selection (MAS) derived products introgressed with genes for biotic and abiotic stresses. Additionally nutritional security is stressed by enriching the grain with micronutrients such as zinc, iron along with protein.

Irrigated Ecosystem

Upland Ecosystem



Area under different rice ecosystems in India

Hill Ecosystem

Deep water Ecosystem

Particulars of Zones, States and test Locations

Region / State	Locations	
	Funded	Voluntary
ZONE I – HILLY AREAS		
North Western Hills		
Jammu & Kashmir	Khudwani (1)	Rajouri, Wadura, Shalimar, Bandipore, Pombay (5)
Himachal Pradesh	Malan (1)	Katrain, Palampur, Dhaulakhan (3)
Uttarakhand		Almora, Bageshwar, Majhera, Ranichouri (4)
North Eastern Hills		
Arunachal Pradesh		Basar (1)
Nagaland	Kohima (1)	
Manipur		Langol, CAU-Imphal (2)
Mizoram		Kolasib (1)
Meghalaya	Upper Shillong (1)	ICAR-Umiam, CAU-Umiam (2)
Sikkim		Gangtok (1)
West Bengal		Kalimpong (1)
Southern Hills		
Andhra Pradesh		Chintapalli (1)
Tamil Nadu		Gudalur (1)
Karnataka		Sirsi (1)
ZONE II – NORTHERN		
New Delhi		IARI- New Delhi (1)
Uttarakhand	Pantnagar (1)	
Punjab	Ludhiana (1)	Gurdaspur, Kapurthala, Rauni (3)
Haryana	Kaul (1)	Karnal (CSSRI), Jind, Rohtak, Kurukshetra, Gautam Buddha Nagar, Panipat (6)
Uttar Pradesh	Nagina, Kanpur (2)	Modipuram (1)
Jammu & Kashmir	Chatha (R.S. Pura) (1)	
Rajasthan	Kota (1)	Banswara (1)
ZONE III – EASTERN		
Orissa	Jeypore, Chiplima (2)	Bhubaneswar, NRRI (Cuttack), Motto (3)
Bihar	Patna, Pusa (2)	Patna- ICAR, Sabour(2)
Jharkhand	Ranchi (1)	Hazaribagh (1)
West Bengal	Bankura, Chinsurah (2)	Canning, Pundibari, Chakdha, Hathwara, Gosaba, Kolkata (6)
Uttar Pradesh	Masodha ,Ghaghraghat, Varanasi (3)	Aligarh, Allahabad, Lucknow, Gorakhpur (4)

ZONE IV – NORTH EASTERN		
Assam	Titabar (1)	North Lakhimpur, Gerua, Karimganj (3)
Manipur	Wangbal (1)	Lamphalpat, Imphal (CAU) (2)
Tripura	Arundhutinagar (1)	Lembucherra (1)
ZONE V - CENTRAL		
Madhya Pradesh	Rewa (1)	Waraseoni, Jabalpur (2)
Chhattisgarh	Raipur, Jagadalpur (2)	Bilaspur, Ambikapur (2)
Maharashtra	Sakoli (1)	Sindewahi (1)
ZONE VI - WESTERN		
Maharashtra	Karjat, Tuljapur (2)	Panvel, Radhanagari, Palghar, Shirgaon, Phondaghat, Vadagaon, Parbhan, Igatpuri (8)
Gujarat	Nawagam, Navsari (2)	Derol, Vyra, Danti, Dabhoi, Bardoli (5)
Goa		Goa (1)
ZONE VII - SOUTHERN		
Andaman & Nicobar		Port Blair (1)
Andhra Pradesh	Maruteru (1)	Ragolu, Bapatla, Machilipatnam, Nellore, Nandyal(5)
Telangana	Rajendranagar, Warangal (2)	Jagtial, Kunaram, Rudrur, Kampasagar (4)
Tamil Nadu	Aduthurai, Coimbatore (2)	Ambasamudram, Paramakudi, Trichy, Annamalainagar, Tirur (5)
Kerala	Moncompu, Pattambi (2)	Vyttila (1)
Karnataka	Mandya, Mugad, Ponnampet, Brahmavar, Gangavati (5)	Sirsi, Mudigere, Bengaluru , Kathalgere (4)
Puducherry	Kurumbapet (1)	Karaikal (1)
Total locations	45	97

Underline :ICAR Institutions

Discipline wise Testing Procedures

Crop Improvement

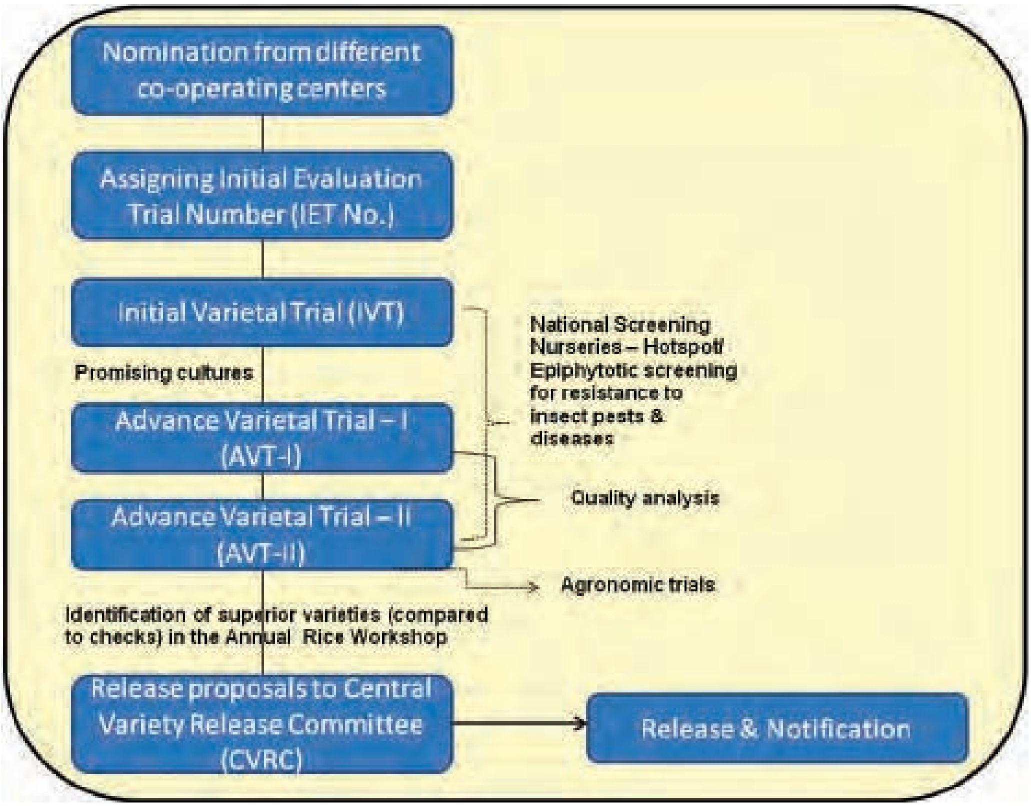
Plant Breeding – Varietal Testing

ICAR-IIRR adopted a unique model that facilitates joint programme planning and implementation of multi-location testing along with exchange of breeding and germplasm material. This "National Evaluation system" follows a three tier system and assigns a number to every nominated entry developed by different cooperating centers known as Initial Evaluation Trail Number (IET No.). The practice of early testing in the form of IET's wasfirst introduced in AICRIP which was later adopted by other coordinated projects. Normally, it takes a minimum of three to four years to identify a promising variety. The first level of testing involves one year Initial Varietal Trial (IVT) followed by two years of Advance Varietal Trials (AVT-1 & AVT-2). These trials help in the identification of elite breeding lines with consistently superior performance over the best checks. Simultaneously, these nominated lines will be screened for resistance to major insect pests and diseases at hot spot locations as well as controlled conditions under well defined disease and insect pressure. Additionally grain quality and agronomic performance will also be assessed for all the promising entries.

Finally, after three years of testing, the details of best performing elite lines possessing desirable characters and required level of resistance will be submitted by the concerned breeder in a proforma along with all the supplementary data and relevant information for consideration of the variety identification to the Variety Identification Committee (VIC) during the annually held All India Rice Group Meeting. Thus the superior test entries identified in the crop workshop/group meeting will be later approved by the Central Sub-Committee on Crop Standards, Notification and Release of varieties (CSCS & NRV) and State Variety Release Committees (SVRC) and those approved cultures would be named and released for general cultivation as Central or as State releases.

AICRIP testing of promising breeding material (varieties, hybrids, etc.) helps in identifying the most stable, high-yielding or superior genotypes suited for different agro-climatic conditions. In the process, varieties are identified and released, not only for the zones/regions where they have been bred, but also for other regions as well. This helps in complementing the efforts of relatively upcoming centers where the breeding programme is not strong enough to cater to the needs of the specific region. In the process, the best material gets identified for release in different regions/ states.

Realizing the potential of molecular markers and accelerated pace at which marker assisted selection (MAS) derived products are being developed in India, it was decided in 2005 Annual Rice Workshop held at Bangalore, to include special trials to test products derived from marker assisted back cross breeding (MABB). Similarly, in Annual Rice Group Meeting held at Srinagar during 2012, it was decided to constitute biofortification trial for evaluation of breeding lines developed with high Zinc content. Thus, AICRIP has continuously evolved from time to time by taking into consideration the technological developments and their needs for testing in different rice ecologies at multilocations.



Procedure for Varietal Testing and Release through CVRC

Program leaders/ Principal Investigators (PI) of Plant Breeding programme:

S. No.	Name	Period
1	Dr DV Seshu	1973 - 1978
2	Dr VVS Murthy	1978 - 1986
3	Dr TE Srinivasan	1986 - 1988
4	Dr MVS Sastry	1988 - 1990
5	Dr J Ramakrishna Rao	1990 - 1996
6	Dr U Prasada Rao	1996 - 2001
7	Dr N Shobha Rani	2001 - 2014
8	Dr V Ravindra Babu	2014 - 2015
9	Dr T Ram	2015 - continuing

List of funded and voluntary centers of Plant Breeding programme in AICRIP

S. No	Funded Centers	S.No	Voluntary Centers	S.No	Voluntary Centers
1	Maruteru	1	Almora (ICAR)	47	New Delhi (IARI)
2	Rajendranagar	2	Annamalainagar	48	Machilipatnam
3	Warangal	3	Aligarh	49	Majhera
4	Jorhat/Titabar	4	Bageswar	50	Mandya
5	Karimganj	5	Bangalore (UAS)	51	Modipuram
6	Patna	6	Banswara	52	Moncompu
7	Pusa	7	Bapatla	53	Mudigere
8	Sabour	8	Barapani	54	Nellore
9	Jagdalpur	9	Bardoli	55	North Lakimpur
10	Raipur	10	Bhubaneswar	56	Palampur/Malan
11	Nawagam	11	Bhudanagar	57	Palghar
12	Navasari	12	Bilsapur	58	Panipat (CSSRI)
13	Kaul	13	Canning	59	Panvel
14	Palampur/Malan	14	Chakdaha	60	Paramakudi
15	Khudwani	15	Cuttack (CRRI)	61	Parbhani
16	R.S.Pura (Chatha)	16	Dabhoi	62	Patna - ICAR
17	Kanke/Ranchi	17	Danti	63	Pombay
18	Mandya	18	Derol	64	Pondaghat
19	Gangavati	19	DRR	65	Port Blair
20	Brahmavar	20	Gangtok	66	Pundibari
21	Mugad	21	Gaghraghat	67	Radhanagari
22	Ponnampet	22	Gerua	68	Ragolu
23	Moncompu	23	Goa	69	Rajouri
24	Pattambi	24	Gorakhpur	70	Ranichouri
25	Rewa	25	Gosabha	71	Rauni
26	Karjat	26	Gudulur	72	Rohtak (CSSRI)
27	Sakoli	27	Gurudaspur	73	Shirgoan
28	Tuljapur	28	Hatwara	74	Shalimar (Khudwani)
29	Imphal (Wangbal)	29	Hazaribagh	75	Sindewahi
30	Upper Shillong	30	Imphal (CAU)	76	Sirsi
31	Chiplima/Sambalpur	31	Jabalpur	77	Tirur
32	Jeypore	32	Jagtial	78	Trichy
33	Kurumbapet	33	Jind (CSSRI)	79	Vadagaon
34	Ludhiana	34	Kalimpong	80	Vyra
35	Kota	35	Kapurtala	81	Vyttila
36	Aduthurai	36	Karaikal	82	Wadura (Khudwani)
37	Coimbatore	37	Karnal (CSSRI)	83	Warseoni
38	Nagina	38	Kathalgere		
39	Kanpur	39	Katrain		
40	Ghaghraghat	40	Kolkata		
41	Varanasi	41	Khudwani/Bondipore		
42	Faizabad (Masoda)	42	Kurukshetra (CSSRI)		
43	Bankura	43	Kunaram		
44	Chinsurah	44	Lamphalpat		
45	Pantnagar	45	Lembucherra		
46	Agarthala/Arundhutinagar	46	Lucknow		

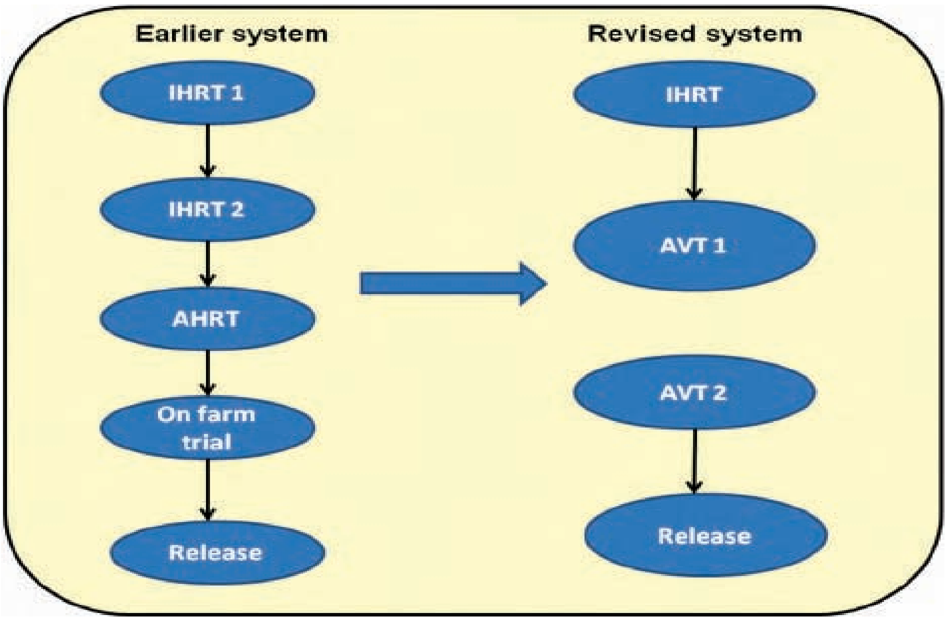
Hybrid Rice

Hybrid Rice is practically feasible and readily adoptable genetic option to increase the rice production, as has been amply demonstrated in People's Republic of China. In view of the potential of the hybrid rice technology in enhancing the production and productivity of rice, Indian Council of Agricultural Research (ICAR), New Delhi, launched a goal oriented, time bound national project on hybrid rice in December 1989. The project was implemented through a well organized national network comprising of 12 centers located across the country. This national network program being coordinated by the Indian Institute of Rice Research (formerly Directorate of Rice Research), Hyderabad, has another 30 voluntary centers represented by public, private and NGO sectors. Besides strong and effective linkages have been established with various national and international agencies such as state departments of agriculture, state agricultural universities, Mahyco Research Foundation, International Rice Research Institute(IRRI), Food and Agriculture Organization (FAO), China's National Hybrid Rice Research and Development Centre (CNHRRDC) and United Nations Development Program (UNDP).

The visionary approach of the policy makers and research managers, generous funding from the ICAR and other donors and effective and efficient implementation of the program by the project personnel, helped India to achieve the distinction of becoming the second country in the world after China to develop and commercialize hybrid rice in a big way. So far, 72 hybrids have been released for commercial cultivation in the country. During the year 2015, around 2.5 million hectares were planted to hybrid rice. Hybrid rice is being cultivated predominantly in the states/ provinces of Uttar Pradesh, Jharkhand, Bihar, Punjab, Haryana and Chhattisgarh. It is likely to play a very pivotal role in achieving the targeted production increase in the near future.

IIRR, Hyderabad, besides coordinating the hybrid rice research across the country, is also involved the multi-location testing of hybrids nominated in the AICRIP trials. Prior to *kharif* 1999, hybrids received from different centers/agencies were pooled together into different categories based on their duration and sent for evaluation at hybrid rice network centers and at the research farms of some private seed companies. Based on the experience and necessity of comparing the hybrids with best available high yielding inbred varieties, the testing system was revised in 1999 in which the promising hybrids identified in Initial Hybrid Rice Trial (IHRT) were tested along with inbred varieties in advance variety trials. The hybrids promoted from IHRT are included in AVT-1 and subsequently promoted to AVT-2 if their performance is good. The evaluation of hybrids in advanced trials is exactly similar to that of the inbred varieties.

Each nominating hybrid entry is assigned IET (Initial Evaluation Testing) number which indicates its identity. An entry possessing IET number suggests that it has undergone multi-location testing in the AICRIP trials. Based on duration of the hybrid entries three groups of trials viz., Early (<120 days), Mid-Early (121-130 days) and Medium (131-140 days) are constituted. Besides this, one more trial (HRT-MS) is constituted based on grain type viz., medium slender grain type (similar to BPT 5204) with a purpose to identify the promising genotypes in this grain type category. Likewise, special trials are also constituted for evaluation of hybrids under abiotic stress conditions like saline alkaline conditions. The Initial Hybrid Rice Trial comprises only the experimental hybrids and the corresponding checks while in AVT-1 and AVT-2 trials, promising hybrids are compared with the promising elite inbred lines. Test hybrids which record more than 5% yield advantage over the best hybrid check and 10% yield advantage over the best varietal check and confirming to the quality (HRT-MS trial) are promoted to next stage of testing. When the hybrid entries from private seed companies are accepted for evaluation in AICRIP trials, a nominal testing fee is charged and collected from the respective companies.



Procedure for testing of hybrids under AICRIP

All the test hybrids are also simultaneously put for screening nursery tests for identifying their reaction to key pests and diseases including blast, bacterial leaf blight, sheath blight, rice tungro virus, sheath rot, false smut; brown plant hopper, white backed plant hopper, gall midge, stem borer and leaf folder. At the AVT-2 stage, hybrids are also tested for agronomic performance. The procedure of identification, release, and notification is similar to that of varieties.

List of funded and voluntary centers of Hybrid Rice programme in AICRIP

S.No	Funded centers	S.No	Voluntary centers	S.No	Private Sector
1	Maruteru	1	Allahabad	1	Advanta (I) Ltd.
2	Warangal	2	Bapatla	2	Ankur Seeds Pvt. Ltd.
3	Jorhat/Titabar	3	Bhubaneswar	3	Bayer Bio.Sc. Pvt.Ltd.
4	Nawagam	4	Cuttack (CRRI)	4	Dantiwada Seeds (P)
5	Navasari	5	Dabhoi	5	JK Agri Seeds
6	Palampur/Malan	6	DRR	6	Ganga Kaveri Seeds
7	Khudwani	7	Faizabad	7	Bio Seed Pvt Ltd
8	Mandya	8	Gudulur	8	Mahyco Seeds Ltd.
9	Brahmavar	9	Hazaribagh	9	Nuziveedu Seeds
10	Mugad	10	Jabalpur	10	Pan Seeds
11	Sakoli	11	Jagtial	11	Pioneer Overseas Corp
12	Chiplima/Sambalpur	12	Karaikal	12	Savannah
13	Aduthurai	13	Karjat	13	Trimurthy Pt. Sc
14	Coimbatore	14	Kaul	14	VNR Seeds
15	Chinsurah	15	Radhanagari		
16	Pantnagar	16	Raipur		
		17	Ranchi		
		18	Shirgoan		
		19	Sindewahi		
		20	Sirsi		
		21	Vadagaon		
		22	Wangbal		

Crop Production

Agronomy

The agronomic investigations under AICRIP were initiated in 1965. Although plant-type-based breeding has doubled the yield potential of rice as it did in wheat, the acceptance rate of the new rice varieties was not as dramatic as that of dwarf wheat. IRRI responded to the situation by undertaking a MINIKIT program that distributed small quantities of seed, fertilizer, and pesticide to farmers. Considering the soaring costs of fertilizer and the need to demonstrate the superior performance of the modern varieties at all levels of fertilizer management, AICRIP distributed seeds, to cover an area of 50 m^2, to thousands of farmers in a district. The new variety under demonstration was also matched with the best local cultivar that it expected to replace under the farmers management practices.

Much of the initial work in AICRIP Agronomy was aimed at identifying the optimum and economic levels of N-response of the newly released and / or pre-release rice varieties of different growth duration across rice ecologies in India. Cost escalation of chemical fertilizers in the subsequent years prompted to develop nutrient management strategies for diverse rice ecosystems. In order to generate information on optimum response to added nutrients and water, a new series of multi-location trials were initiated on the cultural management of new rice varieties at optimum and moderate levels of nutrient application. Much of the emphasis was laid on the optimum spacing and plant population, age of seedlings at transplanting, use of young and healthy seedlings with close planting and appropriate intercultural practices such as hoeing and weeding etc for ensuring a desirable level of panicles per unit area with optimum panicle weight.

Cost escalation of fertilizers in the market prompted to design nutrient management trials for N,P,K using appropriate levels and combinations under diverse water regimes and rice ecologies across the country, evaluating the best times and methods of fertilizer application. Incorporation of basal dose of N and top dressing at panicle initiation stage was emphasized. In rain-fed low lands, where there is no water control, the use of slow-release N fertilizers such as Sulphur coated urea, neem cake coated urea and point placement of urea super granules were tested. In order to economize on P-use, a super-phosphate soil slurry root dipping technique was tested and adopted as a useful practice for saving on P-use. Preliminary work on rice based cropping systems was also initiated for total productivity from unit rice area under diverse rice growing eco-systems. Concomitantly, efforts to define the level of rice-weed competition under different rice ecologies and herbicide screening trials were initiated as part of weed management studies.

In 2000, studies were initiated to find out nitrogen-response of different breeding lines of different types and maturity groups to assist Central Variety

Release Committee (CVRC) in release of suitable varieties under different ecologies. Recently, in the context of scarcity of water and labour as well as the popularity of System of Rice Intensification (SRI) among the farmers, a study on long term effect of nutrients on SRI vis a vis conventional flooded rice on soil fertility and sustainability in rice based cropping systems was initiated since kharif 2012. Similarly, to address the issues of sustainability of food production on account of changing climate, a combination of water and nutrient management practices were tested aiming at water and nitrogen saving. For this purpose an experiment on climate resilient management practices in rice and rice based cropping systems was initiated in 2013.

Genesis of other investigations:-

- ❖ Conservative Tillage Systems (CTS) in comparison with conventional tillage under irrigated transplanted rice was initiated in 1998.
- ❖ Effect of different cropping sequences on the stability of rice-wheat system was initiated during kharif 2000.Studies on amelioration of acidic soils for enhanced rice productivity also started.
- ❖ A trial on evaluation of rice varieties for rotational irrigation under puddle direct sown condition was initiated in 2007.
- ❖ Development of suitable agro-techniques for aerobic rice, suitable varieties and optimum date of sowing under aerobic rice and optimizing seed rate and spacing for aerobic rice were also initiated in 2011.

Program leaders/ Principal Investigators (PI) Agronomy programme:

S. No.	Name	Period
1	Dr MS Chaudhary	1966-67
2	Sri RS Ayyangar	1967-68
3	Dr Ten Have	1968-72
4	Dr Gopala Krishna Pillai	1972-81
5	Dr SK Sharma	1982-89
6	Dr Gopala Krishna Pillai	1990-97
7	Dr. SV Subbaiah	1998-2007
8	Dr SP Singh	2007-2011
9	Dr R Mahendra Kumar	2012- continuing

List of funded and voluntary centers of Agronomy programme in AICRIP

S.No	Funded Center	S. No	Voluntary Center
1	Maruteru	1	Almora (ICAR)
2	Rajendranagar	2	Cuttack (CRRI)
3	Jorhat/Titabar	3	Dharwad
4	Patna	4	Gangawathi
5	Pusa	5	Gerua
6	Jagdalpur	6	Girdhi
7	Raipur	7	Hatwara
8	Nawagam	8	Hazaribagh
9	Kaul	9	Karaikal
10	Palampur/Malan	10	Karnal (CSSRI)
11	Khudwani	11	Lucknow
12	R.S.Pura (Chatha)	12	Navsari
13	Kanke/Ranchi	13	Nellore
14	Mandya	14	Parbhani
15	Moncompu	15	Ragolu
16	Pattambi	16	Sabour
17	Rewa	17	Vadagaon
18	Karjat		
19	Sakoli		
20	Tuljapur		
21	Imphal (Wangbal)		
22	Upper Shillong		
23	Chiplima/Sambalpur		
24	Kurumbapet		
25	Ludhiana		
26	Kota		
27	Aduthurai		
28	Coimbatore		
29	Nagina		
30	Kanpur		
31	Ghaghraghat		
32	Varanasi		
33	Faizabad (Masoda)		
34	Bankura		
35	Chinsurah		
36	Pantnagar		
37	Agarthala/ Arundhutinagar		

Soil Science

Coordinated program in soil science was initiated in early 1970s. It developed into an independent program in 1975 - 76 mostly in association with agronomists and with very limited soil scientist positions at 1-3 AICRIP centers at Mandya, Faizabad, Maruteru, Kanpur or Titabar. Depending on the objectives of the program the funded positions were being shifted to different centers to address location specific production constraints. Since late 1980, the program is organized mainly with the help of soil scientists located in about 10 – 15 voluntary locations including the funded centers. Currently Kanpur, Maruteru and Titabar are the funded centers and in the 12th plan period (2012 – 2017) and seven additional positions of soil scientists at Bhubaneswar (Chiplima), Karaikal (Pondicherry), Kaul, Mandya, Moncompu, Pantnagar and Pusa have been approved to be filled by redeployment.

In the initial years, most of the trials were organized for increasing the efficiency of nitrogen and phosphorus fertilizers by evaluating new fertilizer materials like coated / modified urea material, ammonium poly-phosphates, acidulated / pyrite-treated phosphate rocks and root dipping in phosphate- soil slurry and testing them in different combinations and methods & time of applications. In the later years, experiments on potassium and zinc nutrition in different soils, site specific nutrient management, crop residue management, evaluating influence of nutrient management on grain quality of fine grain varieties, management of nutritional problems in acid, saline and sodic soils were proposed and conducted.

Currently the coordinated program in Soil Science is addressing issues related to sustaining productivity of soil and crop systems on long-term basis, yield gap assessment and site specific nutrient management based on nutritional status in farmers' fields, efficient use of irrigation water, nutrient management in problem soils, genotypic variability in iron and zinc, their partitioning and enrichment in grain, screening for tolerance to soil acidity related problems, nutrient use efficiency and crop productivity under late planted conditions, monitoring soil quality and productivity under emerging systems of rice production as well as testing of computer based nutrient management tool.

Genesis of long term trial: Long-term cropping experiments are critical to monitoring long-term changes in soil parameters and its productivity and the earliest long term experiments were established since 1843 at Rothamsted Classical Permanent Manurial Experiments, England by J.B. Lawes and J.H. Gilbert to study the effects of continuous cropping and manurial / fertilizer application on crop productivity and soil fertility comparing with that of inorganic nutrients and FYM on crop yields and soil health. Later, many such permanent manurial experiments were started in several parts of the world and in India in the beginning of 20th century, to evaluate the long-term effects of inorganic and organic manuring on crop production and soil health.

Similarly, in an attempt to relate the trends in soil-crop productivity with soil fertility as a function of time and management, the Directorate under All India Coordinated Research Project on Rice (AICRIP) initiated Long Term Fertilizer Experiments (LTFE) in 1989-90 at 4 selected locations representing major rice growing regions and rice based cropping systems viz., Mandya, Karnataka (rice-cowpea, Deccan Plateau), Maruteru, Andhra Pradesh (rice-rice, Godavari delta system), Titabar, Assam (rice-rice, Alluvial soils) and Faizabad, Uttar Pradesh (rice – wheat, Indo Gangetic Plains, IGP). The objective of the study was to monitor the changes in yield responses due to continuous application of plant nutrients through fertilizers and organic sources at optimal and sub-optimal levels to develop strategies and policies for rational fertilizer use, improve soil health and also to sustain productivity and environment safety in prevailing cropping systems.

Initially, the treatments consisted of 12 combinations of nutrients involving organic and fertilizer sources including two control plots all arranged in a randomized block design with four replications. A few additional treatments like application of 100% PK in one of the control plots, and 5 t/ha of FYM over and above 100% RDF, STCR based fertilizer dose, N fixing bio-fertilizer inoculation and liming in acid soils of Titabar were introduced in the experiment during 1996, 1998, and 2009 and 2014, respectively in 50% of the plot area after observing the changes in crop productivity and soil fertility in related treatments like 100% NPKZnS, 100% N, and 50% NPK application, respectively.

Genesis of other trials: In cognizance of depleting natural resources like land and water, trials were designed for ameliorating, management and improving the productivity of problematic soils such as acid and sodic soils. For addressing the problems related to quantity and timely availability of water for rice production resulting due to vagaries of climate change, experiments like water and nutrient management under emerging production systems and improving productivity under early and late sown/transplanted conditions were designed. Varietal screening trials are also being planned to identify micronutrient (Zn and Fe) rich genotypes for providing nutritional security.

Program leaders/ Principal Investigators (PI) Soil Science programme:

S. No	Name	Period
1	Dr JC Katyal	1972 - 1975
2	Dr JE Shinde	1975 - 1989
3	Dr M Narayana Reddy	1989 - 2006
4	Dr KV Rao	2006 - 2014
5	Dr K Surekha	2014 – continuing

List of funded and voluntary centers of Soil Science programme in AICRIP

S.No	Funded Center	S.No	Voluntary Center	S.No	Voluntary Center
1	Kanpur	1	Bankura	7	Khudwani
2	Maruteru	2	Chinsurah	8	Mandya
3	Titabar	3	DRR	9	Moncompu
		4	Faizabad	10	Puducherry
		5	Ghaghraghat	11	Ranchi
		6	Karaikal		

Plant Physiology

The coordinated trials in physiology were organized from 1974 at 15 locations in cooperation with the physiologists working in the universities. The trials conducted include 1) Canopy analysis of yield attributing factors, 2) Screening for moisture stress, 3) Screening for low light intensity, 4) Screening for waterlogged conditions, 5) Screening for photosynthetic efficiency, 6) Physiological age of seedlings in relation to growth and productivity, 7) Nature of association between BY, HI and EY, 8) Influence of foliar sprays of growth regulators on productivity, 9) Evaluating the relative efficiency of desiccants.

During the period 1981-85, the major priorities of plant physiology section included stress situations like drought, lowlight, water logged areas, dormancy and location specific problems. Hence, trials were conducted on 1) Evaluation of upland cultures for drought resistance, 2) Evaluation of medium duration elites for lowlight stress, 3) Evaluation of late duration elites for water logged situations, 4) Evaluation of elite and traditional for photosynthetic efficiency, 5) Evaluation of elites for salinity, 6) Studies on yield decline in HYVs, 7) Studies on post-harvest problems in cyclone prone areas, 8) Studies on reduction of grain moisture by desiccants, 9) Studies on nature and intensity of dormancy, 10) Studies on sink potential. During the period, major part of the program had been executed through coordinated experimentation at different test locations keeping in view the specific problems of the area. A total of ten trials were conducted during the period, of which some were of continued long term studies, while others were of short duration, for about 2-3 years.

Plant physiology research during 1988-96 comprised of lead research at DRR and 8 centers established during Seventh Plan representing different ecologies viz., Mandya and Maruteru (Irrigated rice), Faizabad, Kanpur, Rewa and Tuljapur (Upland rice), Calcutta and Chinsurah (Low land rice). Since Chinsurah and Calcutta are located in the same region, Calcutta centre was shifted to Coimbatore. Hyderabad besides being the lead center coordinates physiological research at all centers. CRRI, Cuttack contributed to physiology of rice in low land ecologies. The major areas of research included 1) Abiotic stress – drought, water logging and low light, 2) Yield related studies with emphasis on grain density, 3) Hybrid Rice Physiology, 4) Modelling, 5) Remote sensing of spectral reflectance of rice canopies, 6) Methane emission in Rice based cropping system (Maruteru).

During 1996-2001, thrust areas of research included 1) Hybrid rice physiology, 2) Abiotic stress – drought, water logging, cold tolerance and low light intensity, 3) Generation of spectral signature of rice cultivars and 4) Physiology of yield contributing traits. From 2002 onwards, emphasis is being given to studies on photothermic indexing, nitrogen use efficiency, radiation use efficiency, besides physiological response in aerobic rice, sub-mergence and rainfed uplands. At present, there are 14 co-operating centers, of which six are AICRIP funded centers, five voluntary centers including three ICAR institutes.

Program leaders/ Principal Investigators (PI) Plant Physiology programme:

S.No	Name	Period
1	Dr B Venkateswarlu	1965 - 1990
2	Dr V Balasubramanian	1991 - 2002
3	Dr C Keshava Reddy	2002 - 2007
4	Dr SR Voleti	2008 - 2014
5	Dr D Subrahmanyam	2014 – continuing

List of funded and voluntary centers of Soil Science programme in AICRIP

S.No	Funded Center	S.No	Voluntary Center
1	Maruteru	1	Chinsurah
2	Pantnagar	2	Faizabad
3	Pattambi	3	Karaikal
4	Coimbatore	4	Karjat
5	Titabar	5	IARI
6	Rewa	6	NRRI
		7	IIRR

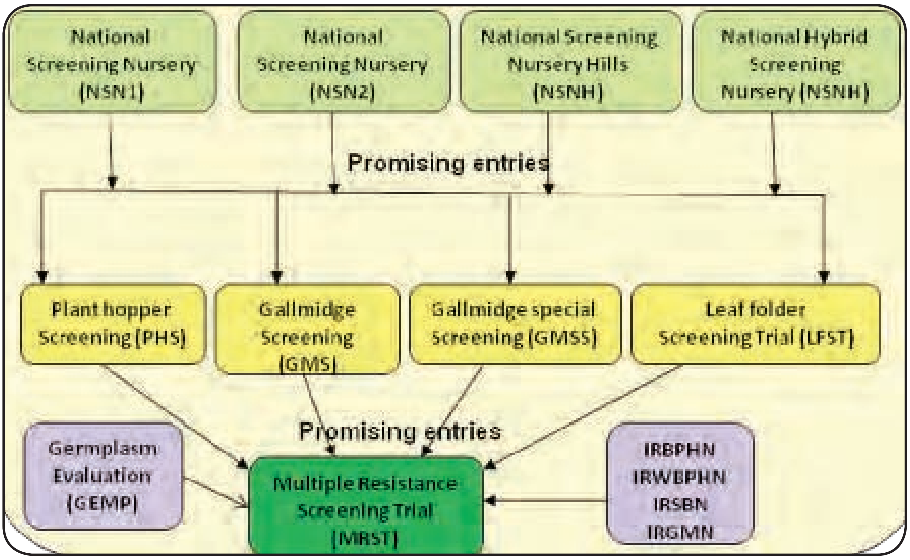
Crop Protection

Entomology

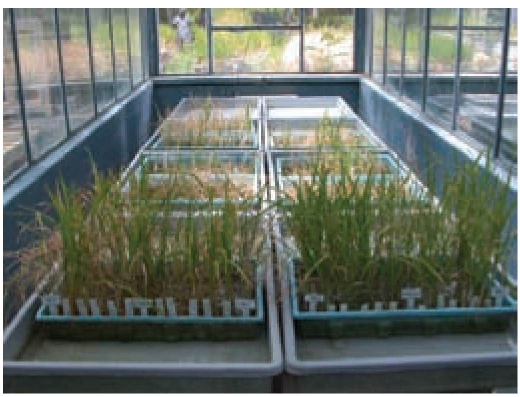
Identification of donors and breeding lines for resistance to gall midge and stem borer was the main aim of entomology programme under AICRIP initially during 70s. National Screening Nursery (NSN) trial was constituted to evaluate the entries for their reaction against major insect pests at multi-locations. Evaluation of new chemicals/ insecticides for their efficacy as well as compatibility was the other objective. However, with the introduction of high yielding varieties and intensive management practices during 80s, some of the insect pests like brown planthopper, cutworm, whorl maggot and leaf folder which were hitherto considered to be of minor importance, assumed major pest status leading to the constitution of location specific trials on these pests. Efforts were also made to develop economical and ecologically compatible techniques of insecticide application. Greater attention was also given to ecosystem approach wherein pest management trial and ecological observations were initiated. International trials like International Rice Brown Planthopper Nursery (IRBPHN), International Rice Gall Midge Nursery (IRGMN), International Rice Stem Borer Nursery (IRSBN), and International White Backed Planthopper Nursery (IRWBPHN) were also conducted at various locations to identify resistant germplasm lines. Based on the light trap collections, changing pest scenario and their intensity was assessed. In 90s, screening trials were continued for major insect pests of rice at hotspot locations and also under greenhouse conditions. Evolution and identification of field biotypes of gall midge led to initiation of gall midge biotype monitoring was done based on the reaction to a set of host plant differentials. On farm IPM trials were conducted at various locations.

During 2000s, emphasis was on eco-friendly pest management wherein innovative approaches like trap crop for stem borer management and use of semio-chemicals was included. As planthoppers gained importance in India and other Asian countries, special studies on planthoppers for identification of genes and insecticide resistance were initiated. Changing rice cultivation practices with the introduction of SRI, aerobic rice and direct seeding resulted in change in insect pest scenario. Hence, studies were initiated to know their impact on pest incidence and damage potential in various methods of rice cultivation. During 2010s, biodiversity and biological control studies were strengthened to initiate in situ conservation of biocontrol agents through ecological engineering. A participatory IPM study with a holistic approach of managing all the pests including insects, diseases and weeds, was initiated in collaboration with agronomists and plant pathologists.

As host plant resistance forms the core of rice IPM, screening for resistance to identify donors and breeding lines against major insect pests is in progress since inception. Pest specific screening trials like Planthopper screening (PHS), Gall midge screening (GMS), gall midge special screening (GMSS) and Leaf folder screening trial (LFST) are constituted by including test entries nominated by entomologists from different locations. The entries include landraces with promising reaction in preliminary tests and advanced breeding lines derived from the known sources of resistance. Promising entries identified in the above pest specific trials are evaluated against major pests in the Multiple Pest Resistance Screening Trial (MRST). Evaluation of National Screening Nurseries (NSN1, NSN2, and NSNH & NHSN) is done across locations against major insect pests. This trial includes promising entries from plant breeding trials viz., Advance Variety Trial (AVT 2) material in NSN1, Initial Variety Trial (IVT) material in NSN2, entries bred for hill region in NSNH and experimental hybrids in NSNH. Besides, in a special complementary network activities include evaluation of rice germplasm collection of National Bureau of Plant Genetic Resources (NBPGR) is being evaluated against major insect pests in hotspot locations.



Entomology screening trials protocol



Program leaders/ Principal Investigators (PI) Entomology programme:

S.No	Name	Period
1	Dr Reed C Bunker	1965 - 1972
2	Dr MB Kalode	1972 - 1993
3	Dr K Krishnaiah	1993 - 1995
4	Dr IC Pasalu	1995 - 2009
5	Dr NV Krishnaiah	2009
6	Dr JS Bentur	2009 - 2013
7	Dr Gururaj Katti	2013 – continuing

List of funded and voluntary centers of Entomology programme in AICRIP

S.No	Funded Center	S.No	Funded Center	S.No	Voluntary Center
1	Maruteru	18	Brahmavar	1	NRRI
2	Rajendranagar	19	Moncompu	2	Iroseimba
3	Ragolu	20	Pattambi	3	Jagtial
4	Warangal	21	Rewa	4	Karaikal
5	Jorhat/Titabar	22	Karjat	5	IARI
6	Pusa	23	Sakoli	6	Madurai
7	Jagdalpur	24	Imphal (Wangbal)	7	Nellore
8	Raipur	25	Upper Shillong		
9	Nawagam	26	Chiplima/Sambalpur		
10	Navasari	27	Kurumbapet		
11	Kaul	28	Ludhiana		
12	Palampur/Malan	29	Aduthurai		
13	Khudwani	30	Coimbatore		
14	R.S.Pura (Chatha)	31	Ghaghraghat		
15	Kanke/Ranchi	32	Faizabad (Masoda)		
16	Mandya	33	Chinsurah		
17	Gangavati	34	Pantnagar		

Plant Pathology

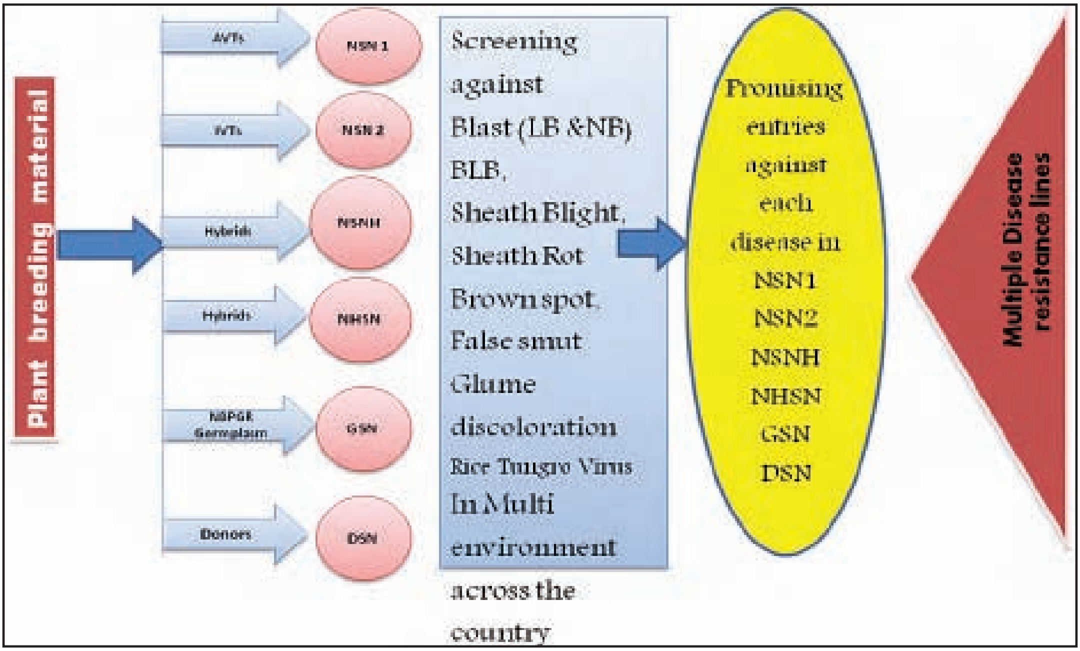
The All India Coordinated Rice Pathology Program has an effective linkage and testing mechanism to assess large number of advanced breeding lines and germplasm over a wide range of ecologies, climatic and disease epidemic conditions at various locations coming under the state agricultural universities, national institutes, and departments of agriculture, agrochemical industry and others to identify specific and broad spectrum of resistance to major rice diseases. This helps in developing need based management methods to control major diseases of rice. One of the major objectives of the program is to accelerate genetic improvement of rice for resistance against major diseases occurring in different ecosystems in the country.

Under the rice pathology programme of AICRIP more than 1000 accessions of germplasm and advanced breeding lines are evaluated annually against major rice diseases across 52 locations throughout the country. Every year during kharif season, different national screening nurseries (NSN1, NSN2, NSNH and NHSN and DSN) are constituted by the plant pathology department after receiving the materials from plant breeding department. The entries include advanced breeding material (AVTs) in national screening nursery 1(NSN1), initial varietal trial entries (IVTs) in NSN2, entries bred for hill regions in NSNH and experimental hybrids in NHSN. All these sets are screened for various rice diseases at multi locations . Besides, in a special network programme, rice germplasm collection at the National Bureau of Plant Genetic Resources (NBPGR) is being evaluated and reactions for major diseases are recorded at hot spot locations every year. The entries are also screened under glass house conditions at selected centers.

In general, the rice crop suffers with three major groups of diseases viz., fungal, bacterial and viral diseases. The important fungal diseases are blast, sheath blight, sheath rot, false smut, brown spot and stem rot. Among the bacterial diseases prevalent in rice, bacterial leaf blight and bacterial leaf streak are considered economically important in the country. Among viral diseases, rice tungro virus disease is most important. Due to change in climate and agronomic practices few more diseases which were minor earlier attained the status of major diseases like false smut, bakane and glume discoloration.

Besides host plant resistance, work was also initiated on the monitoring of virulence of the major pathogens like blast and BLB. The disease observation nurseries were planted across the locations with susceptible varieties to monitor the disease incidence and severity. Several new molecules were being tested in AICRIP pathology for managing the major fungal diseases. Recently a special trial on the management of false smut and varietal screening programme was initiated. The schedules of IDM practices for major diseases at regional level were being worked out.

Production oriented survey (POS) on various aspects of rice cultivation viz., climatic conditions, varietal profile, crop rotations, fertilizer and organic manure application, different biotic and abiotic problems, pesticides application and farmers practices was conducted during crop season by AICRIP centers in various states. The survey was conducted by the scientists of Indian Institute of Rice Research and its cooperating centers located in different states belonging to different state agricultural universities and departments of agriculture.



AICRIP Plant Pathology program

Program leaders/ Principal Investigators (PI) Plant Pathology programme:

S.No	Name	Period
1	Dr VT John	1966 - 1982
2	Dr APK Reddy	1982 - 1989
3	Dr S Venkata Raman	1989 - 1991
4	Dr APK Reddy	1991 - 2000
5	Dr K Muralidharan	2000- 2008
6	Dr CS Reddy	2008 - 2010
7	Dr M Srinivas Prasad	2010 - 2011
8	Dr D Krishnaveni	2011 - 2013
9	Dr M Srinivas Prasad	2013 – continuing

List of funded and voluntary centers of Plant Pathology programme in AICRIP

S.No	Funded Center	S.No	Funded Center	S.No	Voluntary Center
1	Maruteru	17	Pattambi	1	Almora
2	Rajendranagar	18	Rewa	2	Barapani
3	Jorhat/Titabar	19	Karjat	3	NRRI
4	Patna	20	Imphal (Wangbal)	4	IIRR
5	Pusa	21	Upper Shillong	5	Ghaghraghat
6	Jagdalpur	22	Chiplima/Sambalpur	6	Gudulur
7	Raipur	23	Ludhiana	7	Hazaribagh
8	Nawagam	24	Aduthurai	8	Karaikal
9	Kaul	25	Coimbatore	9	Lonavala
10	Palampur/Malan	26	Ghaghraghat	10	IARI
11	Khudwani	27	Varanasi	11	Mugad
12	R.S.Pura (Chatha)	28	Faizabad (Masoda)	12	Navsari
13	Mandya	29	Chinsurah	13	Nellore
14	Gangavati	30	Pantnagar	14	Port Blair
15	Ponnampet	31	Agarthala/ Arundhutinagar	15	Puducherry
16	Moncompu			16	Ranchi
				17	Sabour
				18	Tirur

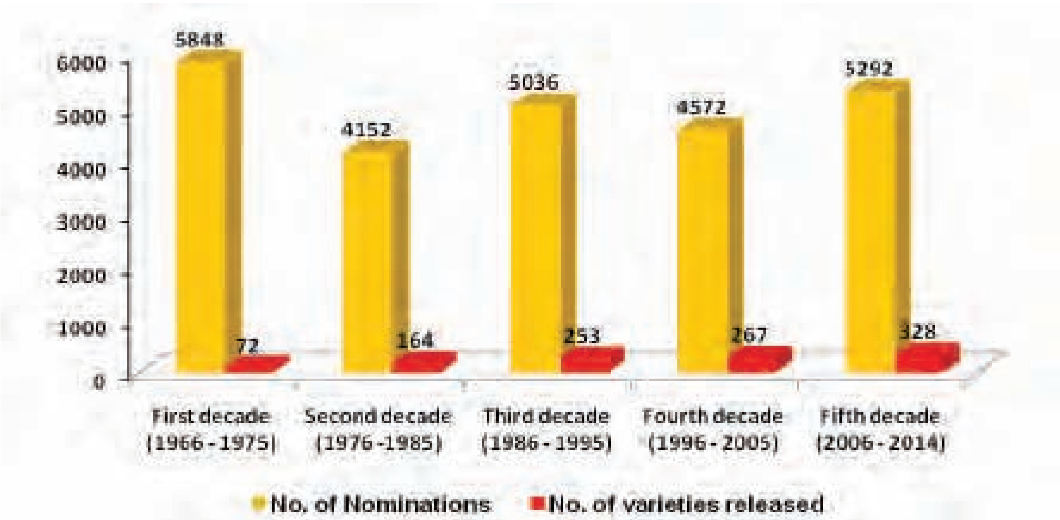
IV. Achievements of AICRIP

During the last five decades, phenomenal changes took place in AICRIP structure and functioning with the objective to coordinate multidisciplinary, multi location testing of varieties, crop production and protection technologies across all rice ecosystems prevailing in the country, for increasing and stabilizing the rice production. At present, there are more than 500 scientists working for AICRIP in 45 funded and over 100 voluntary centers.

i. Overall Achievements

Varieties/Hybrids Tested, Developed And Released

- Till date, 24,900 elite lines developed by rice scientists of different cooperating centers have been tested in multi-location trials across the country under the umbrella of AICRIP at funded, voluntary centers and in partnership with private sector for hybrid rice following ICAR guidelines for varietal testing. Every year about 2000 experiments /trials are laid out in rice. The dynamic time tested multilocation three tier testing programme involving one year of Initial Varietal Trial (IVT) and two years of Advance Varietal Trial (AVT – 1 and AVT -2) as well as screening of elite breeding lines at hotspot locations for generating information on their pest/disease resistance/tolerance, grain quality attributes and agronomic performance has led to the release of varieties and hybrids suitable for all the ecosystems.



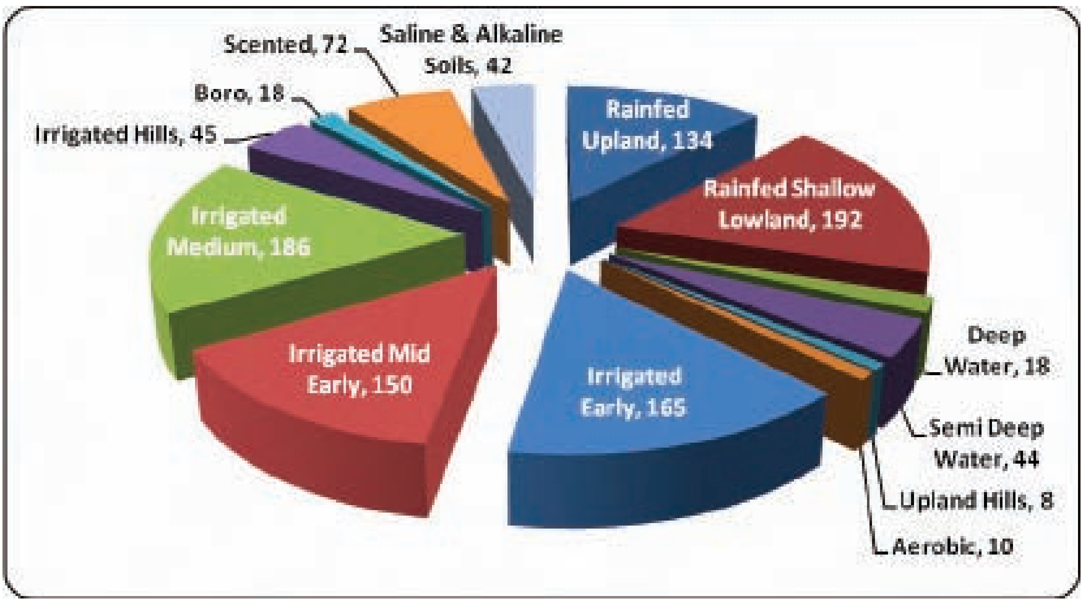
Decade wise nominations tested and varieties released through AICRIP

- Since its inception the AICRIP was instrumental in testing and release of 1084 varieties including 72 hybrids, both from central and state variety release committees for all rice ecologies. Among these 129 varieties and 44 hybrids were released through Central Sub Committee on Crop Standards, Notification and Release of Varieties (CSCS & NRV) while the State Variety Release Committees released 883 varieties and 28 hybrids.

Rice Varieties and hybrids released as central & state releases (1965 – 2014)

Total No. of Varieties	Varieties	Hybrids	Total
Central Variety Release Committee (CVRC)	129	44	173
State Variety Release Committee (SVRC)	883	28	911
Total	1012	72	1084

- Of these varieties, 501 are for irrigated areas, 134 for rainfed uplands, 192 for rainfed low lands, 44 for semi deep, 18 for deep water situation, 53 for high altitudes, 42 for saline and alkaline areas, 10 for aerobic, 18 for boro and 72 aromatic long and short grain varieties were released.



Rice varieties released for various ecosystems during last five decades

Rice varieties and hybrids for various ecosystems released through central and state release system (1965 – 2014)

Ecosystem	No. of Varieties		
	CVRC	SVRC	Total
IRRIGATED			
Irrigated Early	23	142	165
Irrigated Mid Early	27	123	150
Irrigated Medium	31	155	186
Irrigated Hills	6	39	45
Boro	5	13	18
Scented	16	56	72
Saline & Alkaline Soils	14	28	42
RAINFED			
Rainfed Upland	17	117	134
Rainfed Shallow Lowland	17	175	192
Semi Deep Water	8	36	44
Deep Water	3	15	18
Upland Hills	2	6	8
Aerobic	4	6	10
Total	173	911	1084

Rice varieties & hybrids released through state release committees (1965 – 2014)

SVRC	Varieties	Hybrids	Total
Andhra Pradesh	112	3	115
Assam	33	-	33
Bihar	38	-	38
Chhattisgarh	19	2	21
Delhi	2	-	2
Gujarat	32	-	32
Haryana	25	1	26
Himchal Pradesh	6	-	6
Jharkhand	19	-	19
Jammu & Kashmir	18	-	18
Karnataka	47	1	48
Kerala	62	-	62
Meghalaya	12	-	12
Manipur	14	-	14
Odisha	130	4	134
Punjab	23	-	23
Puducherry	8	-	8
Rajasthan	7	-	7
Tamil Nadu	69	5	74
Tripura	12	-	12
Uttar Pradesh	53	2	55

SVRC	Varieties	Hybrids	Total
Uttarakhand	23	2	25
West Bengal	53	1	54
Madhya Pradesh	9	3	12
Maharashtra	57	4	61
Grand Total	883	28	911

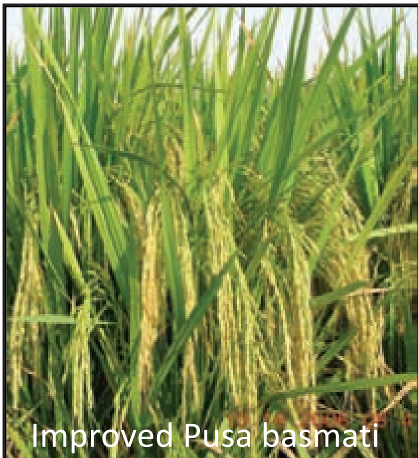
- Considering the scope and potential of quality rices for export, special thrust was given for genetic enhancement of quality rices in the country which has led to the release of 30 export quality basmati and short grain rice varieties.
- Many of these varieties posses' tolerance / resistance to major insect pests and diseases.

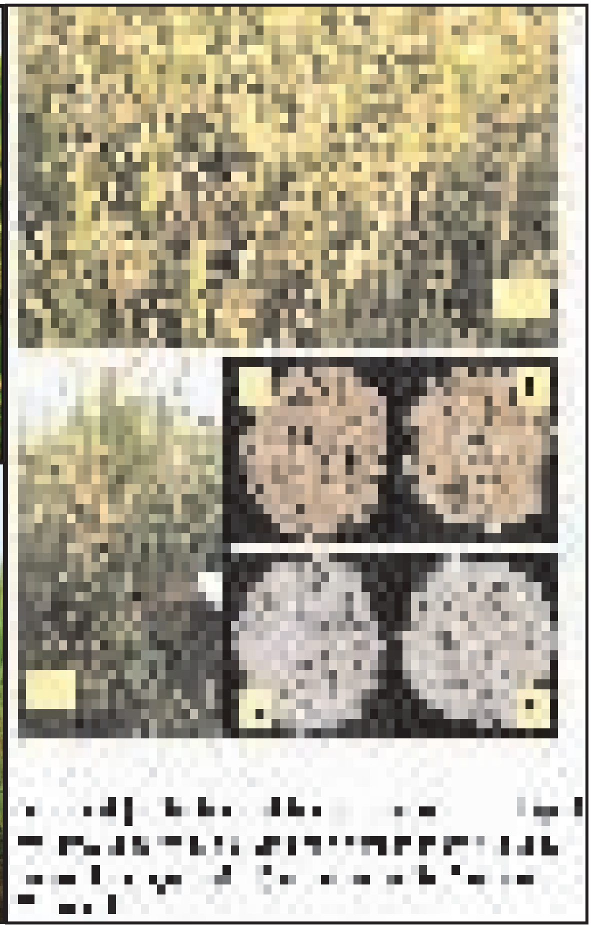
Reaction to Insect Pests & Diseases

Pest / Disease	Resistant	Moderately Resistant	Total
Blast	299	245	544
Bacterial Leaf Blight	96	183	279
Rice Tungro Virus	36	82	118
Sheath Blight	6	87	93
Brown Spot	31	119	150
Green Leaf Hopper	37	39	76
Stem Borer	1	217	218
Brown Plant Hopper	62	97	159
White Backed Plant Hopper	31	57	88
Gall Midge	123	79	202
Leaf Folder	14	67	81

- Development of first medium slender hybrid **"DRRH3"** which is similar to Samba Mahsuri with 25-30% higher yield has already been commercialized by forging MoAs with 10 private companies.
- IIRR released three varieties viz., **Akshaydhan, Varadhan** and **DRR Dhan 38** which are the off-shoots of hybrid rice breeding programme.

- In the last decade effective deployment of biotechnological tools such as molecular marker assisted breeding has resulted in development of land mark varieties such as **Improved Samba Mahsuri** and **Improved Pusa Basmati 1** which involved introgressing BLB resistant genes into the genetic background of Samba Mahsuri, the most sought after rice variety for its grain and cooking quality and Pusa Basmati 1, the important long grain Basmati variety which has a major share in export markets. The two landmark varieties were developed by ICAR-IIRR, Hyderabad and IARI, New Delhi, tested and released through AICRIP as central releases. Similarly, efforts made at IRRI to introgress the major QTL 'Sub 1', for inducing submergence tolerance into popular variety Swarna, were highly successful with the development of **Swarna Sub 1** which was tested in the NIL- Submergence trials of AICRIP and released in Odisha and Uttar Pradesh.

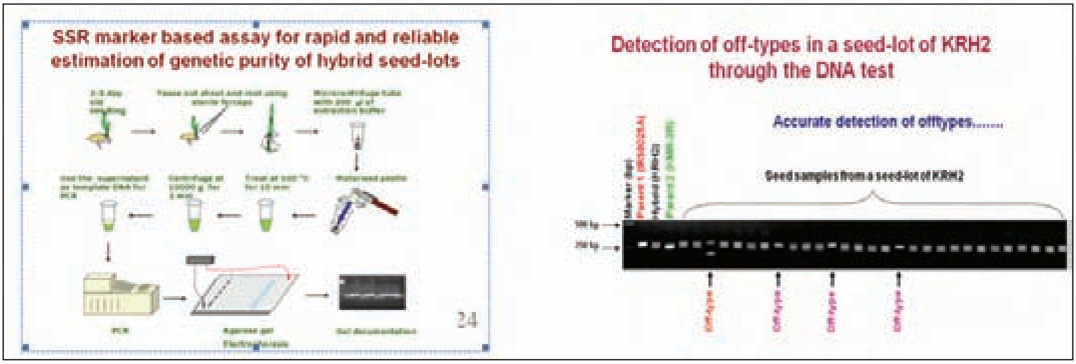




- **Dhanrasi, Jarva** and **DRR Dhan 40** were the varieties developed by introgression of yield traits from wild species with higher yield than hybrid check. They were released for shallow lowland, coastal saline and irrigated ecosystem and DRR Dhan 39 for coastal saline areas.
- Biofortification programme at IIRR started in 2004 and developed high zinc line, DRR dhan-45 (IET 23832) from the cross IR 73707-45-3-2-3/ IR 77080-B-34-3, a mid early duration culture (~130 days) with long slender grains. It recorded an average of 18.18 ppm Zinc content in polished grains which is higher than the checks viz., Kalanamak (16.43 ppm) and Chittimuthyalu (16.71 ppm). It is identified for the states of Karnataka, Tamil Nadu and Andhra Pradesh as high zinc culture with high yield potential.
- High protein line (IET 24780), was developed from the cross ARC 10075/ Naveen by NRRI, Cuttack. It is a mid early duration variety (~125 days). It is semi dwarf, compact plant type and has good initial growth and tillering ability. It recorded yield superiority over all the checks in the states of Odisha, Madhya Pradesh and Uttar Pradesh. It has more than 10.0% protein content in polished grains which is higher than its high yielding parent (Naveen) and other checks and qualifying checks in the trial. Possessing medium slender grains, IET 24780 recorded high HRR (69.7%), AC (25.1%), and GC (37 mm).

- Aerobic rice developed by IIRR - DRR Dhan 41 (IET 22729) is the rice variety developed and released under aerobic ecology utilizing less water.IET 22729 (RP 5311 -PR 26703-3B-PJ7) tested under aerobic situation and is identified for release in Bihar and Karnataka.
- IIRR has developed drought tolerant varieties through its AICRIP system, namely, Vandana (90-95 days duration), DRR Dhan 42 (115-120 days), CR Dhan 305 (120-125 days), Birsa VikasDhan 203 (115-120 days), Birsa VikasDhan 111 (90-95 days), Rajendra Bhagwati (100-105 days), Sahbhagi Dhan (110-115 days) and Jaldi Dhan 6 (100-105 days) are tolerant to drought and suitable to direct seeded upland situations.

- IIRR developed drought tolerant variety **DRR Dhan 42** (IET 22836) - The culture is semi-dwarf with a flowering duration of 85-91 days. It has long slender grains and has moderate resistance to leaf blast and identified for drought prone areas of Andhra Pradesh, Telangana, Tamil Nadu, Madhya Pradesh and Chhattisgarh.
- Low glycemic index (GI) rice varieties – IIRR in collaboration with National Institute of Nutrition (NIN) evaluated three rice varieties viz.,Lalat (GI=53.17), BPT 5204 (GI=51.42) and Sampada (GI=51) and identified to be low in GI and suitable for diabetic patients. Further, research is being conducted for identification of other low GI genotypes and on amylose and amylopectin contents for identifying rice varieties suitable for diabetic people.
- IIRR has been recognized as one of the best DUS centers for maintaining a large reference collection of 629 varieties and for promotion of registration of rice varieties at the Foundation Day Programme of PPV&FRA, New Delhi.
- Another significant outcome of ICAR- IIRR initiative has been the first time notification and IPR enabling of 71 extant varieties of rice with PPV&FRA granting registration certificates. Eight IIRR varieties viz., Krishna Hamsa (Reg. No: 69 of 2012), Improved Samba Mahsuri (Reg. No: 80 of 2012), Shanthi (Reg. No: 58 of 2012), Vasumati (Reg. No.29 of 2013), Sugandhamati (Reg.No.39 of 2013), Triguna (Reg.No.40 of 2013), Dhanrasi (Reg.No.43 of 2013) and Jarava (Reg.No.47 of 2013). Thus, 8 IIRR varieties were granted registration certificates. In addition, 44 farmers' varieties were also registered. On commercializing these IPR enabled varietal technologies benefit sharing would be ensured through adoption of the plant breeders' rights and farmers' rights.
- Marker-based purity assessment of rice hybrids and CMS lines: IIRR has developed a rapid and reliable assay for evaluation of purity of seed-lots of rice hybrids and CMS lines. The hybrid purity assay involves deployment of specific hyper-variable SSR markers and can identify impurities on per seed or seedling basis. The CMS seed purity assay involves a mitochondrial SSR marker and can easily detect contaminants in seed-lots. Both these assays are enthusiastically being taken up by many seed companies and IIRR is also offering these assays for assessment of seed-purity of commercial seed-lots. The DNA marker-based assay is cost effective (saves 30-50% of cost) as the whole assay can be completed within a time period of 1-2 days as compared to the conventional morphology based Grow-out test which takes a full growing season and involves lot of cost in terms of seed-storage.



- Development and use of molecular markers for the major fertility restorer genes Rf3 and Rf4: IIRR has developed a set of closely linked and functional markers for both Rf3 and Rf4 which can work with ~ 92% efficiency. Using these markers, several rice lines possessing both Rf3 and Rf4 have been identified without carrying out time consuming test crosses and these lines are being used in hybrid rice programs as restorers. The markers have been used for targeted improvement of the elite restorer line KMR3R for bacterial blight resistance and the elite maintainer line IR58025B for blast and bacterial blight resistance.
- Identified superior alleles of blast resistance genes Pi54, Pita and Pib from germplasm collections. These have widened the spectrum of resistance and have helped to establish suitable gene deployment strategies
- A major QTL controlling the important grain quality trait of gelatinization temperature called qGT6 has been identified and fine-mapped. The QTL is being deployed in elite rice varieties through MAS, thus making quality improvement programs cost and time effective, particularly in reference to Basmati rice.
- Several candidate genes associated with yield, quality and nutrition have been identified and the outcome of transgenic research is visible with 3Bt transgenic rice events with Cry1A showing resistance to stem borer and 3 independent events with DREB1A gene in Samba Mahsuri background shortlisted for Bio-Safety Research Level (BRL-1) testing. Promising results in the development of golden rice in the background of Improved Samba Mahsuri and MTU 1010 have also been recorded.
- Unique genetic stocks developed by IIRR were granted soft registration by NBPGR, New Delhi. These include six restorer lines viz., RPHR 2, RPHR 12, RPHR 517, RPHR 619, RPHR 1005 and RPHR 1096, four CMS lines viz., DRR 4A, DRR 5A, DRR 9A and DRR 10A, nine biotic stress resistant lines viz., RP 4518-2-6, RP 4621-1842, RP 4621-1845, RP 4639-110, RP 4642-669, Aganni, ARC 15831, INRC 3021, INRC 202, BLB pyramided line – IET 19045, Basmati line- IET 15833 and low phosphorus line – IET 9691, were registered with NBPGR, New Delhi.

Technologies developed and recommended

Crop Production

Agronomy

- Rice cultures for different levels of nitrogen in diverse ecologies - Systematic evaluation of 1800 advanced genotypes for the past 35 years resulted in 340 promising cultures for low levels of nitrogen which on adoption would reduce huge cost towards nitrogenous fertilizer.
- Cultural management trials and development of agronomic package of practices for higher productivity and sustainability
    - o Technologies were developed for rainfed, boro rice, direct seeded, Aerobic, SRI and Aromatic rices including amelioration of acidic soils.
    - o In rainfed uplands rice alone or rice + sunhemp with 60:40:40:50:500 kg/ha NPK, Zn, Lime was found to be the better practice for higher grain yields
    - o Planting with 25 – 35 days old seedlings and fertilizer schedule of NPK + KNO3 2% spray at heading stage or NPK + FYM/paddy straw 5 t/ha are useful for boro rice
    - o Under unpuddled, direct seeded aerobic condition, sowing rice:dhaincha (1: 1) + application of 75% recommended N + spraying pendimethalin @ 0.75 kg a.i./.ha + one hand weeding at 60 days after sowing, was promising.
    - o Hybrids were promising followed by medium duration group under aerobic conditions with intermittent irrigation (reduced water application).
- Studies on SRI proved that it is genotypic specific and hybrids perform better than the varieties and the cost of cultivation too drastically reduced in case of hybrids. Adoption of SRI at proper locations with suitable genotypes has a scope for area increase, enormous saving on seed and 36% saving on water, additional yield of 1.0 to 1.5 t/ha which will add 4-6 million tonnes to our food basket. KRH-2, PA 6444, DRRH 3 among hybrids; Akshaydhan and Swarna among varieties were promising under SRI. SRI and ICM recorded 21% and 13% increase in grain yield over standard transplanting.
- Modification of leaf colour chart (LCC) by IIRR under SSNM, its mass multiplication and distribution to farming community has significantly reduced N application. 2-3 lakhs of LCC were distributed across the country. SSNM recorded 5-16% higher yields over recommended dose of fertilizer (RDF) and considerably reduced the nitrogen application.

- Suitable package for aerobic rice system which reduced the water requirement by 30-40% over continuous flooding was developed and several suitable rice-based cropping systems

(RBCS) and organic farming for sustaining rice productivity recommended. In aerobic rice, promising hybrids identified were PA6201, KRH-2 and PSD-3.

- The 8 row drum seeder is a boon to small farmer. It saves 33% of total labour requirement, 20% of seed and 25% of water which has a positive influence on farming community in adopting this low cost machine. In the event of delayed and erratic monsoon, water stress and labour scarcity which are normal constraints, drum seeder which costs Rs. 5000 only could benefit the farmers on adoption.
- Planting between 1st July and 20th August and application of 100% RDF and 50% N through inorganic + 50% N through organic (FYM) were found to be the best package for obtaining higher yields of aromatic rices.
- For amelioration of acidic soils, RDF + FYM @ 10 t/ha + lime @ 600 kg/ha or RDF + FYM @ 10 t/ha + Silica 100 kg/ha is useful.
- In acidic soils, boron application improved the rice grain yields.

New herbicides tested & identified for different ecosystems- More than 50 new herbicides were evaluated for their suitability in different crop establishment methods for their effective dose and bioefficacy at IIRR and other co-operating centers:

- Transplanted rice - penoxsulam application either pre or post emergence @ 0.0200 kg a.i. /ha is promising. Single application of the combination herbicide (Bensulfuron methyl + pretilachlor) or two sequential applications of Glyphosate followed by combination product (bensulfuron-methy + pretilachlor) was also effective.
- Direct seeded and transplanted rice - Penoxsulam + cyhalofop-butyl @ 120 g/ha were effective for broad spectrum weed control.
- Direct seeded rice under puddled condition - penoxsulam or carfentrazone-ethyl @ 25 g/ha; Dry direct seeded rice - Metamifop was found effective.

Rice Based Cropping Systems

- In rice wheat cropping system, transplanting method was superior along with application of recommended dose of fertilizers (RDF) + green manuring in a system based approach.
- Cultivars, Karmamashuri, Swarna, Mahamaya, Arize, Arize dhan, Bamleshwari, US-337, BPT- 5204 and NK 6303 were found promising for dry seeding as well as direct seeding in puddled field in different RBCS.
- Rabi crops after direct seeded rice gave higher yields.
- Supplementing Zn, Fe and Mn (soil or foliar spray) in addition to RDF and organic manures was found promising over RDF alone.
- The total productivity and gross returns were higher for rice-maize cropping system, followed by rice-pulse, rice-wheat, rice-rice and rice-oilseed systems.

Soil Science

Long term soil fertility management in rice-based cropping systems

- Continuous cropping of rice and rice-based cropping systems (1989 – 2013) without application of fertilizer or manures resulted in gradual decrease in kharif rice productivity under Rice – Rice system in acid alluvial soils (Assam) and Rice – Cowpea system in the southern plateau @ 70 – 88 kg grain/ha/yr due to declining soil fertility, while low yield levels harvested at Faizabad (Rice – Wheat) and likely contribution of silt carried through water in the Godavari delta (Rice – Rice) probably contributed to stable and/or increasing yield trends at these locations.

- Imbalanced nutrient application (skipping or reduced level) influenced crop response and sustainability of the system productivity recording increasing response levels with NP over N alone or with NPK over NP application. Response to major nutrient application was significant at all locations apparently reflecting changes in soil nutrient status, growing environment and management.

- Changes in important soil parameters over the years indicated decline in SOC and K status mainly with omission of some nutrients or reduced level, and increase in P content in acid alluvial soils, positive growth in SOC and declining available N and K status in the delta system. Unsustainable yields despite positive change in P and K fertility and small loss of SOC in the Cauvery commands (Mandya) suggest review of current fertilizer recommendations. To a large extent some of these changes matched the trends in rice productivity.

- Overall, net gain in SOC stock (carbon sequestration) was much higher in the deltaic alluvial soils at Maruteru than other locations indicating delta system to be more stable with better resilience against negative impacts of intensive cultivation. Rice – non–rice cropping system appeared to be less stable particularly in the southern plateau region under Cauvery command.

Nitrogen management

- N losses estimated from coated fertilizers at Faizabad and Raipur revealed that in general, the losses were more with prilled urea especially in light textured soils. Least losses are recorded with neem coated urea on fine textured soils of Raipur. Losses with urea super granules were comparable to neem coated urea.

- In areas where effective top dressing is not feasible on account of poor water management, one time basal application of neem coated urea could bring about better N-efficiency.

- Controlled release N fertilizer (CRN) applied all as basal dose @ 100 kg N/ha was superior to prilled Urea applied in 4 splits and at par with integrated use of GM+PU at Kanpur and Raipur.

- Application of neem coated urea, gypsum coated urea, mussoorie rock phosphate coated urea or urea super granules in single basal dose proved significantly superior to prilled urea application in recommended splits.
- Use of slow releasing N fertilizer in place of prilled urea (PU) helped reduce severity of disease –pest problems such as in BLB endemic rice fields of Titabar, mussoorie rock phosphate coated urea proved to be better than PU and in neck blast endemic rice areas of Ponnampet, neem coated urea was better than PU.
- Superior performance of rice hybrids over inbred varieties could be attributable to their better N use efficiency traits such as higher N uptake AE,PE,NHI, chlorophyll content, LAI and spikelet number coupled with better filled grain percentage. Further, continuous cultivation of rice hybrids for three years did not lead to soil N depletion.

Phosphorus management

- Ammonium polyphosphate, a new complex P fertilizer was found to be superior to both DAP and SSP especially in acid clay loams of Titabar. Likewise, use of 50% partially acidulated phosphate rock was found as good as SSP.
- In high P fixing soils of Titabar, 30 days delay in application of SSP significantly improved grain yields ranging from 0.5 to 1.0 t/ha.
- Use of superphosphate-soil slurry resulted in about 50 per cent saving in the use of phosphatic fertilizers without adversely affecting the yield by maximizing the efficiency of phosphatic fertilizers.
- Basal application of cow dung treated superphosphate increased the averaged grain yield by 0.4 to 0.7 t ha-1.
- In the flooded soils of neutral to alkaline pH, rock phosphate alone as P2O5 source could not influence the crop yields, but in the presence of acid forming materials like pyrite it was as effective as single super phosphate.
- Significant increase in grain yield was recorded at 20 kg applied P2O5/ha in low land locations at Faizabad and R.S.Pura. The upland location, Anandpur, gave significant response up to 30 kg P2O5 ha-1 even though the absolute grain yields expectedly were low in low land since the flooding effects seem to have a beneficial effect. In acid upland soils of chinsurah also, the response to applied P was at higher dose of 30kg P2O5 ha-1.
- Rock phosphate mixed with pyrite (1:5w/w) was as effective as single super phosphate. However, the mixture of rock phosphate and superphosphate (each to supply 30kg P2O5 ha-1) when further mixed with pyrite increased the grain yield by 1.3 t/ha over super phosphate in the neutral soil of Patna.
- The cultures RPA 5929, IR1514, AE666, MTU 2400 and IET 1444 were found tolerant to low soil P conditions mainly due to their better root morphology and release of acidifying exudates into the soil.

Potassium management

- A moderate supply of K @ 40kg K2O /ha was found to increase grain yield significantly for both hybrids and HYVs with higher magnitude of response in case of hybrids obviously due to higher sink capacity in hybrids as compared to inbreds.
- Recommended K supply increased the grain yields due to better grain filling and improved grain weight/leaf area index at Faizabad and Titabar. Response of hybrids to split application of K was higher as compared to inbreds at Titabar.
- Synchronization of potassium supply through split application @ 50% of the dose each at transplanting PI stages was beneficial for rice hybrids in light textured soils at Faizabad and silty clay soils a Moncompu and Titabar with low to medium available K.

Zinc management

- Zinc application to plants by both spraying and soil application increased the yield over control. No difference was found when the ZnSO4 was applied alone or in combination with phosphatic fertilizers.
- Out of several cultures tried MTU 3151, 5122, 3989, RP 4-14, MMDW 13 and 18, MTU 4335, 3991, Jaya, MTU 4884, 5176 and 3626 exhibited moderate zinc deficiency symptoms.
- Neutral/normal soils require a maintenance dose of 50 kg ZnSO4/ha. Saline-sodic soils where fixation of zinc is expectedly more, doubling of the normal dose i.e. 100 kg ZnSO4/ha initially is needed for obtaining better yields of rice.
- Linear responses to applied Zn up to 20kg Zn/ha was observed in alkaline soil at Faizabad while at Mandya, the response was curvilinear with maximum yield at 10 kg Zn/ha. For sodic soil management, suitable genotype (Sarjoo-52/ Vikas) and optimal Zn application (25kg Zn So4/ha) are key factors for realizing full potential yields.

Problem soil management

- In the sodic soil at Mandya with soil pH 9.8, gypsum application at 100% gypsum requirement (GR) recorded maximum yields followed by 50% gypsum in combination with green manuring (Gliricidia) applied @ 6 t ha-1.
- The varieties pokkali, Nona Bokra, IR2153-26-3-5-2, IR 1820-210-3, KR 1-24 and Hamilton were identified as tolerant for soil salinity and alkalinity.
- In sodic soils under rainfed situations of Indo-gangetic plains, improved variety Bejhary coupled with optimal N application @75N/ha contributed more to grain yield irrespective of the quality of irrigation water (even with residual sodium carbonate water) at R.S pura.

- For acid soils at Titabar and Assam, the genotype Narendra 97 was most promising because of its tolerance to Fe toxicity both under limed and unlimed conditions, for better NPK nutrition, higher productivity and responsiveness to lime management, followed by genotypes IET 19749, Gitesh and KRH 2. IET 22218 (NP 218), Vardhan and 27P-63 at Moncompu, Jarava, RP-Bio-226 and Dhanrasi at Ranchi and Prafulla, Aghonibora and SS-3 at Titabar were identified as promising cultures.

Crop Residue management

- Substantial improvement in yield, uptake of nutrients and soil fertility were observed due to incorporation of straw either alone or when supplemented with green manure, microbial culture or nitrogen in rice-wheat cropping system. Straw contributed 20 - 48 kg N, 6-23 kg P_2O_5 and 14-50 kg K_2O ha^{-1} to the crop nutrition.

Soil Health Testing Kit

- Soil testing is key to balanced fertilization and plant nutrition. Rapid soil testing kits are similar to the clinical testing and diagnosis in medicine. The rice soil quality kit developed by DRR is useful for carrying out soil testing in neutral to alkaline soils and will particularly address the problem of non availability of quality soil testing equipments or laboratories across districts and villages. Further aim of the kit is to simplify the soil chemical analysis for ready use by the less skilled personals in the rural areas by the soil testing laboratories and rural service centres.

- The kit provides rapid testing techniques for soil physical, chemical and biological parameters. Clearly defined and contrasting visual color matching system has been developed which sometimes distinguishes from ppm level in case of available ammonium status to as high as 50 kg/ha range in case of available potassium status testing. The basic principle of extraction and estimation has not been undermined and most of the soil available nutrient status estimation involves the principle of reagent systems and extraction procedures based on the respective extraction. Colorimetric test methods are used for most test factors. The Soil quality testing kit offers simplified methods for determination of available nutrients from soils and is rapid, fairly accurate chemical tests. With the present kit user can perform as many samples as he wishes for soil physical characteristics but for all soil chemical, fertility and biological tests about 30-40 samples can be performed. A farmer can generate his own soil health card also after analysing his sample. After exhaustion of the chemicals they can easily take it from soil science division of DRR, Hyderabad. The most important feature of the kit is that even a farmer and a less skilled/ educated person will be easily carrying out such testing.

- The ease in operation and portability to far flung areas/villages coupled with the kit requiring no electricity/power to operate, will be immensely beneficial to the small, marginal, poor farmers and other resource poor stake holder of the region as it will bring soil health assessment to the plot or farmer level.

Plant Physiology

- Abiotic stress tolerance: Promising cultures in different duration groups showing seed dormancy of 1-4 weeks and beyond were identified. Some of the identified cultures had intense seed dormancy that could not be overcome even by heat treatment. Purnendu and WGL-165 were potential donors to introduce dormancy in elite lines.

- Vivek Dhan 82 showed better tolerance to cold than other test cultures at Almora and umiam.

- Low temperature had a general adverse effect on all yield components and yield through impairment of pollen fertility and cyto-membrane integrity. Nitrogen at lower dose compensated the adverse effects of low temperature to some extent.

- Based on important plant traits, the test cultures IET-17814, IET-17836, IET-17810, IET-17812, IET-17829, IET-17838 IET-18244, IET-17509 and IET-18221 were identified as promising cultures for drought tolerance under rain fed lowland conditions at Faizabad. IET-18244 had anthesis coinciding with the dry spell and avoided severe strain with higher relative water content. IET-17808 and IET-17847 were found promising under submerged condition at Chinsurah and Titabar.

- Spraying 1000 ppm salicylic acid on 50th day after sowing was found to induce sterility with 96.7% success in TGMS lines at Coimbatore. Based on the studies on several – physiological, biochemical and yield related parameters BRB 223-2-2-2-IR, CR10, IR58103-62-3R, PMSB3, IR58025B & IR65515-47-2-1-1-19R were identified as efficient parental lines for developing hybrids. Based on the physiological efficiency studies on maintainer and restorer lines conducted at Coimbatore, BRB223-2-2-2-IR was found to be a promising culture or restorer for several traits.

- Based on the regression equations between days to flower and cumulative degree day (cdd) values and cumulative nyctoperiod (cnp), it may be stated that on an average, rice crop requires 1000 cdd and 703 cnp for early maturing, 1500 cdd and 1100 cnp for medium duration and 2050 cdd and 1600 cnp for late duration types. By delaying sowings, the number of days taken to attain panicle intitation (PI) stage was reduced by 6 days.

- Photothermic indexing - Node number as a developmental indicator appeared to be tightly linked with panicle initiation, irrespective of sowing time. Photoperiod is important at maturity while nyctoperiod is at panicle initiation (PI) and flowering stages. Advancing sowing dates by 15 days resulted in meeting cumulative nycto periods (CNP) and cumulative degree days (CDD) requirements and improved yields across the locations from 10.55" to 29.02" latitudes. IET# 20924, 21113, 21119 and Jaya were more consistent in their yield response. Photothermic Indexing and Radiation Use efficiency software for rice crop has been developed based on the studies carried out under AICRIP. IET 20924 was identified having superior photothermic Indexing features and submitted to NBPGR for registration. Three hybrids (KRH2, PA 6201, PA 6444) and IET 20924 have desired cumulative degree days and nycto periods for early sowing with superior yields identified for soft registration for these traits.

- Nitrogen Use Efficiency -The development of secondary branches is largely influenced by management practices where as primary branches are determined by genetic background of the cultivar. The number of secondary branches of the panicle was influenced b y fertilizer application which may be used as selection criterion for identifying fertilizer application which may be used as selection criterion for identifying fertilizer responsive genotypes. Krishnahamsa and KRH-2 are more responsive than other three tested genotypes.

- Dormancy - One early variety JGL 11118; four medium duration variety MTU1001 IET 19859 and IET 19863 IET 20253, IET 20269 and four late duration varieties, MTU171-61-1-1, MTU-IJ226-32-1-1-1 & MTU110-11-1-1-1-15 & MTU194-101 were found promising With strong dormancy displaying less than 10% germination for 3-4 weeks) and are suitable for preventing pre-harvest sprouting during inclement weather of late Kharif season.

- Rainfed Uplands - Based on physiological responses and yield IET 19855 IET 21626, 21628, 21625 and 21605 and IET 19856 were found suitable for rainfed ulands. PA 6129 and Annada, and IET 20708 and IET 20710 recorded high grain yield under dry spell, while IET 21281 and IET210796 were drought susceptible. Rasi (IET 1444) consistently proved its superiority under moisture stress situations.

- Submergence Tolerance - The sub 1 gene improved survival by 2-4 fold and yield by 35-45% (229-314 g/m). All the three sub 1 introgressions i.e. IR-64, Swarna and Sambha Mahsuri exhibited positive effects of the gene introgression in terms of seedling survival under submergence, recovery and yield.
- Radiation Use Efficiency - RUE was highest at panicle initiation stage and lowest at flowering stage. IET 21023 and IET 2O986 had higher radiation use efficiency (RUE) coupled with early vigour, photosynthetic activity and translocation capacities at individual levels.
- Aerobic rice - The aerobic system performed well and yield wise it was almost on par with the conventional rice system except at Coimbatore. Hybrids, PHB-71 and PA- 6444 were found to be superior to other three test entries.
- Boron Nutrition - Application of boron @ 0.4 ppm at anthesis stage resulted in 4-8% yield improvement in IET # 20979, 21007 and 21014. Based on the data on spikelet sterility, high density grains and yield it was found that IET 20979, IET 21114, and IET 21519 showed a positive response to boron application @ 0.4 ppm across locations.
- Silicon solubilizer's application improved grain yield in silicon deficit soils such as, sandy or silty clay soils, sandy loam soils and clay soils.
- The basic research on silicon at IIRR amply demonstrated its use in combating biotic and abiotic stress in rice and harnessing this information would help in reducing the pesticides and also effectively combat climate stress in coming year.
- RGL 5613, MTU 106-16-1-1, MTU 1061(Mid late duration), RGL 9999, JGL 3827, JGL 4147 (Mid duration), WGL 23847, DM 93 (early duration) IHRT 218, 228, hybrids were identified as suitable cultures for growing in coastal regions to avoid cyclone intimidated damage.
- The studies on climate change initiated revealed that 3-70 C increase in temperature results in 24% rice grain yield loss. One important reason for low fertility and high temperature was due to high osmoticum on the stigma causing improper germination of pollen grains.

Crop Protection

Entomology

- **Insect pest scenario in rice:** Insect pest scenario in rice changed drastically in the last five decades. During 1965, only three pests' i.e, gall midge, stem borer and green leafhopper were of serious concern. With the introduction of fertilizer responsive high yielding varieties, changing rice cultivation methods/practices and indiscriminate use of insecticides resulted in changing pest scenario. At present, 19 pests are causing alarm at national and regional level resulting in significant yield loss.

Insect pest scenario in rice during last five decades

- Due to changing pest complex scenario there is a need for emphasis on multiple resistant varieties. A number of donors like Velluthacheera, Banglei, Aganni, ADR 52, Pandi, Chennellu etc. with proven resistance to multiple resistance to gall midge, BPH and WBPH have already been identified. Utilizing these donors multiple resistant varieties viz., Suraksha, Vikramarya, Shaktiman, Rasmi, Daya were developed for release in states like Andhra Pradesh, Odisha, West Bengal, Kerala, Madhya Pradesh etc. In the last decade, about 180 entries have been identified as promising donors for resistance to multiple insect pests.

Varieties resistant to important insect pests of rice

	Insect pest	Resistant varieties
1.	Gall midge	Sneha, Pothana, Kakatiya Erramallelu, Kavya, Rajendradhan 202, Karna, Ruchi, Samridhi, Usha, Asha, MDU 3, Bhuban, Samalei, Orugallu, Abhaya, Shakti, Suraksha, Daya, Pratap, Udaya, IR 36, Shaktiman, Tara, Kshira, Sarasa, Neela, Lalat, Phalguna, Mahaveer, Vibhava, Divya, Dhanya Lakshmi, Surekha, Vikram, Kunti, Triguna, Sita, Samleswari, Karma Mahsuri, Dhanarasi, Mahamaya, Jyothi
2.	Brown Planthopper	Chaitanya, Krishnaveni, Vajram, Pratibha, Makom, Pavizham, Manasarovar, Co-42, Chandana, Nagarjuna, Sonasali, Rasmi, Jyothi, Bhadra, Neela Annanga, Daya, Aruna, Kanaka, Remya, Bharatidasan, Karthika, Vijeta, Cotton Dora Sannalu, KRH2, PA6201, Hybrid 6129, ADT37
3.	White backed planthopper	Haryana Basmati, HKR120, Laatha , Narendra 2002, Jitendra, Satyaranjan

- **Development of multiple pest resistant varieties:** Rigorous screening of advanced breeding lines through National Screening Nurseries viz., NSN-1, NSN-2, NSN for hills and National hybrid Screening Nursery (NHSN), under both artificial and natural pest infestation regimes at different locations under

AICRIP has led to release of varieties resistant to major insect pests as well as identification of promising multiple insect pest resistant donors. Many of these cultivars being high yielders are widely adopted for cultivation in the pest prone areas.

- **Pheromone trap mediated management of yellow stem borer:** Extensive multi-location testing under AICRIP has resulted in successful recommendation of pheromone mediated monitoring as well as mass trapping of yellow stem borer as a practical, cost effective and environmental friendly option for the farmers. Installation of 8 traps with 5 mg impregnated lures per hectare helps in monitoring of yellow stem borer populations, while installing 20 traps per hectare can mass trap male moths of yellow stem borer and help in effectively lowering population of this pest in farmers' fields.

Testing of stem borer pheromones

- Strategic integration of pheromone technology along with the release of egg parasitoids against leaf folder has put biointensive IPM on a sound footing particularly in areas endemic to stem borer and leaf folder.
- **Trap crop for stem borer management:** Attempts to modify rice habitat by employing Pusa Basmati variety as 'trap crop' for the management of yellow stem borer have been successful. Based on the basic principles of trap cropping a strategy was developed at Directorate of Rice Research to trap the YSB insects on a susceptible rice variety (Pusa Basmati 1) and minimize the damage on the main crop in stem borer endemic areas. Planting of main crop and trap crop is

Trap Crop for stem borer management

done at the same time by varying the sowing dates so that the trap crop flowers a week earlier than the main crop. For every 2.5- 3m of main crop, one row of trap crop (Pusa Basmati-1) should be planted preferably in east – west direction. The technique was systematically evaluated through multi-locational testing and recommended for stem borer endemic areas.

- **Identification of effective and eco-friendly insecticides:** Chemical control with its curative effects and ease of application is unavoidable in case of pest outbreaks. Several insecticides, both granules and spray formulations have been identified after systematic evaluation against insect pests specific to different ecosystems AICRIP. Eco-friendly chemicals with novel modes of action and effectiveness at very low doses such as, cartap hydrochloride and chlorantraniliprole against stem borer and leaf folder, ethofenprox, thiomethoxam, imidacloprid, clothianidin, dinotefuran and sulfoxaflor against planthoppers fit well into rice IPM.

Effective granular formulations against insect pests of rice under AICRIP

Insecticide	Rate g a.i./ ha	Stem borer	Gall midge	Whorl maggot	Leaf folder	Hispa	Brown planthopper	Green leaf hopper
Organophosphates								
Phorate	1250	***	***				**	**
Quinalphos	1000	***	***					
Fenthion	1000	***	**	**	***			
Isazophos	600	***	***	**	***		***	***
Carbamates								
Carbofuran	750	***	**	***		**	***	**
Sevidol	1000	***						
Nereistoxin analogue								
Cartap hydrochloride	750	***			***			***
Pyrazole insecticides								
Fipronil	75	***	***	**	**	**	***	**
Anthranilic diamide								
Chlorantraniliprole (Rynaxypyr)	40	***			***			

*** = Moderately effective   ** = Effective   *** = Highly effective**

Spray formulations of insecticides evaluated under AICRIP against insect pests of rice

Insecticide	Rate g a.i./ ha	Stem borer	Leaf folder	Hispa	Brown plant hopper	White backed plant hopper	Cut worms	Green leaf hopper
Organochlorines								
Endosulfan	600	***	**				***	
Organophosphates								
Quinalphos	500	**	***	**		**		
Phosalone	500	***	**	***	**			**
Monocrotophos	500	***	***	**	***	***	**	***
Chlorpyriphos	500	***	***	**		**	**	

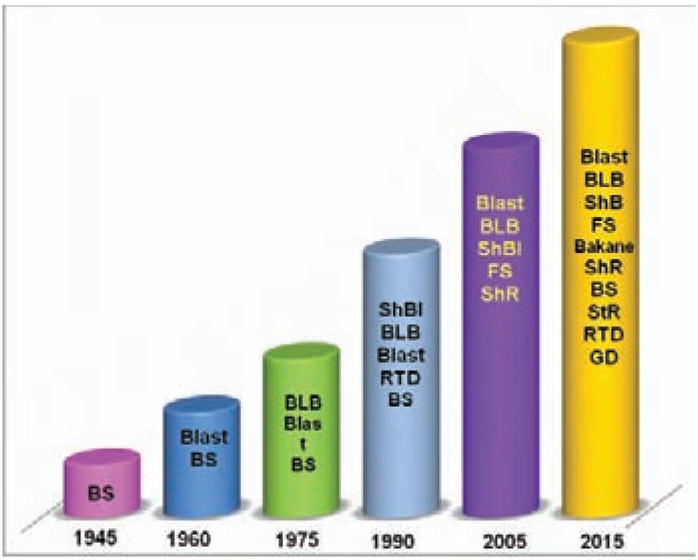
Insecticide	Rate g a.i./ ha	Stem borer	Leaf folder	Hispa	Brown plant hopper	White backed plant hopper	Cut worms	Green leaf hopper
Acephate	750	*	**		**	***		**
Triazophos	500	**	***	**	**	**		**
Fenitrothion	500	*	**				*	
Phosphamidon	500	**	***	**	***	***		**
Fenthion	500	*		***		***		*
Dichlorvos	500		**		**		***	
Carbamates								
Carbaryl	750	*	**	**	***	***		**
MIPC	500	*			**	**		**
BPMC	500	*			**	**		**
Carbosulfan	500	*			**	**		**
Nereistoxin analogue inseciticide								
Cartap hydrochloride	300	***	***				**	**
Ether derivative								
Ethofenprox	75	*			***	***		***
Pyrazole insecticides								
Fipronil	50	***	***	**	***	***	**	***
Ethiprole	50	*	*		***	***		***
Chlorantraniliprole	30	***	***					
Neonicotinoid insecticides								
Imidacloprid	25	*			***	***		***
Thiamethoxam	25	*			***	***		***
Clothianidin	30	*			***	***		***
Dinotefuran	40	*	*		***	***		***
Sulfoximine								
Sulfoxaflor	90	*			***	***		***
Growth regulators								
Buprofezin	100				**	**		**

*** : Moderately effective ** : Effective ***: Highly effective.**

- **Integrated Pest Management (IPM):** IPM is the most appropriate approach to overcome biotic stresses and obtain sustainable rice yield with least damage to the environment. Earlier workers verified and demonstrated the efficiency as well as cost effectiveness of location specific IPM technology on farmers fields compared to conventional farmers practices. However, in order to make IPM more adaptive, there is need to develop more than one IPM modules at every location thereby addressing to the plant protection needs of diverse farmers situations within and across the rice ecosystems. Keeping this in view, the multi location on farm trials carried out under AICRIP demonstrated the availability of more than one IPM modules with superior performance and optimum cost effectiveness for use by the rice farmers at each location in different rice ecosystems of the country. The IPM modules differed in their package of optimized pest management components like resistant varieties, release of biological control agents, suitable manipulation of cultural practices, need based insecticide use etc.

Plant Pathology

- **Disease scenario in rice:** In India, disease spectrum and intensity are changing continuously because of dynamic nature of rice cultivation. Earlier blast and brown spot were considered as major diseases but after introduction of high yielding and fertilizer responsive varieties diseases viz., blast, bacterial blight, tungro and sheath blight have become major diseases. In recent years, blast and bacterial leaf blight diseases have been reported regularly at an alarming intensity in many areas. Sheath blight disease is prevalent in moderate to severe form in almost all the rice growing areas during the monsoon season. Adoption of high yielding varieties, hybrids, crop intensification practices and changes in climatic conditions, many diseases viz., false smut, brown spot, sheath rot, stem rot, foot rot, leaf scald and grain discolouration which were earlier restricted to certain parts of the country, now spreading to other rice growing areas and causing considerable yield losses.



BS-Brown spot;
BLB-Bacterial leaf bight;
FS-False smut;
GD- Grain discoloration;
RTD-Rice tungro disease;
ShB- Sheath blight;
ShR-Sheath rot;
StR-stem rot;
LS-leaf scald

Disease scenario in rice

- **Identification of sources of resistance and resistant lines against major diseases:** To overcome disease challenges, delivering the high yielding varieties with inbuilt durable resistance is the best option. Under the Rice Pathology programme of AICRIP several accessions of germplasm and advanced breeding lines are being evaluated annually against major rice diseases across 52 locations throughout the country. Different national screening nurseries (NSN1, NSN2, NSNH and NHSN and DSN) are being evaluated and reactions for major diseases are recorded at hot spot locations. This programme has also led to the identification and release of commercial disease resistant varieties coupled with high yield and other desirable agronomic characters. Few widely grown varieties are: IR 36, Rasi, IET 2508, Swarnadhan, VLK Dhan 30, Himalaya I, Himalaya II, for blast; PR 4141, Biraj, Suresh, Narendra 2, Gobind, Radha, Ajaya and Improved Samba Mahsuri for bacterial leaf blight; Vikramarya and Nidhi for RTV, Swarnadhan for sheath blight; Rasi, IR 36 for Brown spot diseases.

Disease	Resistant varieties/donars
Blast	Rasi, IR 36, IR 64, Sasyasree, Srinivas, Tikkana, Simhapuri, Parijatha, Salivahana, Gauthami. CRM 49, CRM 51, HKR 98-476, HKR 98-478, HKR 04-487, HKR 05-436, HKR 05-476, Haryana Mahak-11, PAU 3237-1-B-B-19, PAU 3237-1-B-B-20, PAU 3237-1-B-B-22, Pusa 1238-95-73-1, Tadukan, Tetep and Zenith
Sheath blight	Swarnadhan, Vikramarya, Radha, Pankaj, Manasarovar, CR 2612-1-2-2-1, HKR 95-75, HKR 99-103, HKR 06-47, IR 40, IR 64683-87-2-2-3-3, KK 2, KJT 3-2-7-72, OR 1895-2, OR 2336-1, PAU 3832-196-4-1-2, RP Bio Path 3, RPHR 25-104-1-2, SYE 35-4-16-63, Tetep and UPR 2916-2-1-1
Sheath rot	Bala, Cauvery, Kakatiya, Janaki, Tella Hamsa, Sabarmati. Swarnadhan, Vikas, Rajavadlu, Phalguna, Vikramarya
False smut	Bala, Cauvery, Sabarmati, Prakash, Pankaj, HKR 47, HKR 127, HKR 98-418, HKR 2000-645, IR 48725-B-B-86-2-2, IR 65907-191-1-B, PAU 3750-5-1-1-2-1-3, PAU 3832-79-4-1-3-1, PAU 3835-36-6-3-3-4, RR 373-21-1, UPR 2472-18-1-2
Brown spot	Rasi, Jagannath, IR 36
Stem rot	Jagannath, Sabarmati, Pankaj, Govind, Jalmagna, BR 51-282-8-HR 45, BRC 16-127-14-1, Cherno Fingo, CRMAS 2231-37, CRMAS 2622-43-5, CRMAS 2735-12, CSR 30, HKR 99-427, HKR 99-429, HKR 99-491, HKR 08-406, IR 48725-B-B-103-2-3, IRBB 60, K 332, K 334, KJT 3-2-7-72, OR 1752-3, RP Bio 170, RP Bio Path 3, RPHR 25-104-1-2, SYE 35-4-16-63 and Taraori Basmati
Bacterial blight	Ajaya ADT 39, CR 837, HKR 95-128, HKR 95-131, Improved Pusa Basmati-1, Improved Sambha Mahsuri, IRBB 58, IRBB 59, IRBB 60, IR 64, OR 2329-22, PAU 1061-19-22,PR 110, PR 111, PR 114, PR 118, PR 120, Pant Dhan 10, Pant Dhan 11, Saket 4, Sita, PR 4141 Bhudeb, Khitish, Sabita, ADT 39, ADT 36 and Co 43
Tungro	Vikramarya, Manasarovar, Nidhi, Bharani, Nagarjuna, Srinivas, Janaki, Radha, Annapurna,Badami, Ghanteswari, Kshira, Lalat, Nilagiri, Parijat, Prachi, Rajeswari, Vanaprabha, Barathidasan, ADT 38, ADT 44,ASD 16, ASD17, Dinesh , Ambemohar 102, Kataribhog, Latisail and Pankhari 203.

- **Disease mangement trials:** Based on performance of chemicals in field trials under AICRIP, the most economical and effective chemicals recommended/ found promising against different rice diseases along with their dosages and time of application are presented.

Fungicides recommended for the control of important diseases of rice based on the evaluations at IIRR and in its co-ordinated system.

Disease	Fungicide	Application time
Blast	Tricyclazole 75 WP @ 2 g/ kg seed ; Carbendazim 50 WP @ 2 g / kg seed or Tricyclazole 0.6 g/l; Carbendazim 1g/l;Carpropamid 1 ml/l; Azoxystrobin 1 ml/l; Diniconazole 1 ml/l; Kresoxim methyl 1.5 ml/l	Disease initiation (DI) on leaves & panicle emergence (PE) stage
Sheath blight	Diniconazole 1 g/l; Validamycin 3 L @ 2.5 ml; Hexaconazole 5 EC @ 2 ml; Propiconazole 25 EC @ 1 ml ;Iprobenphos 48 EC @ 2 g; Carbendazim 50 WP @ 1g Thiophanate-methyl 75 WP @ 1g; Bitertanol 25 WP @ 2 g; Iprodione 50 WP @ 2 g ; Chlorathalonil 75 WP @ 3 g	Disease Initiation (DI)
False smut	Copper oxychloride 2.5 g/l; Propiconazole 1 ml/l; Triflxystrobin + tebuconazole 1 ml/l; Copper hydroxide 2.5 g/l	Booting/PE
Sheath rot	Mancozeb 75 WP @ 2.5 g / kg seed; Captan 50 WP @ 2 g/ kg seed or Carbendazim 50 WP @ 1g ; Ediphenphos 50 EC @ 1 ml or Thiophanate-methyl 75 WP @ 1g ; Propiconazole 25 EC @ 1 ml ; Hexaconazole 5 EC @ 2 ml per liter water	Booting
Bacterial blight	2,4-D ethyl ester 1 ml/l followed by Streptocycline 200 mg/l + Copper oxychloride 2.5g/l; Spraying twice with 250 ppm of Agrimycin-100; 2,4-D ethyl ester 3 days before inoculation followed by Streptocycline + COC	1 & 11 days after inoculation
Brown spot & Grain discolouration	Mancozeb 75 WP @ 2.5 g / kg seed; Iprodione 50 WP @ 2 g / kg seed or Mancozeb 75 WP @ 2.5g; Iprodione 50 WP @ 2g; Carbendazim 50 WP @ 1g ; Chlorathalonil 75 WP @ 2g ; Propiconazole 1 ml; Hexaconazole 1 ml per liter of water	DI & PE
Stem rot	Propiconazole 1 ml or Isoprothiolane 1 ml or Carbendazim 1g per liter of water	DI and booting
Rice tungro virus disease	Carbofuran 3G (Furadan) granules @ 10 kg./acre ; Phorate 10 G (Thimet) @ 3-5 kg/ac	To control vectors

- **Management of false smut disease:** Forty five false smut of rice (Ustilaginoide virens) isolates were collected across India.. The results from false smut management trials revealed that Spraying of trifloxystrobin 25%+ tebuconazole 50% (Nativo75WG) @ 0.4 g/lt and propiconazole 25 EC (Tilt) @ 1ml/lt at 50% panicle emergence stage effectively reduced the percentage of infected panicles/ m2 and spikelet/panicle.

- **Evaluation of biopesticides:** Of the biopesticides evaluated, Biofer (organic, plant lipids, bioproducts made from natural plant molecules) and Defender (natural plant derived product from Cinnamomum zeylanicum) of plant origin were found promising and effective over other biopesticide formulations in checking the diseases like blast, sheath blight, sheath rot, brown spot, glume discoloration and udbatta.

- **Virulence monitoring of major diseases:** Virulence analysis of two major pathogens from different geographical regions on a set of rice differentials is regularly carried out to monitor any changes in the population structure. Analysis of virulence monitoring data of last 10 years or so indicate that a major shift in bacterial leaf blight pathogen virulence in isolates like Kaul, Raipur, Maruteru and Aduthurai. Similarly, analysis of historical data on virulence monitoring of Pyricularia grisea indicated that blast resistant check IR-64 showed moderate to high susceptibility in locations like Cuttack, Almora, Upper Shillong, Ghaghraghat, Lonavala and Mugad indicating a major shift in genetic structure of blast pathogen.

- **Disease observation nursery with trap crop:** The disease observation nursery with continuous monitoring of intensity of different diseases varied in different locations depending on the varieties, cultivation practices, climatic conditions and sowing time. The different diseases recorded were leaf and neck blast, brown spot, sheath blight, sheath rot, false smut, grain discoloration and bacterial blight. In kharif season, the intensity of different diseases like blast, brown spot and sheath rot were comparatively more in late sown crop while diseases like sheath blight was slightly more in early sown crop.

- **Gene pyramiding against blast resistance:** The major blast resistant genes Pi1, Pi2 and Pi54 were introgressed in the back ground of elite cultivars like Samba Mahsuri and Swarna through Marker assisted back cross method of breeding. The RILs and NILs thus generated in various crossing programmes were phenotyped and geneotyped. The stabilized lines were screened for resistance across the location against major rice diseases. Some of the lines that had shown multiple disease resistance like RP Biopatho -2, RP Biopatho -4, RP Patho -11, RP Patho -12, RP Patho -5 and RP Patho-8 recorded multiple disease resistance.

- **New Genes identified:** Intensive greenhouse and field screening of rice germplasm accessions and wild species of cultivated rice and follow up studies led to identification of new sources of resistance against major biotic stresses and to identification of novel resistance genes.

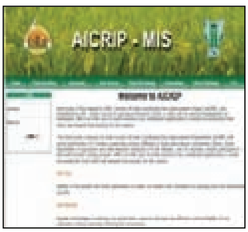
New Sources/genes identified for resistance against biotic stresses

Source	Stress/gene	Source	Stress/gene
O. glaberrima	BPH (Bph22t)	O. brachiantha	BLB/ Xa34t
	BLB/a recessive gene	O. minuta	BPH/Bph23(t)
	Blast new gene	O. nivara	BLB/Xa31
O. rufipogan	BLB/ a recessive gene	RP2068-18-3-5	BPH/New Gene
	BPH / Bph24(t)		
	BLB/ a recessive gene		

- **Integrated Disease Management:** Integration of disease management practices like growing disease specific resistant or susceptible varieties with application of 100 % or 66% recommended dose of nitrogen along with need based fungicidal protection was found effective in managing blast and sheath blight. In addition to that, nitrogen management in case of bacterial leaf blight was found the promising practice in improving the grain yield.
- **Production Oriented Survey (POS):** Production Oriented Survey (POS) was undertaken since late 1970s in the country to identify the production constraints in the rice growing ecosystems during crop season in every year. Various production constraints identified through POS and course corrections suggested. Production oriented survey revealed that blast, neck blast, brown spot, sheath blight, sheath rot, false smut, grain discoloration and bacterial leaf blight among the diseases and brown plant hopper, green leaf hopper, leaf folder, stem borer among the insect pests, were wide spread throughout India.

AICRIP Information Management System

- A national facility of AICRIP information management system was set up with an objective to develop an online system to receive real time data on various activities and other observations for quicker compilation, analysis and reporting. This was successfully hosted at the URL http://www.aicrip-intranet.in and links are available with IIRR.
- Many centers have submitted data through AICRIP MIS for 50th ARGM. There was good response for seed received and crop condition data (Physiology-60%; Entomology -50%; Plant Breeding -30%; Pathology and Agronomy- 20%)



National — Data from All Centers, All Disciplines

Principal Investigator — Data from All Centers Specific

Center In Charge — Data from Specific Center All

Co-operator — Data from Specific Center Specific

Frontline demonstrations

- During last five years, a total of 201 technologies were displayed in about 4125 FLDs in 14-24 states. The ecosystems include irrigated, upland, shallow lowland, deep water, saline & coastal and hill & others. The average yields were in the range of 5.02-6.21 t/ha in irrigated, 4.06-4.81 t/ha in upland, 4.46-5.04 t/ha in shallow lowland, 4.01-7.03 t/ha in deep water, 4.75-5.05 t/ha in saline and coastal, 2.86-5.14 t/ha in hill and others. New varieties/hybrids and other technologies like agronomic practices and plant protection measures demonstrated superiority with a minimum yield gain of around 11% in irrigated, upland and deep water ecosystems; 22% in shallow lowland; 24% in hill & others; 33% in saline and coastal areas.
- The spin-offs from Frontline demonstrations have also proved the merit of the technologies generated and how up scaling the innovations will make a major effect on rice production and productivity enhancement through technological interventions.

Rice Knowledge Management Portal

- A flagship initiative for the first time was undertaken as Rice Knowledge Management Portal (RKMP) funded by NAIP. This extension semantic portal was launched by our Honourable Prime Minister Dr Manmohan Singh on 16th July, 2011. Now RKMP is serving as an information highway for sharing the Rice Knowledge across the country. The total hits received after the launch of RKMP is 1971734 which is a clear indication of its popularity in the e-learning domain.Rice Products.

Rice Products

- Rice Riche Pain Relieving Gel, moisturizing lotion, rice cream for dry skin and cracked heel and face scrub were developed and are being marketed at a smaller scale.

Other activities

- For harnessing the strengths of public and private sector in commercialization of IIRR technologies the Directorate following the ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization entered into 16 MoAs with the private sector seed companies for DRRH2, DRRH3 and Improved Samba Mahsuri in the last five years. IIRR generated an upfront payment amount of ₹ 62.88 lakhs. The benefits would have greater penetration in the years to come, now that the process has been initiated which would ensure that the seed of the best technologies made available to the farmers. The plant breeders' rights as per the provisions of PPV&FR Act 2001 would also be ensured.
- The biggest strength of IIRR research contribution is evident from 101 papers published in national and international journals with >6 impact factor. 54 externally funded projects were implemented or are in the process of implementation during the last 5 years amounting to a total budget for research alone to the tune of Rs. 4,170 lakhs. Some of the externally funded programmes which are addressing important research initiatives include Functional Genomics Project, National Initiative on Climate Resilient Agriculture (NICRA), Rice Biofortification Programme, Metabolic and Molecular Profiling of Aromatic Rices of India, RKMP, ENMAS-PLOMICS, Decision support system for major insect pests of rice based cropping system, Establishment of National Rice Resource Database, Golden Rice Project, and several DST, DBT, NAIP, NFBSFARA and ICAR projects.
- Though IIRR is not an educational institution many of the staff working in various externally funded projects has enrolled for doctoral degree. 16 students were awarded PhD and 68 are pursuing their doctoral thesis work. Many of IIRR Project Staff and students gained employment in India and abroad. In addition, 78 have completed the M.Sc course work or 6 months training in their respective fields of specialization.

ICAR

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

SARDAR PATEL OUTSTANDING ICAR INSTITUTION AWARDS

2001

CITATION

The first Chaudhary Devi Lal Outstanding AICRP Award, 2001 is jointly awarded to the All-India Co-ordinated Rice Improvement Project at the Directorate of Rice Research, Hyderabad, for its significant contribution to the rice improvement.

All-India Co-ordinated Rice Improvement Programme (AICRIP), co-ordinated and administered by the Directorate of Rice Research (DRR), Hyderabad, has completed 36 years of fruitful functioning. Staffed by 51 scientists at headquarters and participation of 205 co-operating scientists at the 44 funded centres, and with involvement of 58 voluntary centres spread over 26 States across the country, this rice programme conducted 6,013 field experiments during the last five-year period. These studies not only covered all the rice ecosystems, viz. irrigated rainfed lowland (shallow, semi-deep and deep water) rainfed upland, traditional basmati-growing areas, hill regions and problem soil areas, but also examined rice-based cropping systems. Crop improvement component of these studies resulted in release of 117 varieties/hybrids by central and state variety release committees. Of the nine hybrids/varieties released, Pusa RH 10 is a fine grain rice hybrid, Yamini (CSR 30) is a salt-tolerant basmati quality rice variety and Nidhi, along with the earlier released variety Vikramarya, are the tungro resistant varieties. Supported by the upstream lead research networks, national and international collaboration, and downstream setups for breeder seed production, frontline demonstrations, and communication and training activities for extension staff, this programme has played a key role in achieving food security for the country. This rice programme through its leadership in concepts and performance, has formed a model for international collaborative research networks.

Indian Council of Agricultural Research

Chaudhary Devi Lal Outstanding
All India Coordinated Research Project (AICRP) Award
2001

The Chauadhary Devi Lal Outstanding All India Coordinated Research Project (AICRP) Award for the year 2001 is presented to

All India Coordinated Rice Improvement Project,
Directorate of Rice Research, Hyderabad

for outstanding contribution in the field of

Rice Improvement

New Delhi
July 16, 2002

Panjab Singh
Director General

Ajit Singh
Union Minister for Agriculture

ii. Center wise Achievements

The contribution of each cooperating center to AICRIP has been two fold - i) Testing of AICRIP materials / technologies, ii) nomination of breeding material as well as technologies generated at that location for nation wide evaluation.

Nominations under AICRIP by different Funding centres in the last 50 years

Region	State	S No.	Location	No. of Nominations
Region 1-Hills	Himachal Pradesh	1	Malan	375
	Jammu Kashmir	2	Khudwani	262
	Meghalaya	3	Upper Shillong	13
Region II-North Western	Uttarakhand	4	Pantnagar	788
	Punjab	5	Ludhiana	142
	Haryana	6	Kaul	438
	Jammu Kashmir	7	Chatha	24
	Rajasthan	8	Kota	141
Region III- Eastern	Orissa	9	Jeypore	14
		10	Chiplima	39
	Bihar	11	Patna	223
		12	Pusa	182
		13	Sabour	9
	Jharkhand	14	Ranchi	134
	West Bengal	15	Bankura	30
		16	Chinsurah	1006
	Uttar Pradesh	17	Nagina	1
		18	Masodha	1176
		19	Kanpur	126
		20	Ghaghraghat	102
		21	Varanasi	163
	Madhya Pradesh	22	Rewa	86
	Chhattisgarh	23	Raipur	1039
		24	Jagadalpur	3
	Tripura	25	Arudhutinagar	29
	Manipur	26	Wangbal	64
	Assam	27	Titabar	139
		28	Karimganj	28

Region	State	S No.	Location	No. of Nominations
Region IV- Westen	Maharashtra	29	Karjat	240
		30	Sakoli	81
		31	Tuljapur	29
	Gujarat	32	Navsari	9
		33	Nawagam	183
Region V- Southern	Andhra Pradesh	34	Maruteru	606
		35	Rajendranagar	621
		36	Warangal	174
	Tamil Nadu	37	Aduthurai	231
		38	Coimbatore	911
	Kerala	39	Moncompu	148
		40	Pattambi	142
	Karnataka	41	Mandya	115
		42	Mugad	31
		43	Brahmavar	2
		44	Ponnampet	4
		45	Gangavati	16
	Puducherry	46	Kurubapet	20
			Total	10339

Location wise achievements are presented below

ADUTHURAI

Tamil Nadu Rice Research Institute (TNRRI)
Tamil Nadu Agricultural University
Tamil Nadu

Agricultural research station, established in 1922 at Aduthurai was upgraded as Regional research station under in 1962 with the mandate of solving problems of rice cultivation in Cauvery delta comprising of Thanjavur, Tiruvarur, Nagapattinam, parts of Trichy, Cuddalore & Pudukkottai. The research station was further elevated as Tamilnadu State Rice Research Institute in 1981 with the mandate of catering the needs of rice farmers across the delta region.

Major contributions to AICRIP

Crop Improvement – Plant Breeding

- 48 high yielding varieties and one hybrid were released. 14 rice varieties introduced. Recently, the varieties such as ADT 42 (IET 13239), ADT 43 (IET 14879), ADT 44(IET 14099) and ADT 48 were tested under AICRIP and released for cultivation in Tamil Nadu.

Popular varieties released from TNRRI, Aduthurai

ADT 36
Parentage – Triveni / IR 20
Duration (Days) –110
Average yield (Kg/ha) –4000
Grain type – Medium
Special features–Resistant to Blast and Brown Planthopper

ADT 37
Parentage – BG 280-12/PTB 33
Duration (Days) –105
Average yield (Kg/ha) – 6200
Grain type – Short bold
Special features – Resistant to many pest and diseases

ADT 43
Parentage – IR 50/White ponni
Duration (Days) –110
Average yield (Kg/ha) – 5900
Grain type – Medium slender
Special features - Resistant to Green Leafhopper, high tillering and fine rice

ADT (R) 45
Parentage – IR 50/ADT 37
Duration (Days) – 110
Average yield (Kg/ha) – 6100
Grain type – Medium slender
Special features - Resistant to Gall midge and moderately resistant to Brown Planthopper

ADT 44 (2000)
Parentage – selection from OR 1128-7-S1 (IET 14099-IR 56/OR 142-99).
Duration (Days) – 145-150
Average yield (Kg/ha) – 6214
Grain type – Medium slender
Special features - Resistant to GLH, blast, field resistant to stem borer and brown spot and field tolerant to leaf folder. Suitable for growing in samba season of Tamil Nadu.

ADT (R) 46 –(2002)
Parentage – ADT 38/CO 45
Duration (Days) –135
Average yield (Kg/ha) – 6178
Grain type – Long slender
Special features: Semi-dwarf plant stature and non-lodging. Suitable for cultivation in Samba/Thaladi seasons in Tamil Nadu .Field resistance to stem borer and leaf folder.

ADT (R) 47 (2005)
Parentage: ADT 43/Jeeragasamba
Duration (days): 118
Average yield (Kg/ha): 6157
Special features: semi-dwarf, erect, non lodging habit It has profuse tillering capacity suitable for SRI cultivation. Moderately susceptible to leaf folder, stem borer, white backed plant hopper and sheath blight.

ADT (R) 48 (2005)
Parentage:
IET 11412/IR 64, ADT (R) 48
Duration (days):99
Average yield (Kg/ha):8750
Grain type – Long slender
Special features: Resistant to stem borer, green leaf hopper and gall midge. Suitable for direct seeding under water scarce contingent situations as well as for transplanting for late Kuruvai season in Nagapattinam and Thiruvarur districts.

ADT 49
Parentage: CR 1009/J.Samba
Average yield – 6170 kg/ha: Potential yield - 10,200 kg/ha
Grain type: Medium slender, white rice with 1000 grain weight of 14.0g
Special features: Moderately resistant to blast, sheath rot, sheath blight, RTD, brown spot and leaf folder.

ADT 50
Parentage – BPT 5204/CR 1009
Duration – 150 days; suitable for Samba season (August sowing)
Average grain yield – 5945 kg/ha;
Potential yield – 10,494 kg/ha
Grain type: Medium slender rice with less 1000 grain weight of 15.9g
Special features: Resistant to leaffolder, moderately resistant to stem borer and moderately susceptible to GLH, brown spot , blast and RTD

Crop production

Agronomy

- Major breakthrough achieved in rice crop establishment techniques wherein direct seeding, SRI method of cultivation and ICM have not only increased yield but also have the potential to save inputs like land, labour, water and seed to considerable extent.
- 100 % RFD application was found promising for all the RBCS (R - R, R - W, R – M, R - P, R - OS) in both the seasons. Organic manures in conjunction with recommended NPK gave higher REY and gross returns in all RBCSs.
- Introduction of new herbicide molecules like Bispyribac-sodium, Penoxsulum and Metamifop and mixtures like Bensulfuron-methyl + Pretilachlor for different rice eco-systems have been found effective.
- Combination of herbicide, Bensulferon-methyl + Pretilachlor (post emergence) in conjunction with Glyphosate (pre-planting) are effective for transplanted condition and Penoxsulum 24 SC @ 0.020 – 0.025 kg a.i/ha and Pyrazosulfuro – ethyl 10 WP @ 0.020 kg a.i. (20 DAS) for direct seeded rice.

Nitrogen response trial

Long term effect of nutrition on SRI

Crop protection

Entomology

- Multiple pest resistance: RRU-2004, OR-2060-9, RRU-9630, and CNB-1259-5-2-1 found free from stem borer and leaffolder damage. Salkathi, RRH 20, WGL 31996, RP 4511 – 257 found to have multiple resistance against leaffolder , stem borer and whorl maggot. RP 4688-53-2-1255 (Aganni x INRC 3021) and donor parent INRC3021 along with TKM6 recorded grade 1 (resistance) against stem borer, BPH and leaffolder. Shyamala x Danteshwari cross and IR64 sub1 was found to possess multiple resistance.

Field screening

Nethouse screening

- Ecological studies: Raising medium duration Pusa basmati (Thaladi) and short duration IRRI 1552 (Kuruvai) in two rows for every 15 rows of main crop was found useful in reducing stem borer damage.

- Biocontrol & Biodiversity studies: Population richness and evenness of the arthropods in direct sown and transplanted rice monitored showed that transplanted crop had the higher levels of pests and predatory fauna than the direct sown crop.
- Species complex and parasitoids dominance in lepidopteran pests in rice indicated up to 79 % natural parasitisation in rice stem borer egg mass under natural condition and *Telenomus* and *Tetratrichus* are the two major indigenous parasitoids found and in more than 50 % of the parasitized egg masses both the species have occurred together and of the two the former was more in proportion (60- 78 %).
- Innoculative release of *Trichogramma japonicum* (@ 40,000/ac) at 40 days after transplanting sequenced with installation of kairomone septa at weekly interval for four times was found useful in augmenting the egg parasitoid in the field.

- The purple foliage entry IRRI 1552, besides attracting stem borer was also found to serve as '*feast crop*' to host maximum number of egg parasitoids viz., *Telenomus* and *Tetrastrichus* and thereby helps in *in-situ* conservation.
- Chemical control: A number of new molecules were tested against major pests of rice and found effective. These include:
  - Stem borer & leaf folder - Indoxacarb 15 EC @ 200ml/ha and Flubendiamide 480 SC @ 30 g a.i./ha, indoxacarb 15 EC 30 g a.i./ha, Bifenthrin. Combination products like Flubendiamide + Fipronil, Imidacloprid + Ethiprole.
  - BPH - Pymetrozine, Lamdacyhalothirn, Virtako, Dinotefuran and Imidachloprid. Imdiacloprid + Ethiprole @ 125 g/ha followed by RIL –IS-109 (Flubendiamide 4 %+ Buprofezin 20 % SC).
  - Rice leaf mite-Fenpyroximate @ 50 g a.i. /ha followed by Diafenthiuron @ 450 g a.i./ha were effective against.

  In pesticide compatibility studies, the following chemicals were found compatible and effective:
  - Indoxacarb 15 EC @ 200ml/ha + Tricyclazole 75 WP @ 200 gm/ha.
  - Profenophos 50 EC@ 400 ml/ha + Propiconazole 25 EC 200 ml/ha.
  - Dinotefuran and Tricyclazole , Flubendiamide + buprofezin or sutothion (Triazophos) when applied with either hexaconazole or tricyclazole.

Other technologies developed:

- Pheromone molecules in leaffolder were formulated and evaluated both in TRRI, Aduthurai (*M. patnalis*) and IIRR, Hyderabad *(C. medinalis).* In IIRR, Hyderabad blend B7 and B6 elicited response in *C. medinalis* and in Aduthurai the blends were found ineffective against *M. patnalis.* A leaffolder blend (B4) elicited orientation response (kairomone) in the larval parasitoid *Xanthopimpla.*
- **TNAU indigenous lure–**Experimental results revealed that the TNAU indigenously developed pheromone blend was effective in attracting YSB male moths.

Plant pathology

- Sprouted seed treatment with Bavistin @ 40 or 60 g / 100 lit. of water / 60 kg of seed and nursery spraying @ 40 or 60 g/25 lit. of water / 8.0 sq. m nursery area were effective in the control of BLB.
- Seed soaking method with fungicides pyroquilon (Gr.5.0) and carbendazim (Gr.5.2) found effective in the control of blast.
- Host Plant Resistance-Rice culture No.11767 was found resistance to BLB disease. Rice cultures IR 26 and IR 20 were resistant to BLB, stem rot and false

smut diseases. Bhavani and ADT 31 were found to be resistant to brown spot, sheath blight and leaf smut diseases of rice.

- Seven rice cultures viz., IET 10157, IET 9831, IET 10417, IET 9803, IET 9824, IET 9573 and IET 9190 were found to be resistant to blast and also moderately resistant to sheath rot, brown spot and grain discolouration.
- Rice cultures IET 11692, SI.1450, SI.1492, IR 64, Kankai-01-5-16 and AS 37800 showed resistant reaction to both blast.
- In the germplasm screening, the cultures GEB 24 and CB 96114 were resistant to sheath blight, AD 93001, AS 89044, IR 64 and CR 1009 were resistant to RTV and CB 96114, CB 95228, CB 96115, DR 1128-7-S1 and IR 64 were resistant to blast.
- Rice cultures viz., IR 4595-54-1-1-3, IR 68305-13-1, IET 14132, AS 95187 and DPI 2502 were found to be resistant to blast. IR 68305-13-1 was found to be resistant to rice tungro disease.
- Rice cultures CB 98004, BR 4 (a), BR 18, MTU 209-20-1, J.R 503-7, UPRI 97-5, EXPH 208, MPH 5445, Triguna and BR 1 showed resistance reaction to blast disease with Gr.3.0.
- Fourteen gene pyramided cultures were found to be resistant to BLB. The cultures with the combination of two genes Xa 13 and Xa 21 or three genes Xa 5, Xa 13 and Xa 21 performed well. The cultures CRMAS 2231-32, 35, 37,38,42,43, 44 and 50 were found to be resistant to BLB.
- Foliar spraying of fungicides edifenphos and pyroquilon at tillering, panicle initiation and flowering stages reduced the severity of blast disease. Fungicides Safeguard (0.1%), Tilt (0.1%), Beam (0.1%) and Contaf (0.2%) significantly reduced blast intensity
- Fungicides EL 273 (13.1%), Hinosan (15.0%) and Miltox (17.2%) were found to be effective in controlling of brown spot of rice.
- Two sprayings with Nickel nitrate 0.3 per cent or Nickel chloride 0.3 per cent at boot leaf stage and 15 days later significantly reduced the bacterial blight incidence and increased the yield. Soil application of potash at 50 kg K_2O/ha in two equal splits at 40 and 50 DAS effectively checked the spread of BLB disease and increased the grain yield.
- Basal and top dressing of gypsum in two split doses @ 250 kg/ha effectively controlled the sheath rot disease. Spraying of Hinosan or Bavistin @ 750 ml/g/ha give better control against sheath rot.

- For the management of sheath blight in rice, the present recommendation of seedling dip with *P. fluorescens* can be replaced with the nursery application of *P. fluorescens* @ 1.5 kg/20 cents nursery (2 days prior to pulling).
- Botanicals formulations Achook 5 ml/l, Neem gold 20 ml/l and fungicides Sheathmar 3L (2.5 ml/l) and Rhizocin 3 L (2.5 ml/l) were effective in containing the sheath blight.
- Hinosan @ 350 ml/ha proved to be effective against kernel smut.
- Two sprays of carbendazim + thiram (1:1) 0.2% or Pseudomonas fluorescens 1 at 0.5% at boot leaf and milky stages was effective in containing the grain discolouration and recorded higher grain yield of 4009 kg/ha with CB ratio of 3.9.
- Azoxystrobin (Amistar 25 SC) @ 500 ml/ha was found as an alternate chemical for the recommended fungicide Carbendazim in the management of blast (63.3% disease reduction) and sheath blight (56.9% disease reduction) and increased the yield (42.5Kocide 2000-54 DF (copper hydroxide) @ 2.5 g/lit was found as an alternate chemical for antibiotics streptomycin + oxy tetracycline compound + copper oxychloride in the management of bacterial leaf blight with 43.3% disease reduction over control and 28.1% increase in yield with C.B ratio of 1:2.93.
- Spraying fungicide Kocide 2000 54% DF @ 2.5 g/l was found very effective in the management of false smut in rice with lesser number of infected panicles (7.0%) followed by recommended fungicide Copper oxy chloride (9.2%) as against 14.5% in untreated control.
- Kresoxim methyl (Ergon 44.3 SC) @ 1.0 ml and Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75 WG) @ 0.4 g /l were found more effective in the control of sheath blight with lesser severity of 25.2 and 27.6% as compared to untreated check with 56.7% disease severity.
- Application of new fungicides viz., Trifloxystrobin 25% + Tebuconazole 50% (0.4 g/l) and Propiconazole 25 EC (1 ml/l) at 50% PE were found to be very effective in the management of false smut

ARUNDHUTINAGAR

State Agriculture Research Station, Department of Agriculture Tripura

The State Agriculture Research Station, Arundhutinagar was established in the year 1962 under the Department of Agriculture, Government of Tripura. The main objective of the station is to disseminate the modern technologies among the farming community of Tripura by carrying out research on various aspects. The Research Units of this establishment namely Plant Breeding, Agronomy and Pest Management conducts basic research on different aspects of Upland direct seeded and irrigated conditions. This station was also associated with ICAR UNDP project for conduction of the Front line Demonstrations with Hybrids and HYV's. The state Department of Agriculture has started to promote SRI method of rice cultivation to attain self sufficiency in food grains. Tripura is the leading state of practicing SRI in paddy cultivation, farmers as well as Scientists from different parts of India and abroad are regularly visiting the State. Data collected from several farmers showed a 165% increase in the net return by SRI cultivation over conventional cultivation and highest yield obtained by farmers was 10.71 t ha^{-1}.

Major contributions to AICRIP

Crop Improvement

Varieties released/ identified

- Release of 'AR-11' variety for upland rain fed direct seeded condition.
- Release of high yielding variety, 'Swati' for irrigated eco-system.
- Development of one hybrid culture, ARH-2 for irrigated eco-system.
- Average productivity of 2.7 MT / ha of Hybrid Rice Seed was achieved against the National average of 1.5 – 2.0 MT / ha
- More than 56 breeding lines were developed of which 5 were nominated under Initial Evaluation Trials since 2009 *kharif*.
- The improved scented rice IET-21277 nominated under ASGON 2009, AICRIP

trials is accepted by the farmers and now being grown in areas exceeding 2000 hectare under shallow land situations. Eventually it has been released and notified as **"Improved Harinarayan"** short grain strong aromatic rice by "State Variety Release Committee" in 2012.

- More than 5 HYV's were brought under massive demonstration programme which has lead to the farmers to replace new improved HYV's under different ecologies. 'Sahabhagi dhan' and "Improved Harinarayan (IET-21277)" are about to replace NDR-97 and the local Scented races, respectively. IET – 17612 is a culture considered to be a better alternative to the existing Boro HYV's.
- More than six (6) hybrids and HYVs have been popularized through FLD, TOT and minikit programme.

Crop Production

Agronomy

- Green manuring crop gaining acceptance in supplementing the organic manure
- Use of plastic cover over the nursery during boro season has become popular with the rice farmers in the state.
- **System of Rice Intensification**- SRI has been widely accepted by the farmers of Tripura. Presently 38 % of total paddy area is cultivated through SRI method. Increase in yield ranges from 25 - 35 %.

- Application of lime @600 kg per ha in low land rice throughout the State showed improvement in soil health.
- Application of zinc sulphate @15kg per ha in rice based cropping system has got wide acceptance among the farming community.
- Foliar application of 2% potassium nitrate (KNO_3) at flowering stage received a positive impact among the farmers to boost up the productivity level.
- Application of water soluble fertilizer (N: P: K) in shifting agriculture system has increased the yield level where application of straight fertilizer is difficult due to land situation and hilly terrain.
- Blending of bio-fertilizer with chemical fertilizer has been followed in nutrition management of rice.

Crop Protection

Entomology

- CR 780-1937-1-1, CR 2008-111 and CR 2260-1-1-1-1 was identified resistant against rice ear head bug and CRHR-29 against WBPH.
- RNR 2413 and RP 4643-1020 were found resistant against stem borer.
- Flubendiamide and Fipronil were found effective for the control of stem borer of paddy.
- Blasticide (Isoprothiolane 40 EC and Tricyclazole 75 WP) and the test insecticide (Fipronil 5 SC and Flubendiamide 20 WG) were found compatible and suitable in the management of blast and stem borer & leaf folder.

Plant Pathology

- CR780-1937-1-1, CRHR32 (Hybrid), DRRH 50, NDR9830145 were found promising against sheath blight and OR190-6-67, MR219, RGL2045 found promising against bacterial leaf blight.
- Fenoxanil 5% + Isoprothiolane 30% @ 2.0 ml/l and Trifloxystrobin 25% + Tebuconazole 50% @ 0.4 g / liter were found to be significantly superior in checking blast disease.
- Use of Trifloxystrobin 25% + Tebuconazole 50% (WG) @ 0.4 g /l proved effective against sheath blight. Need based fungicidal spray with Propiconazole 25 EC and resistant variety (IR-64) with 100% RDN also significantly decreased sheath blight severity and increased grain yield.
- Bactericide namely Kocide 3000 46.1 DF (30% metallic Copper) @ 2.5-3 gm/Lt recommended for checking the spread of BLB disease.
- For the management of false smut disease, Kocide 3000 46.1 DF @ 2.0 g/l, Indofil M-45 75 WP, Kocide 101 77 WP @ 2.0 g/l , Kocide 2000 54 DF , Propiconazole 25 EC and Carbendazim + Mancozeb combination 75 WP were found effective.
- Bio-pesticides viz. Pseudomonas fluroscence and Trichoderma viride are well accepted for seed treatment and soil application by the farmers of this region.

BANKURA

Rice Research Station, Bankura, Natunchatti West Bengal

This rice research station was established in the year 1966 under the Directorate of Agriculture, Government of West Bengal. The objective of this station is to identify varieties suitable for rainfed ecosystem.

Major Achievements

Crop Improvement

- Out of 13 entries nominated from this station, five were found promising and released as varieties. Salient features of these varieties are given hereunder:

Puspa (IET 17509)

- Early maturity type
- Non-lodging, Non shattering suitable for early and late sown
- Also suitable under direct seeded and periodical moisture stress condition
- Resistant to leaf blast, leaf folder, BPH and tolerant to RTD and stem borer.
- It is a short bold grain type
- Average yield - 4500-5000 kg ha^{-1}
- It has 96.2 ppm iron and 7.2 ppm zinc in whole grain

Dhiren (IET 20760)

- BNKR-1 (Dhiren), late duration non-lodging, non-shattering high yielding rice variety
- Grain type is short bold.
- Duration: 142 days
- Moderately resistant to leaf blast, neck blast, brown spot, sheath rot and leaf folder.
- Average yield : 5000-5500 kg/ha

Sampriti (IET 21987)

- BNKR-3 (Sampriti) is non-lodging, non shattering, late maturing variety
- 50% flowering: 124 days,
- Grain type is long bold.
- Moderately resistant to leaf blast, neck blast, brown spot, sheath rot, sheath blight, RTD, BLB and GLH.
- Average yield : 4500-5000 kg/ha
- Brown rice contains 57.3 mg per kg Fe and 108.4 mg per kg Zn.

Dhruba (IET 20761)

- BNKR-2 (Dhruba) is non-lodging, non shattering, late maturing variety
- 50% flowering: 117 days
- It is moderately resistant to leaf blast, neck blast, brown spot and leaf folder
- Its average yield is 5000-5500 kg/ha and yield potential 10608 kg/ha
- Grain type is short bold

Agronomy

- Effect of seed rate and spacing under aerobic rice situation revealed that 30 kg ha^{-1} seed rate and 20 cm row spacing were promising for realizing best aerobic rice yield
- Weedy rice per cent was very low and yield loss was also negligible under western zone (Bankura, Purulia, Paschim Medinipur) of West Bengal. Manual weeding and panicle cutting of weedy rice before harvesting of paddy are the control measures recommended.
- Integrated weed management in aerobic rice - Integration of Pendimethalin @1 kg a.i./ha or Butachlor @ 1.5 kg a.i./ha at 3-4 DAS with Bispyribac-sodium @ 35 g. a.i/ha at 15-20 DAS was found effective in reducing weed menace and thus help in realizing higher grain yields that were comparable to or nearer to need based hand weeding at 10, 20, 40 and 60 DAS.

Soil science

- Study on impact of different sources of organic matter on rice soil health and yield recorded maximum grain yield (4.89 t ha^{-1}) with application of recommended fertilizer dose [N, P_2O_5, K_2O @ 80, 40, 40 kg ha^{-1}] and vermicompost [@ 2.5 t ha^{1}].
- Daransail Bhutmuri, IET 19886, Danaguri Netadhan, IET 20760, Aghonibora, Prafulla, CN 1794-2 , IET 21987, IET 21987, CN1324-913-303-BNKR 13-16-2 and CN1324-913-303-BNKR 13-16-1 were found promising for high Zn and Fe accumulation in brown rice.

BRAHMAVAR

Zonal Agricultural and Horticultural Research Station, University of Agricultural and Horticultural Sciences (UAHS), Shimoga Karnataka

The center was initiated in the year 1985 with the mandate to develop and evaluate rice germplasm/ breeding lines to meet the requirements of farmers of coastal zone of Karnataka. It is presently under UAHS, Shimoga. Evaluation of rice lines against biotic stresses with special reference to gall midge is another focus area.

Major contributions to AICRIP

Crop Improvement

Plant breeding – Varieties developed/ released

KCP-1

- Suitable for Coastal zone of Karnataka as it has best character, better grain yield, good straw yield, red rice, suitable for par btoiling etc.
- Medium duration variety, matures in about 130-145 days
- Long bold garin with a test weight of 24.5 g. Yield potential is 6-6.5 t/ ha

Champaka (IET – 14758) was released with moderate tolerance to Gall midge and Blast, medium duration (125 to 130 days), suited for mid land situation, red kernelled and performed well under rain fed condition in the farmers field with yields 45 -50 qtls/ha.

- Nomination of **IET-14845** paddy variety which is sutable for Lowland situation having high yield, better straw yield, good par boiling character as compared to Phalguna existing variety.

- Varieties in pipeline:_
  1. MO-4 selection
  2. Red rice variety resistant to pest and disease(MO-11,MO-12 and MO-13)
  3. Red rice variety short duration (MO-15)
  4. White rice variety for summer

Crop Production

- Integrated nutrient management in rice- Six year study indicated that significant highest sustainable grain and straw yield was recorded in 50% N through FYM (RNB) + 50 % through inorganic source.
- Integrated nutrient management (Organic farming) long term trial - Sixteen year long term study indicated that 50 % recommended NPK with 50 % recommended compost showed significant increase and stabilization in yield compared to NPK alone without affecting soil parameters.
- Large scale evaluation of manually operated drum seeder and power operated transplanter - Studies indicated that machine planting and drum seeder sowing proved better than direct seeding and random planting both in kharif and rabi and it is on par with line planting and also requires less labour.
- Effect of Rice Hull Ash (RHA) on Phosphorus utilization in paddy soils showed application of rice hull ash with different sources of phosphorus on grain yield of paddy differ significantly.
- Application of 72 kg of nitrogen in four splits (7.2 kg N at sowing + 28.8 kg N at early tillering + 18.0 kg N at active tillering + 18.0 kg N at panicle initiation) with recommended P & K increased the grain yield of drum seeded rice.
- Application of RHA at 2 ton/ha along with recommended NPK (P as rock phosphate) found to be superior in increasing the rice yield.
- Split application of potassium @ 60 kg/ha in three equal splits, at basal, 25 – 30 and 50 – 55 days after planting along with nitrogen for transplanted rice in midland and lowland conditions was found to give higher yields and monetary returns as compared to recommended practice.
- Weed management in sprouted rice in coastal zone found that use of Pyrazosulfuron ethyl 10 WP 250 g /ha at 3 DAS in drum seeding or broadcasted rice gave higher yield and monetary returns compared to other weed management practices.

CHATHA

SK University of Agricultural Sciences & Technology of Jammu (SKUAST-J) Jammu & Kashmir

A sub-station was established by Department of Agriculture at Ponichak, Jammu to carry out the research work on rice. Later on, All India Coordinated Research Improvement Project (AICRIP) nominated it as one of the testing center for coordinated research only that too on voluntary basis (without any financial assistance). The mandate includes breeding high yielding varieties suitable for Sub-tropical, Mid-hills, High-hills and Rainfed areas, increasing grain length of traditional varieties with desired aroma. Public and private sector rice hybrids are being tested and recommended for cultivation among the farming community.

Major contributions to AICRIP

Crop Improvement

- This rigorous screening resulted in isolation of a Japonica-glutinous rice variety **Giza 14** suitable for mid hill areas of the region where hailstorm is the problem. Because of its high yield potential and non-shattering character, farmers accepted it very readily and still cultivating it.
- With the screening of coordinated trials, one more variety viz., **IET 1410** an early maturing semi-fine variety was identified and isolated for sub-tropical areas of Jammu, Kathua, Udhampur and Rajouri districts under assured irrigation and still farmers do cultivate it.
- A number of other cultures viz., **K 39, K 78, K 343** and **K 448** were also evaluated and recommended for mass cultivation in the mid hill and high hill areas of this region.
- Subsequently with the identification of major constraints and donors resistant to various diseases, a comprehensive breeding programme was tailored for execution so as to generate location specific varieties. As a result of these concerted efforts, a semi fine medium maturity rice variety **PC 19** (**Tawi)** was isolated and released for sub-tropical areas. Later on, AICRIP was shifted to R. S. Pura to carry out rice research work on both Basmati and non basmati rice.

Varieties developed & released

Ranbir Basmati (IET 11348)

- Superfine quality rice variety
- Matures 20-25 days earlier to Basmati 370
- Less susceptible to lodging
- Yield potential - 25-30 q ha^{-1}.
- Suitable to Rajouri and Poonch districts

Saanwal Basmati (IET 15815)

- Medium tall Basmati variety of *indica* group
- Average height -140-145 cm having compact and straight panicle
- Slow senescence
- Moderately resistant to shattering
- Matures in 140-145 days
- Recommended for Basmati growing belts of Jammu & Kathua districts.

Basmati 564 (IET 17269)

- Quality parameters similar to Basmati 370 besides having good aroma.
- Resistant to lodging and other biotic stresses.
- Yield potential - 35-40 q ha^{-1}

SJR-5 (IET 19972)

- Recommended for release at national level for the states of Jammu & Kashmir, Haryana and Tamil Nadu.
- Desirable quality characters like HRR (68.25%), grain length (6.96 mm), amylose content (24.57 %) and soft gel consistency.
- Yield potential - 55-60 q ha^{-1}

Giza 14

- Japonica type rice introduced from Egypt
- Highly resistant to hailstorm
- Recommended for mid hills and hilly areas of Rajouri and Poonch districts.
- moderately resistant to blast
- Late in maturity and has short bold grains.

RR 8585 (Ajay)

- Replacement for Jaya and matures about a week earlier
- Very high tillering, has erect, broad and green leaves.
- Non lodge because of its stiff straw
- Panicle is dense and compact with good panicle exertion
- Highly resistant to BLB
- Yield potential - 60 q ha^{-1}.
- Recommended for cultivation in the sub-tropical irrigated conditions of Jammu division.

K 343, K448 and K 39

- Identified and recommended for hill ecology of Jammu region.

Some of the recent released varieties of rice released by SKUAST-Kashmir for temperate conditions Viz. Shalimar rice2, Shalimar rice3 are also cultivated in temperate conditions of Jammu region.

Crop production

Agronomy

Popularizing recent rice production technologies

- System of rice intensification (SRI) is a new technique introduced in the state. The FLD's on SRI conducted using popular cultivars have shown 15-20 % higher yield compared to the farmers' conventional practices.
- Hybrid rice - Farmers in Jammu region are growing hybrid rice very extensively and during kharif 2014 the total area under hybrid rice was more than 6000 hectares.
- Integrated nutrient management (INM) - Farmers are now aware of the judicious use of chemical fertilizers along with other green manuring crops like sesbania which is profitable to add the N requirement in rice cultivation. Generally farmers of the state are applying and incorporating FYM / compost during ploughing. Some progressive farmers are also applying calcium, magnesium and sulphur in combination with NPK.

Crop protection

Entomology

- Pest scenario of the region reveal the extent of damage of paddy nursery by grasshopper to the extent of 20-25%, while transplanted paddy was damaged up to 2-5% by rice hispa and leaf folder.

- One entry 17786 (NDR 9930029) was found resistant rice leaf folder. The parastization of Apanteles sp on C.medinalis ranged from 20-25%.
- The AICRIP paddy trials are being screened for resistance to plant pathogenic nematodes *viz., Meliodogyne graminicola, Helicotylenchus, Tylenchorhynchus,* and *Pratylenchus*.

Plant pathology

- Screening of the germplasm against different diseases is being done regularly to assess the advanced breeding lines and to identify broad-spectrum resistance to brown spot, bacterial leaf blight, sheath blight, false smut and grain discoloration.
- Among the new fungicides evaluated for controlling sheath blight, sheathmar (Validamycin), bumper (propiconazole), contaf (hexaconazole) and metominostrobin 20SC have been found superior over other test formulations.
- Besides Saaf and companion (combinations of carbendazim and mancozeb), contaf and sitara (Hexaconazoles), Indofil M-45 and metominostrobin 20SC were highly effective in checking brown spot.
- Among the biopesticide formulations, defender and florezen-P proved effective in controlling brown spot.
- Three sprays either of saaf (a combination of carbendazim and mancozeb), bavistin, contaf (hexaconazole) or result (propiconazole) at an interval of 10 days after the appearance of disease symptoms, were found effective in controlling glume discoloration in panicles and spikelets besides increasing grain yield over the untreated plots.

CHINSURAH

Rice Research Station, Directorate of Agriculture West Bengal

This rice research station was established in the year 1965 under the Directorate of Agriculture, Government of West Bengal. The objective of this station is to identify varieties suitable for irrigated and rainfed ecosystems.

Significant Achievements

Crop Improvement

- A total of forty six high-yielding varieties (HYVs) for different ecosystems have been released by the scientists of Rice Research Station, Chinsurah which are as follows:

Ecosystem	Nos. of varieties	Name of the variety released
Rainfed upland	6	Panke, Bhupen, Jamini, Khanika, Kiron and Puspa
Irrigated upland / medium land	7	Shatabdi, Khitish, CNRH-3, Kunti, CNM-25, CNM-31 and Lakshmi (CNM-6) , CNRH 3 (Hybrid)
Rainfed shallow	8	Jogen, Bipasa, Sashi, Giri, Kaushalya , Kanak, Dhiren and Sujala
Rainfed semideep	17	Sabita, Purnendu, Amulya, Sudhir, Nalini, Biraj, Suresh, Mandira, Matangini, Golak, Saraswati, Bhagirathi, Bhudeb, Hanseshwari, Ambika, Mahananda and Sunil
Rainfed deep	6	Jaladhi-1, Jaladhi-2, Jalaprabha and Neeraja Jitendra, Dinesh
Hill region	2	Kalimpong – 1 and Munal

- Varieties in pipeline: Aromatic varieties viz. IET 21250, IET 21261 (long slender), IET 21845, IET 21850 and IET 21847; rice hybrids viz. CNRH 102 and CNRH 103.

Recently identified varieties in SVRC include:

IET 22066 (Ajit)

- Early maturing type
- Duration: 108 - 110 days
- Average yield: 5032 kg/ha
- Can also be cultivated in boro (average yield 5500 kg/ha)

IET 17713 (CN 1039-9: Rajdeep)

- Suitable for semi-deep situation (40-70 cm depth of water)
- Long duration: 155 days
- Average yield: 4500-5000 kg ha^{-1}
- Tolerant to sheath blight, sheath rot, stem borer and leaf folder.

IET 23403 Chinsurah Nona 1 (Gosaba 5)

- In Farmer's field at 6 EC, Gosaba 5 recorded 4200 kg/ha
- Good grain quality with 58% head rice recovery

- More than 1200 germplasm are regularly being maintained, characterized and evaluated for better utilization and documentation.
- Three hybrids (CNRH 103, 104 and 105) are in pipeline. Shatabdi A (a CMS line from Shatabdi) has been developed.
- Aromatic entries IET 21261, IET 21549, IET 21845 and IET 21847 lines have average yield potential of 4.5 - 5.5 t/ha with slender grain and showed yield advantages of 20-35% over Basmati entries. The iron-rich rice varieties, Jayasilet, Chapakhushi and Seetabhog, having 4-5 times higher Fe content (40-50 mg/kg of polished rice) than the popular HYVs have been identified.

- In collaboration with CSIR-NBRI, Lucknow, a few low grain arsenic accumulating rice varieties viz. CN 1646-2, CN 1646-5, CN 1643-3 and IET 19226, safe for human consumption have been identified.
- In collaboration with C-DAC, Kolkata, software dependent electronic vision (E-Vision) & electronic nose (E-Nose) system have been developed for quality assessment of aromatic rice in non-invasive & time-saving methods. The instrument is very useful for detecting adulteration in rice.

Crop Production achievements

Agronomy

- Recommendations were made for seedling raising, seedling age, time of transplanting, stand establishment, seedling uprooting, no. of seedlings, spacing for high yield varieties, aromatic rice, boro rice for *kharif* (Aman) season. For obtaining higher yields, application of 100% N through organic sources or 50% recommended fertilizer dose (RFD) + 50% N through FYM is effective.
- Split application of N and K_2O was found effective in improving nutrient use efficiency. Use of sulphur coated urea (SCU) or incubated mud ball was advocated as slow release N-fertilizers in low-lying areas. Studies on recommended fertilizer dose for HYVs, hybrid rice, aromatic rice, semi deep and deep water rice were conducted.
- *N-fertilizer substitution:* Basal application of FYM at 5 t ha^{-1} in conjunction with two top dressings of green foli age of *Glyricidea maculata* at AT and PI stages at 2.5 t ha^{-1} resulted in 1 t ha^{-1} of more grain yield over control. On an average, 10 kg of organic matter (compost + green foliage) gave an extra yield of 1 kg grain.
- Zn nutrition: Besides adding recommended dose of NPK fertilizers, basal application of either $ZnSO_4.7H_2O$ @ 25 kg ha^{-1} or $ZnSO_4.H_2O$ @ 15 kg ha^{-1} has widely been accepted for state as well as national recommendations in Zn-deficient areas.
- Integrated nutrient management: Advocated to follow an INM practice involving green manuring / green leaf manuring + Azotobacter or vermicompost along with 75% RFD for economizing and sustaining rice farming. Green manuring with Dhaincha in rice can substitute 40 kg inorganic N ha^{-1}.

Weed management:

- In nursery, *a*n optimum dose of Metamifop 10 EC (100.0 g ha^{-1}) as post-emergence (POE) application at 12-15 days after sowing (DAS) or 2-3 leaf stage of grasses has been found to be safe and effective weed management tool.

- In direct seeded rice (DSR), POE application of Metamifop 10 EC (100 g ha^{-1}) at 12-15 DAS (or 2-3 leaf stage of grasses) or Cyhalofop butyl 10 EC (100 g ha^{-1}) at 15 DAS is recommended.
- In normal transplanted rice (NTR), Penoxsulam 24 SC at higher dosage of 0.025 kg ha^{-1} as pre-emergence (PE) at 5 DAT / lower dosage of 0.020 kg ha^{-1} as POE at 10 DAT or bispyribac sodium 10 SC at higher dose of 50 g ha^{-1} as POE at 15 DAT is recommended.
- Application of Flucetosulfuron 10 WG at 0.025 kg ha^{-1} at 2-3 DAT + bispyribac sodium 10 SC at 0.025 kg ha^{-1} at 15-20 DAT is more effective for broad spectrum weed management in both direct seeded and normal transplanted rice.

Crop establishment methods:

- *Drum seeded rice:* Direct wet seeding using plastic drum seeder has been found to record about 21% higher yields over farmers' practice in *boro* season.
- System of Rice Intensification (SRI): Field investigations as well as frontline demonstrations (FLDs) clearly showed about 15-20% yield advantage in SRI, compared with input-intensive NTR in different parts of West Bengal.
- *Double transplanting:* In case of delayed planting in water-logged areas, double transplantation of rice seedlings reduces the seedling mortality and increases the yield levels in *kharif*.
- Conservation agriculture: Zero tillage (ZT) has recorded yield improvement up to 10-15%, even in drought season. ZT was found at par with minimum tillage (MT) and both of them recorded significantly lower yields than conventional tillage. Thus, reduced tillage systems (ZT and MT) are rice productivity inhibitive.

Soil science

- *Growth studies of Azolla*: Maximum rate of *Azolla* multiplication was found in August-September and it can be utilized as a partial substitute for N-fertilizers in rice cultivation during *kharif*.
- *Synchronization of potassium supply for rice hybrids:* Split application is advantageous for light textured soils whereas it has no advantage in heavy textured clayey soil having high available K status.
- Influence of soil and nutrient related parameters on aromatic rice: Integrated use of green manure (dhaincha) and 50% inorganic NPK or only use of 100% inorganic NPK along with spraying of cycocel (ccc) at 500 ppm + surfactant (twice) would be an effective nutrient management practice with regard to achieving higher productivity as well as better nutrient uptake in aromatic rice varieties.

- Inclusion of biofertilizer: Use of biofertilizers like Azotobacter and phosphate solublising bacteria can save up to 25% of N and P_2O_5 and also can increase the productivity as well as uptake of nutrients. The effect was more prominent in boro than that in kharif.

- *Germplasm screening for Zn & Fe:* Local germplasm like Jamainadu, Kaminibhog, Dudswar, Banskathi, Medi, Gopalbhog, Ghandheswari and Nadu and some of the HYVs like Khitish, IR 36, ADT 36, ADT 43, Pavizham, Prafulla, Vasumathi, Shalimar rice 1, NDR 6279, Aghoni bora and MTU 3626 have been found promising for their Fe and Zn content.

- *Soil-test based fertilizer recommendation & SSINM:* Based on soil test values, the recommended fertilizer doses for soils having medium fertility status in different rice growing seasons are given in Table below.

Season	RFD ($N:P_2O_5:K_2O$ in kg ha^{-1})	Time of application
Aus (Pre- kharif)	70-35-35 (HYV)	Basal: ¼ N + Full P_2O_5 + Full K_2O 1st TD: ½ N (at AT) ; 2nd TD: ¼ N (at PI)
Aman (Kharif)	80-40-40 (HYV)	Basal: ¼ N + Full P_2O_5 + Full K_2O 1st TD: ½ N (at AT); 2nd TD: ¼ N (at PI)
	90-45-45 (Hybrid)	
Boro	130-65-65 (HYV)	Basal: ¼ N + Full P_2O_5 + ¾ K_2O 1st TD: ½ N (at AT); 2nd TD: ¼ N + ¼ K_2O (at PI)
	150-75-75 (Hybrid)	

AT: Active tillering; HYV: High-yielding variety; PI: Panicle initiation; RFD: Recommended fertilizer dose; TD: Top dressing

Crop Protection Technologies

Entomology

- *Chinsurah Type Light Trap* has been developed by modifying Rothamsted light trap. This is a very popular and most widely used light trap.

- *Screening of promising entries*: Identification of resistant/ tolerant advanced rice lines has been done against different insect-pests

Chinsurah Type Light Trap

- *Nursery and early pest control: Granular application of cartap, fipronil and carbofuran in seed bed was found effective against insect pests of rice. Seedling treatment+ soil drenching was at par with granular application of different insecticides.*
- *Evaluation of new generation insecticides:* Spinosad 45% SC, flubendiamide 20 WG, acephate 75% SP, fipronil 66% WG, rynaxypyr and their combination products were found effective against stem borer incidence throughout the crop growth stage. Dinotefuron 20 SG, buprofezin 25 SC and imidacloprid 40% were very effective against sucking pests.
- *Trap crop:* Stem borer damage in terms of dead heart and white heads was comparatively lower when the main crop, Swarna (MTU 7029) was grown along with Pusa Basmati 1 as trap crop during *kharif* season.
- *Effect of cultivation techniques:* SRI is most effective in reducing the pest population and conserving natural enemies as well as enhancing the yield. Low white head and high dead heart attack were recorded in direct seeded rice as compared to normal transplanted rice.
- *Pesticide compatibility test*: Rynaxypyr + hexaconazole, flubendiamide + isoprothiolane, spinosad + carpropamid and acephate + tricyclazole were effective in minimizing the population of stem borer.

Plant pathology

- Host plant resistance: Evaluation of rice cultivars against major diseases like leaf blast, bacterial leaf blight, sheath blight, sheath rot, brown spot and tungro has been done. Several rice cultivars identified include: a) Leaf blast: Jalaprabha, Jaldi dhan-13, Jamini Mahananda, Jitandra, Manasarovar, Swarnadhan, Tulsi, Neeraja, (Resistant) and Prakash, CNM-25, CNM-31, Golok, Kisan, Kunti, Lakshmi, Munal (Hill), Neeraja, PNR 519, Saraswati, Sashi, Parijat, Pratikshya, Pratap, Savitri, Triguna, Amulya, Anamika, Suresh. (Moderately resistant); b) Bacterial leaf blight: Bhudeb, Utpala, IET- 849, Sabita. (Resistant) and, Lakshmi, Kisan, CNM-31, Daya, Prakash, Neeraja, Manasarovar, Tulasi, Amulya, Anamika, Sashi, Khitish (Moderately resistant); c) Sheath blight: Bhudeb, Giri, Dinesh, Jalaprabha, Jamini, Swarnadhan, Khanika, PNR 519, Munal, Saraswati, Utpala, , Pratikshya, Amulya, Manasarovar (Moderately resistant); d) Sheath rot: Jalamagna, Rassi,Dinesh (Moderately resistant); e) Brown spot: Neeraja, Swarnadhan, Purnendu, Kunti, Lakshmi, PNR 519, Khanika (Moderately resistant); f) Rice tungro: Dinesh (Ressitant) and Golok, Jamini, Manasarovar, Swarnadhan, Tulsi, Amulya, Lakshmi, Saraswati, Utpala, Rajdeep (CR 1039-9) (Moderately resistant).
- Disease Monitoring: a) Isolates (X. oryzae pv oryzae) collected from Chinsurah and Pandua block of Hooghly District were not virulent against-IRBB entries possessing resistant genes namely Xa5, Xa8, Xa13, Xa21,Xa4 +Xa21, Xa5+Xa13,

Xa5+Xa21 or Xa4+ Xa5+Xa13+Xa21. These may be incorporated in the breeding programme, to combat the bacterial blight problem.

- *Management of rice diseases:* It includes development of rice varieties resistant/ tolerant against major diseases, and evaluation of effective bio-pesticides, botanicals and chemical fungicides against major diseases.

  - Sheath blight: Three foliar applications of the following fungicide at 10-12 days interval immediately after appearance of the disease were found effective and recommended i) Hexaconazole 75WG @ 0.13g/l ii) Metominostrobin 20S @2.0ml/l iii) Trifloxistrobin25%+ Tebuconazole 50% @ 0.4g/l iv) Propiconazole25EC @1.0ml/l v) Validamycin 3L@ 2.0ml/l vi) Hexaconazole 5SC+ Captan70% @ 1.5g/l vii) Pencycuron 250EC @ 2ml/l viii) Tebuconazole 25EC @ 1.5 ml/l ix) Azoxystrobin 25SC @1.0ml/l

  - Sheath rot: The following fungicides at heading and milk to soft dough stage were found effective and hence recommended i) Metominostrobin 20S @ 2.0ml/l ii) Hexaconazole 75WG @ 0.13g/l iii) Hexaconazole 5SC @ 2.0ml/l iv) Propiconazole 25EC @ 1.0ml/l v) Kresoximmethyl 40% @ 1.0ml/l vi) Kresoxim methyl 40% + Hexaconazole 8%WG @ 1.0ml/l vii) Azoxystrobin 25SC @ 1.0ml/l

  - Glume discolouration disease: Two foliar applications of the following fungicides at heading and milk to soft dough stage were found effective and hence recommended i) Propiconazole 25EC @ 1.0ml/l ii) Flusilazole12%+ Carbendazim 25% @ 2.0 ml/l iii) Thiafuzamide 24SC @ 0.45ml/l iv) Hexaconazole 5SC@ 2.0ml/l

  - Rice tungro disease: Three foliar applications of the following insecticides at nursery bed, 30DAT & 45DAT were found effective and hence recommended i) Imidacloprid 200SL @ 0.25ml/l ii) Chlothianidin 50WDG @ 0.06g/l iii) Thiamethoxam 25WG @ 0.2g/l iv) Thiamethoxam 25WG + Lamda cyhalothrin 2.5EC @ 0.1g/l+ 0.5ml/l, respectively v) Buprofezin 25WP + Deltamethrin 100EC @ 0.25g/l+ 0.1ml/l, respectively.

  - Damping off and seedling mortality disease in nursery bed: For effective control of damping off and seedling mortality disease in nursery bed during cool weather, both wet seed treatment and seedbed treatment with Metalaxyl 8% + Mancozeb 64% @ 2.5g/l was found effective.

  - Control of Sheath blight disease, stem borers and leaf folder infestation: Effect of combined formulation Flubendamide 3.5%+ Hexaconazole 5% WG @ 1.0ml/l against sheath blight disease, stem borers and leaf folder infestation indicated that three foliar applications of the formulation at 10-12 days interval immediately after appearance of the disease/insect infestation were found effective and hence recommended.

- Pesticides/Botanicals (Phytopesticide):- Effect of the following biopesticides/botanical (Phytopesticide) has been evaluated against sheath blight disease indicated that seed treatment, seedling dip followed by three foliar applications at 10-12 days interval immediately after appearance of the disease were found effective i) Spictuf 4.5ml/l ii) Elorezen-P 2.5g/l iii) Biotos 2.5g/l iv) Liquid formulation of Pseudomonas fluorescens.
- Initiated adaptive research on botanicals, 300 ppm azadirachtin followed by 1500 ppm azadirachtin spray during afternoon hours 4pm @4.5 ml /l may be recommended to the farmers for ecofriendly management of sheath blight.

CHIPLIMA (SAMBALPUR)

Orissa University of Agriculture and Technology Odisha

AICRIP center at this location was initiated in 1971 under OUAT, Chiplima with the major mandate of breeding medium duration varieties for irrigated ecosystem. It was also a hot spot location for gall midge.

Brief summary of major contributions

Crop Improvement

Varieties developed and released from this center:

Variety	IET No.	Parentage	Year of Release (Noti-fication)	Average Yield (Q/Ha)	Ecosystem
Lalat (ORS 26-2014-4)	9947	OBS 677/IR 2071-625// Vikram/W1263	1988 (1989)	42.00	Irrigated Mid -Early
Meher (ORS 26-2008-4)	9849	OBS 677/ IR 2071-625// Vikram/W1263	1992 (1994)	40.00	Irrigated Medium
Pratikshya (ORS 201-5)	15191	Swarna/IR-64	2005 (2006)	50.00	Irrigated Medium
Siddhanta (ORS 102-4)	15296	Jajati/Annapurna	2005 (2006)	30.00	Rainfed Upland

- **Suitable rice varieties identified for different ecosystems:** After evaluation at AICRIP, Chiplima, the following high yielding varieties were identified and released by OUAT, for cultivation in different ecosystems in the West Central Table Land Zone of Odisha.

Upland	Khandagiri, Udayagiri.
Medium Land	Bhoi, Gajapati, Konark, Surendra, Kharavela and Sebati
Low land	Mahanadi, Indravati, Prachi and Ramchandi

Hybrid Rice Evaluation: Hybrid rice varieties like BS 025 (6155 kg/ha), Ajaya (4778 kg/ha), PHB 71 (4917 kg/ha) and Rajlaxmi (5130 kg/ha) have been found suitable for West Central Table Land Zone based on their performance.

Local Land Races Evaluation: Forty seven local land races of rice collected from the districts of Bargarh and Sonepur have been characterized.

Germplasm Maintenance: One hundred forty nine non-aromatic and seventy eight aromatic accessions of germplasm are being maintained.

Crop Production

Agronomy

The following herbicides were found effective for weed management in different ecosystems:

- Transplanted rice: Butachlor 50EC @1.0 kg a.i. /ha (800ml/acre) or Butachlor 50EC + 2, 4-D PE 32 EC@ (1.0+0.4) kg a.i/ ha (800ml +500ml/acre) or Butachlor +Almix (750 ml +20gms / acre).
- *Upland condition:* Pendimethalin 30EC @ 1kg a.i. / ha at 7days after rice emergence followed by 2, 4-D Na salt 80 WP @ 0.6 kg a.i./ha at 25 days.
- Direct sown puddled rice: Mixture of Butachlor + Safener @ 1.5 kg a.i. /ha at 3 days after sowing (DAS) is the most effective.

Intercropping in rice under rainfed upland condition: Out of three rice groundnut combinations (2:1, 3:1 and 4:1), intercropping of rice with groundnut (Var. OG 52-1) in 2:1 ratio was superior in land equivalent ratio (LER) and net returns giving maximum profit than sowing of sole rice (Var. Parijat).

- Sowing of sprouted seeds of rice by using 8-row drum seeder just one day after puddling, use of herbicide, Butachlor at 4-6 days after sowing and one hand weeding at maximum tillering stage is the best practice for direct seeding to get higher yield (4.7 t/ha).
- Application of NPK @ 40:20:20kg/ha (50% of the recommended dose) along with F.Y.M. @ 5 t/ha recorded maximum grain yield (2.6 t/ha) in rainfed upland rice.

- Basal application of Sulphur Coated Urea (SCU) or root zone placement of Urea Super Granules (USG) @ 87 kg N/ha recorded superior grain yield and was found to be remunerative than split application of prilled urea.

Package of practices for hybrid rice: To get higher yield from hybrid rice varieties viz., DRRH – 1, PA – 6201, PHB-71 and PAC-831, practices to be followed include seed density @ 10-20 g/m^2 of nursery, use of 2 seedlings/hill, timely planting with 120:60:60 kg NPK/ha + 25kg $ZnSO_4$/ha, application of 50% of N as basal, 25% N at tillering and 25% N at booting stage as prilled urea.

Crop Protection

Entomology

- Among the botanicals tested against rice pests, neem products like Rakshak @0.05% or Neemazol @0.3% or Econeem @0.5% effectively controlled plant hoppers. Pheromone traps @ 8/ac (1 for 500 m^2) can be used to reduce stem borer attack in rice field.
- Application of Fipronil 0.3G @ 15 kg/ha or Isazophos 3G @ 33.3 kg/ha or Carbofuran 3G @ 33 kg/ha 5 days before pulling seedlings control early stage pests like stem borer, gall midge, whorl maggot in transplanted rice.
- Among the new molecules tested Flubendiamide 20 WDG @ 175 g/ha is effective against stem borer. Dinotefuron 20 SG @ 200 g/ha against plant hoppers. The combination product (Flubendiamide+Buprofezin) 20 SC @ 875ml/ha was best against plant hoppers and stem borer. Cartap hydrochloride 50SP @ 1gm/l and Rynaxypyr 20 SC @ 0.3 ml/l were very effective against stem borer, leaf folder and case worm insects.
- Spinosad 45 SC (1ml/l)+ Carpopramid (0.25 g/l) and Buprofezin 20 +Acephate 50%WP in combination with Tricyclazole 75 WP were effective against stem borer and blast without any phytotoxicity. Imidacloprid 200 SL (0.25ml/l)+Propiconazole 25 EC (1ml/l); Imidacloprid 200 SL (0.25ml/l)+Validamycin 3L (2.5ml/l); Thiamethoxam 25 WG (0.2g/l) + Propiconazole 25 EC (1ml/l); Thiamethoxam 25 WG (0.2g/l) + Validamycin 3L (2.5ml/l) were all effective against brown plant hopper and sheath blight on rice without any phytotoxicity.
- The IPM module developed for this zone includes summer ploughing during May, use of gall midge resistant variety like lalat or pratikshya and transplanting within 15th July, nursery application of Furadan 3G @1 kg a.i./ha or Cartap 4G @ 1 kg a.i./ha 5 days before pulling the seedlings, use of pheromone trap @ 8/ac, application of conventional pesticides like chlorpyriphos or monocrotophos @ 500 ml/ha against stem borer, gall midge, leaf folder once or twice during vegetative period depending up on the ETL and need based application of Ethofenprox (500ml/ha) or Imidacloprid (125 ml/ha) or Buprofezin 25 EC @ 500 ml/ha against plant hoppers at late vegetative/reproductive stage.

Plant Pathology

- Seed treatment with Bavistin or Chlorothalonil followed by foliar spraying with Bavistin 50 WP @ 1g/l during active tillering and panicle initiation stages of the crop were recommended against leaf and neck blast, brown spot, sheath rot and sheath blight diseases for better grain yield.
- Use of Plantomycin, Carbendazim and Copper oxychloride mixture in proportion of 1:1:2.5 g/l was recommended against disease complex of blast, BLB & sheath rot. In BLB endemic pockets, use of resistant or tolerant varieties like daya, pratap, ananga, bhuban & lalat were recommended.
- Application of Tricyclazole (Beam 75 WP) @ 0.6g/l, thrice at maximum tillering, panicle initiation & milking stage was found effective against leaf and neck blast in rice. Application of combination of granular formulations of Coratop 5 G or Kitazin 17 G @ 40kg/ha at active tillering stage followed by one spraying with Bavistin @ 1g/l at boot leaf stage minimized the leaf & neck blast intensity in the main field without any seed treatment or nursery treatment.
- Application of Propiconazole (Tilt 25 EC) @ 1ml/l or Chlorothalonil 40 SC @ 2ml/l or ATEMI 50 SL @ 2ml/l of water at boot leaf stage twice at 15 days interval controlled the initial disease infection of false smut.
- Seed dressing with Fongorene 50 WP @ 4g/kg seed and foliar spraying of Fongorene on appearance of blast disease, at tillering and boot leaf stage was most effective in controlling leaf and neck blast.
- Rovral 50 WP @ 1g/l at initial sheath blight appearance or nursery application of Validacin 3L @ 2ml/l, 3 days prior to uprooting or application of Chlorothalonil 75 WP @ 1g/l proved effective in controlling sheath blight disease.
- Four spraying of RIL-FA 200 SC (Kresoxim methyl) @ 1.25 ml or Amistor 25 SC (Azoxystrobin) @ 1ml at 10-12 days interval starting from first appearance of blast disease effectively controlled leaf and neck blast with 6-30% higher yield. Two sprayings of Amistor 25 SC (Azoxystrobin) @ 1ml or Flusilazole @ 0.5 ml /l at appearance of sheath blight and 10 days after could effectively control sheath blight disease with 14-16% higher yield.
- A ready mix formulation of Flubendiamide 3.5 % + Hexaconazole 5 % WG (RIL -060/F_1 8.5 WG) @ 2g/l was found compatible and equally effective to control sheath blight, stem borer and leaf folder. Trifloxystrobin 25%+Tebuconazole 50% (Nativo75WG) @ 0.4g/l were found effective for both leaf blast & sheath blight.

COIMBATORE

Department of Rice, Centre for Plant Breeding and Genetics
Tamil Nadu Agricultural University
Tamil Nadu

The Department of Rice, previously known as "Paddy Breeding Station" is a constituent of the Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore established in 1912 and is the oldest rice research station in the modern India.

Analysis of head rice recovery using hand operated rice mill

Major Contributions to AICRIP

Crop Improvement

Varieties/hybrids identified/released

The contribution of this department after AICRIP includes 20 rice varieties and four hybrids which have remarkably improved the rice cultivating horizon of the state.

Latest varieties released include:

CO (R) 50 – A CVRC release CO (R) 50 is the new plant type rice variety released by Central Variety Release Committee for South India. On an average the variety produces 7.0 tons per ha but often farmers harvest 10.0 tons per ha.

Rice CO 51: Recently released high yielding short duration variety is matching with the demands of the farmers across the state to have fine rice, multiple resistant and high yielding variety with resistance to blast and BPH. It has superior grain and cooking quality and fetches good market price.

CR 1009 sub 1- A submergence tolerant rice variety for the regions of the tail end of coasted delta districts namely Thanjavur, Tiruvarur, Nagapattinam of Tamil Nadu states about 1-1.5 lakh ha is affected by submergence.

CORH 3 – Notified hybrid for all over India is creating bench mark in rice productivity among the early maturing breeds by often yielding 10.0 tons per ha.

TNAU Rice Hybrid CO4 – A CVRC release is one of the first medium slender rice hybrid from the public sector. Gujarath State Seed Corporation and M/s Rasi Seeds Pvt. Ltd are marketing this hybrid on an MOU with TNAU.

List of rice varieties released in Coimbatore post inception of AICRIP

Varieties	Year	Duration	Special Features
CO 33	1970	105	Short, round grain, non lodging
CO 34	1970	115	Heavy yielder, wider adaptability
CO 35	1970	100-105	Early, high yielding
CO 36	1973	130	Photo-thermo insensitive
Bhavani*	1973	130-135	Direct introduction, long slender quality rice
CO 37	1974	115-120	Resistant to sheath blight, wider adaptability
CO 38	1975	145-150	Blast resistant
CO 39	1975	90-95	Short duration
CO 40	1977	165-175	Heavy yielder, tolerant to blast
CO 41	1979	100-105	Fine rice, low nitrogen responsive
CO 42	1979	135-140	Tolerant to BPH
CO 43*	1982	135-140	Fine grain, tolerant to alkalinity and salinity
CO 44	1983	130-135	Suited for late sown conditions
CO 45	1990	135	Resistant to blast, BLB and RTV
CORH 1	1994	115	First hybrid rice in India, medium slender rice
CO 46	1997	125-130	BPH resistant
CORH2	1998	135	Medium slender white rice non lodging tolerant to alkalinity & salinity

CO 47*	1999	110-115	Medium slender white rice resistance to blast.
CORH 3*	2006	115	First non-aromatic good grain quality rice hybrid.
CO (R) 48*	2007	135	Moderately resistant to blast. Suitable for thaladi season
CO (R) 49*	2008	135	Fine quality, medium slender white rice. Suitable for thaladi season.
TNAU Rice CO 50*	2010	135-140	First 'super rice' - new plant type attributes. Yields 7.0 tons/ ha on an average and resistant to blast.
CORH 4*	2011	130-135	It is a medium duration (130 - 135 days) rice hybrid
CO (R) 51*	2013	105	Resistant to blast and BPH
CR1009Sub 1*	2015	145	Tolerate up to 15 days of submergence when compared with CR 1009

Accomplishments through AICRIP – Crop Improvement

Sl. No	Particulars	Products / Numbers
1	Number of varieties/hybrids released	20 varieties & 4 hybrids
2	Number of CVRC release	One variety CO 50 & One Hybrid CORH 4
3	Number of Entries nominated	169 for the past 15 years
4	Number of entries promoted	46 for the past 15 years
5	Resistant donors identified for biotic stresses	95 for the past 15 years
6	Resistant donors developed & identified for abiotic stresses	16 for the past 15 years
7	Germplasm Enrichment through AICRIP	3500
8	Popularization of technologies	1907
9	Training activities conducted	3162 Beneficiaries

Crop Production

Agronomy

- *Standardization of seed rate:* Based on the duration groups, seed rate was standardized for short duration (60Kgha^{-1}), medium duration (40Kgha^{-1}), long duration (30kgha^{-1}) and hybrids (15 Kgha^{-1}) for transplanted puddled rice.
- *Seed treatment:* includes treatment with Carbendazim or Pyroquilon or Tricyclozole solution; treatment with *Pseudomonas fluorescens*; seed treatment with biofertilizers.
- *Optimum age of seedlings:* For quick establishment found to be 18-22 days for short, 25-30 days for medium and 35-40 days for long duration varieties.

- *Root dipping with biofertilizers*: *Azospirillum* and Phosphobacteria or Azophos inoculant in 40 litres of water for 15 - 30 minutes before transplanting was standardized.

- **Weed management:** Pre emergence herbicide formulations were standardized viz., pretilachor at 1.0 kg a.i. ha^{-1} on 3 DAT + weeding with Twin row rotary weeder at 40 DAT; Pyrazosulfuron ethyl 10 % WP @ 150 g ha^{-1} on 3 DAT + hand weeding (HW) on 45 DAT; Butachlor 0.75 kg a.i. ha^{-1} + bensulfuron methyl 50 g ha^{-1} on 3 DAT + HW on 45 DAT; Oxadiazon 87.5 g a.i. ha^{-1} followed by Post emergence (POE) 2,4-D 1 kg a.i. ha^{-1} along with hand weeding on 35 DAT; PE butachlor 0.75 kg per hectare + bensulfuron methyl 50 g ha^{-1} on 3 DAT followed by mechanical weeding on 45 DAT is effective for broad spectrum weed control. Post - emergence herbicide, Bispyribac Sodium 50 g a.i/ha found to be effective

- **Evaluation of different crop establishment methods for increasing the yield in transplanted rice:** Drill seeding method recorded significantly higher grain yield followed by broadcasting method. SRI method gave 20 per cent higher grain yield over standard transplanting at Coimbatore. Among the crop establishment methods tried SRI method recorded the highest grain yield followed by Integrated Crop Management. In a study on evaluation of age of seedlings, nutrient, weed and water management practices under SRI system, it was found that higher yields could be realized when all the package of practices were adopted under SRI.

- **System of Rice Intensification:** Planting of 15 days old seedlings combined with four times cono weeding recorded higher grain yield. The studies on long term effects of nutrition on SRI vis a vis conventional flooded rice in rice+ rice cropping system revealed that rice crop under SRI method of establishment recorded higher grain yields. Direct seeding with SRI was also found to be promising as compared to conventional transplanting. SRI with 100% recommended inorganic fertilizers recorded higher grain yield and was comparable with 50 % inorganic + 50% (equivalent of N dose) organic.

- Standardization of agro techniques for indigenous aromatic rice; package of practices for hybrid rice, rotational irrigation under puddled direct sown condition and selective mechanization for enhancing productivity and profitability of rice cultivation have been worked out.

Plant Physiology

- The parental lines BRB223-2-2-2-1R, C10R, IR58103-62-3R, PMS10B, IR 60821-34-13R and IR65515-47-2-19R identified as physiologically efficient high yielder based on optimum LAI, higher CGR, more dry matter, high stem thickness, higher chlorophyll, soluble protein, grain yield and harvest Index. So these genotypes can be utilized as parental lines to develop hybrids.

- Spent wash and GA_3 (30g ha^{-1}) + BR (0.3 ppm) combination spray resulted in better panicle exertion in hybrid rice. By delaying sowings, number of days for attaining panicle initiation stage was reduced by 6 days, while the reproductive and grain filling (ripening) period got increased by one day.
- Identified suitable donors with higher Fe and Zn content in grain viz., Jaya, Mandya vijaya, HRRH-1094 and Mugadh sugand. The variety BPT 5204 was found to possess good responsiveness to three nitrogen levels (0, 100 and 200 kg/ha) with higher yield. This was closely followed by other hybrids Ajaya, PA 6444, KRH 2 and NDR 359.
- Node number as a developmental indicator for identifying the panicle initiation (PI) stage under different cumulative degree days (CDD) and cumulative nyctoperiod (CNP) conditions under photothermic study identified IET 20924, IET 21113, IET 21119 cultures as promising.
- Hybrid CORH 3 (4.5 %) and Naveen (6.2 %) had lower yield reduction under intermittent irrigations and may be recommended for water scarce areas of intermittent irrigation.

- In silicon treatments, combination of both foliar spray as Na silicate (0.5%) and silicon solubilizer-carrier molecule imidazole (0.2%) influenced lower light transmission ratio (8.3) and higher leaf area index (5.8) at 50 % flowering there by increased biomass accumulation during cropping period. Among 14 wild species, O. rufipogon. O, punctata and O. longistaminata exhibited highest photosynthesis, and

O. rufipogon was the best wild resource species for improving photosynthesis among all species tested.

Crop protection

Entomology

IPM module was developed and recommended the following practices

- Pseudomonas fluorescens – Seed treatment (10 g/kg), seedling dip (2.5 kg/ha), main field application (2.5 kg/ha)
- Pest and disease management in nursery (preferably neem seed kernel extract 5% or Neem oil 2%)
- Integrated nutrient management - use of neem cake coated urea (5 : 1); inclusion of green manures / biofertilizers; 'N' management by Leaf Colour Chart (LCC); 'K' application: basal (50%) + one top dressing (50%); Adoption of cultural practices.
- Variety selection, spacing based on season, location (endemic / hot spot); Rogueing space (1' for every 8').
- Water management – alternate wetting and drying and submergence at recommended level during critical periods only.
- Release of biocontrol agents, when the moth activity is noticed; Trichogramma japonicum for stem borer @ 1,00,000 (5 cc) ha-1 at weekly interval for 3 times, T. chilonis for leaffolder @ 1,00,000 (5 cc) ha-1 at weekly interval for 3 times

- Set up bird (owl) perches @ 40 to 50 ha^{-1}
- Neem seed kernels extract application - 5% against leaffolder.
- ETL based insecticide / fungicide application (no synthetic pyrethroids)
- Integrated rodent management includes narrow bund maintenance (45 x 30 cms), zinc phosphide baiting (49 : 1) & baiting with bromodialone, trapping with Thanjavur bow trap (100 nos./ha)

Pest scenario & Species complex

- During 2008, two outbreaks have been recorded. BPH outbreak in Gobichettipalayam area in ASD 16 nearing harvest (August end), cut worm caterpillar (Mythimna separata) outbreak in Pudukottai.
- During 2009, severe outbreak of planthoppers was noticed at Bhavani taluk

over an area of 4000 acres. Stray reports on such outbreaks were also reported in other places of Tamil Nadu and these are mainly due to improper use of insecticides.

- There was increase in planthoppers and stem borer incidence throughout the state, especially during October- November of 2010.
- Among the species complex of rice stem borers, yellow stem borer, Scirpophaga incertulas was predominant during vegetative, tillering and milky stage coinciding the months of October, November and December while pink borer population was more after January up to second week of February.

Non-chemical approaches of pest management

- Identified an efficient strain of Beauveria bassiana (B2) against rice pests and the formulation is given for testing under AICRIP in few centers.
- Field testing of Beauveria against leaffolder indicated that incidence was at par with profenophos treatment (3.79 -10.36 %) compared to 15.86 % in untreated check. Yellow stem borer incidence was also comparable with that of standard insecticide.
- Under SRI system, incidence of stem borer was found to be low in both CORH 3 (hybrid) and ADT 43 (High yielding variety) compared to normal planting while gall midge incidence was found to be more under SRI in CORH 3 than normal planting.
- Stem borer incidence was less in the direct sown crop compared to normal planting.

Evaluation of new chemicals for insect pest management

- Evaluated new insecticide molecules flubendiamide, chlorantraniliprole, imidacloprid, thiamethoxam and several combination products against rice pests and new acaricide molecules like diafenthiuron, abamectin spiromesifen etc.
- Conducted physical and chemical compatibility of new insecticide molecules with new fungicide molecules viz., Imidacloprid, thiamethoxam, flubendiamide, spinosad with isoprothialone, carpropamid and tricyclozole.
- Sulfoxaflor was found superior to standard check Monocrotophos in checking the planthopper population. Combination product Buprofezin + Acephate @1000g/ha was found effective against BPH and recorded higher yield.
- Benfuracarb 40 EC sprayed @ 500 g ai ha^{-1} recorded the lowest incidence of BPH, GLH, stem borer and leaffolder and found comparatively safer to spiders and coccinellids.

- Flubendiamide 20 WDG (0.25g/l) and Spinosad 45 SC (0.25g/l) were physically and chemically compatible with Isoprothiolane and Carpropamid when mixed with @1.5 and 1.0 ml/l, respectively without causing any phytotoxic symptoms on rice plants and found effective against stemborer, leaffolder and blast.
- Acephate 95 SG @1.2 g/l and dinotefuron 20 SG @ 0.4g/l were physically and chemically compatible with hexaconazole 2.0 ml/l and tricyclazole @ 0.6ml/l and effective in checking planthoppers.
- Rynaxypyr (Coragen 20 SC) @ 0.30ml/l and Ethiprole + Imidacloprid (Glamore 80 WG) @0.25g/l were physically and chemically compatible with Tricyclozole (Baan 75 SP) @0.6g/l and Hexaconazole (Contaf 5 SC) @ 2.0ml/l.
- Imidacloprid (0.25 ml l^{-1}) and thiamethoxam(0.2 ml/l) were physically and chemically compatible with Propiconozle (1ml/l) and Validamycin (2.5 ml/l).
- Among the acaricides tested against leaf mite, Diafenthiuron @ 900 ml/ha and Fenpyroximate @ 600 ml/ha were effective in the field.

Identification of safer chemicals to natural enemies

- Thiamethoxam was found to be highly toxic among the insecticides tested to T. chilonis followed by Imidacloprid, Ethofenprox, Pymetrozine and Virtako® while Acephate was least toxic.
- Benfuracarb 40 EC @ 500 g ai/ha recorded the lowest incidence of BPH, GLH, stem borer, leaffolder and found comparatively safer to spiders and coccinellids.

Information on screening nurseries evaluation

Every year, almost 800-1000 entries were screened from the seed materials obtained from AICRIP, IRRI and TNAU cultures against BPH, WBPH and GLH. Apart from plant and leafhopper screening, leaffolder and stem borer screening works were also attempted based on the necessity.

- CB 02-290, RIC 06-0204, KAUM 103-104-1, KAUM 95-1 and RP 4636 -52-1-1-1-3-5 were moderately resistant to BPH and CB-01-001, CB 02-586, CB 04-041, CB 03-045 & TNRH 135 were found moderately resistant to WBPH.
- CB 20022- (AD 93019 / AD 41) was gall midge resistant to biotype 4 & 6.
- CB 02-586,CB 21006,TNRH 174, CR 2711-149 MTU 1115,MTU 1123 and MTU 1126 were identified as moderately resistant to both BPH and WBPH.
- RP 4680-1-2-23 and RP 4681-16-2-569 were found resistant to BPH, WBPH and GLH under Multiple Resistant Screening trial for consecutive two years.

- Three cultures, CoRG 15, CoRG 24, CoRG 30 developed at TNAU, Coimbatore were nominated for gall midge resistance screening programme during 2013 and among them CoRG 15 and CoRG 24 were found promising.
- In leaffolder screening trial (LFST) PTB I2, W 1263, LF 293 (IR 36 x LFR 831311) & SB 436 (CO 43 x W 1263) were found resistant for two years and suggested to use as donors. LF 333, LF 256 and 293 were found to be moderately resistant.
- YSB 479, YSB 33 and YSB 301 were found promising against stem borer. Bt hybrids screened at Kuruvikarambai, Tamil Nadu identified MRP 5319, MRP 5445, MRP 5631 and MRP 5629 with low damage.

Plant pathology

Recent findings in RTD Management

- To control the vector, green leafhopper in the main field, spray two rounds of any one of the insecticides viz., Monocrotophos 36 SL (1000 ml/ha), Phosphamidon 40 SL (1000 ml/ha), Fenthion 100 EC (500 ml/ha) on 15 and 30 days after transplanting. The vegetation on the bunds should also be sprayed with the insecticides.

Blast

- A prediction model for rice Leaf Blast Epidemic for western Zone of Tamil Nadu was developed using ten years data.
- REMAP markers developed can be used reliably to study the population dynamics of the fungus.
- Cultivar IR64 (known to possess 9 blast resistance genes) was resistant at Coimbatore from 2005-2008, after which it became susceptible in both the locations. Cultivar Rasi (known to be a slow blasting one) was resistant at Coimbatore until 2010, while at Gudalore it was resistant until 2007 and became susceptible later with an exception in 2011.

False smut

- Spraying Kocide 2000 @ 525 g a.i/ ha at booting and milky stage recorded significantly less percentage of infected panicles/m^2 over control.

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University of Agricultural Sciences, Raichur
Karnataka

Agricultural Research Station Gangavathi was established in the year 1956. All India Co-ordinated Rice Improvement Programme was established in the year 1976 at Agricultural Research Station Siruguppa under University of Agricultural Sciences, Bangalore. Later on it came under the University of Agricultural Sciences, Dharwad in the year 1986. Presently it is under the Jurisdiction of University of Agricultural Sciences, Raichur from 2009 onwards.

Major contributions to AICRIP

Crop Improvement - Plant Breeding

- Released CSR-22, a high yielding, long slender, salt tolerant variety during 2008-09 which has spread in an area of about 1000 ha.
- Released IET-20594(GGV-0-01), a dual season, biotic (blight and blast) and abiotic (salinity) stress tolerant variety possessing genetic yield potential of 10.85 t/ha. From 2007-08 it has spread in area of about 35000ha.
- Nominated 7 varieties to AICRP coordinated trials *viz.*, GGV-05-01, GGV-05-02, GVSAT-05-01, GGV-05-01-1, GGV-05-02-1, GNV-11-01 and GNV-11-02.
- Identified 7 promising genotypes with different grain size and duration for irrigated ecology of northern Karnataka which will be promoted and released in the coming years. These are IET-19251, IET-19828, IET-22076, IET-21575, IET-18299, IET-22096 and IET-22147.
- Handling 30 advanced lines and 350 F4-F5 families and 400 M2 plants which will be further studied. Of these, 30 promising cultures were studied through molecular diversity.
- Collected and characterized morphologically 40 desi/land races to diversify research genetic base.

Popular varieties developed and released

GGV-05-01(Gangavati sona)
Selection from MTU-1076 population. Suitable for both kharif and summer sowing in Tunga Bhadra project area. Recommended both for normal and salinity affected soils, as it with stands salinity levels up to 6.5-8.5ds/m. Average yield is 5966kg/ha, about 15 % higher grain yield over BPT-5204 during kharif and tolerant to sheath blight and BLB and neck blast.

CSR-22 (Salinity tolerant variety)
A promising long slender genotype CSR-22 over best check BPT-5204 is identified for saline situations in Tunga Bhadra Project area and released during 2008-09 for Zone-3 which has been notified during 2009-10 at national level. This variety is identified from NSASN trials, which was developed at CSSRI, Karnal (IET-No 13767)

SIRI-1253
It is a medium slender grain, medium tall variety, maturing about 8-10 days early to check BPT-5204. It yields 17.0 % higher grain yield over BPT-5204. It is released in the year 2013-14 from UAS, Raichur.

Crop production

Agronomy

Nutrient management

- Application of 200:100:100:20 kg N,P_2O_5, K_2O & $ZnSO_4$/ha found optimum for getting higher grain yield in transplanted rice.
- Leaf colour chart No 5 (7 Panel LCC) based nitrogen scheduling was found an appropriate agronomic practice for transplanted rice and drum seeded rice with the added advantage of saving N to an extent of 30% besides higher grain yield.

- The nitrogen scheduling for direct seeded rice revealed that application of 150:60:50 kg N,P_2O_5& K_2O/ha with 1/3 N each at the time of sowing, active tillering and panicle initiation stages recorded significantly higher grain yield.

Weed Management

- In transplanted rice pre-emergence application of Anilofos 30 EC @ 1500 ml/ha 5-7 Days after transplanting gave effective weed control. Similarly pre-emergence application of Bensulfuron methyl plus pretilachlor 6.6% G 5-6 DAT was found effective in controlling diverse weed flora in transplanted rice.
- Pre-emergence application of Pendimethalin 30 EC @ 0.75 kg ai/ha along with dhaincha incorporation at 30 days and one hand weeding at 60 DAS is an effective weed management strategy for aerobic rice. Similarly, pre-emergence application of Butachlor 50EC @1.5kg a.i/ha at 3-4 DAS followed by Bispyribac sodium 10% SC @ 35 g.a.i/ha at 15-20 DAS was effective against all types of weeds including sedges, grasses and broadleaf weeds.
- Post emergence application of Penoxsulam 24% SC at 2-4 leaf stage proved effective in controlling weeds in direct seeded rice under puddled conditions.

Cultural practices

- The agronomic practices for drum seeder rice revealed that drum seeding of sprouted seeds on puddled soil at the rate of 40 kg/ha (30 cm line spacing) during the month of July is an alternative method of establishing rice to transplanting in Tungabadra command area.
- Screening of rice genotypes for aerobic conditions revealed that the genotypes GGV-05-01, MAS-26 and Siri 1276 performed better under aerobic conditions than other genotypes.

Mechanization in rice

- Studies on mechanization in transplanted rice revealed that transplanting by a six row mechanical rice transplanter at a line spacing of 30 x 15 cm recorded 9.0% higher grain yield than traditional random transplanting. The increased grain yields were mainly attributed to pro-fused tillering and better grain filling.

- Standardization of mat nursery techniques revealed that a potting mixture of black soil and vermin-compost (80:20) or black soil and sieved FYM (60:40) is ideal for raising mat nursery and resulted in better establishment of seedlings without gaps.

System of Rice Intensification

- Water requirement of rice in case of SRI was about 1110 mm compared to 1745 mm in traditional method resulting in 36.3% saving of water.
- In SRI, ten days aged seedlings proved superior than 15 days aged seedlings with yield advantage of 5.2%. Pre-emergence application of Anilofos @ 0.6 kg ai/ ha with one hand weeding at 40 DAT or two cono-weedings followed by one hand weeding at 40 DAT is an effective weed management strategy under SRI.

Organic farming

- The net work project revealed that the INM treatment of 50% organics and 50% inorganics recorded significantly higher grain yields in 6 years out of 9 years of experimentation.
- The performance of 100% organics as compared with that of inorganics alone (which is the prevailing practice) indicated that around three years of continuous application of 100% organics is required to attain grain yield levels on par with that of inorganics alone.
- Economic analysis indicated that it takes about four years of continuous application of 100% organics to realize net returns and BCR that are on par with recommended practice of applying 150:75:75 kg, N, P_2O_5 and K_2O/ha along with 10 t/ha of FYM. Further the gross and net returns and BCR in case of 75% organics and 100% organics remained on par from fourth year onwards. The higher gross & net returns and BCR in case of 100 and 75% organics were attributed to premium price of the produce and improved yields.

Precision farming studies in rice

- Precision farming in rice was undertaken on an area of 38.75 ha at Jangamara kalgudi village near Gangavathi, koppal Dist, Karnataka. Grid wise soil analysis indicated large amounts of residual soil P and K. STCR approach is followed for fertilizer recommendation and was found that fertilizers dose of 210 kg N, 24 kg P_2O_5 and 32 kg K_2O/ha was sufficient to realize 85% of the target yield resulting in savings of 37%N, 82% of P_2O_5 and 68% in K_2O.

Crop protection

Entomology

- Insecticides and acaricides were evaluated regularly against major pests for the region and recommendations were given:
  - Imidacloprid 17.8 SL, thiamethoxam 25 WG and Buprofezin 25 SC, sulfoxaflor @ 375 ml/ha are recommended against hoppers.
  - Flubendamide 36% + Fipronil 30%, Buprofezin + acephate and Acephate 95 SG, Buprofezin+ acephate (RIL049/F1) are found effective against major insect pests of rice
  - Mites are effectively managed by application of Abamectin 5 EC.
  - Flubendamide and spinosad showed good compatibility with fungicide Isoprothiolane. Ethiprole + imidacloprid is compatible with standard fungicides like hexaconazole and tricyclazole. Dinotefuran 20 SG showed compatibility with standard fungicides like hexaconazole and tricyclazole. RIL 049 was compatible with standard fungicide like tricyclazole and hexaconazole. Flubendiamide 4%+ Buprofezin 25 SC was compatible with standard fungicide.
- Ecological engineering is encouraging for increasing activity of natural enemies and suppressing the hoppers activity.
- For the organic paddy growers application of vermicompost or green manure+ 50% RDN was found superior in reducing pest incidence and recording higher yield
- Egg parasitisation of hoppers was 16.35%, with Anagrus, Oligosita and Gonatacerus accounting for 10.58, 4.49 and 1.28 per cent, respectively. Anagrus was dominant parasitoid accounting for 64.72 per cent followed by Oligosita (27.46%) and Gonatocerus (17.84%).

Plant pathology

- Screening germplasm for resistance against leaf blast, neck blast, sheath blight, BLB, *etc*.- TNRH-173, IR64 and VOHP3102 showed low susceptible index of 0 and highest 5 by VL30921 and CB06555 against leaf blast. Among all the entries tested, high promising index of 0 was showed by TNRH17 and Swarnadhan followed by index of 1 by MGDP-1, TNRH180, Benibhog, TNRH174, TNRH185, Vikramarya, VL31320 and TN1. A high susceptible index of 5 was noticed in CB06541 against sheath blight.
- Testing new fungicides/bactericides for their efficacy in controlling diseases and formulating effective dosage, frequency and time of application - Among the different treatments imposed, the test fungicide Metaminostrobin 20EC @

200gm ai/ ha was found significantly effective in checking the leaf blast and neck blast severity with the disease incidence of 12.2% and 30.8%, respectively compared to 51.7% and 43.4% in check. Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75 WG) @ 0.4 gm/lit reduced the severity of blast and sheath blight with increased yield (8750 kg/ha) compared to check. (3062 kg/ha).

- Epidemiological study for newly emerging diseases such as false smut, stem rot and grain discoloration - on the second sown crop, KRH-2, DRRH-3, and US-312 found with highest percentage of infected smut balls/sq.m
- Development and evaluation of integrated disease management strategies to combat multiple disease and pest.

GHAGRAGHAT

Narendra Dev University of Agriculture & Technology
Kumarganj, Faizabad
Uttar Pradesh

The crop research station at Ghaghraghat was established in 1976 with the major mandate of developing varieties to suit deep water ecosystem of rice.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

- Altogether, 7 rice varieties belonging to deep water, semi deep water and flash flood situations have been developed at the research station.

Details of varieties released at Crop Research Station, Ghaghraghat, Bahraich.

Sl. No.	Varieties/ Parentage	Released by	Area of adaptation	Yield t/ ha	Special features
1.	Jalmagna Local selection from land race Bodhan	SVRC	Deepwater (>100cm)	4.0	Red kernel, fast elongation,nodal tillering
2.	Chakia 59/ Selection from land race (Bahraich Distt.)	SVRC	Semi deep water (50-100cm)	3.0	White kernel, moderate elongation
3.	Madhukar/ Land race selection from Gonda Distt.	SVRC	Flash flood	2.8	White kernel, submergence tolerance(7-10d)
4.	Jalnidhi/ Local selection from Goanth	SVRC	Deepwater (>100cm)	4.5	Fast elongation,kneeing ability,nodal rooting & tillering, red kernel
5.	Jalpriya/ IET 4060/ Jalmagna	SVRC	Semi deep water (50-100cm)	3.5	Moderate elongation,good grain type,better cooking quality,white Kernel
6.	Barh awarodhi/ Madhukar/ Sona	SVRC	Flash flood	3.5	Submergence tolerance (10d),white Kernel

Sl. No.	Varieties/ Parentage	Released by	Area of adaptation	Yield t/ ha	Special features
7.	NDGR 201/ Selection from land race Pansar (Bahraich Distt)	CVRC	Semi deep water (50-100cm)	4.0	Moderate tillering, red kernel,brown rice zinc content 30.3 ppm & 19.2 ppm iron, polish rice zinc content 18.2 ppm & 8.8 ppm iron.

- In order to identify suitable high yield, better survival traits and grain quality, various experiments were conducted in prevailing rice ecosystem at centre during the past years. The most promising entries ecosystem wise are summarized in table below

Promising varieties/ entries identified till *kharif* 2010-11.

Deep Water Water (> 100cm)	Semi Deep Water Water (50-100cm)	Flash flood (Intermittent flood)
NDGR 403	NDGR 222	NDGR 88
NDGR 426	NDGR 348	NDGR 70
NDGR 444	NDGR 392	FRG 13
NDGR 445	NDGR 250	NDGR 113
NDGR 448	NDGR 272	NDGR 106
NDGR 449	NDGR 373	NDGR 89
NDGR 464	NDGR 266	NDGR 127
NDGR 465	NDGR 278	Bajara-6
NDGR 467	NDGR 296	IR62648-B-5-1
NDGR 469	NDGR 274	IR1398-2-13
NDGR 478	NDGR 340	NDGR 63
NDGR 486	IR65764-R-13-1	NDGR 65
NDGR 489	IR65761-R-15-18	
IR67824-64T96-1-1-5-3	IR65761-R-11-15	
NDGR 530	*NDGR 266	
NDGR 542	NDGR 1501	
	NDGR 1512	
	NDGR 1514	

DWR-AVT-1 experiment sowing water depth at CRS, Ghaghraghat

*** Promising entry in pipe-line and tested in RATDS at State Level.**

- A wide range of donors for different traits were identified from different trials (IRRI, Thai and national trials). The identified donors have been procured to enrich the gene bank for utilization in breeding programme.

List of donors identified for different traits

142.24 mm	Donors
Elongation ability	Jalmagna, Jalnidhi, Saingar, LMN111 IR40905-11-3-15-2-2-21
Kneeing ability	Jalmagna, TCA 269, TCA4
Erect flag leaf blade	IR22, IR24, IR36, IR42, PSBRC2, PSBRC48
Submergence tolerance	Nimbuiya, Beller, Amghaud, Malhi qud, Ramkajari
Drought tolerance	Annada, Varani-deep and Azucena
Purple color of stigma	BP176, DV85, Aswara-Kora & 7 Jalmagna
Anthocynin coloration on stem node	DV85, K39-96-1-1-1-2, ACC13742 PSBRC92, Jalmagna
Stem borer resistance	TKM6, PSBR68, IR46 & CO14

- A wide range of crosses from *Jalnidhi*, *Barh Avarodhi*, FRG13, *Chakia 59*, *Sabita*, *Annada*, *Nagina 22* have been made at CRS Ghaghraghat. Fixed materials received from different crosses, viz. Samson Polo/ Jalnidhi, Ravana / Mahsuri, Sabita/ CN718-8-21-10, Sabita/ CR333-310, Daeng Loem/Jalnidhi, CR661-236/ Swarnadhan, PS41/ CR780-1936-1, PS46/ NDR8009, IR498307/ Gayatri, Swarna/ Pusa 4, Swarna/ NDR 8009, Sambha Mahsuri/ NDR 20 from AICRIP have been evaluated under waterlogged condition. Fixed lines of these crosses are under evaluation in preliminary station experiments.

- Non-destructive screening techniques have been developed for assessing elongation ability. Results revealed that 500 ppm GA3 (Gibberalic acid) application at 4-5 leaf stage, short duration flooding treatment at 21 days old seedling, horizontal orientation of shoots method to distinguish the elongation types from the non-elongating ones.

- Under evaluation of post flood management technology, farmers' participatory approach was followed and found that high and stable yield after double transplanting of rice crop can be obtained by first transplanting 3 weeks old seedling, then uprooting the transplanted crop after 4 weeks and again transplanting. Besides, the aged seedling of 7 weeks old seedling of *Barh Avarodhi* variety after the flood recede has also been recommended for transplanting to minimize the yearly loss of crop productivity and reduce the farmer loss in high risk flood prone areas.

- Under post flood management technology, the sprouted seeds of short duration varieties, *viz*. NDR 97, NDR 118 and NDR 1 directly seeded in the field after receding of last flood performed well. This technology may compensate the loss of farmers in high risk areas.

Flood prone rice varieties showing regeneration after submergence at CRS, Ghaghraghat

Crop production

Agronomy

- Package of practices were standardized for growing deep water rice and found that one ploughing by mould board plough and twice by country plough and planking after each ploughing was the most remunerative tillage practice. Second fortnight of April was the most optimum time for sowing, 80 kg seed/ha by seed drill, 100 kg/ha behind country plough, and 120 kg seed/ha by broadcast method was the optimum seed rate at 25 cm apart. Application of 20 kg N/ha either through urea super granules (USG) placement in 8-10 cm water depth or neem cake coated urea (NCU) as basal resulted the higher yield and nitrogen use efficiency over prilled urea. Pre-emergence spray of butachlor @ 1.5 kg a.i. /ha controlled the weeds efficiently before water accumulation. Use of sweep hoe controlled the weeds effectively in early water accumulation.

- Integrated use of 50% RDN by Farm Yard Manure + 50% RDF through inorganic fertilizers produced the highest yield of rice and succeeding lentil under shallow deep, semi deep water and flood-prone areas.

- Green manuring of *Sesbania rostrata in situ* to rice along with 50% RDF to both rice and wheat gave the higher productivity, nutrient uptake and benefit cost ratio in rice wheat cropping system.

Crop Protection

Entomology

- Among the newer insecticides evaluated over the years, imidacloprid 200 SL @ 25 g.a.i. ha^{-1} & profenphos 50 EC @ 500 g.a.i. ha^{-1} (1998-99); flubendiamide 480 SC @ 24 g.a.i. ha^{-1} & clothianidin 50 WDG @ 15 g.a.i. ha^{-1} (2004-05); and indoxacarb 15 EC @ 30 g.a.i. ha^{-1} & lambda cyhalothrin 5 CS @ 12.5 g.a.i. ha^{-1} (2005-06); neonicotinoid + synthetic pyrethroid 22% @ 44 g.a.i. ha^{-1} & deltamethrin 10 EC @ 15 g.a.i. ha^{-1} (2006-07); flubendiamide 36% + fipronil 30% @ 33 g.a.i. ha^{-1}& bifenthrin 10 EC @ 50 g.a.i. ha^{-1} (2007-08); acephate 75 SP @ 800 g.a.i. ha^{-1}, flubendiamide 20 WDG @ 175 g.a.i. ha^{-1} (2009-10); and acephate 75 SP @ 667 g ha^{-1}, buprofezin + acephate 20+50 WP @ 1000 g ha^{-1} & acephate 95 SG @ 592 g ha^{-1} (2010-11) have been found promising against rice stem borer and significantly superior over untreated control and check insecticides monocrotophos 36 EC @ 0.5 kg.a.i. ha^{-1}, chlorpyriphos 20 EC @ 0.5 kg.a.i. ha^{-1} and carbofuran 3 G @ 1.0 kg.a.i. ha^{-1} under semi deep water situation.
- The sowing of sprouted seed immersed in 0.05% solution of fipronil 5 EC followed by drenching of nursery 5 days before pulling with fipronil 5EC @ 100 g. a. i. ha^{-1} was most effective in suppressing the yellow stem borer infestation and increasing grain yield under semi deep water rice situation.
- The tank mixture of imidacloprid 200 SL @ 0.25 ml lit^{-1} & propiconazole 25 EC @ 1.0 ml lit^{-1}, flubendiamide 20 WDG @ 0.25 g ha^{-1} & isoprothiolane 40 EC @ 1.50 ml ha^{-1} and ethiprole+imidacloprid 80 WG @ 0.25 g ha^{-1} & hexaconazole 5 SC @ 2.0 ml ha^{-1} was effective against stem borer and blast under semi deep water rice situation.
- The ETL for stem borer was estimated to be 5% larval infestation level. The regression analysis and calculation of confidence interval of β indicated that the decrease in grain yield is expected to fall between 39.8 and 209 kg ha^{-1} 95% of times within the range of 0-20% larval infestation levels.
- The estimation of yield losses at booting stage indicated that stem borer caused yield losses of up to 38.1% with 50% WE infestation.
- Growing of trap crop *Pusa Basmati 1* along with main crop *Jalpriya* in 1:9 ratio significantly reduced stem borer infestation and increased the yield of main crop.
- Neemgold-4 (azadirachtin-300 ppm) @ 2.0% and Biolep @ 2.0 kg ha^{-1} was as effective as standard test insecticide chlorpyriphos @ 0.05% against YSB under deep water rice.

Plant Pathology

- The entries from coordinated trials NSN 1, NSN 2, NHSN and DSN have been evaluated against blast and brown spot over the years and several promising entries were identified. IET 21404, 21405, 21857, 22214, 21807, RP Patho-3 and VL 30919 were most promising against leaf blast, whereas IET 21582, 21946, 20370, NVC, RP Patho-3, RP Patho-4 and RP Patho-8 were most promising against brown spot.
- *Barh Avarodhi*, FRG 10 and Cross 116 have been identified as moderately resistant against leaf and neck blast under natural field condition.
- An average yield loss of 35.65% was recorded due to blast (leaf and neck blast) disease. Ecomonas @ 10 g lit^{-1} (bio-pesticide) was found effective against blast. Application of Tilt @ 1lit ha^{-1} was found suitable to control glume discoloration disease of rice. Mancozeb 75 WP @ 2.54 g lit^{-1} was effective against blast and increasing yield. Folt 80 WP @ 2 g lit^{-1} was effective in controlling false smut and increasing yield.
- The variety Tetep showed resistant reaction, whereas Tadukan, Raminad *Str.* 3 and IR 64 showed moderately resistant reaction in field virulence study of *Pyriculariya grisea*.
- In new fungicides evaluation, 3 sprays of tricyclazole 75 WP @ 0.6 g/lit was most effective against leaf and neck blast infestation and increasing the grain yield. Isoprothiolane 40 EC @ 5 ml/lit followed by metaministrobin 20 SC @ 2ml/lit and propiconazole 25 EC @ 1ml/lit were also effective against blast.

JAGDALPUR

S.G. College of Agriculture & Research Station
Chhattisgarh

This station was established in 1997-98 in Bastar district to cater the research needs of tribal rice farmers. Major mandate is to work on all aspects of upland rice ecosystem.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

- Germplasm - A total of 5628 segregating lines of different generations have been handled by Jagdalpur centre. On the basis of station trials, 5 promising entries have also been nominated to AICRIP. Crossing programmes for early duration rice breeding materials were initiated and 130 crosses were made between Vandana and Morobaken introgressed lines and segregants were selected for earliness and high yield.
- Promising lines have been identified for very early, early, mid early, medium and aromatic slender groups along with hybrids
- Upland rice - Extensive survey was made for well adopted local genotypes and selections are being done for sacrifiable grain yield. Among local materials Jdp-12-33, Jdp-12-34 and Jdp-12- 38 are found promising and are under final level of testing.
- Aerobic rice - Traditional varieties were collected from villages of five districts of Bastar division and exotic lines were obtained from International Rice Research Institute, Philippines. Currently, there are 85 lines for aerobic group, of which IR-84887-B- 15- Jdp-12-5 and IR-86887-46-1-1-2-Jdp-12-8 are promising.

- AICRIP nominations - During 2007-2011, five entries were nominated viz. JDP 13-1-RR 419-7 (IET 21278), JDP 39-1-RR 411-36 (IET 21279) and JDP 382-6-DSU-4-4 (IET 22049) in IVT- VE -DS (TP), AVT VE TP and IVT E DS, respectively. Presently, two varieties are in pipeline and will be nominated shortly in AICRIP trials.
- Maintenance Breeding/ germplasm available - Under NATP project more than hundred local genotypes of rice have been collected from different parts of Bastar division and collected germplasm deposited to NBPGR and Gene bank of IGKV Raipur and are being maintained through single plant selection at this station. Apart from the project, 290 local germplasm have been collected and are being evaluated. At present we have 552 accessions under all avenues of rice research.

Hybridization programme - Looking to wide variability in local rice varieties and large area under upland rice, hybridization programme has been started since 2007.

Achievements at a glance

	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Breeding materials generated	130	109	136	89	215	29	146
promising lines identified	11	13	11	10	13	28	32
Attempts on Biotic and abiotic stress tolerant Breeding	-	-	-	-	-	Upland rice breeding programme initiated	
AICRIP nominations	-	-	2	2	1	-	3 entries are in advanced stage of testing
Varieties/hybrids identified/ released	2	3	1	2	4	11	23
Seed Production activities							
Maintenance breeding/ germplasm available	59	68	74	79	120	390	552

Crop Production

Agronomy

Studies have been conducted for levels of nitrogen, interaction between nitrogen levels and cultivars, rice and sun hemp cultivation practices under various fertilizer dosages, dosages and timing of herbicides, nitrogen response trials on selected AVT-2, management practices for enhancing grain yield and soil health of rainfed upland rice, evaluation of new herbicide molecule in direct seeded rice under puddled condition, survey for predominance of weedy rice in different rice ecosystems, management of micronutrient in rice based cropping system, SRI methods, cultural management trials-CMT under upland situation, integrated weed management in aerobic rice and selective mechanization for enhancing productivity and profitability of rice cultivation.

Crop Protection

Entomology

- Host plant resistance studies – Various entries in NSN 2, LFST, MRST, and GMBT were screened for resistance to major pests of rice and identified the a number of promising entries against gall midge, BPH, leaf folder, whorl maggot and GLH every year.
- Under insecticide evaluation studies, several insecticidal treatments targeting leaf folder, whorl maggot, plant hoppers, BPH, GLH, Gall Midge, stem borer were studied and best effective treatments were identified. In Pesticide Compatibility Trials (PCT), insecticide and fungicide combinations for leaf folder, blast, BPH, GLH, stem borer, gall midge were tested and the best combinations were identified.

Plant Pathology

- Under NSN 1, NSN2, NHSN and DSN, 212, 416, 647 and 842 entries were found to be promising on screening for BLB, neck blast, sheath blight and brown spot.
- Through field monitoring of virulence of Pyricularia grisea, highly resistant entries were identified.
- Under Disease Management Trial, some new fungicides were evaluated with check fungicides for the management of leaf blast and neck blast. Trials on evaluation of fungicides against location specific diseases have identified promising dosages.

JEYPORE

Regional Research and Technology Transfer Sub Station, Orissa University of Agriculture and Technology (OUAT) Odisha

This center was started in 1936 by Maharaja of Jeypore. Later, it was handed over to Department of Agriculture, Government of Orissa in 1947 for rice research. Subsequently, it was handed over to Orissa University of Agriculture and Technology (OUAT) after its establishment, in 1963. All India Coordinated Rice Improvement Project (AICRIP) started functioning here as sub-station since 1st April'1975 with the budget provision of 75% ICAR and 25% state share. This is known as the testing, evaluating and germplasm centre of AICRIP for this region.

Major contributions to AICRIP

Crop Improvement

Varieties developed/ identified

- Two varieties viz., Manaswini and Mandakini varieties were developed in collaboration with Rice Research Station, Bhubaneswar.
- The center has tested nearly 250 rice entries of irrigated very early, early, mid-early and medium duration strains of nationally originated.
- Being one of the major regional testing centers, the station has played an important role to provide sufficient data for release of varieties by State Variety Release Committee (SVRC) and Central Variety Release Committee (CVRC) since 1975.
- Released varieties for this region are popularized at farmers' field from inception of AICRIP.
- The most leading varieties recommended and adopted by the farmers of this region are Heera as super fast; Kalinga-III as very early; Pathara, Khandagiri, Mandakini and Sidhant as early; Lalat, IR-64, MTU-1010, Konark, RGL-2538, Pratikhya, Naveen, Manaswani and MTU 1001 etc. under medium duration and under late duration , Mahalaxmi, CR-1009, CR-1030, Indravati, Mahanadi, Ramachandi, Pooja, Sarala, Padmini, RGL-2538 and RGL-2537 etc.

- Rice hybrids like PA6201, PA6444, 6444 Gold, Sahyadri, PHB 71, Rajalaxmi and Ajaya have been accepted by the farmers of this zone by which they are getting more than 20-30% yield over the popular varieties.
- Under the short grain aromatic varieties, Kalajeera, Pimpudibas, Jaiphula, Dubraj and Badshabhog and under aromatic high yielding varieties Gitanjali and Ketakijoha have been recommended for the farmers.
- The technology transferred by this project which includes knowledge about high yielding varieties and suitable package and practices for getting higher yield like line sowing and planting, use of weedicides, insecticides, fungicides and bactericides for controlling weeds, insects and diseases, use of balanced fertilizers and organics, has changed the scenario of rice production and productivity of this region in a big way.

Technologies developed:

- Reduction of chaffiness in grain- spraying of borax @0.25 %(2.5g in one litre of water) at 5-10 days before flower initiation helped in reduction of chaffiness in grains in seed production plots.
- 234 rice local land races are preserved and maintained.
- Farmers' participatory research is going on to popularize the recently released varieties and hybrids.

KANPUR

C.S. Azad University of Agriculture & Technology
Uttar Pradesh

In 1972, a unit of rice research was started at Kanpur aimed at developing varieties having salt tolerance. In 1985, Usar -1 (a cross of Jaya/ Getu) was developed for saline-alkaline conditions. In 1987, Ashwini was released for rainfed and early transplanting conditions of Central Plain and Bundelkhand zones of U.P. In 2004, a **sub-centre of AICRIP** was sanctioned which was executed w.e.f April, 2005. In 2005, AICRP on Rice was established in Kanpur to strengthen research on saline and alkaline soils. C.S. Azad University of Agriculture & Technology is responsible for problem soil areas & irrigated ecology of the central Uttar Pradesh with main focus on saline and alkaline soils, irrigated and scented rice.

- Centre developed two varieties – Ashwini and Usar-1.
- Developed production technology for the cultivation of rice in saline and alkaline soils.
- Developed fertility management package for hybrid rice
- Screened varieties against insect pests
- Found out established method for rice cultivation ie. Aerobic rice, SRI, ICM

KARJAT

Regional Agricultural Research Station
Maharashtra

Regional Agricultural Research Station, Karjat is one of the pioneer rice research station in Maharashtra which was established in 1919 by the Government of Bombay with a view to develop an improved strains from existing tall varieties of Thane and Raigad.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

i)	Breeding material generated	:	~1716 crosses
ii)	Promising lines identified	:	555
iii)	Attempts on biotic & abiotic stress tolerance breeding	:	FL 478 x Valai, FL 478 x KJT 4
iv)	AICRIP nominations	:	62

Varieties/ Hybrids developed & released

Sahyadri 2 (Rice hybrid) : 2004
An early duration (115-120 days) rice hybrid,
Average grain yield 6.0 – 6.5 t/ha.
Long slender grain type
High milling recovery (70.2%)
Resistant to leaf blast, neck blast, brown spot and rice tungro virus.
Identified for commercial cultivation in five states of the country *viz*., Punjab, Haryana, UP, WB and Maharashtra, by the CVRC, during 2008.

Karjat-5 : (2005)
Mid-late duration (125-130 days)
Long bold grain type
15-20% grain yield advantage over check Jaya.
Average grain yield50-55 q/ha.
Multiple resistance to major diseases and pests.


KARJAT 6

Karjat-6 : (2005)
Mid-late duration (125-130 days)
Short slender grain type
High milling percent (75.8%) & HRR 70.2%
Average grain yield - 40-45 q/ha.
Moderately resistant reaction to BLB


Sahyadri 3

Sahyadri 3 (Rice hybrid) : 2005
An early duration (125-130 days) rice hybrid.
Average grain yield 6.5 – 7.5 t/ha.
Long slender grain type.
Resistant to neck blast, moderately resistant to BLB, brown spot, sheath blight and sheath rot.
High milling recovery (74.5%), HRR (60.2%)

Karjat-7 : 2007
Early duration (115-120 days),
Long slender grain type, grain chalkiness absent.
15-20% grain yield advantage over check Ratna.
Average grain yield 45-50 q/ha.
Moderately resistant reaction to major diseases and pests.

KARJAT 7

Karjat 184 : 2008
Early duration (100-105 days), dwarf stature,
Medium slender grain.
35-40q/ha average grain yield.
Moderately resistant to leaf blast and BLB and tolerant to BPH and WBPH.

KARJAT 5

Sahyadri 4 (Rice hybrid) : 2008
An early duration (115-120 days) rice hybrid.
Average grain yield 5.5–6.0 t/ha.
Long slender grain type,
Resistant to leaf blast, neck blast, brown spot and tungro Virus.
Identified for commercial cultivation in five states of the country. viz., Punjab, Haryana, UP, WB and Mah, by the CVRC

Sahyadri- 4

Karjat-8 : 2012
Late duration - 140 to 145 days
Short slender, translucent grain type.
Recorded 17.31 % increased grain yield over check.
Average grain yield - 47.24 q/ha.
Moderately resistant to leaf blast, neck blast, BLB and tolerant to BPH, WBPH and gall midge.

Karjat – 9:(2014)
Medium duration- 125 to 130 days of maturity.
Medium slender, translucent grain.
Moderately resistant to leaf blast, neck blast, BLB and tolerant to BPH, WBPH and stem borer.
Recommended by Joint Agrosco for pre-release in Konkan and Vidarbha region of Maharashtra state.

i)	Varieties/Hybrids registered with NBPGR/PPV&FRA	:	KJT CMS 1A, KJT CMS 2A, KJT CMS 3A, KJT CMS 4A, KJT CMS 5A, KJT CMS 6A and KJT CMS 7A
ii)	Seed production activities (including maintenance breeding, BSP as per DAC & other indents	:	2542.91 q (since 2001)
iii)	Germplasm available	:	779
iv)	Licensing and commercialization of technologies, popular varieties (both traditional and high yielding rice varieties)	:	9
v)	Speciality rices if any	:	BM 4 – is a mutant of land race Botvel having slight flavour is good for preparing 'Modaks" on auspicious occasions

Crop Production

Agronomy

- Integrated nutrient management study in rice-maize cropping system consistently produced higher yield of rice and maize. Application of 5 t glyricidia green leaves /ha along with 150 % highest RFD to *kharif* rice (KJT-3) and to *rabi* maize (PMZ-103) gave the highest net returns.
- In the experiment to develop appropriate techniques for growing direct seeded rice in puddled condition, it was observed that maximum net returns of Rs.10438/ha were realized with the sowing of sprouted seed with 8 row drum seeder same day after final puddling +RFD +one hand weeding and herbicide application, followed by line transplanting +RFD and herbicide application (Rs.10278/ha) whereas saving in labour cost was 13.30% to 16.51% as compared to line transplanting.

- Methods of crop establishment through SRI technique was found promising but it remained at par with integrated crop management (ICM) and paired row transplanting but superior over direct sowing and farmers practice of random transplanting with 6-7 seedlings per hill.
- 90 experiments on various agronomical aspects were conducted. In nitrogen response studies, 44 experiments were conducted comprising 410 rice cultures of different durations. Total 89 rice cultures showed better response to 100 kg nitrogen /ha.
- Four experiments conducted on rice based cropping system under INM revealed that rice cowpea cropping system with 100% RFD +5t glyricidia green leaf manuring/ha appeared to be highly economical.
- Development of appropriate technique in direct seeded rice in puddling with RFD + one hand weeding and herbicide application was found to be a better alternative to line transplanting with RFD and herbicide application under upland soil condition.
- In weed management, Bensulfuron methyl, Trisulfuron + Pretilachlor, Penoxsulam and Butachlor weedicides were found to be comparable with integrated crop management (ICM) but it appeared superior to direct sowing and farmers practice of random transplanting with 6-7 seedlings per hill. Different genotypes (hybrids and HYV) under SRI and ICM practices, hybrids showed better performance in yield over high yielding varieties.
- Package of practices for optimum seedling per hill for hybrid rice was recommended and popularized among the farmers in region.
- Drum seed use in planting of rice crop was popularized in the region by conducting large scale demonstrations on the farmer's field. This technology was benefited to the farmers for labour saving.

Crop Protection

Entomology

- Cultures viz., IR67431-CN9-2, OR2093-4, OR2060-9, OR2077-5, RRU96-30, OR2089-4, OR1659-3, CNB1259-52-1, RPBIO 197, CR2056-1, NDR 9930028 accessions viz., 2261, 2997, 4063 IET 18632, IET 18666, IET 20666, IET 20668 accession viz., IC No. 324094, 334173, 346905 and 2261, 328 2997, 3167 and 4063 are highly promising against stem borer.
- Cultures viz., ARC 13516, ARC 14378, ARC 13564 and PTB 33 found to be promising against gundhi bug.
- Insecticides *viz*., Imidacloprid 200 SL@ 25g a.i/ha., Ethiprole 10 SC@ 50g a.i/ha., Profenophos 50 EC@ 500g a.i/ha., PI 0111@ 25g a.i/ha., Chlorpyriphos 20

EC @ 500g a.i/ha., Chlorpyriphos (50%)+ Chlorpyriphos (5%) 55 EC@ 344g a.i/ha., Flubendiamide 36% + Fipronil 30% 66WG @ 33 g.a.i./ha. Monocrotophos 36 WSC @ 500 g.a.i./ha, E2 Y 45 20 SC @ 40 g.a.i./ha. Acephate 75 SP @ 667 g.a.i./ha found to be highly effective against stem borer.

- A low cost eco-friendly integrated approach involving cultivation of stem borer tolerant variety 'Ratna', use of 20 pheromone traps/ha and need based application of insecticides *viz.* Carbofuran 16.5 kg/ha or Cartap hydrochloride 300 g.a.i./ha appeared to be effective in reducing stem borer infestation.
- Trap crop technology (planting of one line of Pusa basmati after every 9 lines of main crop) for the management of yellow stem borer was demonstrated on the research field and farmer's field in the region and it is popularized among the farmers.
- Eco-friendly, low cost Integrated Pest Management special model was popularized among the farmers by conducting large scale demonstrations in the region.

Plant Pathology

- Total 9428 rice entries were screened against resistance to bacterial leaf blight. Ajaya, Karjat-1, HR-12 have shown resistance to bacterial leaf blight and these entries have been used as donor parents in rice improvement programme.
- Total 10607 rice entries were screened against resistance to leaf blast disease of rice. Rasi, IR-36, Indrayani, Karjat-1 found resistant to leaf blast disease and these have been recommended as donors in rice improvement programme.
- Foliar spray of fungicide Kocide DF 54 (35% metallic copper) @ 3g l was found to be effective in controlling bacterial leaf blight of rice.

KAUL

Rice Research Station
Chaudhary Charan Singh Haryana Agricultural University
Haryana

The rice research station was established in 1974 in the rice belt at Kaul in district Kaithal under Chaudhary Charan Singh Haryana Agricultural University with the mandate of development of high yielding non-scented varieties and export quality scented varieties possessing quality and resistance to major biotic and abiotic stresses.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

Varieties developed & released

A) Medium Duration (135-150days)

HKR 126: Semi dwarf, high yielding, dark green leaf colour with long slender grain, suitable for timely transplanting. It can tolerate water stress up to 10 days without any yield loss. It is resistant to stem rot and WBPH and moderately resistant to bacterial blight.

HKR 127: Semi dwarf, high yielding variety with golden yellow coloured grains and high milling recovery. It matures in 139 daysandwas released and notified in 2009. It is tolerant to false smut and is suitable timely planting.

HKR 128: Semi dwarf, high yielding variety with long flag leaf and long slender grain. It matures in 145 days and has already been tested at farmers' field under. It is likely to be released for general cultivation in the state.

B) Mid-early (120-135 days)

HKR 47: Released in 2005 and takes 135 days from seed to seed. It is semi dwarf, high yielding variety with golden coloured grains. It gives high milling rice recovery. It is tolerant to false smut and suitable for early and late planting.

IR 64: Introduced from IRRI through INGER programme and released after testing in station and coordinated trials. It is semi dwarf, high yielding, resistant to WBPH and moderately resistant to bacterial blight. It is suitable for early and late planting and performs well both in normal and salt affected soils.

C) Early Duration (100-120 days)

HKR 48: A semi dwarf, high yielding variety with sturdy stem and extra long grains. t is moderately resistant to bacterial blight. It matures in 118 days and is suitable for early and late planting.

D) Aromatic

HaryanaBasmati-1: Released in 1991 for general cultivation in Haryana. It is semi dwarf, high yielding, and photoperiod insensitive. Its grains are long slender and elongates twice after cooking. It is resistant to blast and tolerant to stem borer.

HaryanaBasmati-2: A semi dwarf, high yielding having extra long grain like Pusa Basmati 1121. Its grains elongate 2.17 times after cooking and give fragrance. It has also been tested at farmers' field and likely to be released for Haryana state.

E) Hybrid

Haryana ShankarDhan-1: A semi dwarf, high yielding indica rice hybrid maturing in 139 days, with stiff straw, broad, light green and erect leaves and long slender grains (super fine). It is tolerant to WBPH and stem rot and is suitable for timely planting.

Besides, CMS lines, maintainers and restorers were also identified for hybrid seed production as given below.

1 Developed two CMS lines HKR CMS1-1A (PMS3A/HB1) and HKRCMS2-1A (PMS3A/HKR239)

2 The CMS lines IR58025A, PMS1A, PMS2A, PMS3A and PMS10A have been used extensively in hybrid seed production

3 Identified IR50, HKR46, IR64, PR103, HKR124, BR827-35-K2, Pusa 44-33, IRON89-55, RP2151, IR72R,NDR118, IR54742, Indrasan, HKR49, IR54017, IR60913,HKR86-216,HKR93-3, IR54550, HKR86-3, IR52256, IR44962-7,HKR93-101, UPR1230-9-2, IR42266, IR8866, HKR91-108, IR1567,IR49461 PAU1126, IR60821-34, PAU1628 and PR109 as restorers

4 Identified HKR138, PUSA150,IR35546, HKR20, IR9828, HKR134, HKR239, HKR241, PR4141, HKR86-113, IR46823,HKR86-193, HB-1, IR-58110, Manhar, HKR112, HKR95-129, HKR95-128, HKR95-131, HKR95-138,HKR94-404, HKR95-55, HKR49492-2-2-2, PAU1973-121-1-2-1, Pusa150, IR41999-139-1-1-2-3, HKR96-90, IR46823-40-3-11, HKR98-18 HKR 94-105, HKR96-112 and HKR97-41 as maintainers.

Crop production

Agronomy

Chemical weed control in rice

- Oxyfluorfen, basalin, oxadiazon fentrazomide bensulfuron methyl and triasulfuron, pyrazosulfuron ethyl penoxsulam were found effective for weed control in transplanted rice causing greater reduction in weed growth and consequent increase in grain yield.
- Trials on economics of weed control showed that herbicides were economical than hand weeding in transplanted rice.
- Pendimethalin proved better than butachlor, benthiocarb and oxyfluorfen under direct seeded upland conditions
- combination of bispyribacsodium + metamifop (70 kg/ha) + wetter (100 ml/ha) was found most effective under direct seeded puddled conditions
- Studies on weed dynamics in rice-wheat system revealed that population of all types of weeds decreased every year with use of herbicides, but reverse was true for broadleaf weed Ipomoea aquatica.

Cultural management of rice

- • Medium duration hybrid PHB 71 had higher nutrient use efficiency and yielded higher than the medium duration variety HKR 126 under lower dose of fertilizer ($N_{120}P_{80}K_{60}$) while both were at par under the higher dose ($N_{150}P_{80}K_{60}$).
- • Use of various organic sources in Basmati rice (Basmati CSR 30) revealed that organic sources viz. green manuring (Sesbania aculeata) in situ at 5-10 t/ha coupled with application of FYM at 5-10 t/ha with or without blue green algae or azotobacter or phosphate solubilizing bacteria were found superior to

inorganic fertilizers.

- • Evaluation of different duration genotypes under alternate wetting and drying in puddled direct sown conditions revealed that hybrid HKR 1094; inbred HKR 47 and hybrid Haryana Shankar Dhan 1 were found most suitable.

Rice based cropping systems

- Management of rice residues in rice-wheat system revealed that the incorporation or retention of rice residues on the soil surface improved physico-chemical properties of the soil, particularly in the second year, resulting into increase in organic carbon content and decrease in bulk density of the surface soil (0-15 cm) over the in situ residue burning or removal practices.

Crop protection

Entomology

- Screening of rice genotypes against major insect pests: Based on field reaction from various trials viz. PHS, MRST, NSN-1, NSHN etc. from 1980 to 2014, several genotypes found promising against planthoppers, leaf folder and stem borer.
- Insecticide evaluation against major insect pests: Many insecticides formulations belonging to different groups were evaluated singly or in combination and recommended against planthoppers, leaf folder and stem borers.
- Several trials on Insecticides-induced resurgence of insect pests, monitoring species composition of stem borers and leaf folder, biological control, ecological engineering for planthopper management, Monitoring and management of yellow stem borer through pheromone trap, estimation of yield losses, Integrated Pest Management, population dynamics of insect pests through light trap were successfully conducted.

Plant Pathology

- Rice genotypes possessing single or two resistant genes were found susceptible to highly susceptible. Stable resistant sources against bacterial leaf blight have been identified for utilization in resistance breeding programme.
- Various fungi toxicants have been evaluated and effective molecules were identified.
- The genotypes HKR 95-128, HKR 95-131 and HKR 95-138, found resistant to bacterial blight in multi-environmental tests, have been maintained as genetic stocks by NBPGR, New Delhi.

KHUDWANI

Mountain Research Centre for Field Crops
Share e Kashmir University of Agricultural Science & Technology (Kashmir)
Jammu & Kashmir

Given the great economic importance of the crop, rice improvement work was started in the State during early 1950s with the establishment of Rice Research & Regional Station, Khudwani, Anantnag (1560 m amsl) with a well defined mandate of evolving high yielding, early maturing rice varieties having built-in tolerance to the biotic and abiotic stresses prevalent in the target environment. The Research Station has an area of 20 ha out of which 15 ha are available for research and seed production purposes. To cater to the needs of high altitude region, High Altitude Rice Research Sub-Station, Larnoo, Anantnag (2286 m amsl), having an area of 2.9 ha, was set up in 1978 under the administrative and technical control of Khudwani Station. With the establishment of Sher-e-Kashmir University of Agricultural Sciences and Technology in 1982, the station was transferred to the University and re-designated as Rice Research and Regional Station, presently known as Mountain Research Centre for Field Crops (MRCFC), Khudwani.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

Varieties/hybrids released/identified

- Recent releases, particularly Shalimar Rice-1, Shalimar Rice-2 & Shalimar Rice-3 usually churn out around 10 t/ha in station trials Though the rice varieties with a genetic yield potential of 4.5-5.0 t/ha have been developed for high altitudes of Kashmir valley, having reasonable tolerance to cold, are available for cultivation, the rice yields in this ecosystem are low (2-2.5 t/ha) and fluctuating due to climatic aberrations.

- Sixty three rice cultures were nominated to coordinated trials during 2000-2014.
- The station got breakthrough by developing its own high yielding, farmer preferred and cold tolerant varieties such as K-39 (*Indica* type) and K-78 (Barkat) a *Japonica* type.
- Some of the popular varieties developed include Jhelum and Chenab. These varieties together with cost effective technologies made the farmers able to harvest record yield of 8-10 t/ha.
- After thorough survey of fertility status across the valley and other comprehensive fertility experimentation at the research station, standardization of fertility dose was chalked out for different varieties and recommended to realize the actual potential of these cultivars.
- Weed management is a big challenge before the farming community; the use of herbicide gave them a big solace that in turn deemed it as a real revolution because it could triumph over their miseries and discomforts.
- Rice Research Station, Larnoo located in district Anantnag at an altitude of 2280 m amsl made a landmark achievement by developing a cold and blast tolerant and high yielding variety K-332 which replaced most of the landraces namely Siga, Marva and Kuchh traditionally grown by the farmers under high altitude ecology of Kashmir (1900 to 2300 m amsl).
- In the last decade university has bred a number of varieties with striking characteristics and recommended for different ecologies under the name of Shalimar series such as Shalimar Rice-1, Shalimar Rice-2 and Shalimar Rice-3. Shalimar Rice-1 has yield advantage and blast resilience, whereas, Shalimar Rice-2 with good height and strong culm is most suitable for water logged areas of the valley.
- The varieties developed at MRCFC, SKUAST-Kashmir, Khudwani have been adopted for cultivation in other countries as well, including Nepal and Bhutan.
- The centre has a pride of developing varieties notably K 39 and Barkat (K 78-1) that are being internationally used as reference entries for identifying rice genotypes with characteristics conferring tolerance to cold besides being utilized as reliable donors for cold tolerance.

Development of temperate CMS lines

- Two CMS lines from IRRI (IR68888A and IR68897A) were utilized to develop locally adapted temperate CMS lines using backcross breeding.
- K348 (used as recurrent parent), a medium-duration, cold-tolerant variety maintained at the MRCFC, Khudwani, showed 100% pollen and spikelet sterility when test-crossed with these CMS lines at flowering and maturity, respectively.

- With efforts, two cold tolerant CMS lines *viz.*, SKAU 7A and SKAU 11A (first temperate CMS lines in India) were developed with better agro-morphological and floral characteristics.

Progress of AICRIP trials

Name of trial	No of accessions evaluated	Remarks
AICRIP Trials conducted during last ten years	36 different trials	Promising material out of early hills and medium hills has been used in generating variability with the well adapted genotypes and useful material were bred presently in released, pre-released or pipeline status.
Rice cultures bred at Khudwani centre and nominated for evaluation in coordinated trials during last ten years	45	The lines have shown average performance under All India Coordinating Rice Improvement Programme.
Breeder seed/foundation seed produced during last ten years	Breeder Seed produced=563q Foundation seed =6500q	The seed has been produced as per the indent of different seed indenting agencies i.e. State Department of Agriculture and NSC for further multiplication and onward distribution to farmers.
Breeding material generated during last ten years	Fresh crosses and material advancement is being done every year	Every year hybridization among diverse material with well adapted germplasm lines is being done and lot of variability has been generated by advancing the material to different generations using both pedigree and backcross method of breeding.

Crop Production

Agronomy

- Evaluation of different crop establishment methods for increasing the rice yield revealed that System of rice intensification (SRI) and integrated crop management (ICM) were promising and recorded higher grain yields as compared to farmers and standard (recommended) practice.
- Evaluating different principles of SRI for their contribution towards enhancement of grain yield indicated that among the SRI components, age of seedling proved crucial for determining the yield.
- Highest grain yield of 7.9 t ha-1 was realised by transplanting younger seedlings of 12 days age, with 75% inorganics + 25% organics under weed management through cono-weeder and water management by saturation.

- The experiments conducted over years on response of selected AVT-2 (Early and Medium Hill) rice cultures under high and low input management, identified quite a good number of promising nitrogen responsive cultures (varieties) which were then released by CVRC.

- Weed management trials conducted for evaluating the effectiveness of new herbicide molecules in transplanted rice identified promising ones and recommended for use. These include Bensulfuronmethyl, Oxadiazone, Pretilachlor, Cyhalofop-butyl, Penoxsulam, Pyrazosulfuron, Flucetosulfuron. Penoxsulam @ 0.0225 kg ha^{-1} applied 0-5 days after transplanting, found very effective and recorded higher grain yield comparable to Butachlor 1.5 kg ha-1 and weed free plots.

- Pre-emergence application of Penoxsulam @ 0.0225 kg ha^{-1} proved quite effective in improving the grain yields comparable to weed free situation. The increased yield recorded with herbicidal application over control was 44.8%.

- Experiments on screening of rice gemplasm for higher Fe and Zn accumulation showed that IR 36, China 1007, K-116, China 988, Uri zag, SKAU-302, SKAU-334, SKAU-309 accumulated higher Fe and Zn contents and hence proved promising for exploitation in biofortification.

Crop Protection

Entomology

- Pest scenario: The insect pests in comparison to diseases are of minor importance, however, for the last few years, due to climate change, insect pest incidence is emerging as one of the potent threat to rice production.

- Among insect pests, grasshopper (Oxya nitidula, Hieroglyphus spp, Attractomorpha pscittacina) and long-horned grasshopper followed by rice skipper are the major ones. The incidence starts from 45 to 80 days of transplanting.

- Many insecticides were evaluated against grasshopper and found that Acephate +EK Boond was most effective.

- Triazophos was found best against grasshopper at 3 days after treatment whereas, Tricyclazole was the best against blast disease at 10 days after treatment.

Plant pathology

- Research activities on various aspects of diseases under AICRIP and station programme have yielded successful technologies in addition to development of blast resistant varieties for diverse agro-climatic zones of the valley.

- New fungicidal formulations viz., RIL-FA (Kresoxinmethyl), Nativo 75 WG (Trifloxystrobin 25%+Tebuconazole 50%) and Fillia (Tricyclazole and Propiconazole) were found effective against blast, Febuconazole 24 SC and RIL-FA against glume disclouration and brown spot, respectively.
- Among commercially available fungicides Sivic 75 WP (Tricyclazole) was effective against blast whereas, Contaf, Rhizocin and Sheathmar were found promising against sheath blight and Tilt 25 EC (Propiconazole) and Bavistin 50 WP (Carbendazim) against glume discoloration.
- Botanical/Biopesticide formulations viz., Tricure and defender were effective against all the diseases, whereas Biotos was effective against blast and sheath blight and Florezen-P against blast.
- Large numbers of entries were evaluated every year under NSN-1, NSN-2, NHSN, NSN-H and DSN nurseries against blast, sheath blight, sheath rot and brown spot diseases and a good number of promising entries have been identified. Some of these promising entries have been used as donors in disease resistance breeding programme of the station.
- Using blast differential set in the background of LTH and CO-39 procured from IRRI, Philippines, virulence range of blast pathogen population and identification of effective blast resistant gene(s) have been attempted, towards incorporation of durable blast resistance in commercial cultivars.
- Among the varieties released so for, Shalimar Rice-1, Shalimar Rice-2 and Shalimar Rice-3 recommend for low altitudes and K-332 and SKUA-402 for higher mountain ecologies of Kashmir exhibit resilience to blast under natural field conditions.
- Frontline demonstration - Frontline demonstrations totaling 610 ha for the period 2007-2014 registered an yield advantage of more than 25% over the farmers own varieties.

KOTA

Agricultural Research Station, Ummedganj, Kota Rajasthan

This Agricultural research station was established in December 1975 at Kota in Rajastan with the mandate to develop high yielding aromatic / basmati varieties with export quality characteristics, possesses resistance to biotic and abiotic stresses.

Major contributions to AICRIP

Crop Improvement

- In crop improvement, the prominent rice varieties "Pratap Sugandh-1 (RSK-1091-10-1-1) , BK-79, BK-179 and Chambal have been released by SVRC & notified from the centre.
- Rice varieties Viz, Taraori , Mahi sugandh, PHB-71, Pusa Sugandha-4, Pusa Sugandha-5 and Improved Pusa basmati-1 were found better for their intensive cultivation in the zone. All these were also included in the package of practices.
- Rice varieties like, Pusa sugandha-4, Pusa Sugandha-5, Improved Pusa Basmati-1, Pusa Sugandha-2 & 3, Pratap Sugandh-1 and Taraori basmati are most popular in the state for cultivation and covered about 90-95 percent area of total rice growing areas in the Zone.

Popular varieties released from Kota:

Pratap Sugandh-1 (RSK-1091-10-1-1)
Parentage – IET-13846 x Pusa basmati 1
Duration (Days) –135-140
Average yield (Kg/ha) –4500-5000
Special features – Moderate resistance to blast, bacterial leaf blight and stem borer

Chambal
Parentage – IR-8 x NP-130
Duration (Days) –135-140
Average yield (Kg/ha) –6000-6500
Special features – Moderate resistance to bacterial leaf blight and planthoppers

BK-190
Parentage – IR-14 x IR - 8
Duration (Days) –145-150
Average yield (Kg/ha) –7000-7500
Special features – Moderate resistance to bacterial leaf blight and planthoppers

BK-79
Parentage – TN 1 x NP-130
Duration (Days) –125-130
Average yield (Kg/ha) –4500-5000
Special features – kernel is long slender, white and translucent with good cooking quality.

Crop production

Agronomy

Weed management: Significant findings include -

- Application of pendimethalin (STOMP) @ 1.00 kg a.i. / ha. at 3-4 DAT, butachlor @ 1.5kg/ha at 3-5 DAT, Benthiocarb @ 1.00 kg/ha applied as pre-emergence in rice nursery, Anilophos + 2,4-DEE @ 0.4 + 0.53 kg/ha applied at 3-6 days after transplanting, Cinmethylin +2, 4-DEE (50 EC) @ 0.375 kg a.i. / ha applied at 7 days after transplanting, Pretilachlor 50 EC @ 0.750 kg a.i./ha applied at 3-5 DAT, Penoxsulam @ 0.025 kg/ha at 0-5 days after transplanting, Bispyribac-sodium @ 35g /ha at 20 DAT and Anilophos + Ethoxysulfuron (24 + 1 SE) @ 0.3125 + 0.0125 kg a.i./ha at 10 DAT against grassy and broad leaf weeds

Nutrient Management:

- Application of bio-fertilizer (Azolla), one tone + BGA (6 kg/ha) gave 14.0 percent higher grain yield of rice than control (Bio-fertilizer).
- Among the modified urea and coated urea materials, Nimin coated urea applied as basal gave significantly higher grain yield.

- NPK @ 150:60:50 kg/ha was considered to the best for hybrid rice. However 50% N and full P_2O_5 and K_2O as basal at planting and remaining 50% N with two equal splits at tillering and panicle initiation stage. Application of nitrogen @ 90 kg /ha was found to the best for basmati rice. Traditional aromatic rice planted between 10th to 20th July and application of 50 % nitrogen through FYM + 50 % RDF produced higher grain yield.

Water management:

- System of rice intensification (SRI) technique was found effective in transplanted rice and gave higher grain yield and monetary returns against traditional method.
- Irrigation schedule of 150% CPE along with N_{120} P_{60} K_{50} kg/ha was found suitable for grain yield of rice under aerobic rice situation
- Rice hybrids PHB-71 and PA 6201 were found suitable for direct seeding under puddled condition with intermittent irrigation.
- Low cost production technology:
- Dipping of roots of seedling in 0.5% $ZnSo_4$ solution for 12-15 hours was found to be significant superior to foliar spray of $ZnSo_4$ solution with lime applied three times.
- Yield maximization of rice under irrigated condition revealed that maximum grain yield was obtained by 33 percent extra plant stand and recommended fertilizer application.
- 15th July was found most suitable of transplanting date for scented rice varieties in South-Eastern Rajasthan.
- 30kg seed rate / ha with 20 cm row spacing was found most appropriate to produce more grain yield of rice under aerobic situation.

LUDHIANA

Regional Rice Research Station
Punjab Agricultural University
Punjab

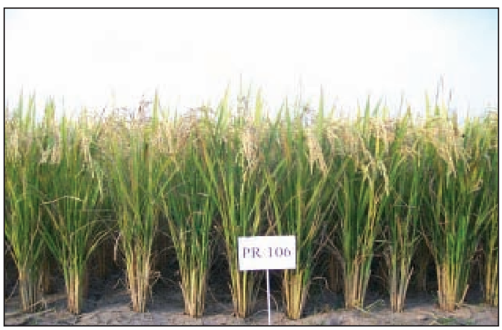
Research on rice crop was initiated in the year 1962 at Kapurthala Farm under Regional Rice Research Scheme. In 1970, the Kapurthala farm was upgraded to a Regional Rice Research Station of Punjab Agricultural University (PAU), Ludhiana. Three regional testing stations viz. Gurdaspur, Rauni and Kapurthala are involved in the multi-location evaluation of rice genotypes. The major mandate of the station is to develop short duration, high yielding non basmati and basmati varieties possessing resistance/ tolerance to biotic and abiotic stresses suitable for irrigated ecosystem.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

Since inception 35 varieties (24 non-basmati and 11 basmati) have been released by PAU, Ludhiana. A very popular variety of rice PR 106 was released in 1976 which remained a predominant variety for more than three decades and covered more than 75 % area. The varieties PR 113, PR114, PR 116 and PR 118 had also found a great favor among the farmers for many years.



Basmati rice is the pride of Punjab and is being grown here since time immemorial. The traditional tall Basmati cultivars are photoperiod sensitive and low yielders, thus several Basmati varieties with semi-dwarf nature and resistance to bacterial leaf blight were developed and released viz., Super Basmati (2003), Punjab Basmati 2 (2008), Punjab Basmati 3 and dwarf version of Traditional Basmati variety Basmati 386. This is the only Basmati variety which is resistant to all the 10 pathotypes of bacterial blight prevalent in the Punjab state carrying genes xa13 and Xa21and is the first product of marker assisted technology developed by PAU. Another variety Pusa Punjab Basmati 1509 developed by PAU is finding favour among the farmers due to its shorter duration coupled with high yield potential.

Work on hybrid rice is also in progress and a set of 26 CMS lines in diverse backgrounds has been developed. Several test crosses are attempted every year to identify the heterotic combination. A very strong pre-breeding program has been initiated at the School of Agricultural Biotechnology PAU Ludhiana for mobilizing the desired genes from related wild species into cultivated backgrounds.

Variety	Parentage	Year of release	Av.yield (kg/ha)	Salient features
Coarse grain varieties				
HM 95	Jhona 349/ TN 1 (F_2 seed irradiated)	1972	4000	Very early maturing variety
PR 113	IR 8// RP 2151-173-1 8/IR8^{*4}	1998	7000	First coarse grain variety resistant to bacterial blight
Non-basmati fine grain varieties				
Palman 579	IR 8/ Tadukan	1972	5200	Short duration, good quality rice variety
RP 5-3(Sona)	GEB 24/TN 1	1972	6000	Good quality fine grains, high yielding
PR 106	IR8//Peta ^{*5}/Belle Patna	1976	6500	Medium maturity, long slender grains, high yield
PR 103	IR 8/IR 127-2-2	1978	5500	Early maturing (125 days) long slender grains, high yielding variety
PR 4141	IR 8/BJ 1// IR 22	1982	6000	Resistant to bacterial blight
PR 108	Vijaya /Ptb21	1986	6625	Tolerant to white backed plant hopper and sheath blight

Variety	Parentage	Year of release	Av.yield (kg/ha)	Salient features
PR 109	IR 19660-73-4/IR 2415-90-90-4-3-2//IR 54	1986	6500	Resistant to bacterial blight and tolerant to white backed plant hopper
PR 110	TN1/Patong 32//PR 106*6	1992	6500	High yielding semi dwarf bacterial blight resistant, long slender grains
PR 111	IR 54/PR 106	1994	6750	High yielding semi dwarf bacterial blight resistant, long slender grains
PR 114	TN1/Patong 32//PR 106*4///IR8	1999	6875	High yielding bacterial blight resistant, long slender grains
PR 115	RP 2151-173-1-8/PR 103*3	2000	6250	Early maturing (125 days) long slender grains, erect flag leaves bacterial blight resistance
PR 116	PR108///TN1/Patong32//PR106*6////PR108	2000	7000	Long slender grains, sturdy plant bacterial blight resistant
PR 118	Pusa 44/PR 110//Pusa 44*3	2003	7250	Medium slender grains, resistant to bacterial blight
PAU 201	PR 103/PAU 1126	2007	7500	High yielding, long slender grains, bacterial blight resistant, moderately resistant to white backed plant hopper
PR 120	PAU 1196/SR817-255	2009	7133	High yielding, bacterial blight resistant, long slender grains, mid-early maturity
PR 121	PR 116///PR 108/IRRI 76//PR 106-P2	2013	7625	High yielding, resistant to all the ten pathotypes of bacterial blight

Variety	Parentage	Year of release	Av.yield (kg/ha)	Salient features
PR 122	PR 108 / IRRI-76//PR 106-P1	2013	7825	High yielding, resistant to all the ten pathotypes of bacterial blight.
PR 123	PR 116///PR 108/IRRI 76//PR 106-P2	2014	7250	High yielding, superfine grain quality, resistant to all the ten pathotypes of bacterial blight.
Basmati/aromatic rice varieties				
Punjab Basmati No.1	Sona /Basmati 370	1982	4000	First improved variety of basmati
Super Basmati	Basmati 320/IR 661	2003	3500	Extra long grains, good cooking quality with strong aroma
Punjab Basmati 2	Basmati 386/Super Basmati	2007	3152	Extra long grains, bacterial blight resistant, good cooking quality with strong aroma
Punjab Mehak 1	IR70423-170-2-3/IR 70446-85-3-2//IR70423-170-2-3	2009	4248	Extra long grains, good cooking quality with strong aroma
Punjab Basmati 3	BB resistant and dwarf version of Basmati 386	2013	4000	High yielding, only variety with BB resistance
Pusa Punjab Basmati 1509	Pusa 1301/Pusa 1121	2013	4525	High yielding, early duration, short stature.

Crop Production

Agronomy:

- To ensure response to high level of inputs, it is advisable to transplant rice at closer spacing of 15 x 15 cm^2 i.e. 44 plants m^{-2} (the normal recommendation is 20 x 15).
- Half of the nitrogen (60 kg ha^{-1}) can be saved by incorporating 6-8 weeks old green manure crop of dhaincha (*Sesbania*) or Cowpea. One third of the nitrogen (40 kg ha^{-1}) can be saved with the application of 20 t ha^{-1} FYM.
- Optimum period of transplanting for improved varieties of rice has been standardized for high crop water productivity *i.e.* 15 - 30 June.
- Optimum period of transplanting for high yield and quality characteristics for Pusa Basmati 1121 and Punjab Basmati 3 is first fortnight of July and for Pusa Basmati 1509, Basmati 386, Basmati 370, it is second fortnight of July.

- For high quality of Basmati crop, 40 kg N ha^{-1} is recommended for Pusa Basmati 1121, Punjab Basmati 3; 60 kg N ha^{-1} for Pusa Basmati 1509 and Punjab Mehak 1; and 20 kg N ha^{-1} for Basmati 386, basmati 370.
- Entire agronomic package for direct seeding of rice was given to the farmers including sowing time: first fortnight of June, seed rate :20-25 kg ha-1, sowing depth : 2-3 cm, weed control: sequential application of pre (Pendimethalin) and post emergence (Bispyribac- Na) herbicides; N dose: 150 kg N ha^{-1} in 3 equal splits (2, 5, 9 weeks after sowing).

Crop Protection

Diseases and insect pests pose a continuous threat for the sustained production of rice crop. Among diseases, bacterial blight is the most serious disease causing huge losses under the epidemic conditions. Till date 10 pathotypes of Xanthomonas oryzae pv. oryzae have been identified and characterized in Punjab. The virulence/ avirulence of the pathotypes is mentioned in Table. None of the known Xa/xa gene when deployed alone shows effectiveness against Punjab pathotypes. So the gene combinations are necessary to develop varieties possessing durable and broad spectrum resistance to all the 10 pathotypes.

Emerging and dominant pathotypes of *Xanthomonas oryzae* pv.*oryzae* showing virulence and avirulence to *Xa/xa* gene (s)/cultivars in Punja

Pathotype of *X. oryzae* pv. *oryzae*	Virulence	Avirulence
PbXo-1	*Xa4, xa5, Xa7,*	*xa8,xa13, Xa21, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118,PR 120, PAU 201, PR120, PR121, PR122, PR123, PR124
PbXo-2	*Xa7*	*Xa4, xa5, xa8,xa13, Xa21, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118,PR 120, PAU 201, PR120, PR121, PR122, PR123, PR124
PbXo-3	*xa5, Xa7, Xa21,*	*Xa4, xa8,xa13, Xa21, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118,PR 120, PAU 201, PR120, PR121, PR122, PR123, PR124
PbXo-4	*Xa4, xa5, Xa7, Xa21, Xa4+Xa21, Xa5+Xa21*	*xa8,xa13, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118,PR 120, PAU 201, PR120, PR121, PR122, PR123, PR124

PbXo-5	*Xa4, xa5, Xa7, xa8, Xa4+xa5,* PR 114, PR 116, PR 118	*xa13, Xa21, Xa38, xa13+Xa21,* IR 64, PR 111, PR 113, PR115, PAU 201, PR 120, PR121, PR122, PR123, PR124
PbXo-6	*Xa4, xa5, Xa7,*PR 114, PR 116, PR 118,	*xa8,xa13, Xa21, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 115, PR 120, PAU 201, PR120, PR121, PR122, PR123, PR124
PbXo-7	*Xa4, xa5, Xa7, xa8,* PR 114, PR 115, PR 116, PR 118	*xa13, Xa21, Xa38, xa13+Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PAU 201, PR 120, PR121, PR122, PR123, PR124
PbXo-8	*Xa7, xa8, xa13, Xa21, xa13+Xa21,* PAU 201	*Xa4, xa5, Xa38, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118, PR 120 PR121, PR122, PR123, PR124
PbXo-9	*Xa4, xa5, Xa7, xa8, , Xa21, Xa4+xa5,* IR 64, PR 111, PR 113, PR 114, PR 115, PR 116, PR 118, PR 120	*xa13, Xa38, xa13+Xa21,* PAU 201, PR121, PR122, PR123, PR124
PbXo-10	*Xa4, xa5, Xa7, xa8, Xa38, Xa4+xa5,* IR 64, PR 111, PR 114, PR 116, PR 118, PR 120	*xa13, Xa21, xa13+Xa21,* PR 113, PR 115, PAU 201, PR121, PR122, PR123, PR124

The fungicides tested and found effective against various diseases are given below:

Diseases	Management
Seed borne diseases	Soak the selected seed 8 kg in 10 litres of water containing 20g Bavistin 50WP (carbendazim) and 1g Streptocycline (streptomycin+tetracycline) for 8 to 10 hours before sowing
	Soak the selected seed 8 kg in 10 litres of water containing 5g Emisan-6 and 1g Streptocycline (streptomycin+tetracycline) for 8 to 10 hours before sowing
Sheath blight	Nativo 75 WG (trifloxystrobin + tebuconazole), @ 200 g/ha; Folicur 25 SC (Tebuconazole) @ 500 ml/ha; Tilt 25 EC (Propiconazole) @ 500 ml/ha; Monceren 250 SC (Pencycuron) @ 500 ml/ha; Bavistin 50WP (Carbendazim) @ 500 g/ha
Brown spot	Nativo 75 WG @ 200 g/ha; Folicur 25 SC (Tebuconazole) @ 500 ml/ha; Tilt 25 EC (Propiconazole) @ 500 ml/ha; Indofil Z-78 (Zineb) @ 1250 g/ha; Hinosan 50 EC (Edifenphos) @ 500ml/ha
False smut	First spray of Kocide 46% DF (copper hydroxide) @ 1250 g/ha at boot stage and second spray of Tilt 25 EC (Propiconazole) after 10-15 days of the first spray; Blitox 50 WP (Copper oxychloride) @ 1250g/ha
Sheath Rot	Tilt 25 EC (Propiconazole) @ 500 ml/ha; Bavistin 50WP (Carbendazim) @ 500 g/ha;

Blast	Indofil Z-78 (Zineb) @ 1250 g/ha; Hinosan 50 EC (Edifenphos) @ 500ml/ha
Bunt	Tilt 25 EC (Propiconazole) @ 500 ml/ha. First spray at panicle initiation stage and second after 10-15 days interval

The following insecticides were tested and found effective against various insect pests.

Stem borer & Leaf folder	Ferterra 0.4G @ 4kg/acre; Coragen 20 SC (Chlorantranilipole) @ 60 ml/acre; Sutathion 40 EC; Mortel (Regent) 0.3G @ 6 kg/acre & Marktap (Cartap hydrochloride) 4G @ 10 kg/acre; Fipronil 80% WG @ 15g/acre; Nidan 4G @ 10 kg/acre; Hostathion 40 EC (triazophos) @ 350 ml; Regent 0.3 G (fipronil) @ 6 kg and Dursban 10 G (chlorpyriphos) @ 4kg/acre; Force 20 EC, a brand of Chlorpriphos; Furadan 3 G (carbofuran) @ 10 kg/acre, twice at 30 and 70 days after transplanting;.
Planthoppers	Crocodile 17.8 SL; Confidor (imidacloprid) applied @ 40 ml/acre.
Hispa	Monocil @ 560 ml; Dursban 20EC @ 1lt and Ekalux @ 25 EC @ 800ml; Accothion 50 EC (fenitrothion)
Rice root weevil	Foratox 10 G (phorate)

Other management practices recommended for insect pest management include:

- Lopping of Basmati at half of its height at 45 days after transplanting to reduces stem borer damage.
- Economic threshold level of 10% damaged leaves recommended for leaf folder.
- PAU 201 was found moderately resistant to WBPH
- Excessive use of nitrogen encourages multiplication of insect pests particularly WBPH in PR 114.

MALAN

Rice and Wheat Research Centre, Kangra
CSK Himachal Pradesh Krishi Vishvavidyalaya
Himachal Pradesh

The rice and wheat research center at Malan was established in Kangra district in 1970 under CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The main mandate was development of high yielding varieties for favourable irrigated environments in mid to low altitude areas. And also to rejuvenate and improve red rices adapted to cooler climates in mid to high altitude areas of the state from 1000 to 2000 m altitudes.

Major Contributions to AICRIP

Crop Improvement

Varieties/hybrids identified/released

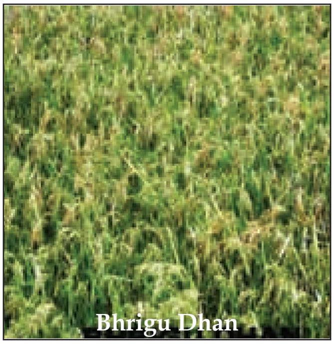
- Till date twenty three rice varieties were developed in different agro climatic conditions by this centre for commercial cultivation. During 2001-2014, seven new rice varieties namely HPR 2143, HPR 1068, HPR 2612 (Palam Basmati 1) and HPR 2720 (Palam Lal Dhan 1) for irrigated areas in mid hills (650 to 1500m); Sukara Dhan 1 for rainfed areas in mid-hills (650 to 1300m); and Bhrigu Dhan (a red rice variety) & Varun Dhan japonica varieties for high hills of HP were released by the State Variety Release Committee for general cultivation in the State. Sukara Dhan 1 was released by the Central Variety Release Committee also for rainfed upland areas of HP, Meghalaya and Uttaranchal. Bhrigu Dhan is a japonica line released in high altitude areas (above 1000m) of the state particularly in Kullu Valley and parts of Mandi and Shimla districts where people prefer short grain, low amylose sticky rice.

Rice varieties & hybrids released during 1970-2014

Name	Year	Adaptability	Maturity (Days)	Av.Yield (q/ha)
Varieties				
T 23*	1971	Irrigated (<1000 m)	140-145	25-30
IR 579*	1975	Irrigated (<1000 m)	140-145	40-45
Himdhan*	1978	Irrigated (<1000 m)	130-135	35-40
Himalaya 1*	1982	Irrigated (mid-hills)	115-120	40-45
Himalaya 2*	1982	Irrigated (mid-hills)	120-125	35-40
Himalaya 741*	1986	Irrigated & rainfed (mid-hills)	115-125	38-42
Himalaya 799*	1992	Irrigated (<1000 m)	120-125	37-40
Naggar Dhan*	1992	Irrigated (>1400m)	135-140	35-40
RP 732*	1992	Irrigated (mid-hills)	130-135	50-55
Himalaya 2216*	1994	Irrigated (mid-hills)	125-130	38-42
RP 2421*	1994	Irrigated (mid-hills)	120-125	37-40
Kasturi	1994	Irrigated (<1000 m)	135-140	30-35
VL Dhan 221	1994	Rainfed (mid-hills)	100-105	25-30
Palam Dhan 957*	2000	Irrigated (mid-hills)	125-130	40-42
Hassan Serai*	2000	Irrigated (<1000 m)	120-125	28-32
Sukaradhan 1	2004	Rainfed (mid-hills)	115-120	28-32
HPR 2143	2005	Irrigated (mid-hills)	125-130	35-40
HPR 1068	2005	Irrigated (mid-hills)	120-125	38-45
Bhrigu Dhan	2005	Irrigated (>1400 m)	150-155	33-44
Varun Dhan	2007	Irrigated (>1400 m)	140-145	25-36
Palam Lal Dhan 1 (Improved Begmi)	2013	Irrigated (>1000 m)	130-135	35-40
Palam Basmati 1 (HPR 2612)	2013	Irrigated (>1000 m)	125-130	40-45
HPR 2656		upland condition		
Hybrids				
HRI 152 (ARIZE 6129)	2007	irrigated upto 1000m		
Arize Swift		up to an altitude of 1000 m		

Note: * Susceptible to the leaf and neck blast

- Collection, evaluation, maintenance and characterization of hill rice germplasm: Out of 500 germplasm lines contributed by the center to National Germplasm Bank in 1977, 189 were received back from NBPGR and 172 lines are being maintained. Every year the local germplasm collected from different parts of the state is being grown for maintenance, evaluation, characterization and use in crosses.



Bhrigu Dhan

Crop Production

Agronomy

- A new recommendation for upland rice includes sowing of rice crop in rows of 20 cm apart using 60 kg graded seed ha^{-1}. For broadcast method of sowing, the seed rate should be enhanced to 80 kg ha^{-1}.
- A large area of rice cultivation in HP is done with the direct sowing of sprouted seeds under puddled conditions while transplanting is practiced in areas having assured irrigation facilities. For managing weeds in these eco systems, use of Pyrazosulfuron ethyl @ 0.025 kg a.i. ha^{-1} applied at 8-12 days after sowing (DAS) for direct seeded sprouted rice and 8-12 days after transplanting (DAT) for transplanted rice was recommended for controlling grassy, broad leaved weeds and sedges under both sets of conditions.
- First fortnight of June is the optimum time for sowing of rice under aerobic conditions. Any delay in sowing results in significant reduction in yield.
- Pre-emergence application of Flucetosulfuron 20 g ha^{-1} (2 – 3 days after transplanting, DAT) or post – emergence application of Bispyribac sodium 25 g ha^{-1} (15 – 20 DAT) or Penoxsulam + Cyhalofop-butyl 135 g ha^{-1} (15 – 20 DAT) were found to be highly effective in managing weeds in transplanted rice and found better than Butachlor 1500 g ha^{-1} (5 – 7 DAT).

- In direct seeded rice grown under puddled irrigated conditions, post emergence application of Bispyribac sodium + Metamifop 70 g ha^{-1} used with or without wetter gave best control of weeds.
- A number of trials were conducted every year to evaluate the performance of promising genotypes of rice in AVT - 2 (Advanced Varietal Trials - 2) under varying nitrogen levels in both direct seeded upland conditions as well as irrigated transplanted conditions (early and medium maturing genotypes).
- Method of rice establishment trials over years revealed that the transplanting gave significantly higher grain yield while lowest yield was recorded with the zero tilled direct seeding.
- Addition of green manure (dhaincha / sunhemp) along with recommended fertilizer dose resulted in significantly higher grain yield of rice.

Crop Protection

Entomology

Emerging pests - For the first time hopper burn due to mixed populations of WBPH and BPH was observed in mid hills of the state during 2007. Chaffer beetle adults hither to unknown pest has become a major pest which feeds on the rice panicle during milky stage. White tip nematode was found to be associated with rice crop at nursery stage. Root-knot nematodes are becoming an alarming problem in rice-wheat eco-system. Black beetle found to damage upland crop during nursery stage. Hispa emerged as a major pest causing severe damage in many districts.

Hopper burn in farmers fields

Hispa adults and damage

Chemical control measures recommended for various pests after evaluation:

- Rice hispa: Spray chlorpyriphos 20EC (0.05%) 1250 ml /ha at 10 DAT or 40 days old crop (direct sown), followed by another spary of chlorpyriphos (0.05%) or Neemazal (0.3%) or Econeem (0.5%) after 40 days of first spray.
- Stem borer: Apply carbofuron (Furadon 3 G) by broadcasting in 3-4 cm deep standing water @ 1 kg a.i./ha at 10 days after transplanting, if necessary spray 500 ml methyl parathion in 500 water/ha.

- Leaf folder: Clip-off the affected leaves. Remove graminaceous weeds. Spray 1250 chlorpyriphos 20 EC (0.05%) or 835 ml monocrotophos 36 EC (0.06%) in 500 L water /ha on the appearance of pest.
- Planthoppers (WBPH & BPH): Monitor the rice fields at weekly intervals to notice the appearance of the pest; spray carbaryl 50 WP @ 1500 g/ ha or monocrotophos 1500 ml /ha; repeat application if hopper population persists beyond a week after application; and while spraying nozzles should be directed at the basal portion of the plants.
- Chaffer Beetle: Spray Cypermethrin 10 EC @ 625ml per hectare or Chlorpyriphos 20EC @ 1250 ml per hectare at panicle emergence stage.
- Case worm: Spray Spinosad 45EC @ 125ml in 500 litre water per hectare at the emergence of pest.

Chaffer beetles & damaged grains

Caseworm damage, adult & cases

Plant Pathology

- Blast, false smut, glume discolouration and brown spot are the major constraints in the rice production in the State. Of late, bacterial leaf blight and sheath blight, diseases of tropics have started appearing in mid-hills of the State while minor diseases of rice *viz.,* sheath rot, leaf scald and narrow brown leaf spot are also regularly appearing during the crop season.

Control measures developed under rice pathology programme:

- ***Rice blast:*** Use of resistant varieties coupled with seed treatment with tricyclazole (Beam 75WP) or carbendazim (Bavisitin 50WP) @ 2g/ kg seed. Spray of carbendazim (0.1%) at tillering, panicle initiation and booting stages or tricyclazole (0.06%) at panicle initiation and booting stages.
- ***False smut:*** Two sprays of copper oxychloride 50 WP @ 0.3% at heading and 10 days thereafter.

- Grain discoloration: First spray of Bavistin 50WP @ 0.1% at the time of earhead emergence, second spray of Indofil M45 @ 0.25% 10 days after and third spray of Blitox 50WP @ 0.3% 10 days after second spray.
- ***Brown spot:*** Two sprays of propiconazole (Tilt 25 EC) at 45 and 65 days after transplanting.
- Field monitoring of virulence's: Field monitoring of virulences in Pyricularia grisea has also been the important part of the rice pathology programme at this centre which helps knowing the extent of variation within the blast pathogen at the centre.

Screening of rice germplasm in Uniform Blast Nursery

Blast infected seedlings of rice in UBN

- **Identification of new molecules against location specific diseases:** New molecules promising against blast include, tricyclazole (Beam 75WP), Metominostrobin 20 SC, RIL 013/F1 35 SC, Kasu B 3 SL, Protéga 300 SC, Rhizocin 3 L, Biofer, Defender, Florezen- P, Trichozen- T, Sivic 75 WP, Kitazin 48 EC, Hexaconazole 75 WG (RIL-012/F1), kresoxim methyl 40% + Hexaconazole 8% WG (RIL-068/F1 48WG), Azoxystrobin 25 SC (Amistar), Kresoxim methyl (Ergon 44.3SC), Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75 WG), Tricyclazole 45% + Hexaconazole 10% (ICF-110), Tricyclazole 18% + Mancozeb 62% WP (MERGER) etc.
- **Integrated disease management:** Integrated disease management trials have also been conducted by combining different disease management practices like adoption of resistant/ moderately resistant varieties/ locally released hybrids, recommended dose of fertilizers coupled with need based application of chemicals (tricyclazole 75 WP) which are effective for the management of rice blast.

MANDYA

Zonal Agricultural Research Station, V.C.Farm, Mandya Karnataka

This Agricultural research station was established in December 1969 as AICRP on rice at V.C. farm of Mandya in Karnataka. It has been upgraded as Zonal Agricultural Research Station under the University of Agricultural Sciences, Bangalore, Karnataka.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

Popular varieties released from Mandya

BR 2655 (IET 17165)
Duration (days) - 140-145
Average yield (Kg/ha) –6000-6500
Special features – Blast tolerance

Thanu (KMP 101) (IET 17164)
Duration (days) - 110-115140-145
Average yield (Kg/ha) –4500-5000
Special features – Earliness and Blast tolerance features

KRH-4
Duration (days) - 130-135
Average yield (Kg/ha) –7500-8000
Special features – Higher grain and straw productivity, MS grain

Raksha (KMP 105)
Duration (days) - 110-115
Average yield (Kg/ha) –5000-5500 an yield potential of 5.0-5.5 t/ha. S
Special features – Earliness and Blast tolerance

KRH-2
Duration (days) - 130-135
Average yield (Kg/ha) –7000-7500
Special features – Higher grain and straw productivity, wider adaptability

Mandya vijaya
Duration (days) - 140-145
Average yield (Kg/ha) –5000-5500
Special features – Good cooking quality and Higher grain straw productivity

- Developed and released 18 Rice varieties for three different ecosystems of Karnataka *viz.,* - Southern *maidan* areas (Zone-4, 5 & 6), Hilly zone (Zone-9) and coastal zone (Zone-10). Madhu, Mangala, Mandya Vani, Pushpa, Mukthi (CTH-1), *Bili* Mukthi (CTH-3), Thanu and Raksha are few important varieties which are still popular and in seed production chain.
- Identified 13 rice varieties from all India Coordinated materials and one variety from INGER materials and released for different rice growing ecosystems of Karnataka. Important varieties among them includes Intan and IET-7191 for Hilly Zone, GMR-17 for coastal zone and IET 7575, IET 8116, IR-20, IR-30864 (for saline-alkaline) and IET 1444 (Rasi) for Southern *maidan* areas (Zone-4, 5 & 6).

- Three Rice varieties *viz.,* MTU 1001, MTU 1010 and JGL 1798 released from ANGRAU have been locally evaluated, endorsed and released to irrigated *maidan* areas of Southern Karnataka through SVRC.

- Developed and released three rice hybrids *viz.,* KRH-1, KRH-2 and KRH-4. KRH-1 was released as first ever rice hybrid in India during 1994. KRH-2 was released in 1996 for Karnataka. Later it was identified by CVRC for all India release in 1998. KRH-4 is a medium duration, ms grain hybrid with a yield potential of 8.5-9.0 t/ha., was released in 2012 for Karnataka.

KRH 2

KRH 3

- Developed more than 100 breeding lines for various traits including resistance to BPH, blast and higher water use efficiency through hybridization and selection, and nominated ten of them for AICRIP breeding trials and two of them for plant hopper screening nurseries.
- Collected more than 350 traditional varieties of rice from different parts of the Karnataka. They are characterized for DUS attributes and evaluated for their yield and other special attributes like Protein, Zinc, Iron and amylose content; and resistance to BPH and Blast.
- Fourteen new CMS lines (KCMS 42 to 53) are developed through backcross breeding and ten promising heterotic restorers have been identified for development of new hybrid combinations. Rice hybrids with an ability to withstand moisture stress and BPH tolerance have been identified.
- Public-Private partnership for commercialization of rice hybrid KRH 2 has been established with two seed companies
- After evaluation of more than 1000 rice genotypes 73, 41 and 71 genotypes have been identified with varied degrees of resistance to BPH, leaf blast and neck blast, respectively that can be used in resistance breeding programmes.

Crop production

Agronomy

- Standardized fertilizer dose @100:50:50 Kg NPK/ha, for varieties and @120:60:60 Kg NPK/ha., for hybrid rice cultivation in Cauvery command and other irrigated *maidan* areas of the southern Karnataka and included in the Package of practices of UAS (B).

- Measures for reclamation of saline soils through different drainage systems and use of press mud as an amendment in problematic soils have been standardized and recommended in Cauvery command area.
- New weedicides *viz.,* Butachlor 50 EC @ 1250 g a.i./ha or Pyrazosulfuron ethyl 10WP @ 25 g a.i./ha or Bensulfuron methyl 60 g + Pretilachlor 600g a.i./ha (66G) or Pretilachlor 50 EC +Safenor @ 300 g a.i./ha is recommended at 3DAS for both wet and dry rice nursery as against Butachlor 50 EC @ 1250 g a.i./ha within 24 hours of sowing that showed phytotoxicty, more weeds/m^2 and less weed control efficiency.
- In mechanical transplanting nursery establishment method, land preparation, planting, weed management *etc.,* have been standardized and recommended as per local needs. Use of machine transplanting increased the paddy yield by 15-20 % over farmers practice of manual transplanting besides saving the cost of up to Rs. 2000/ha.

Crop Protection

Entomology

- Selection of eco-friendly insecticides *viz.,* Indoxacarb 14.5SC @ 0.3ml/ L for leaf folder, Flubendiamide 480SC@ 50 ml/ha or Flubendiamide 20 WDG @ 150 g/ha and Chlorantraniliprole 10% OD for stem borer and leaf folder, buprofezin 25SC @ 1.4ml/l for brown planthopper (BPH).
- Identification of 155 promising entries against BPH.
- Selection of 22 local rice germplasm accessions *viz.,* Ratna choodi-1, Ratna choodi-2, Kala kolli, Kottayam, Honasu-1, Honasu-2, JBT-3614, Myroremallige , Akkalu-I, Akkalu-2, Salem sanna ,Raja mudi,Chinnaponni, Karpoorakeli, Rai bog, Anilamanil, Baiganmanji, Manila,Ugibatta,Najarbaat, PS-339 for tolerance BPH.

Plant Pathology

- Management of Udbatta disease of rice: Seed treatment with Carbendazim 25 + Mancozeb 50 WS @ 4 g/kg of dry seeds or to sprouted paddy seeds one day before sowing.
- Management of rice blast disease in nursery by seed treatment: Seed treatment with tricyclazole 75% WP @ 3 g/kg of seeds.
- Management of sheath blight of paddy: Spray propiconazole 25% EC @ 1ml/lt as soon as the symptoms are seen and if necessary at 15 days interval.

MARUTERU

Andhra Pradesh Rice Research Institute (APRRI) & Regional Agricultural Research Station (RARS), Acharya NG Ranga Agricultural University, Andhra Pradesh

APRRI & RARS, Maruteru was established in 1965 in the typical deltaic soils of West Godavari. Research programmes are being carried out at this Institute with multi-disciplinary approach involving Breeding, Plant Physiology, Agronomy, Soil Science, Entomology and Plant Pathology with the major objective of development of rice varieties/ hybrids suitable for different situations in Krishna Godavari zone.

Major contributions to AICRIP

Crop Improvement – *Plant Breeding*

- Released 48 varieties including 23 pure line selections, 7 improved varieties through crossing, 13 BPH resistant varieties, two rice hybrids (APHR 1 and APHR 2) and two rainfed rice varieties.
- The varieties developed at Andhra Pradesh Rice Research Institute, Maruteru are being extensively cultivated in 13 states in India and four neighboring countries and occupying an area of 12 million hectares
- The research station has the distinction of developing BPH resistant varieties viz., Vajram, Chaitanya, Krishnaveni, Prathiba, Nandi and Deepti in India.
- The centre has distinction of releasing medium duration fine grain CMS lines viz., APMS 6A, APMS 9A which are being currently used extensively to develop medium duration fine grain rice hybrids in India.

Popular varieties released from APRRI & RARS, Maruteru

- Three mega varieties released by this station viz., MTU7029 (Swarna), MTU1001 (Vijetha) and MTU1010 (Cottondora sannalu) occupy approximately 18-20% rice area in the country and contribute about 25 m.t. of rice to the national food pool and thereby benefiting the country to a tune of Rs. 1200 to 1500 crores additional income every year.

MTU 7029 (Swarna) – IET 5656
Parentage: Vasista/Mahsuri
Duration (Days): 150-155
Average yield: 55-60 q/ha
Grain type: short bold, brown husk
Special features: semi dwarf plant type with dark green foliage. It is profuse tillering variety. Resistant to BLB

Cottondora Sannalu (MTU-1010) IET 15644
Parentage: Krishnaveni /IR 64
Duration (Days): 120
Average yield: 40-45 q/ha
Grain type: long slender
Special features: Semi- dwarf (108 cm), resistant to blast & tolerant to BPH

MTU 1001(Vijetha) - IET-13967
Parentage: MTU 5249 x MTU 7014
Duration (Days): 120-125
Average yield: 97 q/ha
Grain type: Medium slender
Special features: semi dwarf (115 cm), tolerant to BPH & blast

MTU 1061 (Indra)
Parentage – PLA 1100/MTU 1010
Duration (Days) –Late
Average yield–48-65 q/ha
Grain type – Medium slender
Special features –Plant height 115 cm, semi- dwarf, tolerant to BPH, BLB and GM biotype 1.

MTU 1075 (IET 18482) (Pushyami)
Parentage – MTU 2716/MTU 1010
Duration (Days) – 135-140
Average yield– 60 q/ha
Grain type – long slender
Special features –Plant height 108 cm, semi-dwarf, tolerant to leaf blast, BLB , sheath blight, BPH, WBPH and leaf folder.

MTU 1064 (Amara)
Parentage – PLA 1100/MTU 1010
Duration (Days) – 115-120
Average yield– 65 q/ha
Grain type – medium slender
Special features –Plant height 115 cm, semi- dwarf, tolerant to BPH,BLB, GM biotype 4, low incidence of SB, flood and salinity tolerance.

Crop production

Agronomy

- Among different crop establishment methods with common date of sowing and transplanted on different dates, highest yield was obtained under SRI method (6039 kg/ha) followed by Integrated crop management (ICM) with 20x20 cm (5942 kg/ha) and was on par to standard method of transplanting with 20x10 cm spacing. On the other hand, Crop establishment methods with different dates of sowing and planted on the same day, ICM method recorded the highest grain yield (6018 kg/ha) followed by SRI method (5831kg/ha).
- Among different varieties tested under aerobic conditions in puddle transplanted situation, MTU-1075 performed well and resulted significantly

superior grain yield (5855 kg/ha) followed by MTU 1010 (5546 kg/ha) and MTU 1064 (5477 kg/ha) under aerobic conditions.

- Rice – Maize system was found more remunerative with 1:1.8 B:C ratio than Rice – Rice system (1:1.66) for Godavari delta.
- Organic package of green manuring-insitu with Dhaincha and FYM application @ 10 t/ha as basal and top dressing of neem cake @ 500 kg/ha in two splits at tillering and P.I stage was found to meet the nutrition requirement as that of inorganic fertilizer dose (60-40-40 kg NPK/ha) for Swarna variety during kharif season.
- In transplanted rice among different herbicides, application of penoxulam 24SC, @ 0.0250 kg a.i/ha at 0-5 DAT resulted in the highest grain yield (5597 kg/ha) and lowest dry weight of weeds at 45 DAT (9.5g/m2). In another trial, Penoxulam + Cyhalofop-butyl at two doses (120 & 135 g.a.i/ha) applied at 15-20 DAT are very much effective and recorded higher grain yields (5662 & 5581 kg /ha) and it was on par with two hand weedings (5959 kg/ ha) and Bispyribac- Sodium 35 g a.i/ha (5336 kg/ha).
- In direct seeded rice under puddle condition, Penoxulam @ 25 g a.i/ha at 15-20 DAS resulted in higher yields (5726 kg/ha) and it was on par with Pyrazosurfuron ethyl @ 20 g a.i/ha at 4-7 DAS (5645 kg/ha), two hand weedings (5806 kg/ha) and weed free (5871 kg/ha) treatments.
- Studies on weed dynamics in rice – rice system indicated that the application of Glyphosate @ 0.75 kg a.i. /ha at 15 days before crop establishment without standard method of farmer's field preparation coupled with Bensulfuron-methyl + Pretilachlor (6.6GR) @ 0.06 + 0.60 kg a.i/ha at 8-15 DAT (post - emergence) resulted in better control of weeds and recorded higher grain yield of 5714 & 5738 kg/ha during Kharif and Rabi, respectively. This treatment was as effective as two hand weedings. Residual effect of different herbicides was not conspicuous.

Soil Science

- Conjunctive use of organics and inorganics (substitution or 25 to 50% N through green manure and / or FYM) produced yields comparable to yield obtained with 100% N applied through urea only after seven seasons of continuous usage of organics.
- In situ incorporation of Sesbania sp., pillipesara / black gram and application of paddy straw, FYM etc., have contributed to the nutrient needs of Kharif rice in part as revealed by on par yields obtained with 50% and 100% NPK treatments. The contribution of crop residues to the succeeding Rabi rice was, however, marginal.

- Commonly used complex fertilizers like DAP, 28:28:0, 17:17:17 and APP and straight fertilizers like single super phosphate (SSP) were equally effective in respect of P uptake, buildup of soil P and rice yields. Continuous application of SSP has however, resulted in significantly higher buildup of Calcium and Sulphur suggesting the usage of SSP now and then to enrich the soils with these two secondary nutrients.
- Nitrogen dose of 60 kg/ha was observed to be optimum for rice during Kharif season but for varieties like Swarna 30 kg/ha is adequate.
- A dose of 40 kg P_2O_5 was found to be necessary for Kharif rice, while 60 kg/ha was optimum and economical for Rabi rice in Godavari alluvial soils analyzing for low to medium available phosphorus.
- Application of phosphorus bio-fertilizer at 2.5 kg/ha was found to be effective in solubilizing and making available, the phosphorus present in rock phosphate and also the native fixed P in the soil, which are otherwise not readily available to the rice crop.
- Potash application @ 40 to 45 kg/ha was found to be optimum for getting higher yields in Godavari alluvial soils irrespective of soil available K_2O content. Split application of potassium has no additional advantage over entire basal application in these heavy soils.

Crop protection

Entomology

- Eight brown planthopper resistant donors viz., PTB 33, Velluthacheera, Huru Honderwala, Rathu Heenati, PTB 12, Manoharsali, CRMR 1523 and ARC 6650 were identified. MTU IJ 206-7-4-1 (BM 71) havve been identified as new resistant donor having field resistance to planthoppers.

- Anjungbyeo, BR314-B-4-6 and Hamnam 15 were identified as resistant donors to yellow stem borer
- New insecticide molecules effective against insect pests were identified and included in the state level package. These include:
  - Planthoppers - Ethofenprox 10EC @ 2.0ml/L, fenobucarb 50 EC @ 2.0 ml/L, imidacloprid @ 0.2ml/L, thiamethoxam 25WG @ 0.2g/L, buprofezin @ 1.6 ml/L, ethiprole 40%+imidacloprid 40% @ 0.25 g/L, pymetrozine 50 WG @ 0.5 g/L and sulfoxaflor 24 SC @ 0.75 ml/L of water

- Planthoppers, leaf folder and stem borer - Acephate 75 SP @ 1.5 g/L water
- Stem borer and leaf folder - Cartap hydrochloride 4G @ 8 kg/ac, fipronil 0.3 G @ 5 Kg/ac, cartap hydrochloride 50WP @ 2g/L, fipronil 5 SC @ 2.0 ml/L, chlorantraniliprole 20 SC @ 0.4 g/L of water.
- Leaf folder and rice hispa - Profenophos @ 2.0 ml/L of water

- Use of pheromone traps @ 3traps/acre for monitoring and 8 traps/acre for mass trapping has been recommended for yellow stem borer management.
- The occurrence of rice panicle mite, Steneotarsonemus spinki was reported for the first time in the state and its management by spraying with profenophos @ 2 ml or dicofol @ 5 ml /L or diafenthiuron 50 WP @ 1.5 g/L of water, once at panicle initiation stage and another at 15 days later was recommended.
- Recommended the effective insecticide and fungicide combinations against insect pests and diseases *viz.*,ethofenprox + hexaconazole; acephate 75 SP + hexaconazole; imidacloprid + validamycin; imidacloprid + propiconazole; thiamethoxam + validamycin; thiamethoxam + propiconazole against planthoppers and sheath blight. While, cartap hydrochloride 50WP+ hexaconazole and acephate 75SP + hexaconazole against sheath blight, leaf folder and stem borer.
- Created awareness among the farming community about the IPM practices and developed two IPM modules for K.G. Zone i.e., cultivation of a BPH tolerant variety like Vijetha (Kharif) and Cotton dorasannalu (Rabi) with need based application of insecticides against other major pests and diseases or cultivation of BPH susceptible HYV with timely plant protection against planthoppers realized higher benefit cost ratios.

Plant Pathology

- Sheath blight, blast and bacterial blight forecasting techniques were developed using trap plot techniques.
- A yield loss regression equation to sheath blight disease was developed.
- Seed dressing with carbendazim 50 WP was found to control seed borne sheath blight and blast disease pathogens.
- Blast disease was found to be controlled up to 40 DAS in direct seeded upland rice by treating the seeds with fungorin @ 3g/kg of seed at least 24 hours before sowing.
- Tricyclazole 75% WP @ 0.6 g/litre and edifenphos 50EC @ 1 ml/l were found to control rice leaf and neck blast disease effectively.
- Propiconazole 25 EC @ 1 ml/litre, Hexaconazole 5 EC 2 ml/l. and Validamycin @ 2 ml/lwere found effective against sheath blight.

- Bacterial leaf blight tolerant varieties like MTU 7029, MTU 1061, MTU 1031, MTU 4870, MTU 9993, IR 36, IR 40, IR 42, Jaya, Satya and Mahsuri were identified.
- Rice tungro tolerant varieties: MTU 9992, Suraksha, Vikramarya, Bharani
- Several resistant / moderately resistant / tolerant rice cultures were identified against bacterial leaf blight, sheath blight, brown spot and blast.
- Hexaconazole 5 EC 2 ml/L, Propiconazole 25 EC @ 1 ml/L, and validamycin @ 2 ml/L, carbendazim @ 1.0g/L and benomyl @ 1.0g/L were found effective against stem rot of rice.
- Carbendazim 50 WP@ 1.0g/L or benomyl 50WP @ 1.0g/L was found effective against red stripe disease.
- Azoxystrobin 18.2% + Difenconazole 11.4% SC (Amistar top) @ 1.25 ml /l was found effective against sheath blight of rice.
- Tebuconazole 25.9% EC @ 2.0 ml/l was found effective against stem rot of rice.
- Isoprothiolane 40 EC @ 1.5 ml/litre was found to control both leaf and neck blast. Trifloxystrobin+ tebuconazole (Nativo) 75WG was found to be effective against sheath blight. This was also found effective against sheath rot, false smut and grain discolouration. Hence these were recommended in the University (ANGRAU) package of practices.
- Validamycin 3L @ 2.0 ml, hexaconazole 5 EC @ 2.0 ml, propiconazole 25 EC @ 1.0 ml, carbendazim 50WP @ 1.0 g, benomyl 50 WP @ 1.0g/litre and tebuconazole 25.9 EC @ 2.0 ml/l were found effective against stem rot disease in rice.
- Red stripe is a new disease problem in areas where rice- rice cropping system is prevailing. The disease occurs from panicle initiation to crop maturity when conditions like high temperatures and high humidity are prevailed. Recently its pathogenicity was proved and the causal agent has been identified as *Nigrospora oryzae*. It can be controlled by spraying with either carbendazim 50 WP or benomyl 50 WP @ 1.0g/l.

MASODHA (FAIZABAD)

Crop Research Station

Narendra Dev University of Agriculture & Technology, Kumarganj, Faizabad Uttar Pradesh

The Crop Research Station, Masodha, Faizabad formerly known as Rice Research Station, was established in the year 1951 with the mandate to conduct rice research on different ecosystems viz., drought prone rainfed upland, rainfed shallow lowland and semi deep ecology, irrigated etc. This station is a satellite centre of Narendra Dev University of Agriculture & Technology (NDUAT), Faizabad.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

High yielding varieties developed at this center have contributed a lot in enhancing the productivity of irrigated areas not only of Uttar Pradesh but many other states too.

Sl. No	Variety	Parentage/ Designation	Year of release	Maturity (days)	Yield (q/ha)	Grain type
A. Upland drought prone very early						
1	Narendra-1	Belle Patna/IR8	1981	105	35-40	MB
2	Narendra-118	IR 36/Hansraj A	1987	85	35-40	MS
3	Narendra-97	Nagina-22/Ratna	1992	90	35-40	LS
4	Barani Deep	C1064-5/IR 9129-320-3-3-3//IR 54	2001	100	35-40	LS
5	Shushk Samrat	C 1064-5 / Kalkari// IR 54	2007	105	35-40	LS
B- Irrigated						
Early (100-115d)						
6	Narendra-2	IR 8/Tadukan / (TKM6 /TNI)/ /IR8/IR24	1982	115	40-45	LS
7	Narendra-80	Nagina-22/IR 36	1986	115	40-45	MS

Sl. No	Variety	Parentage/ Designation	Year of release	Maturity (days)	Yield (q/ha)	Grain type
8	NDR 2026	SIPI 632-63 / CHAINUNG SEN YU 47/ TAICHUNG SEN 12	2005	115	40-45	MS
9	NDR 2064	Pant Dhan 4/Saket4 // NDR 2017	2007	115	50-55	MS
10	NDR 2065	Pant Dhan 4/Saket 4// NDR 2018	2011	120-125	50-55	LB
11	NDR 2101 (Shivraj)	Pant Dhan 4/NDR 2018	2013	120-125	50-55	LB
Medium Duration (120-130d)						
12	Sarjoo-52	TN 1/Kashi	1980	130	60-65	LB
13	Narendra-359	BG90-2-4/OB677	1993	130	60-65	LS
14	Narednndra 3112-1 (Prakhar)	NDR 313-1/NDR 359	2009	125-130	50-55	LB
15	NDR 370133 (Narendra Sona)	NDR 359/NDR 3026	2013	130	55-60	LB
16	Narendra Laher	IR 68068-99-1-3-3-3/ Janak//IRRI 105	2014	130	55-60	LS
Hybrid Rice						
17	Narendra Shankar Dhan-2	IR58025A/NDR3026-3-1	1998	130	65-70	LS
Rainfed Lowland Shallow Deep (30-50cm)						
18	NDR 8002	IR 67493-M – 2	2004	140	40-45	LS
19	Jal Lahri	Pankaj/Mahsuri// TKM6	1993	145	40-50	MS
D. Usar/Problem Soil						
20	Narendra Usar Dhan - 2	IR1814/IR1366- 120 -3-1//IR1539- 37-3-1	1995	125	30-40	LS
21	Narendra Usar Dhan -3	LEUNGYAI 148/IR 9129-209-2-2-1 //IR 18272-27-3-1	1999	130	45-50	LS
22	NDURH-3	IR58025A/NDRK5026 -1 R	2005	130	50-55	LS

Sl. No	Variety	Parentage/ Designation	Year of release	Maturity (days)	Yield (q/ha)	Grain type
23	Narendra Usar Dhan 2008 (NDRK 5088)	TCCP 266-249-B-B-3/IR 262-43-8-1	2009	120-125	45-50	LB
24	Narendra Usar Dhan 2009 (NDRK 50002)	NDRK 5024/NDR 423	2012	120-125	45-50	MB
E. Aromatic Rice						
25	Lalmati	Land Race	2007	110	30-35	SS
26	NDR 6093	NDR 637/Type-3	2012	128	40	LS
27	NDR 6244	IET 13549/Taroari Basmati	2013	130-35	40	LS
28	Narendra Parag	Selection from Vishnu Parag	2014	130-35	40	SB

Narendra Shankar Dhan 2

- Breeding material nominated – Every year 250-300 crosses were made and 1500-2500 segregating populations were screened for various traits covering all the ecologies. Of these, 19-37 entries were nominated to AICRIP.
- Altogether 1078 exotic and indigenous germplasm have been maintained.

Crop Production

Agronomy

- Rice based cropping systems: Out of six rice based cropping systems tested, rice-wheat system found to be quite feasible and economically sound. Rice-potato + mustard - black Gram crop sequences proved to be the most remunerative followed by rice- wheat-green manure crop sequence. With adoption of dhaincha (Sesbania) for green manure in summer season, the grain yield of rice and wheat may be enhanced by 5-6q/ha compared to fallow with saving of 40 kg N/ha.

- Nutrient management: For fertilizer economy, 25% of recommended fertilizer dose (120 kg N+60 kg P20s + 60 kg K2O/ha) may be applied through FYM and rest 75% through inorganic fertilizers. Half dose of nitrogen along with full dose of phosphorus and potash should be applied as basal, half N as top dressing at the active tillering and PI stages of crop growth.
- Cultural practices: Transplanting of medium duration rice varieties should be done at the end of June or early July, short duration by mid July while traditional photo period sensitive varieties by the end of July with 50 hills per square meter. The sowing in line under puddled condition by DRR 7 rows drum seeder using 100 kg sprouted seed was at par to transplanting and better than farmers' practices as well as broadcasting of sprouted seed in puddled conditions.
- Weed Management: Hand weeding twice, at 20 and 40 days after sowing/ transplanting has been found effective. Use of Butachlor @ 1.5 kg ai/ha or Anilophos 30 EC @ 0.6 kg a.i./ha applied within 3-4 days after sowing/ transplanting was most effective.
- Scented rice: For better yield, transplanting of scented dwarf rice varieties must be completed before 3rd week of July. These varieties responded to N linearly up to l20 kg N/ha while tall traditional varieties up to 90 kg N/ha.

Soil Science

Long term effect of continuous cropping and manuring:

- Twenty years results showed that there is need of P application in both the crops i.e. rice-wheat. In long run, nitrogen responds only in presence of phosphatic fertilizers.
- The loss of applied N due to prilled urea application through leaching and ammonia volatilization could be reduced by the application of the neem cake coated urea, urea super granules and large size granulated urea.
- Nitrogen application, irrespective of sources increased $NH4^+$, N concentration 86.6% in the soil. The application of urea in three splits recorded highest grain yield as well as nitrogen use efficiency.
- Maximum uptake response and recovery of applied nitrogen was observed with prilled urea followed by 50% organic +50% inorganic fertilizer.
- Maximum paddy yield was recorded in the treatment 120 kg N, 60 kg P_20_5& 60 kg K_2O, 25 kg $ZnSO_4$, 10 kg S + FYM @ 5t/ha as compared to other combinations of inorganic and organic manure treatments.
- Application of 5.0 ppm of Zn recorded maximum paddy yield, where as application of Zn beyond 5.0 ppm decreased the yield.
- Fe & Zn lines - Rice germplasm for higher Iron and Zinc content in grain was screened and promising genotypes were identified.

Physiology

- For drought prone rainfed conditions, findings emphasized the need for evolving rice cultivars possessing greater sink potential (product of grain number and grain size) and increased drought resistance particularly plant sustenance with maturity duration around 90 days which is actually the maximum span of the rainy season in eastern Uttar Pradesh.
- For rainfed upland situations compact and awned panicles have been found to lose less water, hence beneficial under limited water supply conditions. Panicle water relations and genotypic variation therein provide opportunity for identifying adaptive mechanisms of great practical significance.
- "Tri-nodal rooting"- a unique rooting system in rice seedlings has been identified and found to increase drought resistance through maintaining higher leaf water status and increased seedling vigor.
- Root-box studies have shown that the root length densities of deeper soil zone were beneficial than root length densities of upper soil zones in maintaining water status of plant under depleting soil moisture conditions.
- Enhanced capacity of dry matter accumulation during vegetative stage and subsequent translocation of stored assimilates for grain filling during stress period have been found desirable characteristics for increased production and productivity under stress situations.
- The exogenous application of ABA may be of value for plant survival under depleting soil moisture conditions and regrowth upon rewatering.
- Pre-sowing drought hardening prevented turgor loss, increased net chlorophyll content and enhanced both proline and sugar accumulation in the leaves during drought.

Crop Protection

Entomology

Cultural practices

- Transplanting before 15th July helps to avoid high infestation of rice whorl maggot. Alleys formation after every ten rows hinders the development of BPH.
- Rain supported with dry spell in the month of October encourages the development of ear cutting caterpillar. Flooding the field is recommended to check their multiplication.

Chemicals identified

- Chlorpyriphos was effective against rice ear cutting caterpillar. Spray formulation gave better result than the dust. Chlorpyriphos 10G, Carbofuron 3G and Monocrotophos 40 EC were found' effective for controlling the whorl maggot after 10 DAT.

- Carbofuran 3G and Phorate 10G @ 1 kg a i./ ha are very effective against rice stem borer at 30 and 50 DAT.
- Mixture of BPMC+DDVP (l: 1) @ 1 litre/ha and Monocrotophos one litre/ha spraying was most effective for controlling BPH and WBPH.
- Dipping of uprooted nursery in 0.02% Chloropyriphos 20 EC for 12 hours was very effective to control whorl maggot, gall midge and leaf hoppers.
- Synthetic pyrethroids, Quinalphos and Methyl parathion should not be sprayed as they cause resurgence of BPH.

Plant Pathology

Disease management - Following chemicals were found effective:

- Sheath rot (SR): Bavistin 50 WP @ 0.1 %; Brown Spot (BS) and Grain discoloration: Indofil M -45 @ 0.2-0.25 %; Sheath Blight (ShB): Bavistin 50 WP @ 0.1 % & Hexaconazole 5SC @ 0.2%; False Smut (FS): Propiconazole @ 500 ml/ha
- New chemicals- Foliar Spray: Sheath blight- Sheathmar @ 2.5 l/ha, Nativo 75 WG @ 200 g/ha, Thiafluzamide 24 SC @ 200g/ha, Propiconazole @ 500ml/ha, Opus @ 2.0 l/ha, Swing @ 2.0 l/ha, Folicur @ 0.6 l/ha, Armure @ 0.7 l/ha RILFOO4 @ 2 kg/ha Sheath rot- Swing @ 2.0 l/ha.
- Sheath Blight - Bavistin 50 WP @ 0.2% followed by seedling treatment before transplanting by dipping the seedlings in 0.05% Bavistin solution for 10 minutes

Cultural Management

- Nitrogen management - Significant differences in reduction of BLB and ShB infection and higher yields were obtained by stopping the nitrogen application at disease initiation. Draining out the standing water is also recommended to check the diseases.
- Early and medium duration varieties escaped sheath rot disease when nursery was planted within first week of June. Irrespective of date of nursery planting, late varieties were very little affected by the disease.
- Timely sown short duration rice varieties escaped false smut disease.

Basic studies

- Root dip in Bavistin 50 WP (0.05%) before transplanting for 10 minutes followed by foliar spray of Bavistin 50 WP @ 0.1 % at 12 to 15 days interval with initiation of sheath rot disease effectively managed the disease.
- Bio-control of Sheath blight -Pseudomonas fluorescence controlled ShB with significantly higher yields when prophylactic sprays were given but the treatment was not at par with chemical control.

MONCOMPU

Rice Research Station, Kerala Agricultural University
Kerala

The Rice Research Station, Monkompu is located at Monkompu, Thekkekkara of Champakaulam Panchayat in Kuttanad Taluk of Alappuzha District. A unit of All India Co-ordinated Rice Improvement Programme started in the year 1974 with an objective to exclusively deal with the research on rice in Kuttanad ecosystem with emphasis on development of rice varieties suitable for this ecosystem.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

- The centre was instrumental in solving several problems in deep water areas such as Kuttanad. The Centre has so far released 22 rice cultivars.
- Most of these varieties are resistant/tolerant to brown plant hopper, gall midge, blast and sheath blight.
- Seven rice varieties developed and released by RRS, Moncompu (Mo 13, MO 15, MO 16, MO 17, MO 18, MO 19 & MO 20) were protected under the Plant varieties and Farmer's Rights Act 2001.
- Bhadra (Mo 4), Karthika (Mo 7), Makom (Mo9), Uma (Mo16), Revathy (Mo17) are nationally acclaimed varieties

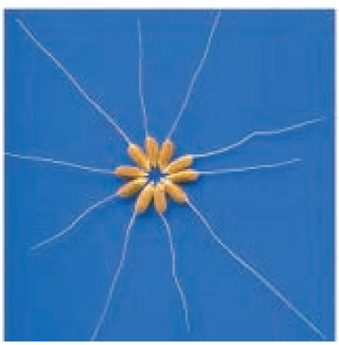
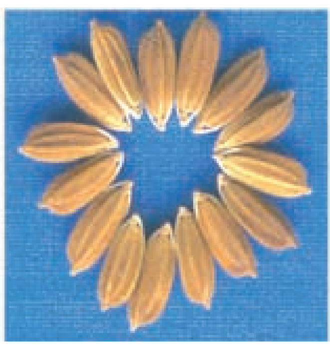
Varieties released/ identified

Variety No.	Variety name	Year of release	Pedigree	Important Characteristics
MO.1	Chettivirippu	1945	Pure line selection from Chettivirippu	Resistant to salinity
MO.2	Kallada champavu	1945	Pure line selection from Kallada champavu	Resistant to acidity and salinity
MO.3	Kochathikkira	1968	Pure line selection from Kochathikkira	Resistant to acidity and salinity
MO.4	Bhadra	1978	IR 8/ PTB 20	Resistant to BPH
MO.5	Asha	1981	IR 11-1-66/ Kochuvithu	MR to BPH, sheath blight, sheath rot and bacterial blight
MO.6	Pavizham	1985	IR 8 /Karive nnel	MR to BPH, sheath blight, sheath rot and stack burn
MO.7	Karthika	1987	Triveni/IR 1539	MR to BPH, sheath blight, sheath rot and bacterial leaf blight
MO.8	Aruna	1990	Jaya/ PTB 33	MR to BPH, stem borer, Gall midge, sheath blight, bacterial leaf blight and brown spot
MO.9	Makom	1990	ARC 6650/ Jaya	MR to BPH, leaf folder, stem borer, gall midge, sheath blight, sheath rot and brown spot
MO.10	Remya	1990	Jaya/ PTB 33	MR to BPH, gall midge, sheath blight, sheath rot
MO.11	Kanakom	1990	IR 1561/PTB 33	HR to BPH, MR to stem borer, gall midge, sheath blight, sheath rot, blast and bacterial leaf blight
MO.12	Renjini	1995	Mo.5/Improved Sona	Resistant to Blast
MO.13	Pavithra	1998	Surekha/ Mo.5	R to GM biotype 1 to 5, Tolerant to sheath blight and sheath rot
MO.14	Panchami	1998	Pothana/ Mo.5	R to GM biotype 1 to 5, Tolerant to sheath blight and sheath rot.
MO.15	Remanika	1998	Mo.6/ Pokkali	MR to major pests and diseases.
MO.16	Uma	1998	Cul.12814/ Mo.6	MR to BPH, GM biotype 5. Possess Dormancy.
MO.17	Revathy	1998	Mutant of Mo. 1	MR to Blast, sheath blight and sheath rot. Resistant to BPH and Stem borer
MO.18	Karishma	1998	Mo.1/ Mo.6	R to BPH, moderately resistant to GM biotype 5 and tolerant to iron toxicity and sulphide injury

Variety No.	Variety name	Year of release	Pedigree	Important Characteristics
MO.19	Krishnanjana	1998	Mo.1/ Mo.6	R to BPH, moderately resistant to GM biotype 5 and tolerant to iron toxicity and sulphide injury
MO.20	Gouri	2002	Mo.4/ Cul. 25331	Tolerant to Sheath blight.
Mo.21	Pratheeksha	2010	IET 4786/MO.8	Semi tall, Short duration. Rich in Iron and Zinc

- MO 16 (Uma) is the most popular rice variety of the State currently occupying more than 60 % of the rice area of the State and more than 80% area in Kuttanad.

- Speciality rices - RRS, Moncompu has a sizeable collection of the traditional rice varieties of Kerala including the medicinal rices and aromatic rices. Forty accessions of the medicinal rice Njavara, are maintained in the germplasm and purification of the heterogenous mixture has resulted in the identification of five distinct types of Njavara as detailed below. Breeding programs to improve the yield potential of Njavara is in progress at the station. Pureline selection from the accessions and induced mutagenesis of yellow as well as black Njavara yielded progenies far superior to their parents in yield and phenotypic acceptability.


Crop Production

Agronomy

- The most popular and viable crop establishment method prevailing in the Kuttanad region from 1980 onwards is broadcasting of sprouted seeds.
- Use of seed drill for wet sowing in puddled soils has been found to regulate the plant population, reduce the seed rate to 60-80 kg ha^{-1}, increase the yield and result in higher net profit under standard management practices.
- The different methods of transplanting viz. line planting, planting seedlings raised through dapog nursery, sowing sprouted seeds by seed drill and broadcasting sprouted seeds were evaluated under continuous submergence and cyclic submergence.
- Direct sowing is a viable option in the silty clay soils of Kuttanadu provided optimum weed management and fertilizer management practices are adopted.
- The feasibility studies of using transplanter for mechanical transplanting revealed higher grain yield compared to direct sowing. It was also observed that while the direct sown crop was completely lodged due to heavy rain at the time of maturity, the transplanted crop was not affected. However the use of mechanical transplanter is limited to areas where the soil is having sufficient bearing strength to support the weight of the machine.
- Mechanized transplanting along with early post emergence application of herbicide at 4 DAT followed by one cono weeding at 40 DAT can be adopted as an alternative to broadcasting in areas of high weed infestation.
- Of late, heavy infestation of weedy rice (introgression between *O.sativa, O.rufipogon* and *O.nivara*) is becoming a serious threat to rice cultivation in the direct sown rice fields of Kuttanad. The centre has come up with viable management strategy against varinellu (wild rice) in rice by coating seeds with calcium peroxide

Different ecotypes of weedy rice in Kuttanad

Soil Science

- Amelioration of Acidic Soils for enhanced rice productivity - Different soil ameliorants like lime, silica rice husk ash and FYM were recently evaluated along with Recommended Dose of Fertilizer (RDF) in acid soils to achieve higher productivity and production of rice and recommended lime application in direct seeded as well as transplanted rice @600 kg/ha in two split doses to correct soil acidity.
- A study on the best management practice for optimizing grain yield in transplanted rice revealed that NPK @ 90:45:15 Kg/ha + FYM 5 t/ha as basal+ $MgSO_4$ 20 Kg /ha + lime top dressing @ 250 Kg/ ha recorded significantly higher grain yield than that of farmers practice of applying fertilizer alone @90:45:45 and the recommended dose of fertilizer @90:45:15 +FYM 5 t/ha +lime top dressing @ 250 Kg/ha.
- KAU rice varieties viz., Bharathi, Bhadra, Asha, Karthika, Makom, Gouri, Prathyasa, Vytilla 6 and few selections from the medicinal rice Njavara were found promising in accumulating comparatively higher Fe (23-70 mg/kg) and Zn (37-151 mg/kg) in the grains.
- The soil fertility status of Kuttanad soils have been uploaded in the web portal www.keralasoilfertility.net. Soil Health Card and Nutrient Management Recommendation was generated and distributed to farmers to make them aware of the soil health status of their soils.

Crop Protection

Entomology

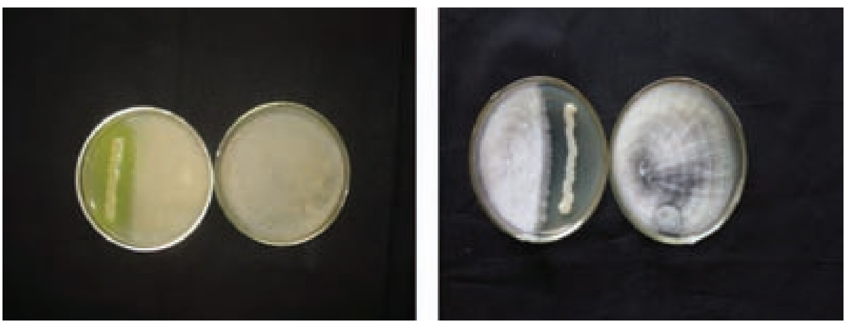
- After the wide spread cultivation of the rice variety Uma (MO 16) which shows very low damage by gall midge the population has come down in Kuttanad and even the susceptible varieties also escaped gall midge attack.
- Studies were conducted on trap crop for stem borer management (TCSB) using stem borer susceptible variety Pusa Basmati I as trap crop and Jyothi as main crop by adjusting the sowing time and found low dead heart damage by stem borer.
- New molecules were identified for controlling leaf folder. Acephate 75 SP @1.6g/l and Flubendiamide (Fame 39.35 SC) 0.35g/l were found effective against leaf folder.
- The combination treatment of Rynaxypyr with Tricyclazole reduced white ear damage significantly showing that there were compatible.
- Four species of stem borers viz., Yellow Stem Borer (YSB), White Stem Borer (WSB), Pink Stem Borer (PSB) and Striped Stem Borer (SSB) were present in Kuttanad. White stem borer was higher at tillering stage while that of yellow

stem borer was higher at heading stage.

- Of the 26 natural enemies identified, twelve were parasitoids and many of which were first reports from Kerala.
- An Integrated pest management strategy has been worked out for Brown Plant hopper of rice.
- An indigenous cheap and efficient rat trap "the Moncompu trap" has been designed for trapping rats in rice fields. Novel methods for rat control by use of rat traps, using food baits like raw tapioca or lemon peel etc have been demonstrated to farmers and are being successfully used by farmers now.

Plant Pathology

- The major diseases in rice include neck blast, sheath blight, brown spot, sheath rot and bacterial blight.
- Out of the total 9080 cultures i.e, NSN-1 (3079), NSN-2 (8340), NHSN (1253), DSN(1594)) screened against blast, sheath blight, brown spot, sheath rot and bacterial leaf blight, 1362 cultures showed multiple resistance for all major diseases.
- Sheath blight disease was observed in low to moderate intensityin Swarna, Tapaswini and TN-1 in all three dates of planting. It was very low in normal and late planted crop of Uma and IR 50. Low to moderate incidence of Bacterial leaf blight was recorded in early and normal planted crop of Swarna, Tapaswini and TN-1. In late planted crop, the incidence was very low in all the varieties except IR 50.
- The biocontrol agent *Psuedomonas fluorescens*is being mass multiplied and the talc formulation of the same are being distributed to the farmers from the station from 2008 onwards for encouraging the eco-friendly management of plant diseases. Many of the farmers adopt seed treatment with *Pseudomonas fluorescens* to control the seed borne diseases of rice. Foliar application of the same is also followed by the farmers. New native isolates of *Pseudomonas fluorescens* and *Bacillus sp.* were identified for the management of false smut.



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New native isolates of *Pseudomonas fluorescens & Bacillus sp*

MUGAD

Agricultural Research Station, UAS, Dharwad
Karnataka

Work on the improvement of the rice in Malnad region was taken up in the year 1923, when the Agricultural Research Station was established at Mugad, which is a true representative of the tract.

Major contributions to AICRIP

Crop Improvement

- ARS, Mugad played an instrumental role in testing and release of important varieties like Jaya, Intan, Prakash.
- After inception of AICRIP, several promising entries viz., Avinash (Gama-318) for midland, Abhilash (IET-5882) for lowland were released in 1985.
- Abhilash variety has been quite popular in farmers' fields in Dharwad and Uttara kannada districts.
- Amruth (IET-7991) and Prasanna (IET-7564) were released during 1993 and 1994, respectively. Among these, Amruth has been found promising and popular for drill sown upland conditions of Karnataka.

Table 1: Paddy cultivars released for rainfed cultivation from ARS, Mugad

Cultivar	Year of release	Duration (days)	Target Ecology	Yield (t/ha)	Relevant Features
A 67	1931	140-145	Upland	2.7 – 3.0	Blast resistance
M 161	1931	140-145	Upland	2.7 – 2.8	--
A 90	1931	150-160	Midland	2.7 – 2.8	Blast resistance
M 81	1931	155-160	Midland	2.7 – 2.8	Blast resistance
M 249	1931	150-165	Midland	2.7 - 2.8	Blast resistance
A 200	1931	160-170	Lowland	2.8 – 3.0	--
M 141	1931	160-170	Lowland	2.8 – 3.0	--
WANAR 1	1945	130-135	Upland	1.3 – 1.5	VE, Blast & Drought resistant
D 6-2-2	1945	130-135	Upland	2.0 – 2.2	VE & Drought resistant
K 44-1	1945	160-165	Midland	2.7 – 2.8	Medium-fine & scented
Y 4	1945	160-170	Lowland	3.3 – 3.6	Fine & high yielding

HY 256(p)	1960	160-165	Midland	2.2 – 2.5	Purple cultivar
HY 258-1	1960	170-175	Midland	2.5 – 2.8	Fine and scented
HY 246-13-1	1960	170-175	Midland	2.5 – 2.8	Very fine & scented
HY 449-17	1960	180-185	Lowland	2.8 - 3.3	Medium fine
HY 26-10	1960	180-185	Lowland	2.8 - 3.3	Medium fine & Blast tolerant
AVINASH	1985	140-145	Midland	3.8 – 4.0	Pest & Disease resistant
ABHILASH	1985	155-160	Lowland	4.2 – 4.5	Pest & Disease resistant
AMRUTH	1993	105-110	Upland	3.5 – 3.6	Early & Drought tolerant
PRASANNA	1994	95-100	Upland	3.0 – 3.2	VE, Drought & Blast tolerant
MUGAD SUGANDHA	2001	130-135	Midland	3.2 – 3.5	Basmati quality
VIJETHA	2002	130-135	Midland	4.5 – 4.8	High yielding
MGD-101	2008	125-130	Upland	3.5 - 4.0	High yielding and drought tolerant
Mugad SIRI-1253	2010	135-140	Midland	4.5 – 5.0	High yielding and fine grained (MS); good quality
PSB-68	pipeline	140-145	Lowland	4.5 – 5.0	High yielding suitable for puffing and flaking

Mugad Sugandha (IET-13549)
Parentage: Selection from Basmati RP-ST-328
Duration: 130-135 days
Grain yield: 32-35 q/ ha
Garin type: long slender
Special features: Dwarf (65 cm), moderately resistant to blast, moderately tolerant to LR

MGD-101 (IET-19554)
Duration: 125-130 days
Grain type: medium bold
Grain yield: 38-45 q/ ha
Special features: Identified as superior drought tolerant as well as high yielding genotype for rainfed uplands.

Asha (IET 9926) has been released during 2010 for cultivation under shallow land situation of Karnataka State.

IET-22704 (MGD-1104) is found promising in the states of Punjab, Odissa, Bihar, Chhattisgadh, Jharkhand and Tamil Naduunder aerobic condition.

IET-21839 (MGD-109) pure line selection from Kumud a land race is promoted from IVT-ASG during kharif 2012.

Mugad SIRI-1253 (IET-19803)
Duration: 135-140 days
Grain type: medium slender
Yield: 45-48 q/ ha
Special features: high yielding, moderate blast resistance and good cooking quality

Crop Production

Agronomy

- The seed rate of 65-80 kg/ha with 20 cm row spacing has been found to be optimum for drilled paddy.
- A fertilizer level of 100-50-50 kg N-P2O5-K2O with 12 cart loads of farm yard manure per hectare are found to be optimum for drilled paddy cultivation.
- Application of 33% extra seeds and 33% extra NPK fertilizers, alone or in combination with 10 t FYM and 20 kg ZnSO4/ha was found to increase grain yield and net profit considerably, compared to the normal practice in lowlands.
- Split application of N @ 33.3% of the total recommended N, each at 20 and 40 days after seeding and at panicle initiation gave higher yield with better weed management in comparison with earlier recommended practice of 50% as basal and remaining 50% as basal and remaining 50% as top dress in drill seeded rice.
- Application of Urea coated with Nimin @ 75 kg N/ha gave higher yield compared to prilled urea at 100 kg N/ha.
- Application of P through Rock-phosphate + DAP (50:50) yielded higher in rainfed drill sown as well as transplanted rice.
- Rice yields were higher when K was applied in three splits of 50% basal, 25% at 25-30 days after planting and 25% at 50-55 days after planting.
- Spraying weedicide Butachlor @ 1.5 kg/ha or Pendimethalin 30 EC @ 3.3 L/ha or Aniloguard 30 EC @ 300 g ai/ha at 3-5 days of seeding combined with hand weeding at 30 days after seeding controls weeds effectively and economically in rainfed drill seeded rice.

- Wet seeding of sprouted paddy seeds @ 40 kg/ha with eight row drum seeder was found better alternative in place of transplanting under lowland conditions.
- Mixing of Sun hemp seeds @ 15 kg/ha with paddy seeds at the time of sowing, followed by incorporation at 40 days after sowing helps in improving the soil fertility besides sustained paddy yields.
- Nitrogen management through leaf colour chart saved the fertilizer besides sustained yields. Leaf colour chart reading of 3 for Intan and 4 for Abhilash under lowland condition was found to be optimum and also reduced the blast incidence.

Crop Protection

Plant Pathology

- Major diseases noticed under rainfed ecosystem region are blast and brown spot whereas bacterial leaf blight, sheath blight and blast appear in severe form in command areas. Other diseases like Udabatta, false smut, leaf scald,rice tungro virus (RTV), grain discolouration and sheath rot appear in moderately severe form depending upon the climatic conditions.
- Seed treatment with carbendazim @ 2 g / kg seed and spraying of Carbendazim (@ 2 g / lit) or Tricyclazole @ 0.06% thrice; First spraying to be given soon after the disease appearance then 20 days later and third spray at panicle initiation stage controls both leaf and neck blast.
- Seed treatment with Pseudomonas fluorescens @ 8 g /kg seed + 2 sprays of Nimbicidine @ 5 ml / l water was effective against leaf and neck blast.
- The pathogen Pyricularia grisea exihibits a great genetic variability which is evident by the prevelance of IA, IB and IC race groups of the pathogen in Northern Karnataka. Among the different blast resistant genes (Pi- genes) screened, Pi-1, Pi-2, Pi-1 + Pi-2 and Pi-9 showed resistance reaction across the North Karnataka.
- Resistance sources identified for blast disease are: VSR-8, Vajram, Tetep, Casebatta, Vdarsali.
- Spraying of Carbendazim or Ediphenphos 1 g/l twice at flowering stage is effective for the control of brown spot. Resistant varieties for brown spot are Prasanna, Abhilash, Amruth and Vijetha.
- For control of Sheath blight, spraying of Hexaconazole @ 2 ml/lt or Validamycin @ 1.5 ml/l was effective.
- Management of Bacterial leaf blight- seed treatment with streptocyclin @ 0.1 g and Copper Oxychloride @ 0.1 g/kg seed or soak the seeds in the solution of Agrimycin-100 @ 0.1 g and Copper oxychloride @ 0.1 g/l for 20 minutes before sowing.

NAGINA

Zonal Research Station

Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut Uttar Pradesh

Nagina is one of the premier research stations of the country established by Imperial Government in 1921, which is situated in the foot hills of Great Himalaya. This station is known as birth place of scented rice. AICRIP station at this location was established in 2006 with the objective to breed varieties suitable for irrigated upland and irrigated low lands.

Major Contributions

Crop Improvement

- Station has released 24 rice varieties for different eco-systems like T-3, T- 21, T- 88, T-100, N-22, N-12, N-27 and N-10B.
- An export quality aromatic rice variety Type -3, known as Dehraduni Basmati, is the first variety by which the quality rice export was started first time by our country, was also released by this station.
- Another rice variety N-22, a drought resistant variety, is still being used as donor parent for drought resistant breeding in India and abroad
- A heterotic rice restorer line NRR-51 identified for CMS line IR 580 25A.
- Nagina Rice Hybrid -1 (NRH-1, parentage IR 580 25A x NRR51) has been developed with basmati quality, yield potential 65q/ha, maturity 115-120 days.
- NR77 (Type 3 x Sarbati) has been developed with basmati quality genotype, having yield potential up to 50q/ha, maturity 105- 110 days.
- Collection, maintenance and evaluation of over 528 rice germplasm

Agronomy

- Combinations of weedicides revealed that application of Oxadiagryl @ 100g/ha at 2-3 DAS as pre emergence followed by application of Bispyribac sodium @ 300ml/ha at 25 DAS effectively controlled weed flora under direct seeded rice.
- PA 6444, PHB 71, PRH 10 Pusa sugandh -4, Pusa Sugandh -5 , Improved PB-1, Pusa 1401, Vallabh Basmati 21, 22 & 24 were identified as suitable rice hybrids/ varieties for the area of this university.

NAVSARI

Navsari Agricultural University
Gujarat

- During XI plan period (2007-2012), AICRIP center at Navsari in southern Gujarat of western India was added.
- More than 25 improved varieties of rice have been developed.
- The Agronomic practices like nursery raising, green manuring, planting geometry, planting time, sprouted seed technology, manure and fertilizer management including INM, water management, weed management, cropping pattern, bio-fertilizers, tillage etc. have been developed for the farming community growing irrigated rice in different agro-ecologies of the state.
- Recommendations on SRI and SIRA have also been made very recently. Similarly, for the drilled paddy, technology for spacing, fertilizer, weed management and proper harvesting time have been developed.
- The control measures of bacterial leaf blight, grain discolorations, blast and false smut of paddy have been developed.
- The centre also nominated 16 high yielding rice varieties to AICRIP.
- SRI - SRI technology is performing well and is being well popularized and many of the small and marginal farmers adopted the technology.
- Aerobic rice - Some of the genotypes found suitable for this technology and the agronomical experiments for seed rate, spacing, weed management and fertilizer management have been conducted.

NAWAGAM

Main Rice Research Station, Anand Agricultural University Gujarat

The centre for research on paddy was established at Nawagam in 1945 by the Dept of Agriculture of Imperial Government of British ruler. With the formation of the Gujarat State in 1960, the station was developed as the Main Rice Research Station keeping the headquarter of the Rice Specialist and creating various disciplines such as Rice Breeding, Agronomy, Entomology, Plant Pathology and Biochemistry. In 1971, All India Coordinated Rice Improvement Project (AICRIP) was commenced. In 1972, the main Rice Research Station along with its sub-centers was transferred from state administration to the Gujarat Agricultural University (GAU). In 2004, GAU was split into 4 agricultural universities. Since, 2004, this station is under Anand Agricultural university. The mandate of the center includes evolving high yielding and quality varieties of rice, resistant to major pests and diseases under varied conditions of cultivation.

Major contributions to AICRIP

Crop Improvement

- 16 traditional varieties and 34 high yielding varieties (HYVs) were developed at this location

Most popular varieties are:

Early	: GR-3,GR-4, GR-6, Gurjari,GR-7, GR-12, GAR-2, GAR-3
Mid-late	: Jaya, GR-11, GAR-13, GAR-1(Scented)
Late	: Mahsuri, GR-103
Aromatic	: GR-101, GR-102, Narmada, GR-104
Rainfed transplanted	: IR-28, GR-3, GR-7
Upland Drilled	: Sathi-34-36, GR-5, GR-8, GR-9, AAUDR-1, Ashoka 200 F
Salt tolerant	: Dandi

Varieties released/ identified

Sr. No.	Name of the Variety	Parentage	Year of release	DFF	Plant height (cm.)	Average Yield t/ha.
1	GR-5	Selection (NVS-18)	1990	60-65	100-105	1.8-2.5
2.	GR-8	Selection (Vyara-55)	2001	45-50	70-90	1.5-2.0
3.	GR-9	Sathi-34-36 / CR-544-1-2	2001	70-75	110-120	2.3-2.5
4.	AAUDR-1	Sathi-34-36/ DadriKolam	2007	60-70	110-120	2.4 - 2.5
5.	Ashoka-200 F	Kalinga III / IR-64	2006	55-60	90-95	1.5-2.0
6.	SahbhagiDhan (CVRC)	IR-55419-4 /Way Rarem	200	75-80	85-90	3.8-4.5
7.	GAUR-1	Zinnia-31/IR-9-60	1973	85-90	105-110	4.0-4.5
8.	GAUR-2	IR-8 /Kada-176-12	1976	75-80	75-80	5.0-6.0
9.	GR-3	Nawagam-19/IR-9-60	1977	75-80	90-90	5.0-5.5
10.	GR-4	Zinnia-31/IR-8-246	1981	80-85	100-105	4.5-5.0
11.	GR-6	GR-3/Pusa-33	1991	90-95	95-105	4.5-5.0
12.	GR-7	GR-3/Bas.370	2001	85-90	105-115	5.0-6.0
13.	GURJARI	Asha /Kranti	1998	90-95	110-115	6.0-8.0
14.	IR-66	IR-13240-108-2-2-3 /IR-9129-209-2-2-2-1	1992	80-85	100-105	4.2-5.2
15.	IR-28	IR-833-6-1-1-1/IR-1561-149-1//IR-1737	1975	75-80	90-95	4.0-4.5
16.	GR-12	GR- 7/IR-64	2005	90-95	115-120	5.0-6.5
17.	GAR-2	Gurjari/IET-14714	2011	90-95	110-125	4.5-5.0
18.	GAR-3	Gurjari/IET-14714	2013	95-100	125-135	5.0-5.5
19.	GAUR-10	Zinnia-31/IR-9-60	1973	90-95	99-95	5.0-5.3
20.	GR-11	Zinnia-31/IR-8-246	1977	100-105	110-115	5.5-6.0
21.	SLR-51214	Vijaya/PTB-21	1983	100-105	90-95	4.5-5.0
22.	CR-138-928	Jaya/TKM-6	1983	95-100	100-105	4.0-4.5
23.	DANDI	PNL-2/IET-8320	2001	100-105	115-125	4.5-5.0
24.	JAYA	T(N)-1/T-141	1970	100-105	105-110	5.0-5.5

Sr. No.	Name of the Variety	Parentage	Year of release	DFF	Plant height (cm.)	Average Yield t/ha.
25.	IR-22	IR-8 /Tadukan	1975	105-110	85-90	5.0-5.5
26.	GAR-13	GR-11/IET-14726	2009	100-105	125-130	5.5-6.5
27.	GAR-1 (Aromatic)	Narmada/IET-14708	2010	95-100	120-125	5.0-6.0
28	GAUR-100	Zinnia-31/IR-8-246	1973	95-100	95-100	5.0-5.5
29.	GR-101	IR-8/Pankhali-203	1984	105-110	100-105	4.0-5.0
30.	GR-102	IR-8/Pankhali-203	1987	110-115	110-115	4.0-5.0
31.	GR-103	GR-11/Mahsuri	1991	95-100	75-95	5.5-6.5
32.	GR-104	GR-101/Bas. 370	2002	105-110	120-130	4.0-5.0
33.	Narmada	T(N)-1/Bas.370	1991	105-115	110-125	4.0-5.0
34.	Mahsuri	T-65 /ME-80-2	1968	110-115	110-125	4.5-5.0

Newly released variety

GAR-13
Parentage: GR 11/IET 14726 (TNAU 92094)
Duration: 130 – 135 days
Grain type: medium slender
Yield: 60 – 65 q/ ha
Special characters: Resistant to BLB, leaf blast, neck blast, white backed planthopper. Moderately resistant to stem borer, leaf folder.

Crop Production

Agronomy

- A number of Agronomic practices like nursery raising, green manuring, planting geometry, planting time, sprouted seed technology, manure and fertilizer management including INM, water management, weed management, cropping pattern, bio-fertilizers, tillage, *etc.* have been developed for the farming community growing irrigated rice in different agro-ecologies of the state.

- Recommendations on System of Rice Intensification (SRI) and Sawant's Integrated Rice Agro-technology (SIRA) have also been made very recently. Similarly, for the drilled paddy, technology for spacing, fertilizer, weed management and proper harvesting time have been developed.

Crop protection:

Plant Pathology & Entomology

- Control measures of bacterial leaf blight, grain discolorations, blast and false smut of paddy have been developed.
- Need based control measures for pest complex of paddy viz., rice stem borer, leaf defoliators, rice leaf and plant hoppers, BPH, WBPH and rice gundy bugs have also been recommended for the farming community of the State.
- Recently an eco-friendly recommendation has been made for biological control of sucking and leaf eating insects by enhancing the population of natural enemies of the pest like spiders.
- To economize the expenditure on insecticides a recommendation has been made for spot application of the granules for the control of pest complex.

PANTNAGAR

Govind Ballabh Pant University of Agriculture & Technology (GBPUAT) Uttarakhand

AICRIP center was established in 1966 at Department of Genetics & Plant Breeding, College of Agriculture, GBPUAT, Pantnagar with an objective to develop varieties suitable for plains of Uttarakhand.

Major contributions

Crop Improvement

Plant Breeding

- Since 1969, 17 varieties of rice were released including 3 aromatic and 2 hybrids.

Varieties released

Sl. No.	Name of Variety	Year of Release	Duration (Days)	Yield (q/ha)	Area of adaptation
1	IR 24	1972	120-125	55-60	Plains of Uttarakhand Valleys upto 500 m & Uttar Pradesh
2	Prasad	1978	120-125	50-55	Plains of Uttarakhand & Uttar Pradesh
3	Govind	1982 SVRC, 1989 CVRC	95-100	30-35	U.P.,Uttarakhand, M.P. Pondichery, Gujarat, Maharashtra
4	Pant Dhan 4	1983	126-130	55-60	Plains of Uttarakhand & Uttar Pradesh
5	Manhar	1985	115-120	50-55	Plains of Uttarakhand & Uttar Pradesh

Sl. No.	Name of Variety	Year of Release	Duration (Days)	Yield (q/ha)	Area of adaptation
6	Pant Dhan 6	1986	113-120	40-45	Transplanted Conditions of Uttarakhand Hills
7	Pant Dhan 10	1992	121-130	58-60	Transplanted Condition in Plains of Western Uttar Pradesh & Uttarakhand
8	Pant Dhan 11	1992	118-125	42-48	Transplanted Conditions of Uttarakhand hills
9	Pant Dhan 12	1994	113-122	55-58	Plains of Uttarakhand & Uttar Pradesh
10	Pant Sankar Dhan 1	1997	115-120	55-60	Plains of Uttarakhand &Uttar Pradesh
11	Pant Dhan 16	2001, CVRC	105-110	50-55	Bihar, West Bengal & Haryana
12	Pant Sugandh Dhan 15	2003	135-140	35-40	Plains of Uttarakhand & Uttar Pradesh
13	Pant Sankar Dhan 3	2004	130-135	65-70	Plains of Uttarakhand & Uttar Pradesh
14	Pant Sugandh Dhan 17	2004	135-140	35-40	Traditional basmati growing areas of Northern India
15	Pant Dhan 18	2007 , CVRC	125-130	55-60	A.P.,Karnataka,Kerala, WB T.Nadu, Bihar, Chhattisgarh
16	Pant Dhan 19	2007 , CVRC	120-125	55-60	Punjab, Haryana, Gujarat & Maharashtra
17	Pant Sugnadh Dhan 21	2012	135-140	35-40	Plains of Uttarakhand & Uttar Pradesh

- ***Release proposals:*** Release proposal of four rice cultures, two each for SVRC and CVRC were submitted in 2014. UPR 3425-11-1-1 (IET 22096) is named as Pant Dhan 24 and found suitable for Bihar and Orissa whereas UPR 3506-7-1-1 (IET 21953) named as Pant Basmati 2 is found suitable for basmati growing areas of Punjab, Haryana, U.P. and Uttarakhand. However, UPR 2825-30-1-2 (Pant Sugandh Dhan 25) is an aromatic rice variety found suitable for Uttarakhand plain. Another culture UPR 2962-6-2-1 (Pant Dhan 23) will be a replacement of our popular variety Pant Dhan 12 for mid-early maturity group of irrigated ecosystem in the state.

Crop Production

Agronomy

- ***Time and method of planting*:** Based on a large number of dates of sowing trials, the plantings for varieties belonging to different durations were estimated and popularized. Broadcast transplanting yielded significantly on par with conventional transplanting with a labour economy of about 35-50% over conventional random planting.

- ***Concept of System of Rice Intensification (SRI)*:** Package and practices like age of seedling, planting date, spacing, weed management practices, evaluation of varieties etc were developed for SRI cultivation.

Concept of direct seeding aerobic rice: Package and practices have been developed for direct seeded aerobic rice cultivation.

Soil fertility and fertilizer use: Numerous culture/varieties including national and local checks of early, mid-early and medium duration and basmati cultures were evaluated at low, optimum and high input mainly nitrogen (i.e. 50, 100 & 150 % recommended doses of N) and aerobic conditions.. Crop management experiments were conducted for the exploitation of production potential of hybrid rice and basmati type varieties

- ***Slow release fertilizers to increase NUE:*** The slow release fertilizers and urea super granule (USG) showed an economy of 25-30% in fertilizer use over urea in irrigated as well as rainfed lowland rice.

Browning of *Sesbania aculeata* by 2,4-D

- ***Zinc deficiency (Khaira disease) and its control*:** Zn deficiency could be corrected by spraying with 0.5% ZnSO4 mixed with 0.25% Calcium hydroxide in water in 1965 revived the cultivation of rice in *Tarai*.

- ***Use of Bio-fertilizer*:** Use of Azolla as green manuring with or without fertilizer N increased rice yield by about 25%.

- ***Nutritional requirement of rice in long term rice-wheat cropping system*:** Yield decline of rice under rice-wheat cropping was found related with soil depletion of nutrients and could be arrested by the application of balance fertilization. In a long-term experiment of comparative study of using organic, chemical and integrated approach of nutrient management, sustainable nutritional packages were identified.

- ***Water requirement and irrigation*:** Water requirement of transplanted rice (from planting to maturity) in Tarai is around 1000 mm, 40-60 % of which is met through irrigation (10 to 20 irrigations of 50 mm each). Maintaining 1 cm water flooding to field capacity was also sufficient to meet the water requirement of rice instead of flooding 5 cm.

- ***Weed control*:** In transplanted rice, one pre-emergence application of herbicide followed by one hand weeding at 20-25 DAT was found most prominent in controlling weeds of transplanted rice and equally good with weed free check and two weeding.

Plant Physiology

- ***Physiology of grain filling process:*** Physiological studies have revealed that terminal stage of phenology decides the adversity on yield and yield components which is generated much earlier during the course of ontogeny. Relative water Content (RWC) did not show any significant relationship with yield component and grain yield.

- ***Studies on nutritional genomics (Biofortification):*** It was found that average content of Fe and Zn in the rice grain was 40-60 mg/kg and 20-30mg/kg respectively

- ***Aerobic rice cultivation:*** The study revealed that alternate wetting and drying treatment can save five irrigations with slightly reduced yield components and yield.

- ***Studies on photothermic indexing*:** By delaying sowings the number of days taken to attain PI stage was reduced by 6 days while the reproductive and grain filling (ripening) period got increased by one day. Several breeding lines were characterized.

- ***Studies on nitrogen use efficiency:*** Among the varieties tested for nitrogen use efficiency (NUE) PA 6444 was found to possess good responsiveness to N-levels coupled with higher yield closely followed by KRH 2, Ajaya, and BPT 5204.

- ***Effect of Boron on spikelet fertility:*** Application of Boron at 0.4ppm resulted in significant increase in grain yield (4-8%).
- ***Radiation use efficiency:*** Radiation Use Efficiency was found to be highest at panicle initiation stage and lowest at flowering stage.
- ***Heat tolerance in genotypes****:* Screening of high temperature tolerance showed that IET 20734, IET 20893, IET 20907 and IET 20905 were least affected. The dry matter remobilization under high temperature was higher in rice genotypes IET 21577, IET 21415, IET 21404 Varadhan and PHB-71.
- ***Silicon solubilizers***: The efficiency of silicon solubility and availability can be enhanced by addition of carrier molecules or by application of sodium potassium silicates. Silicon accumulated rice genotypes were found to be tolerant to biotic and abiotic stresses.

Crop Protection

Plant Pathology

Host plant resistance

- Each year, more than 500 entries under different nurseries viz. GSN, NSN, NSN-Hill, NHSN, DSN, IRBBN, false smut screening, etc. were planted and sources of resistance identified and reported.
- Bacterial leaf blight caused (BLB) by *Xanthomonas oryzae* pv. *oryzae* (Xoo) is the most serious biotic constraint of rice in the region. The existing population of Xoo in the region was highly virulent and genetically diverse.

BLB infested field

- Twenty one haplotypes were detected among a collection of 193 strains by each of the PCR technique used i.e. rep-PCR and IS-PCR. The high value of total haplotypic diversity (HT=0.79) reflected the genetic heterogeneity of Xoo population infecting popular varieties.
- Strains responsible for severe BLB outbreaks were grouped into 8 distinct lineages. Virulence assay revealed the presence of 11 pathotypes. The interaction of lines with strains was found significant (P<0.01) confirming the pathogenic specialization of Xoo in U.S.Nagar. The potential of Xa21 alone or in combination

with xa13 and xa5 could be exploited for pyramiding into well adapted rice cultivars for the effective management of the pathogen in this region.

Disease Control Trials

Over the years, several new fungicides were evaluated against major diseases of rice in the region. The following were found effective:

- *Sheath blight* - Foliar sprays with Haxaconazole (Contaf) @ 2.0 ml/l, and Propiconazole 25 EC (Tilt) @ 1 ml/l were found highly effective. Foliar sprays with RIL 010 1.5 ml/l, @ Thiafluzamide 0.75 ml/l, Validamycin @ 2 ml/l, Contaf @ 2.0 ml/l, and Tilt @ 1 ml/l were found highly effective. Foliar sprays with Biotas @ 2.5 ml/l, Neem Azal @ 3ml/l were found effective. Foliar sprays with *Trichoderma harzianum* or *Psuodomonas fluorescenc*e (rice leaf isolates) were found best in reducing sheath blight. Soil amendments with neem cake, FYM or Dhaincha enhanced the effectivity of *P. fluorescenc*e in increasing seedling emergence, reducing sheath blight severity
- *False smut* - Propiconazole 25 EC (Tilt) @ 1.0 ml/l was found to be highly effective. Chlorothalonil @2.0 g/l, Propiconazole 25 EC @ 1.0 ml/l, Indofil M-45, @ 2.5 g/l and Copper hydroxide 3.g/l were found highly effective in controlling false smut.
- *Bacterial leaf blight* - Kocide 2000 54 DF @ 2.5.g/l was found significantly effective. Higher rates of Streptocycline (20 g or 25 g/ha) + Copperoxychloride (1000g or 1500 g/ha) applied as foliar sprays significantly reduced disease index (BLB) and chaffy grains as well as increased grain yield/ha and 1000 grain weight. neem leaf extract followed by Neem Azal, Hing, Neem Gold and. Haldi help in reducing the disease index (BLB). Kasu B + Copper oxychloride or cow urine applied three days before Bacterinashak spray resulted in maximum reduction in disease index (BLB).
- ***Effect of fertilizers on disease incidence:*** Incidence of sheath rot was maximum in KRH-2 (47.07%) followed by Jaya (18.45%). The disease incidence increased with increase in the nitrogen level from 120 to 180 Kg. /ha. Application of neem coated urea resulted in minimum disease index. Application of zinc sulphate along with NPK significantly reduced sheath rot.

Entomology

- **Identification of resistant sources against major insect pests:** The centre has evaluated thousands of donors, elite breeding lines, cultures and varieties for resistance against major insect pests. The data generated is being used for the breeding of resistant varieties.

Hopper burn caused by BPH and WBPH

- ***Assessment of losses due to insect pests:*** Several experiments have been conducted to assess the losses due to Stem Borers and Leaf Folder under natural and simulated conditions. It has been estimated that each percentage of white ear caused by stem borers may result in 0.50-1.38 percent loss in yield in different varieties.

- ***Compatibility of insecticides and fungicides:*** Acephate + Hexaconazole, Acephate + Tricyclazole, Dinetofuran + Hexaconazole, Dinetofuran + Tricyclazole have been found compatible.

- ***Monitoring of insect pests and their natural enemies:*** Yellow Stem Borer, BPH, WBPH are the major pests of rice while leaf folder, rice hispa and rice bug are minor pests in *tarai* and plains of Uttarakhand. Pink stem borer and WBPH are major pests in Almora district. Among natural enemies, *Telenomus* sp., *Tetrasticus* sp. parasitize the egg mass of YSB while spiders feed on hoppers and leaf folder.

- ***Effect of rice cultivation system on incidence of insect pests:*** Influence of rice cultivation methods and cultivars on the incidence of rice stem borer indicated that damage of rice stem borer was significantly low in direct seeded rice as compared to normal transplanted rice. Population of BPH was higher in direct seeded rice as compared to transplanted rice. In case of WBPH mean population was higher in transplanted rice as compared to direct seeded rice and more hoppers were seen in KRH-2 as compared to HKR-47.

- ***Effect of date of planting on incidence of insect pests:*** Infestation of stem borer was significantly higher in normal and late planted crop as compared to early planted crop while mean population of BPH and WBPH remained more or less similar in different plantings.

- ***Front line demonstrations on management of YSB through pheromone traps:*** Front line demonstrations conducted in basmati rice at large scale in farmer's field revealed that sex pheromone mediated male annihilation technique is highly effective in managing yellow stem borer below economic injury level.

PATNA

Agricultural Research Institute (ARI)
Rajendra Agricultural University, Pusa, Samastipur
Bihar

This institute was established in 1973 under Rajendra Agricultural University, Pusa, Samastipur, Bihar. The objective of this station is to identify/ develop varieties suitable for irrigated medium and rainfed shallow ecologies.

Major Contributions to AICRIP

Crop Improvement – Plant Breeding

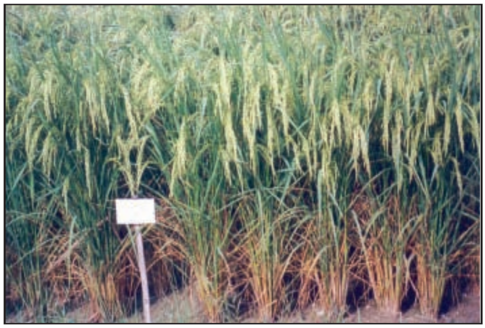
Rice variety developed.			Rice variety adopted		
Sl. No	Name of Variety	Year	Sl. No	Name of Variety	Year
1.	Pankaj	1971	1.	Cauvery	1971
2.	Sita	1972	2.	Bala	1971
3.	Panidhan 1	1972	3.	Ratna	1971
4.	Panidhan 2	1972	4.	IR 20	1971
5.	RajendraDhan 201	1979	5.	Mahsuri	1971
6.	RanjendraDhan 202	1979	6.	Milinj	1971
7.	Jaishree	1981	7.	Jagannath	1971
8.	Sungandha	1983	8.	Deepa	1972
9.	Janki	1983	9.	Archana	1972
10.	Sunjata	1984	10.	Saket – 4	1972
11.	Randha	1984	11.	Narsingh	1972
12.	Kanak	1987	12.	Vishnu	1972
13.	Shakuntla	1995	13.	IR 36	1983
14.	RajendraMahsuri – 1	2003	14.	Pusa Basmati – 1	1994
15.	RajendraSweta	2004	15.	RajendraBhagwati	2005
16.	SabourSurbhit	2012	16.	Swarna sub – 1	2005
17.	Sabour Shree	2014	17.	Sabour Deep	2014
			18.	SabourArdhjal	2014

- Several rice varieties were developed from the center and released through AICRIP. The following varieties were developed/ identified from this center:

Promising Elite Rice Lines in advance Stage

IET No.	Designation	Grain Type
18620	RAU 678-82-4	LS
19924	RAU 637-99-52	MS
20248	RAU 759-5-41	LS
20766	RAU 731-2-20	MB
	Kalanamak Mutant	Fine slender scented

Sabour shree



RAU 637-99-52

- Breeder Seed Production: Around 2000 qts of Breeder Seed of the varieties Sita, Sujata, Kanak, Rajendra Mahsuri – 1, Rajendra Sweta, Sugandha, Subhasini, Kasturi etc. were produced as per the indent.

Crop Production

Agronomy

- Agro-technologies on different aspects like NVT, Cultural management, Weed management, Rice based cropping systems, etc. were developed/fine-tuned as per farmer's needs of the state. The major contributions include:
- *System of Rice Intensification (SRI):* SRI was found significantly superior crop establishment method for irrigated well drained land. This is a technique for transplanting 10 days old rice seedling with single seedling per hill in wider spacing (25 x 25 cm) having specific nutrient, water and weed management.
- Hybrid Rice: Hybrid rice varieties PHB 71 and KRH-2 were found suitable for Bihar conditions. Application of 150N + 60P + 60K kg/ha produced higher grain yield. Cyclic submergence i.e. saturation maintained in the field and

before hair crack stage water given up to 2 cm depth was found significantly superior water management method.

- Weed Management: Among the new herbicides tested, Penoxlan 24 SC @ 0.025 kg a.i. ha^{-1}, Bensulfuran-methyl 60 DF @ 0.05 kg a.i. ha^{-1}, Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1}, Almix 0.004 kg a.i. ha^{-1}, Bispyribac sodium @ 100 g LSC @ 35 g a.i. ha^{-1} were found superior to control weeds in irrigated transplanted rice.
- Yield Maximization: A combination of recommended dose of NPK 80:40:20 kg ha^{-1} + Zinc 25 kg ha^{-1} + Sulphur 20 kg ha^{-1} + Multiplex 0.5 % foliar application twice + Green Manuring (Sesbania rostrata) supplemented with either rice husk 50 q ha^{-1} or deep tillage was found very effective in increasing grain yield significantly.
- DSR/Aerobic Rice: DRR drum seeded rice crop fertilized with 80:40:20 NPK kg ha^{-1} + 25 kg Zinc sulphate ha^{-1} and weed control through Butachlore + one spot weeding gave highest grain yield. Technology for Dry Direct Seeded Rice (DSR) in Bihar has been developed and released by the University.

Crop Protection

- Rice Pathological and Entomological studies were carried out in the areas of Surveillance, Epidemiology, Evaluation of Germplasm/Cultivars and integrated management of location specific diseases like Bacterial blight, Sheath rot and Sheath blight and insect pests like BPH, Stem borer, Mealy bug, Leaf folder, Gundhi bug, etc.

PATTAMBI

Regional Agricultural Research Station
Kerala Agricultural University
Kerala

This station established in 1963 under Kerala Agricultural University was one of the co-operating AICRIP center since the start of the project. Testing the adaptability and suitability of improved varieties in various trials.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

- Efforts for yield improvement, initially improvement of traditional rice varieties resulting in the release of 34 improved traditional varieties with an average yield of 800kg/ha to 2500kg/ha. These improved traditional varieties are known nationally and internationally as donors for biotic and abiotic stress resistance breeding.
- PTB 10- Thekkancheera, very short duration variety posses' gene for high photosynthetic efficiency is utilized throughout the world in hybridization programmes.
- PTB- 33 is another important donor variety, carrying genes against 3 biotypes of BPH. PTB 18, PTB 21 are also worth mentioning as donors of multiple resistance.
- Annapoorna (PTB 35) is the first short duration high yielding variety of India, developed through hybridization released in 1966 from Pattambi. Subsequently

24 high yielding varieties suitable for different rice ecosystems were released from this station.

- Jayathi (PTB 46) is an internationally known high yielding multiple resistant variety released from Pattambi.
- Hybrid rice research programme was launched to identify effective maintainers or restorers for CMS lines. KAURH2, a white kernelled hybrid has been developed.
- Many varieties with abiotic stress tolerance were also released from this station. PTB 47 and PTB 48 (Neeraja and Nila) are high yielding varieties with tolerance to deep water submergence. PTB 42, 43 and 55 are drought tolerant suitable for upland rice cultivation. PTB 44 (Rashmi) is mutant with salinity resistance. Mangala Mahsusri (PTB 53) and Karuna (PTB 54) are tolerant in iron toxicity and shallow flooding.
- Collection, conservation, characterization and evaluation of rich genetic diversity of rice was initiated in this station.
- Genetic Stocks Registered: Two of the varieties, Athira and Harsha have been registered with PPV&FR Authority.

Recently released varieties

Swetha (PTB 57)
Released in 2002. Semi tall, non lodging, medium tillering, erect and photoperiod insensitive variety, suitable for transplanting during second crop season. Duration is 140-145 days. Grains are straw coloured with white kernels (milling % 71.5). Moderate resistance to gall midge and stem borer, low susceptibility to blast, brown spot, sheath blight and sheath rot with a grain yield of 4.5 - 5.0 tonnes/ha

Anashwara (PTB 58)
Photosensitive, semi-tall non-lodging variety with red, medium bold grains. Duration of 125-130 days. Moderately resistant to blast, sheath blight, leaf folder, stem borer and gall fly. Released in 2007 by 'γ' irradiation of PTB 20 has excellent cooking quality.

Samyuktha (PTB 59)
Photo-period insensitive, medium tillering variety of 112 - 117 days duration. This short-bold red kernelled rice variety is moderately resistant to major pests of rice crop. Released in 2010. It is non-lodging in the koottumundakan system of cultivation, with non-shattering grains and moderate dormancy.

Vaishakh (PTB 60)
Red, short bold variety with 117- 125 days duration. Suitable for direct seeding during kharif season in uplands. Tolerant to moisture stress. Moderately resistant to blue beetle, stem borer and whorl maggot.

Released varieties from RARS Pattambi with AICRIP tested data

Sl. No.	Variety	Year of Release	IET No.
1	Annapoorna (Ptb 35)	1966	
2	Rohini (Ptb 36)	1971	
3	Aswathy(Ptb 37)	1971	
4	Triveni (Ptb 38)	1971	11747
5	Jyothi(Ptb 39)	1974	2700
6	Sabari(Ptb 40)	1974	2236
7	Bharathi(Ptb 41)	1974	16707
8	Suvarnamodan(Ptb 42)	1978	
9	Swarnaprabha(Ptb 43)	1985	8301
10	Rasmi(Ptb 44)	1985	7344
11	Matta Triveni (Ptb 45)	1990	
12	Jayathi (Ptb 46)	1990	
13	Neeraja (Ptb 47)	1990	11525
14	Nila (Ptb 48)	1992	
15	Kairali(Ptb 49)	1993	12419
16	Kanchana(Ptb 50)	1993	13636
17	Aathira (Ptb 51)	1993	12888
18	Aiswarya (Ptb 52)	1993	12421

Sl. No.	Variety	Year of Release	IET No.
19	Mangala Mahsuri (Ptb 53)	1995	14083
20	Karuna (Ptb 54)		
21	Harsha (Ptb 55)	2001	16707
22	Varsha(Ptb 56)	2002	16709
23	Swetha(Ptb 57)	2002	14735
24	Anashwara(Ptb 58)	2006	17608
25	Samyuktha (Ptb 59)	2010	22127
26	Vaishakh (Ptb 60)	2010	22128

Crop Production

Agronomy

- Experiments on INM were conducted with organic and inorganic manures to find out the sustainable productivity of rice in acid sandy loam soils during two main cropping seasons.
- Experiment on growing cowpea and sunhemp as intercrops in dry sown rice so as to meet the green manure requirement indicated significant improvement in grain yield due to the intercropping and subsequent incorporation of cowpea, whereas sunhemp did not show promising.
- Either liming at 600 kg/ha or 100 kg of silica was needed to ameliorate the acidic soils and improve the fertilizer use efficiency in Kerala.
- A study conducted during 1971-74 to find out the water requirement of transplanted lowland rice revealed that the water requirement of rice from transplanting to the milky stage of grain was about 1700mm and consumptive use of water amounted to 821.7 mm.
- Agronomic practices like line sowing of adequate quantity of seed rate of 60 kg/ ha, using vermicompost with 50% NPK fertilizers, N in 3 splits (50% at 15 DAS, remaining 50% in two equal splits at maximum tillering and panicle initiation stage), mechanical row seeding were found to be promising in increasing the grain yield of rainfed upland rice.
- Chemicals like Butachlor, 2, 4-D and c-18649 were very effective over normal practice of weed control. Bispyribac-sodium@25 or 30 gai/ha applied 15-20 DAT (Days After Transplanting) gave excellent control of most of the annual grasses, sedges and broad leaved weeds and it was recommended for inclusion in Package of Practices
- The influence of physiological age of seedlings on growth and productivity of rice was studied using both short and medium duration varieties in 1974-76. The older seedlings produced larger number of panicles per square meter.

Plant physiology

- Plant physiology experiments were started at the station during 2005-2006 onwards. Higher N levels definitely had a higher yield but in terms Among the entries tested, Ajaya was found to possess good responsiveness to N- levels coupled with higher yield followed by NDR 359 and PA 6444 then followed by BPT 5204 and Vasumati.

- Popular high yielding varieties were evaluated for heat unit requirement during various growth phases as influenced by photoperiod and thermal regimes. Late sown set entries recorded less cumulative day period and cumulative night period requirement for maturity and recorded low yield when compared with early sown sets.

- Four entries namely, DRRH 1, KRH-2, Hyb-6444 and Jaya (check) were evaluated for the effect of maintaining soil water status at saturation level as a measure of water saving technique to normal practice. The treated set had recorded lower RWC values and plant height and lesser number of days to general flowering. Yield components were also reduced in treated entries namely tiller number, panicle number, spikelet number and grains per square meter.

- Aerobic study on rice revealed that Rasi, PA 6201, Harsha and Kanchana can perform better under aerobic condition without any yield reduction by saving 40-50% of water, with alternate weekly wetting and drying cycles, starting from 15 days after planting to maturity.

- Application of boron as boric acid@0.8 ppm significantly increased the grain yield. Boron application resulted in 9.2% increase over the control.

- Soil application of silicon solubilizer, imidazole (1.5%) and sodium potassium silicate (1.0%) during vegetative and panicle initiation stage improved the grain yield and resistance to stem borer.

- The genotypes KRH-2 and IET-21577 showed more tolerance under high temperature stress in terms of number of filled grains /panicle.

- IET23383 and IET24084 have been identified as drought tolerant lines suited for rain-fed upland condition.

- N-22 has been identified as a heat tolerant with 87.7% spikelet fertility under high temperature conditions (38-42°C).

- IET 22100 and IET 21582 are moderately tolerant to high temperature conditions.

Crop Protection

Entomology

- ***New Records of pests:*** Whorl maggot and thrips during 1971-72; Pink stem borer, *Sesamia inferens, Chilo fuscifluora, Brachmia arotrae, Leptocorisa pseudolepida* during 2005-08; *Apsilops scotinus* (Tosquinet) (Ichneumonidae: Hymenoptera) found parasitizing larvae of case worm reported first from India during 2013-14.

White stem borer, *Chilo fusciflora*

Leaf folder, *Brachmia arotrae*

Case worm larval parasitoid, *Apsilops scotinus*

- Host plant resistance studies: PTB2, 9, 25, 26 , 32, 44, KAU 8770, 8759, 8775 RPW 6-13 and RPW 6-17showed consistent resistance to gall midge. PTB 12, 16, MO -15-6-3, NDR -118, Cul.93 showed consistent resistance with below 10% dead heart damage. IR8, PTB 33, GEB 24, Co 29, TNAU LFR FR-831311, OR-142-93, Tarori Basmati and W1263 showed resistance to leaf folder. PTB 7, 10, 12, 18, 19, 20, 21, 33, 34, Cheriya chiteeni, Parakulam, Velluthacheera, KAU cultures viz., 9401-2, 9409-6, 9409-12, F3-11-3, F5-23-2, C3-2 (KM) showed resistance to BPH. PTB 4, PTB 9, PTB 12, PTB 18, PTB 20, PTB 28, Rohini were found resistant to blue beetle.

- *Insecticides evaluated:* Seedling root dip with chlorpyiphos 20% EC @ 0.02% ; Carbofuran 3G @ 1000 g a.i/ha, Phorate 10G @ 25kg a.i.ha and carbosulfan 6G @ 1000 g a.i.ha was recommended against gall midge. Cartap hydrochloride 4 % G @ 1000 g a.i.ha, Carbosulfan 6 G @ 1000 g a.i.ha, Flubendiamide 480 SC @ 25 ga.i./a, Flubendiamide 20% WDG @ 24 ga.i./ha, Indoxacarb 14.5%SC@ 30 ga.i/ha, Spinosad 45% SC @ 45g a.i.ha was included in POP of the University for stem borer and leaf folder management. Recently, Chlorantraniliprole 18.5 SC @ 30 g a.i/ha and Flubendiamide + Buprofezin @ 210 g a.i./ha was accepted for inclusion in POP of the University for stem borer and leaf folder management. A number of insecticides tested against leaf folder were found effective. Thiomethoxam 25 G @ 25g a.i. /ha and Acephate 75%SP @ 600 g a.i./ha against leaf folder was included in POP of the University. Resurgence of leaf folder by application of carbofuran was reported from this station. Flubendiamide + Buprofezin @ 210 g a.i. /ha was acepted for inclusion in POP of the University against BPH management. Indoxacarb 14.5%SC@ 30 ga.i/ha was found effective against blue beetle.

Plant Pathology

- *Screening for disease resistance:* The screening nurseries for evaluation of different entries for resistance to major diseases helped to find out the resistance for sheath blight, blast and bacterial blight. The new sources of resistance identified through the screening programme under AICRIP were included in the breeding programme of the centre. The pre release cultures of the station were also routinely included in the screening programme to identify new sources of resistance as well as to test the level of resistance of these cultures to blast and sheath blight. Since bacterial blight was becoming a major problem in Kerala, screening for bacterial blight resistance has been initiated from 2010 onwards

- Screening for multiple disease resistance: Attempts were also made to identify rice varieties resistant to major diseases. One such experiment to screen rice varieties against major diseases was started in 1973-74. Twenty varieties selected from various screening trial such as NSN, IRS HBN, UBN and IRDN were tested for their yield potential in a comparative yield trial with Triveni, Jyothi and jaya as check varieties.

- Research programmes to evolve rice varieties with multiple resistance to blast and sheath blight, two major diseases of rice in Kerala resulted in release of varieties Kairali, Kanchana, Athira and Aiswarya in 1993 with a fair degree of resistance to both diseases. This was continued in the following years and the varieties released with resistance to both the diseases are Mangala Mashuri, Karuna and Harsha.A culture with multiple resistance to blast, sheath blight, sheath rot and brown spot was identified and released as Swetha in the year 2002.

- Monitoring the virulence of pathogens: Virulence analysis of blast and BLB is being carried out and no change in pathogen population has been noticed over the years from 2008.

- Chemical control: Recommendations included in the Package of practices recommendations of KAU/ new molecules under testing in farm trials for inclusion in POP.

- Foliar spray with carbendazim (Bavistin 50WP) @1g/l or zineb (Dithane Z 78) @4g/l against blast of rice; Seed dressing with Carbendazim (Bavistin 50WP)

@2g/kg seed or Pyroquilone (Fungerone 50WP) @2g/kg against blast of rice

- Carpropamid (Protega 27 SC) @1ml/l for the control of blast; Isoprothiolane (Fuji one 40EC) @1.5ml/l was found to be effective for the management of blast.
- Foliar spray of the fungicide, propiconazole (Tilt 25EC) (1ml/l) against sheath blight.
- Trifloxystrobin 25% + tebuconazole 50% (Nativo 75WG) @0.4g/l for the control of blast and sheath blight
- Carbendazim + mancozeb (Saaf – 1.5g/l), hexaconazole 5SC (Contaf plus -2 ml/l) and propineb (Antracol 75WP) for the control of brown spot and are being tested in farmers field.
- Spraying of the fungicides trifloxystrobin 25% + tebuconazole 50% (Nativo 75WG) @ 0.4g/l, Kresoxim methyl (Ergon 44.3SC) @1ml/l or propiconazole (Tilt 25 EC) @1.0ml/l for the management of false smut being tested in farmers field
- Combination product, Flubendamide 3.5%+Hexaconazole 5% (RIL-060/ F1 8.5 WG) a ready mix formulation was tested @2 g/l and compared with hexaconazole 5EC (Contaf) @ 2 ml/l and insecticide flubendiamide 20 WG (Takumi) @ 0.35 g/l against sheath blight and leaf folder.
- Biological control of diseases and use of biopesticides: Pseudomonas fluorescenswas applied as seed treatment @ 10g/kg of seed, followed by three foliar sprays (0.2%) at 30, 60 and 90 days after transplanting was significantly superior to control in reducing the disease and increasing the yield.
- *Integrated disease management:* Use of bio control agent *Pseudomonas fluorescens* and vermicompost application significantly reduced (49%) the neck blast and increased the grain yield (12.74%) compared to the plots without any management practices.

PONNAMPET

Agricultural Research Station
University of Agricultural Sciences, GKVK, Bangalore
Karnataka

Agricultural Research Station, Ponnampet was established in 1951 under the University of Agricultural Sciences, GKVK, Bangalore. The station is situated in 867 m above MSL with latitude of 12.29N and Longitude of 75.56E. The station is in hill zone and receives an average annual rainfall of 2200 mm. The research mandate includes screening and development of blast tolerant paddy varieties and integrated management of pests and diseases in paddy. The station has been recognized as hotspot for blast screening.

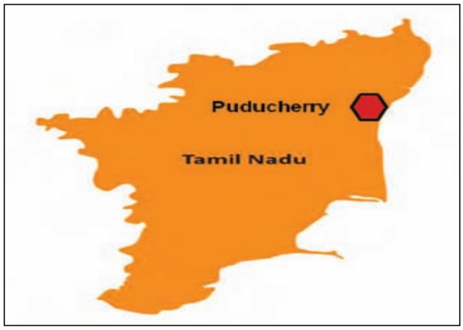
Crop Protection

Plant pathology

- Screened > 25,000 genotypes against blast
- Identified and released IET-7191, KHP-2, KHP-5, Tunga (IET-13901), KHP-10 (red rice), Intan, Hemavathi (DWR-4107), Sharavathi (IR-57773) for the zone.
- Identified Tricyclozole 7SWP and Carpropamid WIN 300 sc, SI VIC – 75 WP, Protega as effective fungicide against blast

PUDUCHERRY

P.K. Krishi Vigyan Kendra
Puducherry



Rice Research in Puducherry (formerly Pondicherry) started with the establishment of Krishi Vigyan Kendra (KVK) in 1974. From its inception, the KVK has been identifying high yielding varieties suited to Puducherry with features like non lodging, high yielding, resistant to insect pests and diseases, fine grains suitable for different seasons and duration groups in range of 90 to 150 days. It has also developed production technologies to cater to the needs of farming community. This Kendra is located about 8 kms from Puducherry town and occupies an area of 45 acres of land of which 62.5 acres is wet land for rice farming. This centre was administered by Tamil Nadu Agricultural University, Coimbatore up to March 1992. The technical and administrative controls of this centre have been taken over since then by the Government of Puducherry. The KVK was recognised as one of the AICRIP centers during 1979.

Major Contributions to AICRIP

Crop Improvement

Varieties developed and released:

Name of the Variety	Year of Release	Suitable Season	Duration (Days)	Yield (t/ha)	Characteristics
PY-1 (Puduvai Ponni)	1979	Late Samba	135	5.5	Saline tolerant
PY-2 (Punithavathi)	1980	Sornavari Navarai	95-100	5.0	Fine, white rice
PY-3 (Bharathidasan)	1984	Sornavari	115	5.5	BPH resistant
PY-4 (Jawahar)	1989	Samba	145-150	6.2	Medium fine, white rice
PY-5 (Aravidar)	1994	Sornavari	100-105	6.0	Long slender, white rice
PY-6 (Subramania Bharathi)	2000	Samba	135	5.5	Medium slender, moderately resistant to blast, gall midge
PY-7 (Annalakshmi)	2007	Late Samba	125	5.5	Medium slender moderately resistant to blast, tolerant to stem borer & leaf folder

PUSA

Rajendra Agricultural University
Bihar

This center was established in the year 1980 by Rajendra Agricultural University, Bihar. The main focus is on the rice research for deep water and boro rice ecologies.

Major contributions

Crop Improvement

Varieties developed / released

Sl. No.	Year of Release	Name of the Variety	Yield (q. /ha.)
1.	1972	Sita	40-45
2.	1972	Saket-4	35-40
3.	1983	Sugandha	25-30
4.	1983	Janki	15-25
5.	1983	I.R.-36	45-50
6.	1985	Sujata	40-50
7.	1984	Radha	50-60
8.	1987	Kanak	50-60
9.	1987	Rajshree	45-50
10.	1989	Sudha	20-25
11.	1994	Pusa Basmati	30-40
12.	1994	Prabhat	65-70
13.	1994	Vaidehi	30-35

Sl. No.	Year of Release	Name of the Variety	Yield (q./ha.)
14.	1995	Shakuntala	35-45
15.	1995	TurantaDhan	25-30
16.	1995	Gautam	70-75(Boro)
17.	1999	Kishori	45-50
18.	1999	Satyam	45-50
19.	2000	Richaria	35-40 (Kharif),50-60 (Boro)
20.	2000	Dhanlaxmi	45-50 (Kharif) 60-65 (Boro)
21.	2001	Saroj	45-50 (Kharif), 60-65 (Boro)
22.	2001	Santosh	45-50
23.	2003	RajendraMahsuri	50-60
24.	2003	RajendraSuwasani	45-50
25.	2004	RajendraSweta	40-50
26.	2004	Rajendrakasturi	40-45
27.	2006	RAU-3036	35-40
28.	2006	RAU-724	45-50
29.	2010	Swarna Sub-1	50-55
30.	2010	RajendraBhagwati	45-50

The salient features of some of the recently released varieties for different ecosystems are given here.

RAJENDRA BHAGWATI
Ecology : Upland and Medium
Duration : 110-115 days
Grain Type : Long Fine
Yield : 45-50 Q/ha
Special Feature : Tolerant to pest and diseases, Suitable for Boro season also.
Aroma: Mild

RAJENDRA MAHSURI
Ecology : Lowland
Year of release : 2005
Duration : 140-145
Yield potential : 60-65q/ha.
Head rice recovery : 50-60%

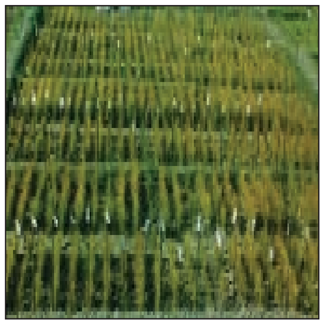
RAJESHREE

Ecology	: Lowland
Year of release	: 1987
Duration	: 135-140
Yield Potential	: 40-45q/ha.
Head rice recovery	: 50-60%

VAIDEHI

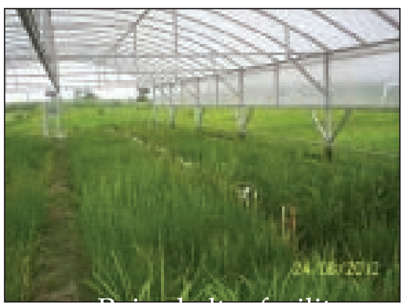
Ecology	: Deep water
Year of release	: 1995
Suitability	: For deep water where water stands 1 meter or above
Yield potential	: 30-40q/ha.
Head rice recovery	: 60%

- Screening a large number of boro rice genotypes at Pusa, a hot spot. Five varieties Gautam, Richharia, Dhanlaxami, Saroj & Prabhat have been developed for Boro cultivation.



- Facilities for screening for abiotic stresses were developed at this center.

Deep water screening facility



Rain Shelter facility

Crop Production

Agronomy

- Agronomic practices for rainfed upland rice : Concurrent growing of dhaincha (up to 25 DAS with 40 kg seed rate of dhaincha and its subsequent killing with the help of 2, 4-D @ 0.8 kg ai/ha) with rice along with 80-50-30 kg NPK/ha under rainfed upland condition.
- Nitrogen and weed management practices in Aerobic rice: Pre-emergence application of pretilachlor @ 0.75 kg a.i. ha^{-1} or pendimethilin @ 1.0 kg a.i. ha^{-1} followed by one hand weeding at 60 DAS along with 100 kg N ha^{-1} in rice + dhaincha system.
- NPK requirement of transplanted rice: NPK requirement for mid and long duration varieties were reformulated as 120-60-40 kg NPK ha^{-1} against the earlier recommendation of 80-40-20 kg NPKha^{-1}.
- Deep water rice: Seed rate of base crop (rice) and companion crops like sesame and moong bean was standardized (2:1) to obtain maximum total yield in the system in farms of rice equivalent but also appreciably reduced the weed dry weight.
- Agro-technique for quality rice: Transplanting during 15-20 July along with 25-50% substitution of Inorganic N with organic sources (Preferably vermicompost) is ideal for quality rice.
- Agronomy of hybrid rice: NPK combination 150-60-60 kg NPK ha^{-1} with Nitrogen in four splits – 1/4th each at Basal, AT, PI and PE and Potassium in two splits – 70% Basal and 30% PI; saturation or cyclic submergence (5 DAD) recorded maximum yield of hybrid rice.
- FYM schedule in Rice-wheat system: With regard to frequency of FYM @ 10 t ha^{-1} along with RDF in rice-wheat system, application of FYM in Kharif was more beneficial than rabi. Again FYM application in rice in alternate year is more economical. This schedule was able to control the occurrence of khaira disease after two years.
- Standardizing Agro-technique for SRI : 15 days old seedling along with concurrent growing of dhaincha @ 40kg ha^{-1} for 20 days for brown manuring with the help of 2, 4-D spray @ 0.8 kg a.i ha^{-1} followed by two cono weedings at 25 and 35 DAT gave highest yield and economic return under SRI method of rice cultivation.

RAIPUR

Rice Research Station
Indira Gandhi Krishi Vishwavidyalaya, Raipur
Chhattisgarh

In the British regime one agricultural research station was established in 1903 known as "Labhandi Farm". This Labhandi Farm later became the campus of Indira Gandhi Krishi Vishwavidyalaya, Raipur. Rice Research Station (RRS) was started in 1968. Later in 1974 Madhya Pradesh Rice Research Institute (MPRRI) was established under the leadership of great rice scientist Dr. R. H. Richharia. Indira Gandhi Krishi Vishwavidyalaya, Raipur was started on January 20, 1987 after bifurcation from Jawaharlal Nehru Agricultural University, Jabalpur.

Major contributions to AICRIP

Crop Improvement

Plant Breeding

- High yielding dwarf varieties released from Raipur centre during 1975 to 1993 include Pragati, Kranti, Tripti, Abha, Deepti, Asha, Usha, Samridhi and Madhuri. From 1987 to 2014, sixteen rice varieties were released and one identified in 2014. Rice genotypes like Dagaddeshi, Bakal, Assam Chudi were identified as new donors for drought tolerance.
- A total of 23250 germplasm collection of rice accessions are being maintained and evaluated for various biotic and abiotic stresses along with yield contributing traits.
- Based on evaluation dataset, Catalogue on Indigenous Rice Germplasm has published in two parts, Part -1 has 5096 accessions (Indigenous Rice Germplasm of Chhattisgarh and Madhya Pradesh and Part -2 has 7599 accessions (Indigenous Rice Germplasm of Chhattisgarh and Madhya Pradesh), both parts characterized for 23 qualitative and 12 quantitative characters.

- A total of 9860 rice lines from CG Gene bank of IGKV, Raipur representing different collection sites mainly the Chhattisgarh and adjoining part of MP and advanced breeding lines have been analyzed for four nutritional quality traits; total protein, lysine, iron and zinc contents.

List of varieties released from IGKV, Raipur

S. No.	VARIETY	IET NO.	NOTIFICATION NUMBER
1	Poornima	IET 12284	S.O. 360 (E) dt 1-5-97
2	Mahamaya	IET 10749	S.O. 1(E) dated 1-1-96
3	Shyamla	IET 12561	S.O.. 360 (E) dt 1-5-97
4	Danteshwari	IET 15450	S.O. 1134 (E) dt.15.11.01
5	Indira sugandhit dhan-1	IET 15376	S.O. 124(E) dt.2.2.05
6	Bamleshwari	IET 14444	S.O. 1134 (E) dt. 15-11-01
7	Sambleshwari	IET 17455	S.O. 1178 (E) dt. 20-7-2007
8	Jaldubi	IET 17153	S.O. 1178 (E) dt. 20-7-2007
9	Chandrahasini	IET 16800	S.O. 1178 (E) dt. 20-7-2007
10	Indira sona (hybrid)	IET 18872	S.O. 1178 (E) dated 20.7.07
11	Karma mahsuri	IET 19991	S.O. 2458 (E) dt. 16.10.2008
12	IGKVR-1244	IET 19796	S.O. 456(E) dt.: 16.3.2012
13	Indira barani dhan-1	IET 21205	S.O. 456(E) dt.: 16.3.2012
14	IGKVR 1 (Rajeshwari)	IET 19569	S.O. 283(E) dt.: 7.2.2011
15	IGKVR 2 (Durgeshwari)	IET 19795	S.O. 283(E) dt.: 7.2.2011
16	Indira aerobic 1	IET 21686	- awaited -

Indira Sugandhit Dhan

Chandrahasini

Sambleshwari

- The aromatic IET **21842 (R 1536-136-1-17-1)** identified as promising for different states UttarPradesh,West Bengal, Assam and Chhattisgarh. This variety possesses high yield, short bold grain withgood in quality exhibiting superior performance.
- Low genetic variations for grain Fe levels were observed compared to that of grain Zn contents. In screening of homozygous breeding lines, two rice lines

viz; **R-RF-31** and **R 1033-968-2-1** identified from the state and drought breeding trails as High Zinc rice genotypes (> 27 ppm Zn). These genotypes are currently in the pipeline of release of varieties, which will be useful in the drought prone areas of eastern Indian state including CG.

- The eight different genes for gall midge resistance has been identified namely Gm-1(Sarekha), Gm-2 (Sarekha), Gm-3 (RP 2068-18-3), Gm-4 (Abhaya), Gm-5 (RC 5984), Gm-7 (RP 2333-156), Gm-8 (Jhitpiti) and Gm-9 (Line 9). The national identity number allotted is IC 296614.

Gall – midge Resistant Genes Registered by IGKV, Raipur

S. No.	Genes Registered for	INGR No.	National Identity	Genotype
1.	Rice gall Midge resistance gene GM-1	04003	IC 296614	Samridhi
2.	Rice gall Midge resistance gene GM-2	04004	IC 296614	Surekha
3.	Rice gall Midge resistance gene GM-3	04005	IC 296614	RP 2068-18-3-5
4.	Rice gall Midge resistance gene GM-4	04006	IC 296614	Abhaya
5.	Rice gall Midge resistance gene GM-5	04007	IC 296614	ARC 5984
6.	Rice gall Midge resistance gene GM-6	04008	IC 296614	RP2333-156-8
7.	Rice gall Midge resistance gene GM-7	04009	IC 296614	Jhitpiti
8.	Rice gall Midge resistance gene GM-8	04010	IC 296614	Line 9

Crop Protection

Entomology

- More than 50,000 rice entries were tested for the Raipur Gall midge and BPH resistance and near about 3000 gall midge and 300 BPH resistant entries were identified as potential donors for various International, National and State level variety development programmes. Insect resistant varieties were developed from Raipur are Asha, Usha, Samridhi, Ruchi, Abhaya Kranti, Bangoli-5, Mahamaya, Bamleswari, Danteswari Samleswari, Chandrahasni, Karmamahsuri etc.
- During the last two decades 20 new Insecticide chemical molecules, two bio and two botanical insecticides were tested and recommended against the major insect pests of rice.
- Based on long term monitoring through light trap catches for different insect pests of rice, major active period of the pest was identified. Third week of Sept. to last week of Oct is identified as the period of peak activity for most of the pests. In light trap monitoring studies the timings of 6.30 PM to 10.00 PM is identified as ideal time for operating this instrument by receiving maximum adult catches.

- In field monitoring studies, September and October months were identified as the period of peak activity for most of the insect pest. Most the natural enemies were found active in the month of September. The pest defender (P:D) ratio was found ideal i.e. 1:2 up to 20th September.
- *Platygaster oryzae* was identified as the major larval/pupal parasitoid of gall midge found active during September month. Stem borer egg mosses parasitization was maximum during mid October and Teleomus sp was dominant species. Larval parasitization by some unidentified pathogens was ranging from 15-25% and maximum larvae were found parasitized in variety Kranti, TN-1 and Indira Sona variety of rice.
- In the last decade insect gall midge was known as the most distractive pest of rice but now stem borer, brown plant hopper, case worm and cut worm are becoming serious pests in this area
- Rice stem borer incidence has reached at the alarming situation in rice cultivation of Chhattisgarh state. Use of trap crop is found as a novel approach in eco-friendly management of this pest. To minimize the damage of yellow stem borer in the main crop (variety- swarna) by planting a trap crop (variety- Pusa basmati 1) in the ratio 9:1 was found effective and economical.
- Raipur gall midge was designated as Biotype -1, after continuous monitoring of natural population occurring during last three yeasr it was found as the mixture of Biotype –I (95%) & Biotype–II (5%).
- Acephate found safer to *Platygaster oryzae*, the major parasitoid of gall midge.
- PM package for management of Paddy pest complex: Mahamaya, Danteswari Indira Sona, Samleswari, Chandrahasini, Jaldubi, Karmamahsuri etc variety planted up to 25th July after seedling root dip treatment by chlorpyriphos nursery treatment is an ideal practice. After that, installation of light trap which is operative during 6-10 P.M. for monitoring and mass trapping of paddy insect pests is a good practice. Installation of bamboo pegs which serve as bird perches and also help in increasing the activity of stem borer egg parasitoids. In the month of September, weekly release of *Trichogramma japonicum* is effective in increasing parasitization of stem borer egg masses. Monitoring and mass trapping of yellow stem borer through pheromone trap in the month of October is helpful in trapping the YSB adult. Need based application of Phorate 10 g 10 kg/ha or Fipronil 0.3 G 25kg/ha at tillering stage and spraying of Monocrotophos 36% 1100 ml/ha or Chlorpyriphos 20% 2000 ml/ha at the panicle initiation stage provides satisfactory protection to the paddy crop against internal feeders. Spraying of Monocrotophos 36% 1100 ml/ ha or Imidacloprid 100 ml/ha, or Fipronil 5% 800 ml/ha is helpful in managing leaf and plant hoppers.

RAJENDRANAGAR

Rice section, Agricultural Research Institute
Professor Jayashankar Telangana State Agricultural University (PJTSAU)
Telangana State

The section was established in 1928 to develop suitable varieties for the Telangana region in particular, AP state in general and later strengthened with rice specialist in 1950 to develop varieties for kharif and rabi seasons. Later the section was strengthened through AICRIP during 1964-65 with 4 disciplines viz. Rice Breeding, Agronomy, Entomology and Pathology.

Major Achievements

Crop Improvement

Plant Breeding

- With the efforts of Breeders 15 promising varieties with high yield potential, resistant to pests and diseases suitable for Telangana region were developed and they became popular. In addition, cost effective crop production and plant protection technologies were developed and propagated for the benefit of farmers.

Varieties released

S. No.	Name	Parentage	Duration (days)	Characters	Year of release
1.	Hamsa	HR 12 / T (N)1	115	Tolerant to cold	1968
2.	Tellahamsa (RNR 10754)	HR 12 / T (N)1	110	Tolerant to cold	1971
3.	Rajendra (RNR 12392)	IJ 52 / T(N)1	110	Suitable for I.D.	1976
4.	Mahsuri	T65/Mayang Ebos 80 / Mayang Ebos 80	150	Fine grain	1972
5.	Saleema (RNR 29692)	GEB 24/Sigadis/IR8/ RNR 8102	135	Resistant to blast	1987
6.	Satya (RNR 1446)	T.Hamsa/Rasi	120	Tolerant to cold	1987
7.	Chandan (RNR 74802)	Sona/Manoharasali	145	Tolerant to BPH & Blast	1989
8.	Sagar Samba (RNR 52147)	IR 8/Siam 29/IR 8/ Ptb 21	150	Resistant to blast and GM	1993
9.	Rajavadlu (RNR 99377)	Rajendra / IR 30	135	Resistant to blast	1993
10.	Early Samba (RNR M7)	Mutant of Samba Mahsuri	135	Excellent cooking quality	1999
11.	Sumati (RNR 18833)	Chandan / Pak basmati	140	Scented	2002
12	Taramati (RNR-23064)	Tellahamsa / BPT-5204	135	Tolerant to cold & salinity.	2009
13	Sugandha Samba (RNR-2465)	RNR M7 / RNR-19994	135	MS, Aromatic	2010
14	Krishna (RNR 2458)	Chandan/ BPT 5204	135	MS, Blast resistance	2012
15	Shobhini (RNR 2354)	RNR M7 / RNR-19994	135	MS, Aromatic	2014
16	RNR 15048*	MTU 1010/ JGL 3855	125	SL, Blast R	2015
17	RNR 15038#	MTU 1010/ JGL 3855	135	SL, Blast R	

***Proposed for release in SVRC; # Variety in pipeline**

- About 450-500 quintals of breeder seed of various varieties is being produced, each year and provided to public and private agencies.

Crop Production Technologies

- Fertilizer dose of 120-60-50 kg NPK and 50 kg Zn ha^{-1} was optimized for hybrids (DRRH-1 & KRH-2).
- Developed technology of direct seeding with 8 row seeder + herbicide application (Butachlor @ 1.0 kg a.i. ha^{-1} at 7-8 DAS) + one hand weeding and application of 120-60-30 NPK ha^{-1} and 50 kg Zn ha^{-1} found effective over broadcasting of seed @ 100 kg ha^{-1}.
- Pre-emergence application of Butachlor + Safener @ 1.5 kg a.i. ha^{-1} at 4-5 DAT was found to be cheaper than manual weeding. The same combination @ 1.0 kg a.i. ha^{-1} at 10 DAS was effective under direct seeding in puddled soil.
- In situ incorporation of dhaincha benefited rice crop as well as following rabi maize, saving 20-30 kg N ha^{-1} and green manuring + 50% RDF was on par with 100% RDF.
- Covering nursery beds with polythene sheet during night time at 2 feet height protected nurseries from cold injury in rabi season.
- Developed organic farming package for rice.
- On farm trial on selective mechanization for enhancing the production and profitability of rice cultivation revealed that maximum grain yield was obtained with use of Kuboto transplanter followed by SRI method of cultivation compared to Yanji transplanter and farmers method.
- Transplanting of 15 days old seedlings and pre-emergence application of

butachlor @ 1.50 a.i. ha^{-1} / anilophos 0.6 kg a.i. ha^{-1} at 5 DAT + one hand weeding or 2 times cono-weeder at 10, 20 days after transplanting was recommended.

- Three row power operated weeder was found suitable for weeding in rice, resulting in 10% higher yield.
- Medium duration varieties (MTU 1010) and hybrids (KRH 2, PA 6291 and PA 6444) realized higher yields under rice-wheat cropping system. However, early varieties will have the advantage of facilitating timely sowing of wheat.

Crop Protection Technologies

- Donors viz., ARC 5984, ARC 6650, BM 71, MTU 4870, MTU 1001, MTU 1071, MTU 1010, MTU 1064, MTU 1075 for BPH; Siam 29, PTB 21, Vibhava, JGL 1798, Kavya, JGL 13595, JGL 11690, WGL 32100, WGL 14, RNR 19994 for gall midge; Sigadis, Tetep, IR 72, NLR 34449, Mandya Vijaya, NLR 145, IR 64 for blast; RNR 19994, Pakistan Basmati, Pusa Basmati, Kalanamak, Chittimutyalu, Badshabhog, Sumati, Vasumati, Pusa 1121, Ranbir Basmati, Yamini for scent; HR 12, IET 9994, IR 64, Tellahamsa, Rajendra, Erramallelu for cold and BPT 5204, WGL 14, WGL 32100, JGL 384, JGL 1798, RNR M7, Chandan, Mahsuri, White Ponni, PKV Sona for quality were identified.
- Technique of spraying twice (panicle emergence and milky stage) with monocrotophos @1.6 ml or carbaryl @ 3 g/lit. of water from periphery to the centre of the field was developed for the management of gundhi bug.
- Application of carbofuran 3 G @ 1.5 kg a.i. ha^{-1} at 5 days before pulling the nursery was identified as an alternative technique to seedling root dip with chlorpyriphos.
- Developed comprehensive scale for screening against panicle mite, Steneotarsonemus spinki.
- Generation of rice cultivation system based insect pest information to evolve suitable protection package is under progress.
- A new combination of Spiromecifen @ 1ml + Propiconazole @ 1ml/l of water resulted in reduced incidence of panicle mite /grain discolouration.
- Effective components of IPM in rice viz., dry seed treatment with carbendazim @ 3 g/kg seed; resistant variety; deep summer ploughing; carbofuran 3 G @ 1.5 kg a.i. ha^{-1} nursery at 5 days before pulling; formation of alley ways; need based plant protection, release of Trichogramma sp., pheromone traps @ 20/ha for yellow stem borer were established.
- Protective spraying of Fenoxanil + Isoprothiolane combination (RIL 013/F1) @ 2.0 ml/l twice at 15 days interval during maximum tillering to panicle initiation was effective against leaf blast and neck blast.

RANCHI

Birsa Agricultural University
Jharkhand

AICRIP at Kanke under Birsa Agricultural University, Ranchi, Jharkhand was started in the year 1981. The soil and climate of the state are very much favourable for hybrid rice cultivation and hybrid rice along with SRI has been able to provide good yield of rice in the farmers' field. This center is associated with the development of Sahbhagidhan with 115-120 days duration and yield potential of 40-50 q ha^{-1}.

Major Achievements

Crop Improvement

Varieties released/ identified:

S. No	Variety	Characters
1	Birsa Dhan-101	Tolerant to blast, BLB, stem borer and drought. Suitable for rainfed upland ecosystem. Matures in 80-85 days, yield potential 8-10 q/acre.
2	Birsa Gora-102	Red rice, resistant to drought but susceptible to Brown spot, Gundhi bug & Stem borer. Matures in 90-95 days, yield potential 7.0 to 7.5 q/acre.
3	Birsa Dhan-103	Tolerant to brown spot, blast, BLB, Stem borer and Gall midge. Suitable for rainfed upland ecosystem. 95-110 days duration, yield potential 12 to 14 q/acre.

S. No	Variety	Characters
4	Birsa Dhan-104	Long and bold seed. Tolerant to blast, BLB, Stem borer, BPH and Gall midge. Suitable for rainfed upland ecosystem. Matures in 85-90 days, 8 to 10 q/acre yield.
5	Birsa Dhan-105	Tolerant to blast, BLB, Stem borer and Gall midge. Suitable for rainfed upland ecosystem. Matures in 85-90 days, yield potential 10 to 12 q/acre.
6	Birsa Dhan-106	Tolerant to blast, BLB and Stem borer. Matures in 90-95 days, yield potential 10 to 12 q/acre.
7	Birsa Dhan-107	Tolerant to Brown spot, blast, BLB, Gall midge and Stem borer. Suitable for rainfed upland ecosystem. Matures in 90-95 days, yield potential 10 to 12 q/acre.
8	Birsa Dhan-108	Tolerant to blast, BLB and stem borer. Early maturing variety. 70-75 days duration, 10 to 12 q/acre yield.
9	Birsa Vikash Dhan-109	Superfine and long slender grain. Tolerant to blast, BLB Stem borer, and drought. Matures in 85 days with yield potential of 10 to 12 q/acre.
10	Birsa Vikash Dhan-110	Superfine and long slender grain. Tolerant to blast, BLB, stem borer and drought. Suitable for rainfed upland ecosystem. Matures in 95 days with yield potential of 10 to 12 q/acre.
11	Birsa Vikash Dhan-111	Deeply rooted having medium tall plant (Plant height- 84-95 cm). It has weed smothering capabilities and also superfine and long slender grain (L- 9.3 mm, Breadth- 2.4 mm). Tolerant to blast, BLB, Stem borer and drought. It matures in 85 days, yield potential 9 to 10 q/acre.
12	Rajendra Dhan-202	Semi dwarf with compact and long panicle, straw coloured hull and long bold grain with white kernel. Resistant to blast, BLB and drought. Matures in 120-125 days with yield potential of 16 to 18 q/acre.
13	Birsa Dhan -201	Long, bold with white kernel. Suitable for medium land. Resistant to blast, brown spot and Gundhi bug. Matures in115-120 days, yield potential 14 to 16 q/acre.
14	Birsa Dhan -202	Long, bold with white kernel. Suitable for medium land. Resistant to blast, brown spot and Gundhi bug. Matures in120-125 days and has yield potential 16 to 18 q/acre.
15	Birsamati	Long slender grain with good aroma. Suitable for rainfed medium low land. Resistant to all major pests and diseases. Matures in130-135 days, yield potential 16 to 20 q/acre.
16	Lalat	Long, bold with white kernel. Suitable for medium land. Resistant to Gall midge & moderately resistant to blast, BLB, false smut,stem borer, Gundhi bug. Matures in120-125 days and has yield potential 18 to 20 q/acre.

S. No	Variety	Characters
17	Birsa Vikash Sugandha -1	Long slender grain with 3.71 mm L:B ratio and aromatic. Moderately resistant to blast, BLB, Brown spot, stem borer and gundhi bug. It matures in120-125 days and has yield potential of 16 to 18 q/acre.
18	Birsa Vikash Dhan -203	It may be cultivated in transplanted in drought prone medium land of Jharkhand. Long slender grain, non lodging, semi dwarf plant type. Moderately resistant to blast, BLB, Brown spot, stem borer and gundhi bug. Matures in120-125 days, yield potential 16 to 18 q/acre.

Crop Production

Agronomy

- System of Rice intensification (SRI) has become very popular in all the districts of Jharkhand because, following 2-3 components of SRI, farmers are harvesting 15-20 % more grain yield in comparison to conventional method of transplanting of rice. Considering the importance of SRI the BAU centre Ranchi has also conducted a number of experiments on SRI after following all the components or even only one component also. Therefore university is likely to release a technology of SRI after considering the significance of each and every components of SRI that technology may be recommended/released for the farmers of Jharkhand.
- In rainfed medium and low land situation of Jharkhand, sedges weeds *i.e.* *Cyperus* spp. and broad leaves weeds are prevalent and it is very difficult for controlling them by manual weeding in rice. It was found that sedges and broad leaves weeds reduce the grain yield of rice up to 30-70%. Carfentrazon (a herbicide) @ 25g a.i./ha was found most suitable in controlling sedges as well as broad leaves weeds.
- In Jharkhand, there are three agro-ecological situations i.e. upland, medium and low land rainfed. The rainfed upand is highly acidic (<4.5), with low organic carbon (<0.33%), low in K and also very low in rice productivity (8-10 q/ha). Hence a trial of amelioration of acidic soils for enhancing the rice productivity was conducted at Ranchi centre and found out that the application of RFD+FYM+LIME+100% extra K increased grain yield upto 20 q/ha.
- Based on station trials followed by validation trials on farmers' field, technologies were developed to enhance the productivity and profitability of

rainfed upland rice, aerobic rice, hybrid rice and organic rice.

- Integrated Crop Management (ICM) resulted in 15% more yield as compared to System of Rice Intensification (SRI) in irrigated medium land situation.
- Crop like urd bean, soybean and pigeon pea were identified as suitable inter crop with rainfed upland rice.

Crop protection

Entomology

- During 1980's based on field trials conducted at Ranchi centre, gall midge (*Orseolia oryzae* wm) got the separate identity as the *gall midge bio-type-3.*The variety *Rajendra Dhan-202 (RD-202)* was developed by the Ranchi centre as *resistant to* the gall midge biotype-3 during 1980's. Based on regular survey and surveillance, Simdega, Gumla, Lohardaga, Khunti and some pockets of Ranchi districts of Jharkhand were identified as endemic areas to rice gall midge biotype-3.
- Rice varieties *viz.* Kavya, Naveen Lalat and IR-36 proved to be resistant against gall midge (biotype-3) with <10% silver shoots. Sahbhagi and Abhishek exhibited moderate resistance to gall midge. Thitpiti, INRC 202, MR1523. RP-2068-18-3-5, INRC 1997, INRC 3021, Aganni, ARC 6605 and Abhaya remained almost free form the attack of gall midge biotype – 3
- Saket-4, Deepti, Ratna and SashyaShree varieties were identified as resistant against yellow stem borer.
- Application of carbofuran 3G @ 30 kg /ha, phorate 10G @ 10 kg/ha or cartap hydro-chloride 4G @ 25 kg/ ha at 15-20 days after transplanting (DAT) proved to be effective against gall midge, yellow stem borer, GLH, BPH and moderately effective against hispa and leaf folder.
- Seedling root dip of rice in water solution of chlorpyriphos 0.02 percent proved to be highly effective against gall midge and yellow stem borer.
- Combination product, flubendamide 36% + fipronil 30%, 66 WG @ 50 g/ha applied on need basis as foliar spray was found effective against gall midge, yellow stem borer, GLH ,leaf folder and hispa followed by another combination product, Imidacloprid 40% + ethiprole 40%, 80 WG @ 125 g/ha.

- Foliar spraying of the combination product RIL-IS-109, flubendamide 4%+ buprofezin 20 %, @ 875 ml/ha or acephate 75 SP @ 800 g/ha or Acephate 95 % SG @ 592 g/ha were highly effective against gall midge, YSB, leaf folder, hispa and GLH.

- Catap hydrochloride 50 SP @ 1300 g/ha proved to be the most effective against gall midge, yellow stem borer, and gundhi bug and gave grains yield of 47.1 q/ha. Sulfoxaflor (24%) @ 375 g/ha belonging to the new group sulfoximine was highly effective against GLH and gall midge. The improved molecule of triazophos 40 EC @ 1250 ml/ha reduced significantly the pests like gall midge, YSB, leaf folder, hispa, GLH and gundhi bug, realizing substantially higher yield (47.0 q/ha).

- Broad casting / application of carbofuran 3G @ 33 Kg/ha or phorate 10G @10 kg/ha in the nursery bed, followed by application in the main field could be responsible for significant management of rice root gall nematode.

- Tank mix application of Acephate 95 SG plus hexaconazole 5SC @ 1.2 g + 2.0 ml per lit water and acephate 95 SG plus tricyclazole 75 SP @ 1.2 g + 0.6 ml per lit of water proved highly effective and compatible in reducing the incidence of major insect pests i.e. YSB, hispa, GLH, gall midge, leaf folder along with leaf blast and brown spot diseases. Dinotefuran 20 SG plus either hexaconazole or tryclazole was found compatible and effective against major pests and diseases of rice. None of the pesticide combinations were found phytotoxic to the rice plants.

- Incidence of GLH, gall midge and hispa was significantly higher in the normally transplanted system as compared to the direct wet seeded rice, whereas the leaf folder incidence was higher in the direct wet seeded rice. Incidence of stem borer did not differ significantly between the two cultivation systems.

- Participatory IPM trial conducted in farmers fields revealed that IPM operations and timely application of insecticides reduced the crop damage due to GLH, GM, YSB, and leaf folder in IPM blocks resulting in higher grain yield and BC ratio as compared to farmers practices.

REWA

Jawaharlal Nehru Krishi Vishwa Vidyalaya
Madhya Pradesh

In January 1968 All India Coordinated Rice Improvement Project was sanctioned for Madhya Pradesh with its lead centre at Raipur (Now under IGKVV) and sub center Rewa for rainfed rice research and voluntary center at Jabalpur. Later, Rewa under Jawaharlal Nehru Krishi Vishwa vidyalaya has become main center for upland rainfed rice research.

Major contributions to AICRIP

Crop Improvement

Varieties/ Hybrids released/ identified

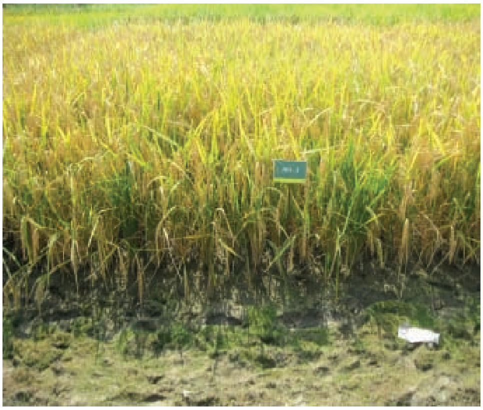
Name of the variety	IET No.	Year of release	Flowering duration	Grain type	Avg. yield (q/ ha)
JR503	16783	2005	98	LS	40
JR201	13832	2005	76	LS	35
JR 3-45	13623	2001	90	LS	42
JRH 4	19496	2007	85	MS	70
JRH5	19497	2007	82	MS	70
JRH8	20414	2009	80	MS	70

- 21 Breeding lines nominated from AICRIP Rewa.
- 900 germplasm lines collected and being maintained for drought tolerance and quality lines

Rice hybrids developed by JNKVV

JRH-4
Duration : 100-105 days
Yield : 70-75 q/ha
Specific features:
Early maturing
Suitable for double cropping under rain fed situation (Rice-Gram or Rice-Oilseed)
Grain long bold
Most suitable for rice fallow area of MP, Chhattisgarh and Jharkhand.

JRH-5
Duration : 100 days
Yield : 70-75 q/ha
Specific features:
Early maturing
Suitable for double cropping under rain fed situation (Rice-Gram or Rice-Oilseed)
Shown excellent performance in rice fallow chickpea programme
Drought tolerant
Grain long bold
Most suitable for rice fallow area of MP, Chhattisgarh and Jharkhand.



JRH-8
Duration : 100-105 days
Yield : 65-70 q/ha
Specific Features:
Early maturing
Suitable for double cropping under rain fed situation (Rice-Gram or Rice-Oilseed)
Identified at national level for suitability under saline and rain fed situation
Shown excellent performance in rice fallow chickpea programme
Drought tolerant
Grain medium slender

Crop Production

Agronomy

- Yield maximization of rice under irrigated conditions- Increasing the fertilizer by 33% and plant stand by 33% to get maximum yield for which a spacing of 15 X 10 cm and fertilizer dose of 120: 80: 50 NPK Kg/ha was recommended.
- Weed control for direct sown rice under rain fed upland ecosystem -Application of Anilophos 30 EC 0.6 kg ai/ha followed by 2,4-D 80 (WP) produced maximum numerical grain yield 22.80 q/ha over unweeded check (9.20 q/ha.). Two hand weedings and herbicide application were equally effective.
- Techniques for transplanting under puddled conditions - Transplanting in lines, herbicides Butachlor application at 4-6 DAT, recommended fertilizer (120:60:40 NPK kg/ha) + Zinc 20 kg/ha produced maximum grain yield 40.98 q/ha over other local methods of sowing.

- Development of suitable agro techniques for aerobic rice in upland conditions - Among the management practices N75% .PE + Rice : Dhaincha (1:1) + 2,4 D Na salt application (0.80kg a.l./ha) at 25-30 DAS was found significantly superior for the management of weeds and increasing the grain yield.
- Integrated weed management in aerobic rice: Application of Pendimethalin or Butachlor at 3-4 DAS + Bispyribac sodium at 15-20 DAS proved next best alternative to need based hand weeding.
- Studies on suitable varieties and optimum date of sowing for aerobic rice- 20th June was found to be suitable for aerobic rice at Rewa center. Among the rice varieties tested for performance under aerobic condiation PHB -71, BH – 21, Sahbhagi and Govinda yield was found suitable.
- Cultural management - Line sowing with mechanical row seeder (60kg/ha) + FYM 5t/ha application 15days before sowing and recommended N: P: K. (N in 3 splits-50% after 15days +25% at active tillering + 25% at panicle initiation stage) and weed control with herbicide recorded an average grain yield of 35. q/ha.

Plant Physiology

- *Photothermic indexing study in rice genotypes:* Photo thermal and dark period requirement in terms of cumulative degree days and nycto period for vegetative , reproductive and ripening period with yield related variable and development indicator exhibited that the number of days to PI and grain filling reduced by 14 and 11 days, respectively in 26 days sowing. The mean early set yield was 254 g/m^2 and the difference in early –late set was 76 g/m2.
- *Variation in CDD and CNP:* Cumulative solar radiation in photo period (CDD) and nycto period (CNP) is calculated that at PI stage the difference was 96 CDD between early and late sown sets irrespective of genotypes, while CNP was 39 in early and late sown sets. The cumulative degree stages CDD at GF was 1122 and1220 with the difference of 98 in early and late sown sets. Thus, the photo period is required for dry matter production and Nycto period required for flowering process.
- Moisture stress study: Higher grain yield under moisture stress conditions were found in IET-21638, IET-21629 IET-21602, IET 20708, IET 21626 and IET 21625 IET 20710, 21076, 21106, 21119, 21625, 21626 IET-20859, IET-22038 and Sahbagidhan. These entries were relatively tolerant to drought, could be promoted for rainfed situations.

- Heat tolerance of short duration elite rice cultures: A perusal of daily temperature data indicate that the crop was exposed to higher temperature during the month of September and October which corresponded to the anthesis and grain filling stage of the crop. Several tolerant genotypes viz., IET 20132, IET 20134 and PSD-3 hybrid, IET 20907, 20893, 20924, 21009 and 21523, Varadan, PA-6444, IET, 21601, 21582 and KRH-2 were found to be efficient genotypes under high temperature with marginal reduction.

- Influence of Boron on spikelet fertility: Boron applied @ 0.4ppm at anthesis significantly increased grain yield by 9.6% in IET 22218, 21540, 22225 and 21519 and yield attributes along with biomass by increasing grain filling and reducing spikelet sterility.

- *Partitioning of dry matter under Upland condition:* Pre sowing wetting and drying during seed treatment in IET 13170, 13652 and IET 13943 had higher grain yield due to higher LAI (4.52-5.5) at flowering and CGR (3.8-4.2g/m2/day), PGR and stem reserve during GFP.

- *Characterization of sink capacity in hybrid rice:* KRH2 and Sahayadri had efficient dry matter partitioning (87.7 and 80.0%), HI (34.2 and 34.0%) and yield 76.3 and 71.8q/ha, respectively. Thus, these hybrids were found suitable for Kymore plateau region in Madhya Pradesh.

Crop Protection

Plant Pathology

- Evaluation of new fungicidal formulation against leaf blast: Among the tested new formulations, the superiority of fungi toxicity was recorded in Sivic 75 WP (3566 kg/ha-[1]) followed by Tricyclazole (3533 kg/ha-[1]) over untreated check. Nativo and Filia were found the best formulations and found on par with the tricyclazole formulations in checking the disease. Among the tested fungicides none was found comparable with Propiconazole 25EC (4063 kg/ha) over untreated check (3000kg/ha). Among the other tested fungicides evaluated, Metaminostrobin20SC @200gai/ha was found highly effective for checking the leaf blast infection and in increasing the grain yield (7040kg/ha) followed by Tricyclazole (Baan) (6467kg/ha) over untreated check (4840kg/ha).

- Evaluation of fungicides against location specific disease: Of the tested products, Contaf 5EC (ie 1 ml/l) was found significantly superior in increasing the grain yield and reducing the leaf blast severity (9.9%) and brown spot (12.6%) over untreated check.

- Evaluation of Botanicals against leaf blast of rice: Bio pesticides Wanis (@ 5ml/l) was found most promising in controlling the leaf blast and increasing the grain yield (3704kg/ha-1) followed by Neem gold & Achook over untreated check (2893 kg/ha) .

- *Control of false smut of rice:* Control of false smut of rice was studied against hybrid PA 6444 under natural epiphytotics. Among the tested fungicides, Kavach 75WP @2g/l, Kocide 10177WP@2g/l Result25EC @1ml/l and Saaf 75WP @1.5g/l were found highly effective.

- Evaluation of Bio agent Pseudomonas fluorescens) and its formulation against location specific diseases: Among the tested fungicides under study Tricyclazole was found highly effective for checking the leaf blast (25.3%) and in increasing the grain yield (65q/ha) followed by Hexaconazole 75WG (61qkg/ha) over untreated check (3146kg/ha). Pseudomonas flourescens Pf1 liquid formulation was not comparable with fungicides. However, it was effective for controlling the leaf blast infection over untreated check.

Entomology

- Gundhi bug control: Percent grain damage brought out the superiority of carbofuran check insecticide (12.7 % grain damage) as compared to Chlorpyriphos granules (28.7 to 37.6 % grain damage). Among the spray formulations, monocrotophos check insecticide recorded the least grain damage (12 %) followed by ethiprole + imidacloprid (17.3 % grain damage) as compared untreated control (47.31 %). Application of Acetamiprid 0.4%+ Chlorpyriphos20EC with trade name Gharda gave significantly good control the gundhi bug population and increased the grain yield under irrigated ecosystem.

- Insecticide evaluation for armyworm: Buprofezin + Acephate (20+50) @ 1000 ml / 500 liter water found effective to reduce the 100% population of armyworm caterpillar up to 10 days after spraying. Maximum yield was recorded in this treatment. It can be used by the farmers for the control of Army worm, which may increase 46.06% yield over control.

- Pesticide compatibility trial (PCT): The combination of Tricyclazole (Baan) 75WP + Flubenbendiamide 20WG gave superior results for controlling the gundhi bug and leaf blast of rice and in increasing the grain yield followed by Tricyclazole(Baan)75WP+ Fipronil 5SC over untreated check. Glamore + Contaf and Glamore + Baan combination gave highest grain yield and reduced the population of WBPH. Glamore insecticide was found to be compatible with both the fungicides whereas, Coragen insecticide was not compatible.

SAKOLI

Agriculture Research Station
Dr. Panjabrao Deshmukh Krishi Vidyapeeth
Maharashtra

This research station was established in 1979, representing irrigated ecology of eastern Vidarbha region of Maharashtra under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Major contributions to AICRIP

Crop Improvement

Varieties identified/released

SKL-6
Released in 1978. Early duration, R-Blast, Suitable for *Kharif* & *Rabi*, LS grain with yield potential 40-50 q/ha.

SKL-7
Released in 1988. Scented, Mid late, high HRR, Yield potential 40-45 q/ha.

SKL-8
Released in 2000. Late duration, multiple pest and disease resistance, LS grain with yield potential 40-45 q/ha.v

PKV-Ganesh
(SKL 3-11-25-30-36)
Released in 2003. Mid late duration, short slender grain, MR to plant hoppers, gall midge, stem borer, stem borer, leaf folder and rice hispa and diseases, yield potential 40-45 q/ha.

PDKV KISAN
Released in 2012. Mid late duration, dwarf, medium slender grain (16.1 g), MR to major pests and diseases. Higher yield than popular rice varieties. Good cooking quality, yield potential 40-42 q/ha.

SKL- 30-39-24-8-9
Released in 2012. Mid late Duration, dwarf medium slender grain (24.1 g), Resistant to Gall midge biotype 4 and moderately resistant to bacterial leaf blight, neck blast and Stem borer. Good cooking quality yield potential 43-45 q/ha.

- 120 AICRIP breeding experiments from 32 trials were conducted at this center from 2000 to 2014 and 3248 entries were evaluated, ~1200 pure lines were generated as breeding material, around 510 rice germplasm available.
- 2 rice varieties registered in PPV & FRA: PKV- SKL 3-11-25-30-36 (Regn. No.186/2013) & SKL-11-28-29-55 (SKL-8) (Regn. No.142/2014)

Crop Protection

Entomology

- 8702 entries were screened in AICRIP Entomological trials against major pests. Of these, sixteen cultures of ARS, Sakoli have been identified promising against biotic stresses in AICRIP under National screening programmes.

TITABAR

Regional Agricultural Research Station
Assam Agricultural University
Assam

Regional Agricultural Research Station, Titabar was established in 1969 by Assam agricultural university. It is one of the funded centres under AICRIP and has been nominating rice cultures for testing in coordinated trials in the country for different ecosystems particularly from nineties.

Crop Improvement

Varieties developed/ identified

- The station has so far developed 45 rice varieties and after testing in AICRIP trials, they have been recommended for cultivation for various seasons and ecosystems in the state. These varieties cover more than 70% areas of HYV in the state.
- The most popular rice varieties include Ranjit, Bahadur, Luit, Keteki, Aghoni and Jaymati.
- The variety Ranjit is also cultivated in neighbouring countries like Bangladesh, Nepal and as well as in different states of India like West Bengal and N. E states.
- Keteki, an aromatic short grained rice and Aghoni, a glutinous rice of long duration group are also becoming popular and were released in Orissa.
- A number of genotypes contributed from RARS, Titabar having high Fe content were Aghoni bora (47 ppm), Prafulla(35 ppm), Betguti (42 ppm), Gitesh (45 ppm). Besides, a few cultures were found to be high in both Fe(25-28 ppm) and Zn(32-40 ppm) content viz. Malbhog, Goalbhog, Aghonibora and Prafulla. These varieties were identified as potential donor for improved nutritional quality and for special purpose *through bio fortification*

- Jalashree, Jalkuwari developed at RARS, Titabar along with Swarna sub1, BR 11 Sub 1 and IR64 sub1 have been identified as potential rice cultivars to tolerate submergence stress up to 10-12 days at early growth stage.

Varieties developed at RARS, Titabar & released

Variety	Eco system	Season	Parentage	Remarks
Madhab	Irrigated	Ahu	IR8/CH63	Mid early variety
Rongdoi			Prasadbhog/IR8	
Lachit			CRM13-3241/Kalinga II	
Chilarai			IR24/CR44-118-1	
Gopinath			Pusa2-21/IR36	
Luit	Irrigated/ rainfed	Ahu and Sali	Heera/Annada	Very early, suitable for pre and post flood situation
Kapilee				
Disang			Lachit/Kalinga III	
Ranjit	Rainfed shallow low land	Sali	Pankaj/Mahsuri	Long duration variety
Aghoni			Gandhi bora/Kmj1-52-2	Glutinous rice variety
Rongilee			Ghew bora/Kmj 1-52-2	
Bhogali			Ghew bora/Kmj 1-52-2	
Keteki Joha			Sabitri/Badsah bhog	Short grained long duration aromatic rice
Bokul Joha			Sabitri/Badsah bhog	
Jalashree	Flash flood affected lowland	Sali	Pankaj/FR13A	Long duration submergence tolerant variety
Jalkuwari		Sali	Pankaj/FR13A	
Prafulla		Sali	Akisali/Kushal	Long duration variety suitable for staggered planting
Gitesh		Sali		
Manah	Semi deep water	Sali	Kmj1-17-2/ IET 10016	Long duration rice variety suitable for low land waterlogged areas
Diphalu				
Chakra Sali				
Dhansiri				
Saytaranjan			IET 9711/ IET11162	Medium duration variety suitable for double cropped areas
Basundhara			IET8711/IET11161	
Shrabani			APMS6B / Piolee	
Mulagabharu			Jaya/Mahsuri	

Variety	Eco system	Season	Parentage	Remarks
Jaymati	Irrigated	Boro	Jaya/Mahsuri	Modern boro rice variety
Kanaklata				
Bishnuprasad			K 343-29-1/Sweon 334	
Jyotiprasad				

Crop Production

Agronomy

Technologies generated and validated include:

- Use of low plastic tunnel for raising boro (summer rice) seedlings to increase seedling height and vigour was recommended
- Direct seeding of sprouted seed after 12-24 hours of puddling with 8-row drum seeder in post flood situation was recommended.

Agronomic management practices identified

- Standardization of suitable agro-techniques *viz,.* Sowing time, seed rate, spacing, age of seedling, manures and fertilizers, time of application of fertilizers for direct seeded and transplanted autumn rice, winter rice, late winter rice (transplanted) and boro/summer rice have been recommended. Depth of planting, no. of seedlings/hill for normal as well as late transplanting of short and long duration varieties recommended.
- Maximum grain yield (5.99 t/ha) of Bahadur (150-155 days) was recorded by applying 60-20-40 kg N, P_2O_5 and K_2O /ha which was based on soil test crop response studies (STCR) closely followed by application of 40-20-20 (5.8t/ha). Application of FYM in addition to 40-20-20 kg/ha had no positive response (4.92 t/ha). Application of Zn could not improve yield.
- *Management of direct seeded kharif rice:* Direct seeding (wet) using a 8-row drum seeder developed at DRR, Hyderabad, could produce a yield (3.64t/ha) as high as farmers' practices of transplanting provided weeds are properly managed in var. Lachit (120-125 days). Direct seeding of sprouted seeds in lines along with pre emergence butachlor application and hand weeding at 40 DAS could yield more than that of transplanting.
- Application of 100% RDN (60 kg N/ha) gave higher N response (kg grain/kg N) over 150% RDN.
- ICM as an alternative to SRI was found to be more flexible .While studying the response of early (Luit and Disang) medium (Satyaranjan and Basundhara). Late varieties (Ranjit and Bahadur) and hybrids (KRH 2 and NK 5251) to 1CM, the performance of late cultures were found promising.

- Weed Management: Hand weeding twice raised the yield of dry seeded autumn rice to the double than that of herbicide application due to interculture involved in hand weeding. Application of anilophos either alone or in combination with 2, 4-D (Na- salt) as pre and post emergence respectively, yielded better than butachlor and pendimethalin either alone or in combination with 2,4-D in direct seeded autumn rice. Combined application of Flucetosulfuron 10% WG @ 20 g and at 2-3 DAS and Bispyribacsodium 10% SC @ 25 g a.i/ha at 15-20 DAS produced at par yield compared to weed free treatment in short duration variety Luit.
- Study indicated that for adoption of SRI in boro season, age of seedling and number of seedlings/hill are the two critical components for achieving higher productivity in boro season.

Soil Science

- Application of neem coated urea (1:5) proved a better source for N >sulphur coated urea > urea super granules > prilled urea in *kharif* low land rice and highest N recovery was obtained in NCU (56.12%).
- The rice var. Rasi and IET 5914 showed better phosphorus utilization efficiency at low levels of P in acid soil (pH 5.5).
- Significant improvement of rice productivity was observed with supplementation of recommended fertilizer dose (40 kg N, 20 kg P_2O_5, 20 kg K_2O/ha)+ $ZnSO_4$ @20 kg/ha+ 5t FYM/ha once in a season and correspondingly improved soil fertility as well as soil biological properties.
- Omission of N, P, K, Zn and S and 50% reduction in nutrients brought in considerable yield reduction in rice-rice system.
- Linear trends of productivity in rice over 25 years improved growth rate of about 100 kg/ha/year with a supplementary dose of 5t FYM/ha along with recommended fertilizer dose of 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha
- Varietal evaluation for high Fe and Zn content in rice grain were initiated from 2008. A number of genotypes having high Fe content were obtained viz. R 979-67-2(37 ppm), MTU1010(30ppm), ADT 45 (39ppm), BR-2655(54ppm), ADT 36(56 ppm), ADT 37(33 ppm), Aghoni bora (47 ppm), Prafulla(35 ppm), Betguti (42 ppm), Indobhog(40 ppm), IR 64 (30 ppm), Jawaphool (52 ppm), MTU 3626 (53 ppm), Gitesh (45 ppm). Besides, a few cultures were high in both Fe(25-28 ppm) and Zn(32-40 ppm) content viz. Bilsa ahu, Malbhog, Goalbhog, ADT-45, Aghonibora and Prafulla
- IET 19749, IET 20556, IET 10016, IET 21579, IET 20997 and WL 21 were found to be promising to counteract Fe toxicity through application of lime.

Plant Physiology

- IET 13116, IET 13119, Sabita, Utkalprova, and IET 10016 have been identified for seedling survival under waterlogged condition
- The cultivars Chakra sali, Manah, Dipholu and Dhansiri exhibited prominence for adaptability at waterlogged ecology wherein a water depth of more than 30 cm prevails in a stagnant water environment.
- Modern variety Govind and traditional variety Fapori exhibited inherent potential to grow under moisture stress conditions. Both the varieties recorded higher leaf proline, leaf water potential and relative leaf water content under stress.
- IET 18645 and IET 17509 have been identified as potential donors of upland rice for both drought tolerance and grain dormancy.
- For submergence tolerance and regeneration ability, seed rate of 25 g/m^2 (heavy seedling) was found to be better than recommended seed rate(50g/m^2)
- Purnendu, Swarna sub1and IR64 sub1 have been identified to be potential rice cultivars to tolerate submergence stress at early growth stage. The desirable traits of maintenance of low profile of the pace of degradation of carbohydrate, chlorophyll content and dry matter accumulation with low tissue water potential during stress period reflected the inherent capabilities of those varieties.
- Seed priming with 3% KCl together with foliar feeding of 2% potassium at tillering and PI stages have been found to be a potential drought mitigation management practice for upland summer rice
- Harvest of ahu rice usually coincides with rainy weather. Discolouration as well as sprouting of seeds in the panicle itself or after harvest is due to high moisture content of the seeds. To overcome such problem spraying of diquat 0.05% or paraquat 0.1% or common salt (NaCl) 10% should be done on the ear head @ 1000 lit/ha in terms of chemical solution at 20-25 days after 50% flowering. These chemicals enhance the maturity by 5-7 days.
- Application of sodium molybdate @ 150ppm at three stages viz. flowering, ripening and physiological maturity significantly reduced both pre and post harvest sprouting in rice.
- Critical levels of cumulative degree days (1500 CDD) and cumulative nyctoperiod (1100 CNP) were estimated from the data of last few years of experimentation (2010 -2013) with medium duration genotypes. Advancement of sowing date by 15 days resulted in some cultivars Viz. KRH2, IET 20924 and IET 22218 to meet the required CDD and CNP. The entry IET 20924 performed consistently well for few consecutive years and may be used as breeding lines for developing climate resilient rice cultures.

- The results from 3 consecutive years (2006-2008) of experimentation on evaluation of panicle topological features for better N use efficiency suggest that the number of secondary branches per panicle is largely governed by environment, whereas the primary branches are determined by genetic background of the cultivars. This could be one of the simple selection criteria in developing HYV with better response to external inputs.
- The study on influence of boron on spikelet fertility in rice for 3 consecutive years (2009-2011) revealed that application of 0.4ppm boron at anthesis resulted in increase in grain number and reduced the number of unfilled spikelet to the tune of 18-20% in IET 20979 and IET 21014.

Crop Protection

Entomology

- A number of promising entries were identified after screening NSN entries for resistance against major pests of rice.
- **Insecticide Evaluation-**Insecticide evaluation trial was undertaken to evaluate the effectiveness of insecticides at lower dosages and new insecticides at higher dosages against major insect pests of rice taking eight treatments including untreated control in both *Ahu* and *Sali* rice in the year 1987-90. Chloropyriphos granules, a promising insecticide was tested at lower dosage (1kg a.i./ha) while Cartap and Ethoprop (new formulations) were tested at higher dosages (1.5 kg .i /ha) along with carbofuran granules (1kg/a.i./ha) as a standard check.
- During 2007 to 2011, the following combination of insecticides gave profound results in reduction of rice insect pests specially stem borer, leaf folder, gall midge, case worms etc. These include, Flubendiamide 36% + Fipronil 30% @ 33g a.i. /ha; Buprofezin 20% +Acephate 50% @ 800 ml/ha; Suthathion (Triazophos) 40% a.i. @ 750 ml/ha.
- During 2012-13, Rynaxypyr reduced the maximum population of stem borer and leaf folder followed by Monocrotophos and Triazophos at higher doses and showed superior performance over other treatments.
- During 2013-14, Rynaxypyr (Coragen 20 EC) at 30 g a.i. /ha was the best treatment followed by acephate 95 SG at par and dintefuran (Token 20SC) blended with EK boond, a new non ionic organo silicone wetting agent which was significantly different from rynaxypyr and acephate alone.
- **Pesticide Compatibility Studies-**Glamore 80% a.i. @ 0.25g/litre + contaf 5 % a.i. @ 2.0 g /litre was found effective against two insect pests /diseases and obtained highest yield compared to other insecticide and fungicide formulation in 2010. Acephate 35% a.i. @ 1.2 g/L + Bacon 75% a.i. @ 0.6 g /L was the best treatment against target pests as compared to other formulations.

Flubendiamide 35g + hexaconazol 50g/kg was effective on containing severity of sheath blight, damage by stem borer and leaf folder.

Plant Pathology

- Information on disease screening - Titabar centre has screened several cultures against major rice diseases of the state and identified a few promising lines.
- **Control measures developed-**Contaf 2ml/L has been proposed for recommendation for management of 'stem rot' disease of rice.
- The IRBB lines pyramided with BLB gene were found highly resistant and the lines are being utilised for developing BLB resistant variety by the breeders.
- Application of carbofuran 3G @ 3g /m^2 in the nursery 5 days before uprooting, application of carbofuran 3G at 10 DAT and spraying of chlorpyriphos (0.05%) at 10 DAT reduced the early insect pests of rice.
- **Evaluation of fungicides -** Biotos(2.5ml/L), Armure 30EC 1ml/L were found promising against Glume discolouration(GD); Thiafuzamide 24 SC, Biotos(2.5 ml/L, Bevistin 50WP 1 ml/L against GD; Contaf 5 SC(2ml/L), Taquat 75 UP(1.5/L) , Metominodtrobin (2ml/L) against Stem rot; Hexaconazole 5 SC(2ml/L), Propenconazole 25 EC(2ml/L) against Stem rot; Kresoxim methyl (1ml/l), Propiconazole 25 Ec (1ml/L) against False smut.

TULJAPUR

Agriculture Research Station
Marathwada Agriculture University, Parbhani
Maharashtra

This AICRIP station was established in 1980-81 as plan scheme funded by ICAR under Marathwada Agriculture University, Parbhani. This station is located in Osmanabad district of Maharashtra. The research work is ongoing for the development of superior varieties, suitable for drought areas, resistant to iron chlorosis, long slender grain type in addition to high yield. Considering the interest of farmers and consumers, started a breeding programme to develop aromatic varieties. The work on collection, evaluation and maintenance of land races is in progress.

Major Contributions

Crop Improvement

Varieties developed & released

On the basis of superiority in yield potential, tolerant to drought and blast disease, early duration (105-110 days) variety was released under the name 'Ambica' in the year 1984-85 and was released under the name 'Terna' during the year 1989-90 for upland rainfed area of the region.

Crop Production

Agronomy

- Agronomical trial conducted on seed rate of rice revealed that 40 kg seed per ha is sufficient.
- The experimental finding for nitrogen and row spacing indicated that 50 kg N/ha with 30 cm row spacing is optimum for upland rainfed rice.
- Experiments conducted on rice-based cropping system revealed that rice- gram is beneficial as compared to rice-sunflower, rice-safflower, rice- lentil systems. In rice based intercropping system 6:2 proportion of rice and red gram was beneficial than sole crop of rice.
- Weed management of direct sown rice under rainfed upland condition revealed that hand weeding twice at 20 and 40 DAS is the best practice. Among

weedicides, pendimenthalin 30 EC @ 1.5 kg per ha was found effective to control the weeds.

Plant Pathology

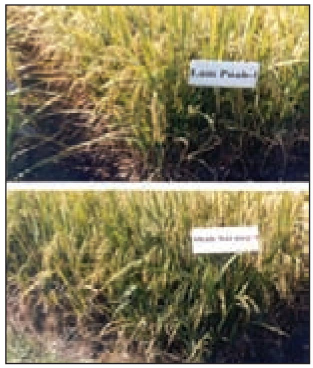
- Paddy seed treatment with Bavistin 25 SD @ 4 gm/ kg of seed followed by one spray of Bavistin 50 WP (1gm/lit) at the time of earliest notice of the blast lesions and second spray of Hindson 50 EC (1ml/lit) 15-20 days later to be adopted.
- Seed treatment with Carbendazim @ 1 gm/kg of safflower seed and Carboxing @ 1 gm for gram seed is advocated.
- Paddy cultures developed at this station viz. TUP-9, TUP-26, TUP-28, TUP-34, TUP42 and TUP-47 were identified promising against foliar as well as neck blast disease under nursery condition.
- Paddy seed treatment with Fongorene 50 WP @ 4 gm/kg of seed followed by two sprays of Bavistin 50 WP @ 1 gm/lit at tillering and panicle initiation stages was significantly superior in minimizing the foliar as well as neck blast incidence with increased grain yield.

UPPER SHILLONG

Department of Agriculture
Meghalaya

This center was established in 1968 under the department of agriculture. The centre is located at an altitude of 1840 msl having a temperate climate. The mandate of is to conduct trials at different locations in order to identify appropriate varietal and management technologies for different eco-systems and to facilitate the exchange of information with scientists of other agricultural research organizations. Presently, varietal trials for high and mid altitude regions were conducted during kharif and boro seasons, in low altitude region were conducted during boro season.

Major Contributions



- Due to the lack of facilities no breeding work is being conducted at the center. However, it closely operates with the ICAR Research Complex, Umiam in matters relating to improvement in yield. The center played a significant role in the release of four varieties, namely, Shah Sarang and Lampnah for lowland conditions and Bhalum-1 and Bhalum-2 for upland conditions of mid altitude region by collaborating with the Research Office, Shillong and the ICAR for North Eastern Hill Region, Umiam.

Plant Pathology

- Leaf Blast Resistance: 2510, 2511, 2512, 2515 from NHSN, 09/124 05/131 from NSN H, 3712, 3301 from NHSN, GSR 104,GSR 126, GRS 142, IET 22592, T – 30 – 37., T – 30 – 38 ,T – 30 – 39 from DSN were found promising.
- Sheath Blight - 809, 2701 from NSN-1, 06/119, 14/104, 15/132, 16/109, 21/112, 23/115,28/110 ,01/104, 05/113 from NHSN, 3521,3711, 3712, 3301, 3106,3601,3602 from NSN – H, CB 12593,CB 12599, GSR 141, IET 21839, IET 21751, IET 22985, RP Patho-17 from DSN were promising against sheath blight.

VARANASI

Banaras Hindu University (BHU)
Uttar Pradesh

AICRIP center at Varanasi was established as a sub center in 1976 at Institute of Agricultural Sciences, Department of Genetics & Plant Breeding, BHU with the objective of developing varieties suitable for rice-wheat cropping system keeping in view the constraints of high rainfall, poor drainage and poor soil fertility. Presently, emphasis is given to hybrid rice and boro rice.

Major Contributions

Crop Improvement

Varieties Identified & Released

HUBR 2-1(Malaviya Dhan-1)
SVRC release in 2005
Parentage: HBR92/Pusa Basmati/Kasturi
Duration: 130-135 days
Grain yield: 45-50 q/ha
Characters: medium duration, high yielding variety, having fine grain, and high aroma

HUR-36 (Malviya Dhan 36)
SVRC release in 1997.
Parentage: Mahsuri by mutation breeding
Duration: 135-140 days
Grain yield: 40-45 q/ ha
Characters: Semi tall, matures 10-15 days earlier to the parent

HUR-105 (Malviya Sugandh-105)
CVRC release in 2009
Parentage:
Duration: 135-140 days
Grain yield: 45-50 q/ha
Characters: photo insensitive variety, high yielding variety, having long grain, and strong aroma

HUR-3022 (Malaviya Dhan-2)
SVRC release in 2005
Parentage: IR36/ HR137
Duration: 110-115 days
Grain yield: 45-50 q/ha
Characters: Early variety with fine grain quality

HUR-4-3 (Malviya Sugandh 4-3)
CVRC release in 2009
Parentage: Mutation breeding of Lanjhi, a tall aromatic land race
Duration: 130-135 days
Grain yield: 60-65 q/ha
Characters: fine grain with mild aroma

HUBR 10-9 (Malviya Basmati Dhan 10-9)
CVRC release in 2013
Parentage: Taraori Basmati/Jaya Duration: 134-137 days
Grain yield: 50-60 q/ha
Characters: fine grain with moderate aroma for basmati areas, responsive to fertilizers. Suitable for rice-wheat cropping system.

HUR-917(Malviya Sugandh Dhan-917)
SVRC release in 2014
Parentage: selection from Dehradoon Basmati
Duration: 134-137 days
Grain yield: 45-50 q/ha
Characters: tall (110 cm) and does not lodge, high hulling and milling recovery, excellent cooking quality with good taste and mild aroma

Crop Production

Agronomy

- For double transplanting or locally known as "Sunda planting" of rice in flash flood areas, nursery period of seedling should not be extended beyond 7 weeks. It should be of 3 + 3 weeks or 3 + 4 weeks. All double transplanting (with tall Mahsuri variety) performed better as compared to single transplanting.
- Concerted efforts of AICRIP and State dept of agriculture resulted in increase in hybrid rice area.
- Rice seedling with 8-row drum seeder should be done 6 hours after puddling and should not be beyond 24 hours.
- Hybrids APHR-2, VRH-4, Pro Agro-6201, PHB-71, KRH-2 and Arize-6444 were found promising under agro climatic zones of Varanasi.
- Hybrid rice could be fertilized with 150 kg N, 20 kg Mg and 1.0 kg B along with basal application of 75 kg P2O5, 60kg K2O and 5.25 kg Zn per ha for increasing productivity as well as for improving quality.
- Among scented rice varieties, Haryana basmati, Pusa basmati-1 and GR-32 were found promising and yielded maximum at 60 kg N ha^{-1}.
- Application of Butachlor or Anilophos fb. 2, 4-D Na were found to be most effective in managing the weeds in direct sown rice.
- For managing weeds in transplanted rice, new herbicide molecules of Flucetosulfuron, Penoxulam + Cyhalofop- butyl, Bispyribac sodium as well as

sequential application of Flucetosulfuron followed by bispyribac sodium were found effective.

- Farmers were motivated to adopt SRI method of cultivation, especially with hybrid rice for increased productivity.
- Aerobic rice yield (Var. HUR-3022) increased significantly with increasing seed rate from 25 to 35 kg ha^{-1} whereas 20 cm row spacing recorded significantly higher yield as compared to wider row spacings (25 and 30 cm). Application of Pendimethalin + Bispyribac sodium for managing savior weed problem of weeds in aerobic rice proved as effective as need based hand weeding.
- Higher Zn and Fe content in aromatic rice grain (variety HUBR 2-1) can be achieved with the application of Zn EDTA @ 1 kg ha-1through soil and Fe-EDTA @ 0.5 kg ha-1through foliar spray separately.

WANGBAL

Rice Research Station, Wangbal
Manipur

The Rice Research Station was established during 1963 and has become funded center of AICRIP during 1973-74 on 50: 50 basis. The major objective of this station is to increase the productivity level of jhum cultivation, semi deep & deep water rices and develop high yielding varieties.

Crop Improvement

Varieties Developed & Released

Sl. No.	Name of variety	Parentage	Year of re-lease	Eco-system	Salient Features
1.	PUNSHI (KD 6-18-7)	PHOUREN/IR 661-1-1-140-1	1980	HYV area irrigatd /rainfed	Semi-dwarf, 100 cm, 135 days duration, SL grain 6-8t/ ha. with highly preferred local taste, good for direct seeding with less fertilizer requirement.
2.	PHOUOIBI (KD 6-2-1)	PHOUREN/IR 661-1-1-140-1	1980	HYV area irrigatd /rainfed	Semi-dwarf ,100 cm plant ht, 133 days duration, extra long slender grain,6-8t/ha slightly earlier to PUNSHI, moderately tolerant to major pests & diseases of Manipur
3.	LEIMAPHOU (KD 2-6-3))	MOIRANG-PHOU/ LAWAGIN	1990	HYV area irrigatd /rainfed and wet terraces	Semi-dwarf, 95 cm ht, 130 days duration, SL grain, 6-8t/ ha. high popping quality, cold tolerant at reproductive stage, good for late planting, moderately tolerant to major pests of Manipur

Sl. No.	Name of variety	Parentage	Year of re-lease	Eco-system	Salient Features
4.	AKUTPHOU (KD 14-1-9)	LANGPHOU/ IR 1364-37-3-1	1990	Semi low Land/ semi deep	Semi-tall, 130 cm ht, 145 days duration, SL grain with reddish husk but white rice, 4-6t/ha., non lodging, moderately resistant to major pests & diseases of Manipur
5.	SANAPHOU (KD 2-7-6-2)	MOIRANG-PHOU/ LAWAGIN	1999	HYV area Rainfed/ Irri-gated	Semi-dwarf, 104 cm ht, 135 days duration, SL grain, 6-8t/ha., cold tolerant at reproductive stage good for late planting with late leaf senescence, moderately tolerant to major pests/ diseases.
6.	EREIMA-PHOU (KD 7-9-20)	TAOTHABI/ IR 1125-21-2-1	1999	Semi -deep To deep water	Tall with high kneeing ability, 135-175 cm ht, 145 days duration, partly awned/ awnless, SL grains with white rice, 4-5t/ha.modera-tely tolerant to major pest/disease
7.	GINPHOU (KD 5-2-8)	PHOUREN/ IR 22	2006	HYV area Irrigated/ rainfed	Semi-dwarf with SL grains & high rice recovery, 135 days duration, 6-8t/ha.. moderately tolerant to major pests/diseases
8.	PARIPHOU (WR 3-2-1)	PHOUGAK/ NEELA	2006	Early & late cropping	Semi-dwarf, 90 cm ht, 110 days duration, SL grains, mildly scented, 5-6t/ha. Early maturing, good for early & late cropping In valley/hill, moderately tolerant to major pests/ diseases

Promising rice lines near release

Sl. No.	Designation	Parentage	Eco-system	Salient Features
1.	KD 5-3-14	PHOUREN/ IR 22	HYV area Irrigated/ Rainfed	Semi-dwarf, 98 cm plant ht, 105 days duration, SL grains(L/B ratio : 3.6), 5-7 t/ ha yield, Gall midge resistant with fine grain.
2.	KD 6-18-7-1	PHOUREN/ IR 661-1-1-140-3	HYV area Irrigated/ Rainfed	Semi-dwarf, 95 cm plant ht, 100 days duration, 6-8 t/ ha yield, SL grain(L/B ratio : 3.6), BPH resistant.

Sl. No.	Designation	Parentage	Eco-system	Salient Features
3.	WR 1-9-1-1	PHOUGAK/ IET 9221	HYV/ Home Stead area	Semi-dwarf, 95 cm plant ht, 85 days duration, SL grain, Gall midge resistant, 5-7 t/ ha yield, prominent flag leaf with late leaf senescence.
4.	WR 3-2-6-1	PHOUGAK/ NEELA	Early/late Cropping	Semi-dwarf, 90 cm plant ht, 70 days duration, very long slender grain(L/B ratio -4.2), very early maturing, yields 4-6t/ ha, moderately tolerant to major pests/diseases of Manipur
5.	WR 15-6-1	PUNSHI/ BASMATI	HYV area	Semi-dwarf, 95 cm plant ht, 90 days duration, SL grain (L/B ratio - 3.6) with good popping quality, 6-8 t/ ha yield, tolerant to major pests/diseases.

WARANGAL

Regional Agricultural Research Station, Warangal
Professor Jayashankar Telangana State Agricultural University (PJTSAU)
Telangana State

Rice gall fly research at Warangal was initiated during 1959–1960 with one Assistant rice specialist and this was strengthened in 1965 with a rice breeder and supporting staff for developing high yielding varieties of rice with gall midge resistance. In 1966, the station along with the scheme was transferred to Andhra Pradesh Agricultural University. In the year 1969, this station was recognized as a National centre for breeding gall midge resistant varieties. All India Coordinated Rice Improvement Project (AICRIP) started with an Entomologist in the year 1969. Subsequently one Scientist (Breeding) position was also sanctioned in XI plan under AICRIP. Presently, it is under Professor Jayashankar Telangana State Agricultural University (PJTSAU), formerly part of Acharya N.G. Ranga Agricultural University (ANGRAU).

Major Achievements

Crop Improvement

Plant Breeding

RARS, Warangal centre has the distinction for

- Development of India's first gall midge resistant variety 'Kakatiya' in 1974.
- Development of first extra early maturing rice variety "Varalu" for contingency situation.Development of cold tolerant high yielding varieties "Erramallelu" and "Sheethal".
- Development of high yielding varieties having good cooking quality viz., Surekha, Warangal Samba, Warangal Sannalu, Ramappa and Siddhi.

- Development of high yielding, gall midge resistant varieties like Surekha, Pothana, Divya, Kavya, Orugallu, Bhadrakali, Keshava, Shiva, Ramappa and Siddhi.
- New gall midge biotype (4m) and new gene conferring resistance (Gm-11t) to gall midge were identified.
- Inheritance of gall midge resistance was studied and reported. Resistance was found to be under the control of single dominant gene.
- About 250 germplasm lines were collected and maintained every year and 30 lines were documented.

Varieties developed and released

S. No.	Variety	Parentage	Duration (Days)	Characters	Year of Release
1	Kakatiya (WGL-13801)	IR 8/W-1263	120	R-Gm 1	1974
2	Surekha (WGL-13400)	IR 8/SIAM -29	135-140	R-Gm 1, LS, good cooking quality	1976
3	Pothana (WGL-22245)	IR 579/W 12708	125	R-Gm 1, LS grain type	1985
4	Divya (WGL-44645)	WGL-23022/Surekha	125-130	R-Gm 1, LS grain type	1989
5	Erramallelu (WGL-20471)	BC 5-55/WR-708	120	T-Cold, LS	1991
6	Kava (WGL-48684)	WGL-27120/WGL-17672/Mashuri//Surekha	135	R-Gm 1 & 3, MS grain type	1991
7	Orugallu (WGL-47970)	OB 5677/IR 70-473-2-5	140-145	R-Gm 1, LS grain type	1993
8	Bhadrakali (WGL-3962)	Phalguna/IR-36	130-135	LS grain type	1994
9	Shiva (WGL-3943)	Phalguna/IR-50	130-135	LS grain type	1995
10	Keshava (WGL-3825)	WGL-28712/IR-36	120-125	R-Gm 1, LS grain type	1996
11	Varalu (WGL-14377)	WGL-20471/CR-544-1-2	90-95	R-Gm 1, LS grain type	2002
12	Warangal Samba (WGL-14)	BPT-5204/ARC 5984//BPT 3291	140	R-RTV, low incidence of SB	2005

13	Warangal Sannalu (WGL-32100)	Divya/BPT-5204	130-135	T-Salinity	2006
14	Ramappa (WGL-23985)	Kavya/AC-20	125-130	R-Gm 1,3, 4, 5, 6	2009
15	Siddhi (WGL-44)	BPT-5204/ARC 5984//Kavya// Kavya/BPT-5204	140-145	R-Gm & BPH	2012
16	Sheethal (WGL-283)	Chaitanya/ Tellahamsa	130	T-Cold & BPH	2012

Popular varieties released by RARS, Warangal

Kakatiya (WGL-13801)
Year of Release : 1974
Pedigree : IR-8/W-1263
Duration (days) : 120
Yield potential (t/ha): 5-5. 5
Reaction to pests : Gall midge resistant
Salient features: First gall midge resistant variety developed in India, Coarse grain
Area of adoption : Denotified

Surekha (WGL-13400)
Year of Release : 1976
Pedigree : IR-8/Siam-29
Duration (days) :130
Yield potential (t/ha): 5.5-6
Reaction to pests: Gall midge (Biotype 1) resistant
Salient features: Long slender grain, good keeping quality after cooking.
Area of adoption : Telangana region and in Madhya Pradesh during kharif

Pothana (WGL-22245)
Year of Release : 1985
Pedigree: IR-579/W-12708
Duration (days) :125
Yield potential (t/ha) :6.0-6.5
Reaction to insects: Gall midge (Biotype1 and 3) resistant
Salient features : Plant is pigmented with pink tinge, long slender grain, suitable for kharif, rabi and edagaru
Area of adoption: Popular inTelangana

Warangal Sannalu (WGL-32100)
Year of Release : 2006
Pedigree : Divya/BPT-5204
Duration (days) : 135 days
Yield potential (t/ha) : 6.5-7.0
Salient features: High yielding, slender than BPT-5204, tolerant to salinity
Area of adoption :Andhra Pradesh, Telangana State for kharif and Rabi season

Siddhi (WGL-44)
Year of release : 2012
Pedigree:BPT-5204/ARC-5984//Kavya///Kavya/BPT-5204
Duration : 140-145 days
Yield potential : 7 – 7.5 t/ha
Reaction to insects :Gall midge resistant
Salient features: High yielding with medium slender grain, good physico-cooking quality.
Area of adoption: Telangana, Andhra Pradesh particularly gall midge endemic areas for *kharif*

Sheethal (WGL-283)
Year of release: 2012
Pedigree : Chaitanya/Tellahamsa
Duration : 125-130 days
Yield potential : 6.5 – 7.5 t/ha
Reaction to insect: Tolerant to BPH
Salient features : High yielding with cold tolerance, long slender grain with good physico-cooking quality traits
Area of adoption: Cold prone areas of Telangana during *rabi* season only.

- Varieties in pipeline: Three high yielding entries viz., WGL-347, WGL-482 and WGL-32183 have completed minikit testing. Three high yielding entries viz., WGL -401, WGL-505 and WGL-558 are in minikit testing now.
- Hybrid rice research: Developed gall midge resistant CMS line (WGL MS-1A) through conversion of Surekha. Few experimental hybrids (WGLRH-1, WGLRH-5, WGLRH-6 and WGLRH-8) were also developed and they are under confirmatory testing.

Crop Protection

Entomology

- **Gall midge biotype studies**: At Warangal, gall midge biotype studies were initiated in 1975. The differentials were standardized into 3 groups based on resistance genes involved.From 1988 onwards; gall midge population is being regularly monitored. W-1263, ARL-6605, Phalguna, Vellantachera, Aganni, Ptb10, T-1477 and Abhaya were found to be free from gall midge incidence, indicating the existence of native gall midge biotype-I population even from 1988-89.
- Since, 1996 change in reaction pattern was observed indicating mixed populations of biotypes. Later on, the deviation in reaction pattern continued and from 2002 to 2006, group I and Group II differentials were found to be susceptible and in group III differentials except CR-MR 1523 all other differentials have shown resistance to gall midge population at Warangal. During 2000-01, the gall midge biotype pattern was designed as S-S-R-S (Biotype-4) instead of earlier R-R-R-S pattern, indicating shift in the population of gall midge. This was later re-designated as Biotype-4M (S-S-R-R-S) during 2005. However, from 2009-10 onwards again there was shift in gall midge biotype. This was evident from the fact that, all the differentials were showing susceptible reaction.
- Identification of resistant donors against gall midge: Gall midge resistant donors HR 22, Eswarakorra, PTB-18, PTB-21, D. Jalita, Jhitpiti, Siam-29 were identified. Some lines with immune reaction to gall midge (Aganni/Banglai, Aganni/Abhaya, MR-1523/RP-2068-8-3-5, MR-1523/Abhaya, Bhumansan/MR-1523, etc.)
- **Gall midge population monitoring:** Characterization of local gall midge population / biotype on three gall midge differentials *viz*., W-1263 (gm-1), Phalguna (gm-2) and TN-1 revealed that 23% population was of biotype-I, 10% was of biotype-2, 8% biotype-3, 2% biotype-4 and 57% non-descriptive.
- Insecticide evaluation trial: Number of new insecticides were evaluated for their efficacy against insect pests of rice:
- Broadcasting of granular insecticides Isazophos 3G @ 2 kg *a.i.*/ha or Cartap hydrochloride 4G @ 1.5 kg *a.i.*/ha or Carbofuran 3G @ 2 kg *a.i.*/ha in nursery 5 days before pulling of nursery, protected the transplanted crop up to 30 DAT from gall midge, stem borer, whorl maggot and leaf folder.
- Carbofuran 3G @ 2 kg *a.i.*/ha was effective against gall midge up to 40 DAT. Seed treatment with Fipronil 5 SC @ 10 ml/l and Imidacloprid @ 2.5 ml/l solution and spraying at 5 days before pulling nursery gave higher yields.

- Triazophos 20 EC followed by Imidacloprid and Curacron at 30 DAT, Indoxacarb @ 12.25 g a.i./ha, Flubendiamide @ 4 g a.i./ha and Methofenozide 22.9 EC @ 100 g ai/ha were effective against leaf folder.
- Triazophos 20 EC followed by Imidacloprid and Curacron at 30 DAT, Chlorpyriphos 10 G @ 1 kg a.i./ha, Carbofuran 3G @ 1 kg a.i./ha, Confidor ultra 100 EC @ 30 g ai/ha and Confidor 200 SL @ 20 g ai/ha were effective against gall midge.
- Against BPH, sulfaxoflor @ 70 g *a.i.*/ha and sulfaxoflor @ 90 g *a.i.*/ha recorded significantly lower population of 19.3 hoppers/10 hills and 27 hoppers/10 hills at 10 days after second spray followed by buprofezin @ 200 g *a.i.*/ha (19.6 hoppers/10 hills).
- Imidacloprid 200 SL @ 25 g a.i./ha and Silafluofen 20 EC @ 100 G a.i./ha, Canfidor ultra 100 EC @ 30 g a.i./ha and Confidor 200 SL @ 20 g a.i./ha, Buprofezin @ 800 ml/ha were effective against BPH.
- In the study conducted on efficacy of certain miticides against panicle mite, dicofol @ 5ml/lt + Propiconozole @ 1 ml/lt and Profenophos @ 2 ml + Propiconozole @ 1 ml/lt spray have proved most effective.
- Propargite @ 570 g a.i./ha followed by Ethion 500 g a.i./ha, Fenpropathrin 150 g a.i./ha and Spiromesifen 72 g a.i./ha were found better in reducing discoloured spikelets by panicle mite.
- Insecticide induced resurgence studies: Profenophos 50%EC @ 2 ml/lt, Lambdacyhalothrin 2.5% EC @ 1 ml/lt, Chlorpyriphos 20% EC @ 2 ml/lt caused resurgence of BPH after 2nd application. Among the three insecticides, Lambda cyhalothrin @ 1 ml/lt was found to cause severe resurgence.
- Population dynamics through light trap catches: Long term data revealed that gall midge population attains peak during October. Stem borer occurs in two peaks, during October and during first week of April. BPH peaks were also recorded in 3rd week of September and 2nd week of October.
- **Integrated pest management:** Adoption of IPM practices in the Variety- Shiva, (IPM components - Pheromone traps for yellow stem borer, formation of alleys, balanced fertilization, chlorpyriphos spray) resulted in low pest incidence and higher yield over farmer's practice.
- Insect pest incidence in different rice cultivation systems: Study on the incidence of insect pests in different rice cultivation systems revealed that, leaf folder incidence was more in SRI than normal; gall midge was more in SRI, stem borer less in SRI (per cent dead hearts).

iii. Contributions of other ICAR Institutes

National Rice Research Institute (NRRI), Cuttack Odisha

The outbreak of devastating epiphytotic brown spot disease of rice (*Helminthosporium spp)* in 1942 in the then Bengal Province (the areas of which are now in the state of West Bengal in India and Bangladesh resulted in a serious shortage of rice that culminated in the Great Bengal Famine of 1943. Due to this famine, the Central Government in 1944, decided to intensify research on all aspects of rice crop. In 1945, the Government of India decided to establish a central Institute for rice research. As a result, the Central Rice Research Institute (CRRI) was setup on 23 April 1946 at Bidhyadharpur, Cuttack, Odisha with an experimental farm land of 60 hectares provided by Government of Orissa. Dr. K. Ramiah, an eminent rice breeder, as its founder Director. Subsequently, in 1966, the administrative control of the institute was transferred to the Indian Council of Agricultural Research (ICAR).

It was renamed as National Rice Research Institute (NRRI) since 2015. The Institute has two research stations- Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh, in Jharkhand, and the Regional Rainfed Lowland Rice Research Station (RRLRRS), Gerua, in Assam. These research stations were established to tackle the problems of rainfed uplands, and flood prone rainfed lowlands, respectively.

Major Contributions

AICRIP, renamed as the Indian Institute of Rice Research, was commissioned at Hyderabad in 1965 and functioned as a part of Central Rice Research Institute till 1988. Since the inception of Co-ordinated project, CRRI has been a major participant in coordination besides its own research activities. After the establishment of All India Coordinated Rice Improvement Project (AICRIP), the genotypes were evaluated in multilocation testing program and NRRI could release its first variety Padma in1968. Through AICRIP, genotypes were evaluated in 14 ecosystems and NRRI contributed nearly half of the entries. These genotypes suitable for low land were highly promising. On an average NRRI conducts 35 AICRIP trials each year suitable for different ecosystem except for hills.

During the period 1965-2015 NRRI had released 114 rice varieties for different ecosystems which were tested through AICRIP programme. Out of these, 21 were suitable for upland, 7 for aerobic, 41 for irrigated, 2 for boro, 21 for shallow lowlands, 12 for semi deep, 4 for deep water, and 4 for costal saline areas. Out of these the varieties like Vandana, Annada and Sahbhagidhan are popular in upland ecosystem; Naveen, Shatabdi, Ajaya, Rajalaxmi and very old variety like Ratna are popular in irrigated ecosystem. Similarly recently released submergence variety Swarna Sub-1 ,Savitri, Pooja, Dharitri and Gayatri are popular in low land areas. The variety developed by NRRI for unfavorable condition like CR-1014,Varsadhan, Sarala, and Durga are suitable for semi deepwater condition are popular with the farmers. The varieties developed for coastal saline condition Lunishree for wet season and Luna Sankhi for dry season are well accepted. Recently NRRI also indentified a high protein rice CR dhan-10 suitable for irrigated areas. It has 10.3 % protein content in comparison to 6% in normal condition.

Besides these, many genotypes were also used as parents for developing high yielding varieties in different centers and were also directly released in other rice growing countries.

Varieties released/ identified

Varieties for Upland ecosystem

Vandana (RR 167-982): It is an early maturing (90-95 days) variety, released and notified (1992 & 2002 & 2002) for upland situation of Odisha and Chhotanagpur plateau. It is a short statured (95-110 cm) genotype has tolerance to drought and soil acidity. It has long bold grain quality with moderate resistance to blast and brown spot. It has an average productivity of 3.5 t/ha.

Shabhagidhan (IR 74371-70-1-1-CRR-1): It is an early duration (100 days) dwarf statured (85-90 cm) highly drought tolerance popular variety suitable for upland, rainfed direct seeded as well as transplanted conditions. It is released and notified (2008 and 2011, respectively) for cultivation in state of Jharkhand and Odisha. It bears golden husked long bold grains and has average productivity of 3.8 -4.5 t/ha. It is resistant to leaf blast and moderate resistant to brown spot, sheath rot, stem borer, and leaf folder etc.

Varieties for Irrigated Medium lands

Satabdi (CR 146-7027-224): It is a mid-early duration (120 days) variety suitable for irrigated ecosystem and released and notified (2000) for cultivation in state West Bengal. It bears excellent quality long slender grains and has an average productivity of 4.0-5.0 t/ha. This variety is moderately resistant to bacterial leaf blight, sheath blight and Sheath rot etc. It has vast seasonal adoptability, can grow under all rice growing season of the year. It has quick maturing ability so that could be harvested before pre- monsoon rain; therefore, it is most popular for cultivation during dry season. It could be taken up in place of local boro/dry season varieties.

Naveen (CR 749-20-2): It is a mid-early duration (115-120 days) semi-dwarf (105cm) variety suitable for upland and irrigated ecosystem. It is released and notified (2005 and 2006) for cultivation in Odisha, West Bengal, Tripura and Andhra Pradesh. It has medium bold grains with average productivity of 4.0-5.0 t/ha in Kharif and 5.0-6.0 t/ha in Rabi season. This variety has resistance capability against stem borer, blast and brown spot. It could be cultivated in place of Lalat variety.

Varieties for Shallow lowlands

Gayatri (CR 210-1018): It is a late duration (160 days), semi tall (110 cm) photosensitive popular variety, released and notified (1988) for cultivation in low land of state Odisha, West Bengal and Bihar. It has short bold good cooking quality grains with average productivity of 5.0 t/ha. It has field tolerance against major diseases and pests. It has significant extent of grain dormancy, can tolerates up to 50 cm water stagnation and suitable for delayed transplanting.

Pooja (CR-629-256): It is a late duration (150 days) short height (90-95cm) popular variety, released and notified (1999/1999) for cultivation in shallow low land area of states, Odisha, Assam, Madhya Pradesh and West Bengal. It has medium slender grains and gives an average yield of 5.0 t/ha. It possesses field tolerance to all major diseases, pests. It tolerates water stagnation (up to 25 cm) and suitable for late transplanting with aged seedlings.

Swarna Sub-1 (CR AC 2539-1): It is a late duration (143 days) semi dwarf (100 cm) variety, released and notified (2009) for cultivation in low land area of Odisha. It can tolerate complete submergence for two weeks, because of incorporation of Sub-1 gene (submergence tolerance gene) in the genetic background of the popular mega variety Swarna. Hence it is a solution to the problem of inundation due to flash floods in coastal areas. It has brighter panicle colour than Swarna and bears medium slender grains with an average productivity of 5.0-5.5 t/ha. It has field tolerance against all major diseases and pests.

Varieties for Semi deep water conditions

Sarala (CR 260-77): It is a late duration (160 days) semi tall (110-120 cm), non- lodging, photo-sensitive variety, released and notified (2000) for cultivation in semi deep water/ coastal area of Odisha. It has medium slender grains possesses seed dormancy and has an average productivity of 4.0 t/ha. It is highly popular among the farmers because of grain quality and has got an advantage that aged seedling (up to 50 days old) can be transplanted without any yield loss. It can tolerate a submergence situation up to 50 cm.

Varshadhan (CRLC 899): It is a long duration (160 days), tall (150 cm) non-lodging, stiff strewed photosensitive popular variety, released and notified (2005 and 2006) for cultivation in low land area of the state Odisha, West Bengal and Assam. It has long bold grains with average productivity of 4.0 t/ha. It is tolerant to neck blast, bacterial leaf blight, sheath rot and white backed plant hopper. It can tolerates prolong water logging up to a depth of 75 cm.

Varieties suitable for Coastal saline conditions

Luna Shankhi (CR 2577-1): It is an early duration (110 days) variety, recently released and notified (2012 and 2013) for cultivation in irrigated condition in coastal saline area of Odisha. It has medium slender grains with average yield capacity of 4.6 t/ha. It is moderately resistant to blast and sheath blight and suitable for dry season cultivation.

Luna Suvarna (CR LC2096-71-2): It is a tall (135 cm) late maturing (150 days) salt tolerant (5.0 to 8.0 dsM-1) variety, recently released and notified (2010 and 2011) for cultivation in coastal saline area of Odisha. It has medium slender grains with an average productivity of 3.5 to 4.0 t/ha. It can also withstand with up to 45 cm water stagnation. It is recommended for early transplanting (before July15th) with 40 days old seedlings.

- **Identification of germplasm/breeding lines for drought tolerance at seedling/ vegetative and reproductive stages:** Moisture stresses may occur during any stage of the crop growth with varying durations leading to yield loss of 20-80% even some time 100%. For such situations the rice varieties with built in tolerance to drought will be of paramount importance. So there is urgency in identifying more and more donors to evolve better varieties with higher drought tolerance coupled with higher grain yields, in view of the fast changing environments.
- About 10,000 rice germplasm lines comprising upland rice, lowland rice, deep water rice, wild rice, advanced breeding lines and fixed lines are screened under simulated stress condition during dry seasons since 2001 till date and about 370 lines were identified as vegetative stage drought tolerant by SES score '1' following SES method (1-9 scale) at soil moisture content of 5 – 8 % and ground water table down below 100 cm.

Field Screening for drought tolerance under controlled irrigation and simulated stress

- Seven genotypes (Zingsaingma; Lucharxgur-Metraxbram; Nachin II; Patnaigosaba; Mahulata; Brahamana Nakhi and WGP 9) are confirmed as best tolerant lines under rainfed upland condition. These lines experienced three drought spells (8-10 days each time) exhibiting yield potential more than 1.0 t ha^{-1} and are being used as donors for varietal development programme.
- Three land races Mahulata (AC No. 35186) collected from the farmers field in Chipilima village of Sambalpur district of Orissa, Brahman Nakhi (AC- 35678) collected from the farmer's field in Baliapada village of Jagatsinghpur district and Sal-kaiin (AC- 34992) collected from the farmer's field in Sarsara village of Sundargarh district of Orissa state are identified as a new sources of vegetative stage drought tolerance and are registered in NBPGR, New Delhi.

- A breeding line CR 143-2-2 developed at CRRI, Cuttack-6 is identified as a vegetative as well as reproductive stage drought tolerant rice variety, yielding more than 1.2 t ha^{-1}.
- Mapping population of Mahulata x IR 20 is being developed and field phenotyping of 360 lines is under progress in the current season.
- Two wild rice accessions of ***Oryza nivara*** (IC -330470 and IC -330611) collected from West Bengal are also identified as vegetative stage drought tolerant lines (SES '0' & '1') and are being used in breeding programme.
- Sahabhagidhan (IR 74371-70-1-1, IET 19576) is released as a drought tolerant variety in the state of Jharkhand, Orissa from the combined effort of IRRI-India Drought Breeding Network.

Crop Production

Since long, Scientists in the Agronomy Department / Section have been involved in the AICRIP program studying different aspects of crop management of rice under varying ecologies.

Following areas of studies were addressed across the rainfed favorable and unfavorable lowlands including deepwater rice and irrigated ecologies in the Agronomy over the seasons.

- IVT, AVT-I and AVT-II of promising pre-released rice cvs./ genotypes,
- Stand management namely dry and wet DSR, SRI, sowing / planting geometry,
- Nutrient management mostly N from different sources both organic / natural and inorganic / chemicals,
- Weed management both chemical (new formulation) and mechanical,
- Aerobic rice, and
- Dry season / Boro rice

Crop Protection

- Since the establishment of a unit of the AICRIP at CRRI, the institute has contributed immensely to rice crop protection activities. The Entomology and Pathology units of CRRI are actively contributing under HPR, continuously screening the genotypes for resistance against several diseases and insects, particularly for blast, BLB, sheath blight, tungro, brown spot, brown plant hopper, stem borers, leaf folder, gall midge rice root-knot and seed borne nematode.
- Both the units of NRRI (Formerly CRRI) have actively participated in evaluating different synthetic chemicals/botanicals each year and provide data on reaction against NRRI insect populations and disease strains. The biotype monitoring of BPH and gall midge is being continuing from this location and the change in population reaction to different known gene differentials is being reported time to time. The Institute also worked on various aspects such as optimum pest cotrol method in pre-released varieties, yield loss assessment due to pests etc. The BPH- resistant donors and developed breeding lines of NRRI were also supplemented for multilocational testing under PHS and MRST of AICRIP.
- The donors CR Ac. No 34997(purified Salakathi), 35181 and 35184 (purified Dhobanumberi) as well as promising breeding lines developed from their introgression such as CR 2711-76, CR 2711-149, CR 2711-114, CR 2711 – 139, CR 3005 – 77-2, CR 3005-230-5, CR 3006-8-2 were also found highly promising under multilocational trial.

Indian Agricultural Research Institute (IARI) New Delhi

Indian Agricultural Research Institute (IARI), New Delhi is the leading institution for agricultural research, education and extension in the country. During the fifties, the advancement of scientific disciplines constituted the core program of IARI and provided the base for its fast expansion in the 1960's and 1970's. It attained the status of a Deemed University in the year 1958. The green revolution that brought smiles to millions of Indians, bloomed from the fields of IARI with the development of famous wheat varieties which contributed an estimated one billion tones of additional production.Currently, the Institute has 20 divisions 5 multi-disciplinary Centres situated in Delhi, 8 regional stations, 2 off-season nurseries, 3 All India coordinated research projects with headquarters at IARI and 10 national Centres functioning under the all India coordinated research projects.

Basmati crop improvement program

Basmati rice is known for its unique grain and cooking quality characters and pleasing aroma. However, the traditional Basmati rice varieties were long duration, tall IARI has been instrumental in genetic improvement of Basmati rice leading to release of first semi-dwarf, photo-insensitive high yileding Basmati rice variety, Pusa Basmati 1in 1989. Consequently, IARI has released number of highyielding Basmati/aromatic rice varieties and hybrids(Pusa Basmati 1, Pusa Basmati 1121, Improved PusaBasmati 1, Pusa Basmati 6, PusaSugandh 2, PusaSugandh 3, PusaSugandh 5, Pusa 1612, Pusa 1592, Pusa 1609 and hybrid Pusa RH10),wherein the duration of traditional Basmati rice varietieshas been reduced from 160 days to 120 days withenhancement of productivity from 2.5 tons/ha to 6-8tons/ha. These varieties are in great demand among the farmers in the Basmati growing states of

India.

At present, based on the breeders seed indent of the Basmati rice varieties, the improved high yielding Basmati varieties developed at IARI covers around 75% of the total breeder seed indent and accordingly the proportionate area under Basmati rice cultivation.The higher productivity of Basmati rice complimented by rice mills with superior processing technology, the foreign exchange earnings from export of Basmati rice has seen a phenomenalrise in foreign exchange earnings from a mere Rs. 294 crores in 1990-91 to Rs. 29,999 crores in 2013-14.

Varieties identified/ released

Characteristics of Basmati rice varieties developed at IARI, New Delhi

Pusa Basmati 1509

Developed from the cross Pusa 1121 x Pusa 1301, this variety overcomes all major weaknesses of Pusa Basmati 1121. It matures in 115 days with an average yield of 5 tons/ ha and possesses non-lodging and non-shattering habit. On account of being early it saves 6 irrigations. It has excellent grain and cooking quality traits superior to Pusa Basmati 1121.

Crop of Pusa Basmati 1509 in farmer's filed

Pusa Basmati 1121 - World's longest Basmati rice: Pusa Basmati 1121 was released by the Delhi State as Pusa 1121 (PusaSugandh 4) in 2003 and subsequently notified as Pusa Basmati 1121 in the year 2008. This variety possesses unique Basmati quality characters namely, extra-long slender (7.71 mm) highly aromatic grains. It has longest kernel length after cooking (up to 22 mm) with an exceptionally high cooked kernel elongation ration of 2.5, volume expansion more than four times, appealing taste, good mouth feel and easy digestibility. It has seed to seed maturity of 145 days with an average yield of 45 q/ha.

Crop of Pusa Basmati 1121 in farmer's field at Urlana, Panipat.

Improved Pusa Basmati 1 (Pusa 1460) - First product of molecular breeding in rice in India: Pusa 1460 is an improved version of Pusa Basmati 1 with resistance to bacterial leaf blight. Developed through molecular breeding in collaboration with National Research Centre on Plant Biotechnology, IARI, New Delhi, this variety was released in 2007. Pusa 1460 has two genes (xa13 and Xa21) conferring resistance to bacterial leaf blight. It matures in 135-140 days with an average yield of 55-65 q/ha. In quality attributes, it is similar to Pusa Basmati1 and has less than 5% chalky grains and strong aroma.

Crop of Improved Pusa Basmati 1 in farmer's field at Urlana, Panipat.

Pusa Basmati 6 (Pusa 1401) - Superior grain quality: Pusa Basmati 6 (Pusa 1401) is an improvement over Pusa 1121 in its yielding ability, agronomy and cooking quality. It is characterized by semi-dwarf plant type, tolerant to lodging, chalky grains less than 4%, its grain on cooking has uniform shape and strong aroma.

Pusa RH10 - The world's first superfine grain aromatic rice hybrid: It was released by CVRC in 2001 for commercial cultivation in the irrigated eco-systems of Haryana, Delhi and Uttaranchal. Pusa RH10 is an early hybrid having average yield of 7 tons/ha. and seed to seed maturity of 110-115 days against 135 days taken by the best check variety Pusa Basmati-1, with 40% higher yield and 76% higher per day productivity.

Central Soil Salinity Research Institute (CSSRI) Karnal

Central Soil Salinity Research Institute (CSSRI) is a premier research institute dedicated to pursue interdisciplinary research on salinity/ alkalinity management and use of poor quality irrigation waters in different agro-ecological zones of the country. The Govt. of India constituted an Indo-American Team to assist the Indian Council of Agricultural Research to develop a comprehensive water management programme for the country. As a follow up of these recommendations, it was decided to establish the Central Soil Salinity Research Institute under Fourth Plan period. The Institute started functioning at Hisar (Haryana) on 1st March, 1969. Later on, it was decided to shift this Institute to Karnal during October, 1969. In February 1970, the Central Rice Research Station, Canning Town, West Bengal was transferred to CSSRI, Karnal to conduct research on problems of coastal salinity. Another Regional Research Station for carrying out research on problems of inland salinity prevailing in the black soil region of western parts of the country started functioning at Anand (Gujarat) from February, 1989. As per recommendation of the QRT, the station was shifted from Anand to Bharuch in April 2003. Keeping in view the need of undertaking research for situations under surface drainage congestion, high water table conditions, relatively heavy textured soils, and indurated pan for managing alkali soils of Central and Eastern Gangetic Plains, another Regional Station was established during October, 1999 at Lucknow. The Coordinating Unit of AICRP on Management of Salt Affected Soils and Use of Saline Water in Agriculture is located at the Institute with a network of eight research centres located in different agroecological regions of the country (Agra, Bapatala, Bikaner, Gangawati, Hisar, Indore, Kanpur and Tiruchirapalli). The Coordinating Unit of AICRP on Water Management functioned at the Institute from early seventies till it was shifted to Rahuri (Maharastra) in 1990.

Crop Improvement

Breeding efforts in rice got impetus with the identification, selection and introgression of salt tolerance from land races like Damodar (CSR1), Dasal (CSR2) and Getu (CSR3) which were native to the coastal Sunderban areas in West Bengal. These are the traditional, tall and photo-sensitive selections which served as donors for salt tolerance for developing high yielding salt tolerant, semi-dwarf and early maturing varieties with better grain quality. Many elite genotypes were developed using mutation bulk and pedigree breeding method. Similarly, for developing the first salt tolerant basmati variety CSR Basmati 30 (Yamini) derived from the cross BR4-10/Pakistan Bas.1, the donor BR4-10 from coastal saline areas of Maharastra was used. Many eminent rice breeders contributed significantly in developing salt tolerant varieties and other breeding lines at CSSRI, Karnal.

The efforts were initiated and continued to evaluate the available germplasm of rice for their salt tolerance. Physiological traits related to salt tolerance behaviour of sensitive and tolerant genotypes were also identified. Based on these findings, the tolerant genotypes were crossed amongst themselves as well as with high yielding genotypes to develop and screen the germplasm lines best adapted to the target soils in terms of higher yield and salt tolerance potential. Sustained efforts were made to broaden the base by acquiring more lines from NBPGR New Delhi, DRR Hyderabad and CRRI Cuttack, international agencies like IRRI Philippines as well as the target areas having saline and sodic soils. The improved germplasm was further evaluated at CSSRI and its centres and under the respective All India Coordinated programmes.

Varieties developed/ released

CSSRI has developed seven salt tolerant rice varieties for salt affected soils (Table 1). CSSRI, Karnal also led the country wide program on rice improvement for salt affected soils encompassing different salinity centres which resulted in the development of other genetic stock with salt tolerant rice varieties.

CSR13

Parentage	CSR1 / Bas.370 // CSR5
IET No.	10348
Year of release	1998
Plant height(cm)	115
Maturity days	145
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	< 9.0
Sodicity (pH_2)	<10.0
Yield (t/ha)	
Non stress	>6.0
Salt stress	>3.0
Grain type	Long slender
Recommended ecology	Sodic and inland saline soils of UP, Haryana, Gujarat and Maharastra.

CSR23

Parentage	IR64 // IR4630-22-2-5-1-3/ IR 964-45-2-2
IET No.	13769
Year of release	2004
Plant height(cm)	115
Maturity days	130
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	<10.0
Sodicity (pH_2)	<9.9
Yield (t/ha)	
Non stress	>6.5
Salt stress	>4.0
Grain type	Long slender
Recommended ecology	Sodic soils of Haryana, UP and coastal saline areas of Maharastra. Gujarat, Tamil Nadu, Kerala and West Bengal.

CSR27

Parentage	NONA BOKRA / IR565-33-2
IET No.	13765
Year of release	1998
Plant height(cm)	115
Maturity days	125
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	<10.0
Sodicity (pH_2)	< 9.9
Yield (t/ha)	
Non stress	>6.5
Salt stress	>4.0
Grain type	Long slender
Recommended ecology	Sodic and Coastal saline soils of India

CSR30

Parentage	BR4-10 / Pak. Basmati
IET No.	14720
Year of release	2001
Plant height(cm)	155
Maturity days	155
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	<7.0
Sodicity (pH_2)	<9.5
Yield (t/ha)	
Non stress	>3.0
Salt stress	>2.0
Grain type	Basmati
Recommended ecology	Sodic areas of UP, Haryana and Punjab.

CSR36

Parentage	CSR13/Panvel 2//IR36
IET No.	17340
Year of release	2005
Plant height(cm)	110
Maturity days	140
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	<11.0
Sodicity (pH_2)	<10.0
Yield (t/ha)	
Non stress	>6.5
Salt stress	>4.0
Grain type	Long slender
Recommended ecology	Sodic soils of Haryana, U.P. and Pondicherry

CSR 43

Parentage	KDML 105 / IR 4630-22-2-5-1-3/ / IR 20925- 33-3-1-28
IET No.	18259
Year of release	2011
Plant height(cm)	100
Maturity days	110
Tolerance limits	
• **Salinity**	
• (ECe:dS/m)	<9.0
Sodicity (pH_2)	<10.0
Yield (t/ha)	
Non stress	>6.5
Salt stress	>3.5
Grain type	Long slender
Recommended ecology	Sodic soils of U.P

Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR-VPKAS) Almora

It is one of the multi-crop and multi-disciplinary research institutes of the ICAR in northwestern hills, covering the states of Jammu and Kashmir (J&K), Himachal Pradesh (HP) and Uttarakhand (UK). The research efforts in the institute focused on development of high yielding varieties through conventional methods and biotechnology for biotic and abiotic suited for rainfed and irrigated conditions; collection, evaluation and maintenance of germplasm from unexplored areas; development of suitable crop production and protection technologies; monitoring of pests and soil health hazards, integrated pest management; development of appropriate eco-friendly crop production technologies; more remunerative cropping systems; organic farming; protected cultivation; conservation and management of rain water and nutrients; designing suitable farm implements for farm mechanization and reduction of drudgery & cost of cultivation; enhancing the availability of fodder and effective dissemination of crop production technologies.

The institute has made significant contributions in the improvement of hill crops as well as resource and pest management. It has developed more than 140 improved varieties and hybrids in 25 different hill crops along with the appropriate production and protection technologies. It has networking with other ICAR institutes, SAUs and KVKs spread across the North-Western Hills through All India Coordinated Research Projects.

Varieties released from ICAR-VPKAS, Almora through AICRIP

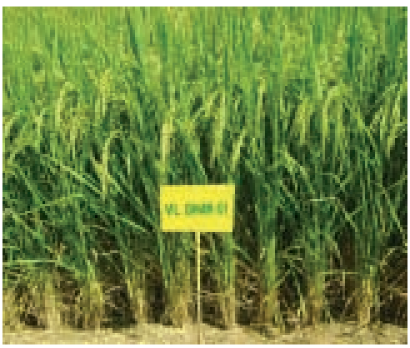
Irrigated transplanted early maturity

VL *Dhan* 81(IET 13792, VL 91-1695): This variety was developed from the cross of China 988 x HPU 741. It is released by Central Variety Release Committee in 1999. It has straw colour bold grain. It matures in115-120 days. It has 90-95 cm plant height. It is resistance against leaf and neck blast. The average yield potential this variety is 45-50 q/ha.

***Vivek Dhan* 82(IET 15473, VL 94-3143):** This variety is released by Central Variety Release Committee in 2001. It is developed from the cross VL *Dhan* 221 x UPR 82-1-7. It is recommended for cultivation in irrigated transplanted conditions in the hills of Uttarakhand, Himachal Pradesh and Meghalaya. It has shown resistance against blast. It has 116-136 cm plant height with the maturity period of 120-125 days. The average yield potential this variety is 40-45 q/ha.

VL Dhan 86(IET 16863, VL 97-3861): This variety is developed from the cross VL Dhan 16 x VL Dhan 221and it has small bold grain. It is released by Central Variety Release Committee in 2006. It is suitable for cultivation in irrigated transplanted conditions in the hills of Uttarakhand and Himachal Pradesh. It is resistance against leaf and neck blast. Its maturity period is 112-120 days. It has 110-120 cm plant height. The average yield potential this variety is 45-50 q/ha.

Irrigated transplanted medium maturity



VL Dhan 61(IET 13485, VL 89-11179): This variety is developed from the cross Jaya x Ta-poo-choz. It is released by Central Variety Release Committee in 1997 for its cultivation in irrigated transplanted conditions in the hills of Uttarakhand and Himachal Pradesh. It has an average yield potential of 45-55 q/ha. It is resistance against leaf and neck blast. It has 110-115 cm plant height and bold grain. It matures in 130-135 days.

Vivek Dhan 62(IET 14621, VL 91-1754): This variety was released by Central Variety Release Committee in 2000 for cultivation in irrigated transplanted condition in the hills of Uttarakhand, HP, Manipur and West Bengal. It was developed from the cross China 4 x BG 367-4. The yield potential of *Vivek Dhan* 62 is 45-50 q/ha with maturity period of 125-130 days. It has 100-105 cm plant heightk, short bold grain, resistant to leaf and neck blast, sheath rot and leaf scald.

VL Dhan 68(IET 22283, VL 31611): It was released by Central Variety Release Committee in 2014. It is suitable for irrigated transplanted conditions in the mid hills of Uttarakhand and Meghalaya. It is derived from the cross VL 3861/SR 1818BF-4B-1-2-1-2. It has an average yield potential of 45-50q/ha. It matures in 125-130 days. It has long bold grain, 110-120 cm plant height. It is resistance to leaf and neck blast.

Rainfed upland June sown rice

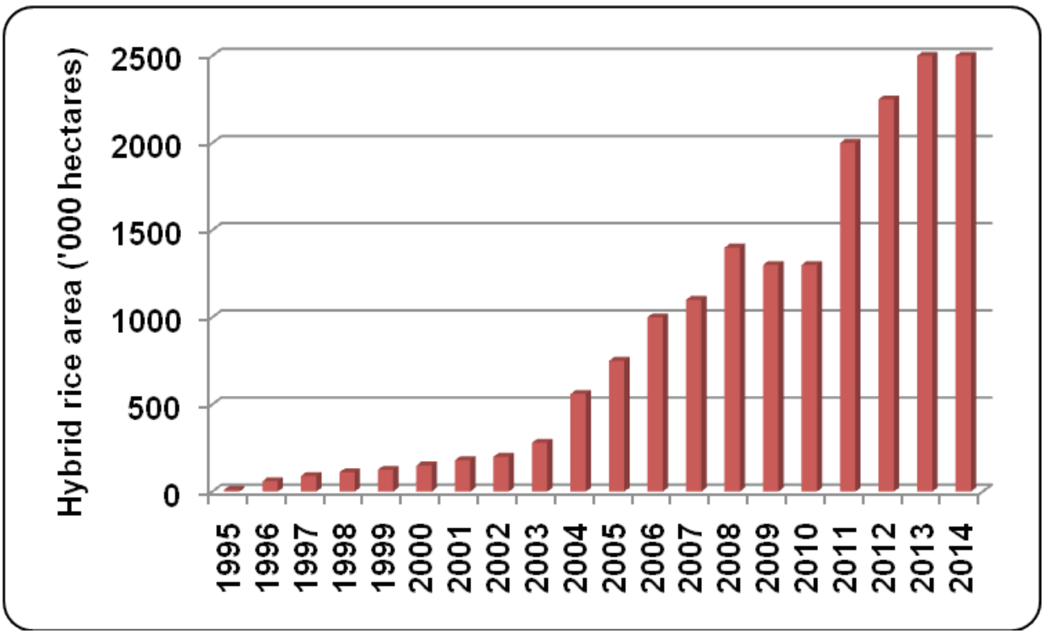
VL Dhan 221(VRS 221-1-3-2-2): This variety was released for commercial cultivation for June sown rainfed upland condition of Uttarakhand and H.P. hills in 1992. It is developed from the cross IR 2053-521-1-1-1 x Ch 1039. It has 90-95 cm plant height, short bold awnless grain and matures in 110-115 days. It gives 20-25 q/ha grain yield. It is resistance against leaf and neck blast, moderately resistance to leaf scald and sheath rot diseases and tolerance to stem borer and leaf folder insect pests.

VL Dhan 157 (IET 22292, VL 8302): This variety was released by Central Variety Release Committee in 2014 for lower hills of Meghalaya and medium elevated hills of Uttarakhand under direct seeded, rainfed upland June sown condition. It has an average yield potential of 20-25 q/ha in lower hills and 18-20 q/ha in medium hills. It is developed from cross VR 9588/A-57 with 100-110 days maturity duration. It has light yellow, short bold awnless grain. It is resistance to leaf and neck blast.

V. IMPACT

i) National Impact

Rice production and productivity in India has undergone a significant change during the last five decades despite limited expansion in area of cultivation. Rice area increased from 30.8 m ha in 1950-51 to 44.7 m ha in 2000-01, an increase of 45%. Thereafter the area expansion has slowed down and slightly declined or remained almost same with an area of 43.9 m ha during 2013-14. Thereafter the area expansion has slowed down and slightly declined or remained almost same with an area of 42.5 m ha during 2014-15. However, increase in production has been spectacular during the same period. The production of 34.5 mt in 1960-61 doubled by 1990s (74.3 mt) and increased by three times to 93.4 mt in 2006-07. In the last five years, the production levels scaled new heights and even crossed the century mark recording an all time high of 106.5 mt during 2013-14. Similarly productivity rose from 668 kg/ha in 1950-51 by almost 200% to 2102 kg/ha in 2005-06. In the last five years it has risen by another 300 kg/ha reaching the level of 2413 kg/ha in 2014-15 (Fig--). This has been largely due to the release of high yielding varieties and hybrids after systematic multi-location testing and development of farmer friendly appropriate technologies enabling enhanced adoption by the rice farmers across various ecosystems in the country.



Five decades of Area, Production and Productivity of Rice in India

Rice Exports

Rice has become an item of commerce since mid-eighties. First, it was only basmati rice which our country exported, while non-basmati rice exports also went up since mid-nineties. The upward trend continued steadily with the quantum of basmati export raising up to 3.7 million tonnes in 2014-2015 and the value realized being 27,597 crores. Non-basmati rice has also become a thrust area for export promotion though there have been fluctuating trends depending on the policy changes of the government from time to time. In 2004-2005, India exported 3615 metric tonnes of non-basmati rice earning Rs. 3945 crores and in 2014-15, the quantum of export was up to 82, 74, 050 metric tonnes earning very high foreign exchange of Rs. 20,428 crores. Samba Mahsuri, IR 64, Jyothi and few other varieties are being exported in this category. So, the country has witnessed a significant rise in rice exports and India has gone from the status of ship to mouth existence to leading rice exporter in the world agriculture.

Rice exports from India during 2004 - 05 to 2014 -15

Year	Basmati		Non basmati		Total rice	
	Qty ('000T)	Value (Rs. crores)	Qty ('000T)	Value (Rs. crores)	Qty ('000T)	Value (Rs. crores)
2004-2005	1163	2823.9	3615.1	3945.02	4778.1	6768.92
2005-2006	1166.57	3043.1	2921.6	3178.17	4088.17	6221.27
2006-2007	1045.73	2792.8	3702.22	4243.07	4747.95	7035.87
2007-2008	1183.36	4344.58	5286.08	7410.03	6469.44	11754.61
2008-2009	1556.41	9477.02	931.89	1687.37	2488.3	11164.39
2009-2010	1216.87	10889.6	139.54	365.3	1356.41	11254.9
2010-2011	2370.68	11354.8	100.68	231.29	2471.36	11586.06
2011-2012	3178.18	15449.6	3997.72	8659.12	7175.9	24108.71
2012-2013	3459.89	19409.4	6688.00	14448.8	10147.9	33858.19
2013-2014	3757.36	29300.1	7018.53	17493.2	10775.9	46793.28
2014-2015	3702.26	27597.9	8274.05	20428.5	11976.3	48026.38

Hybrid rice

The impact of hybrid rice technology in India has been perceptible with increasing area under hybrids year to year to the current level of nearly 2.5 million ha for its economic viability with additional net profit of Rs. 3000-6000/ha. Hybrid rice seed production is highly profitable with net profits ranging from Rs. 25,000 to 35,000/ ha, besides potential for employment generation to 60-80 person days /ha for the rural women.

The area under hybrids picked up from an initial level of 10000 hectares in 1995 and reached 1 million hectares in 2006. During the last 10 years, popularity of hybrid rice is mainly increasing among rice farmers of eastern Uttar Pradesh, Bihar, Jharkhand and Chhattisgarh and the area under hybrid rice has exceeded 2.5 million hectares in 2014 9Figure…). With this much area under cultivation, the hybrid rice technology has contributed an additional 4-5 million tonnes to the total rice pool in the country. With the prospects of adoption of this technology by the farming community appearing to be brighter in the years to come, the country is looking forward to closing the gap with China in becoming the leading rice producer in the world.

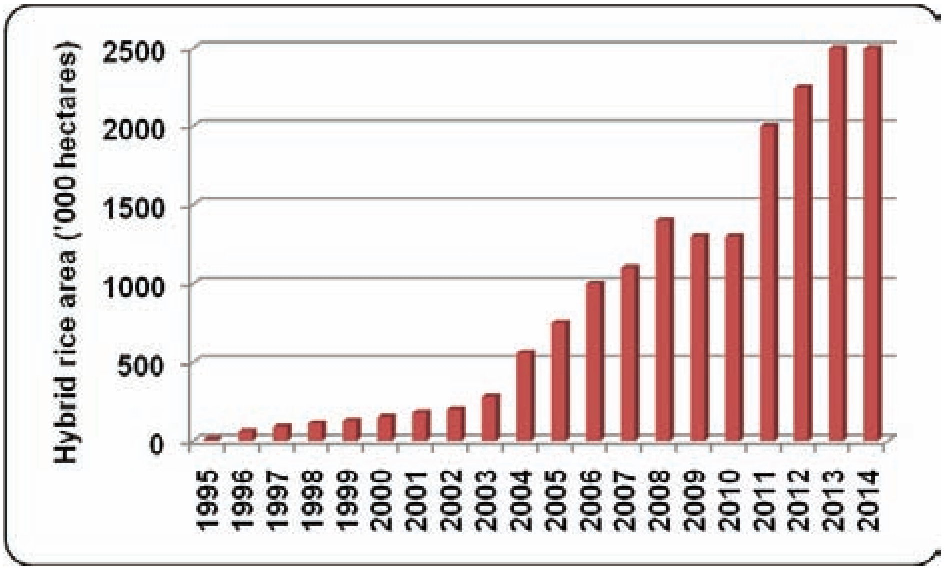


Figure----Hybrid rice area in India

Crop Improvement

Plant breeding – varieties tested & released

- First semi-dwarf high yielding variety "Jaya" released by AICRIP in 1968 ushered the green revolution in India. This transformed the country to a state of self-sufficiency by mid-eighties and stalled rice imports beginning an era of exporting rice, earning high foreign exchange by early nineties.
- Extensive testing under the All India Coordinated Rice Improvement Project which is one of the largest networks for any single crop in India has contributed to the release of 1084 varieties including 72 hybrids for all the major rice ecosystems of the country during the last five decades (1965-2014). It is impressive to note that 173 varieties with wider adaptability were released through Central Varietal Release Committee (CVRC) while 911 were released by various states.

- Of the 1084 varieties released in the country about 217 varieties have been in the breeder seed production (BSP) chain. Based on analysis of BSP indent from Department of Agriculture and Cooperation (DAC), 63 varieties have maximum adoption by the farmers within one state or across several states in terms of their spread. The analysis also substantiates the categorizing of varieties as (1) mega varieties when the magnitude of BSP is very high being indented all through the last 18 years period (1995-2013), (2) most popular varieties which have been indented most frequently for 14 to 17 years and (3) popular varieties which have been often indented at least for 10 years of the 18 years period taken into consideration.

1. Mega Varieties Most frequently indented in all 18 years through BSP (1995-2012)

S. No	Name of Variety	Developed by	No of Years in BSP	Total Production (Qtls)	Eco
1	Jaya	DRR	18	1112	IM
2	Mahsuri	CVRC	18	531	RSL
3	Swarna (MTU 7029)	ANGRAU, Hyderabad	18	3617	RSL
4	Pantdhan 10	GBPUAT, Pantnagar	18	724	IRE
5	Rasi	DRR	18	455	IRE
6	Samba Mahsuri (BPT 5204)	ANGRAU, Hyderabad	18	2511	RSL
7	Govind	GBPUAT, Pantnagar	18	755	RUP
8	Intan	CVRC	18	148	RSL
9	IR 36	CVRC	18	2808	IRE
10	IR 64	CVRC	18	3550	IRME
11	Sarjoo 52	NDUAT, Faizabad	18	1745	IRM
12	Tella Hamsa	ANGRAU, Hyderabad	18	431	IRE

2. Most Popular Varieties frequently indented in BSP for 15-17 years

S. No	Name of Variety	Developed by	No of Years in BSP	Total Production (Qtls)	Eco
1	BPT 3291 (Sona Mahsuri)	ANGRAU, Hyderabad	17	302	RSL
2	Lalat	OUAT, Bhubaneshwar	17	863	IRME
3	Lunishree	CRRI, Cuttack	17	88	RUP
4	Basmati 370	RRRS, Kapurthala	17	257	SCR
5	IR 50	CVRC	17	183	IRE
6	Jyothi	RARS, Pattambi	17	621	IRE
7	Pusa Basmati-1	IARI, New Delhi	17	749	SCR
8	PR 111	PAU	16	284	IRM

9	Pusa 44	IARI, New Delhi	16	425	SCR
10	IR 20	CVRC	16	180	IRM
11	Kranti	IGAU, Raipur	16	5270	IRE
12	Ratna	CRRI, Cuttack	16	411	IRE
13	Taroari Basmati	RRS, Kaul	15	150	SCR
14	MTU 1001(Vijetha)	ANGRAU, Hyderabad	15	1828	RSL
15	PNR 381	IARI Regional Station, Karnal	15	397	RUP
16	PR 106	PAU, Ludhiana	15	196	IRM
17	Savithri	CRRI, Cuttack	15	560	RSL
18	Annada	CRRI, Cuttack	15	244	RUP
19	Narendra Dhan 359	NDUA&T, Faizabad	14	1102	IRM
20	Narendra Dhan 97	NDUA&T, Faizabad	14	418	RUP
21	Pantdhan 12	GBPUAT, Pantnagar	14	531	IRME
22	Phalghuna	DRR, Hyderabad	14	112	RSL
23	Swarnadhan	DRR, Hyderabad	14	228	RSL
24	ADT 37	TNAU, TRRI, Aduthurai	14	139	IRE
25	ADT 39	TNAU, TRRI, Aduthurai	14	95	IRME
26	Kavya (WGL 48684)	ANGRAU	14	73	IRM
27	Krishna Hamsa	DRR, Hyderabad	14	161	Boro

3. Popular Varieties frequently indented in BSP for 9-13 years

S. No	Name of Variety	Developed by	No of Years in BSP	Total Production (Qtls)	Eco
1	Cotton Dora Sannalu (MTU 1010)	ANGRAU, Hyderabad	13	3686	IME
2	PR 113	PAU, Ludhiana	13	428	IME
3	Pantdhan 11	GBPUAT, Pantnagar	12	116	HRIR
4	Rajashree	RAU, Ranchi	12	204	RSL
5	Khitish (IET 4094)	RRS, Chinsurah	12	163	IRE
6	ADT 36	TNAU, TRRI, Aduthurai	11	42	IRE
7	ADT 43	TNAU, TRRI, Aduthurai	11	181	IRE
8	CSR 30 (IET -14720, Yamini)	CSSRI, Karnal	11	398	SCR
9	CSR 27	CSSRI, Karnal	11	126	IRSA
10	PR 114	PAU, Ludhiana	11	419	IRM
11	PR 116	PAU, Ludhiana	11	318	IRM

S. No	Name of Variety	Developed by	No of Years in BSP	Total Production (Qtls)	Eco
12	Ranjeet	RARS, Titabar	11	224	RSL
13	Mahamaya	IGAU, Raipur	11	652	IRM
14	Pusa Sugandh 2	IARI Regional Station, Karnal	11	151	SCR
15	Surekha	ANGRAU, Hyderabad	11	56	IRM
16	Kasturi	DRR, Hyderabad	10	37	SCR
17	Krishnaveni (MTU 2077)	ANGRAU	10	98	RSL
18	Pantdhan 4	GBPUAT, Pantnagar	10	681	IRM
19	Pooja (IET 12241)	CRRI, Cuttack	10	689	RSL
20	PR 115	PAU, Ludhiana	10	122	IRME
21	Sita	RAU, Patna	10	76	IRM
22	Uma	RRS, Moncompu	10	159	IRME
23	Anjali	CRURRS, Hazaribagh	10	52	RUP
24	JGL 1798	ANGRAU	10	258	IRME
25	Poornima	IGAU, Raipur	10	304	IRM
26	Pusa Sugandh 3	IARI, New Delhi	10	214	SCR
27	Sabita (NC-492)	RRS, Chinsurah	10	28	SDW
28	Tulasi	DRR, Hyderabad	10	99	RUP
29	GR 11	MRRS, Nawagam	9	31	IRME
30	HKR 126	RRS, Kaul	9	86	IRM
31	IET 7191	UAS, Bangalore	9	80	RSL
32	JGL 384 (Polasa Prabha	ANGRAU, Hyderabad	9	84	IRM
33	Kanak	RAU, Patna	9	68	RSL
34	Vandana	CRURRS, Hazaribagh	9	139	RUP
35	ADT 44	TNAU	9	7	RSL
36	Pankaj	RRS, Chinsurah,	9	37	RSL
37	PR 118	PAU, Ludhiana	9	331	IRM
38	Vasumathi	DRR, Hyderabad	9	33	SCR

- In the last decade, application of biotechnological tools, particularly the marker assisted selection (MAS) or breeding (MAB) have further enhanced the impact due to refinement in quantitative as well as qualitative breeding in rice. Landmark achievements include products of marker assisted backcross breeding (MABB). "Improved Pusa Basmati 1" was the advancement of first semi-dwarf basmati variety – Pusa Basmati 1 which has 50% share in the export market through fortification with Bacterial Blight (BB) resistance by introgressing Xa21 and xa13 genes. Production demand of fifteen tonnes of breeder seed as per DAC indent in the last 4 years endorses the impact of this technology in increasing the production as well as net returns to the basmati growing farmers and also in boosting India's basmati rice exports.

- One of the finest accomplishments in the deployment of molecular marker technology was to develop varieties resistant to biotic stresses. The first MAS derived product "Improved Samba Mahsuri" was developed by IIRR which possesses 3 BB resistant genes xa5, xa13, Xa21 and has tremendous impact potential in the years to come. 397 quintals of breeder seed (BS) as per DAC indent and another 332 quintals of Truthfully Labeled Seed (TLS) have been produced so far and the area of cultivation under this variety has gone up to 60,000 hectares. Further aggressive efforts have been initiated under ICAR-CSIR "Blight out" programme where IIRR is a partner to up scale the delivery system for Improved Samba Mahsuri with an objective to popularize the technology among the farmers particularly in BLB endemic areas. With this disease spreading very fast in the last few years, Improved Samba Mahsuri variety cultivation is expected to cross 2 million ha, in the next two years.
- Another fine example of the utility of MAB having a substantial impact is the development of "Swarna Sub 1" variety, released in the states of Orissa and Uttar Pradesh for submergence prone areas. It is also a product evaluated and validated through AICRIP testing. A major QTL Sub1 has been introgressed into Swarna which is the most popularly grown variety occupying nearly 8 to 10% of rice grown area in 8 states of India. This culture was developed at IRRI and has the potential to give same yield as Swarna in non-submerged conditions and 1 t/ha or more than the recurrent parent when affected by submergence. The findings after extensive evaluation and validation under AICRIP, have been significant and according to Mackill et al (2012), 5000 tonnes of Swarna Sub 1 seed was produced and distributed to 1,00,000 farmers during Kharif 2010. Through concerted efforts of IRRI programmes complimented by GOI initiatives under NFSM, BGREI, RKVY, NICRA and informal farmer to farmer exchange it

is estimated that Swarna Sub 1 covered an area of 1.1 m ha during Kharif 2012. The wide scale adoption Swarna Sub 1 in the near future would be a boon to the farmers where recurrent submergence often means total crop loss.

- In the area of hybrid rice research the analysis has shown that some of the recently released hybrids got standard heterosis of 26-34% over relevant check varieties. Twenty seven hybrids are released on account of their superior yield advantage (7 public bred and 20 private). The adoption of these hybrids would positively increase the coverage of **hybrid rice in India and usher in more production and productivity.**

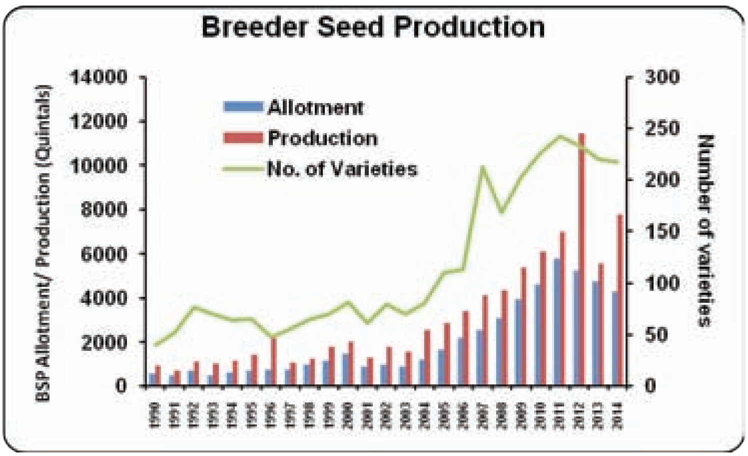
Extent of standard heterosis observed in some of the recently released hybrids

Name of the hybrid	AICRIP years of testing	Yield (kg/ha)		Yield advantage over check (%)
		Hybrid	Inbred check	
DRRH-3	2005-2007	6074	4620	31
27P11	2006-2008	7225	5613	29
Indam 200-017	2007-2009	5384	4121	31
VNR 202	2008-2010	5956	4742	26
VNR 204	2008-2010	7023	5226	34

- Development of first medium slender hybrid "DRRH3" which is similar to Samba Mahsuri with 25-30% higher yield has also proven its merit by being most sought after hybrid. It is already commercialized by forging MoAs with 8 private companies. As these MoAs are made in the last couple of years, once the companies make strong effort in up scaling the seed production and delivery mechanism, the technology which has a tremendous potential would have a positive impact in increasing the area under hybrid rice.

- Seed purity of commercial seed for sale is one of the most critical components in popularization of hybrid rice cultivation in India. IIRR developed a rapid and reliable assay for assessment of purity of seed-lots of rice hybrids and CMS lines. The hybrid purity assay involves deployment of specific hyper-variable SSR markers and can identify impurities on per seed or seedling basis. The CMS seed purity assay involves a mitochondrial SSR marker and can easily detect contaminants in seed-lots. Both these assays have been enthusiastically taken up by many seed companies and IIRR is also offering these assays for assessment of seed-purity of commercial seed-lots. The DNA marker-based assay is cost effective (saves 30-50% of cost) as the whole assay can be completed within a time period of 1-2 days as compared to the conventional morphology based Grow-out test which takes a full growing season and involves lot of cost in terms of seed-storage.

- The Breeder seed production (BSP) tripled from 2006q to 7757q in the last 10 years and the varieties under BSP have gone up from 81 varieties in 2000 to 217 in 2014 bringing the latest releases under breeder seed chain. The production of Truthfully labeled seed (TLS) of popular IIRR varieties such as Improved Samba Mahsuri, Akshaydhan, Varadhan, DRR Dhan-38, DRR Dhan-39 (latest releases), Sugandhamati, Vasumati etc., increased tremendously. Such enormous increase in seed production would certainly have an impact on seed replacement rate particularly for IIRR varieties.

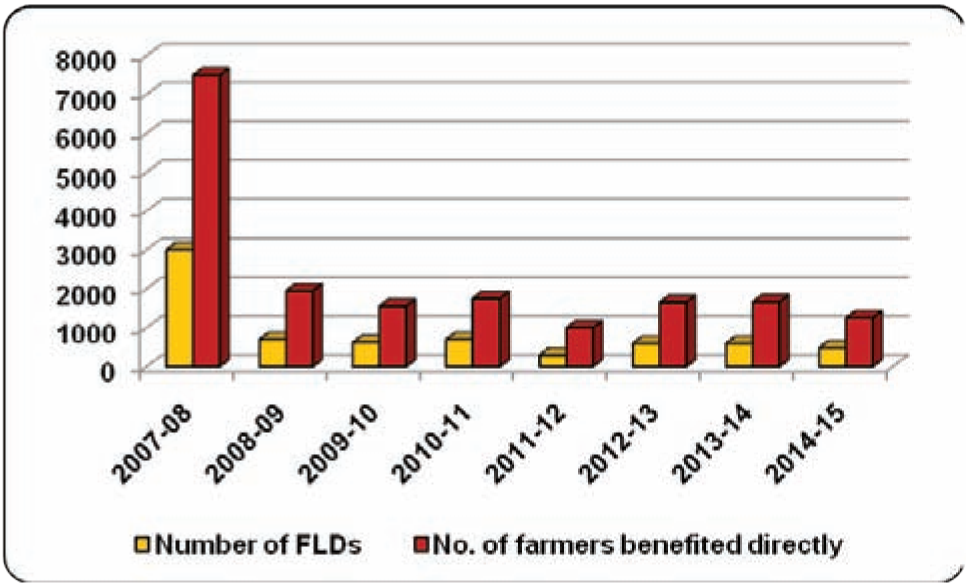


- ICAR-IIRR has been recognized one of the best DUS centers for maintaining a large reference collection of 629 varieties and for promotion of registration of rice varieties at the Foundation Day Programme of PPV&FRA, New Delhi.

- Studies on SRI have proved that it is genotypic specific and hybrids perform better than the varieties and the cost of cultivation is also drastically reduced in hybrids. Adoption of SRI at proper locations with suitable genotypes has a scope for area increase, enormous saving on seed, 36% saving on water and additional yield of 1.0 to 1.5 t/ha which will add 4-6 million tonnes to our food basket. KRH-2, PA 6444, DRRH 3 among hybrids; Akshaydhan and Swarna among varieties have been promising under SRI.
- Modification of leaf colour chart (LCC) by DRR under SSNM, its mass distribution to farming community has significantly reduced N application. 2-3 lakhs of LCC were distributed across the country. SSNM recorded 5-16% higher yields over recommended dose of fertilizer (RDF) and considerably reduced the nitrogen application.
- Suitable package for aerobic rice system which reduced the water requirement by 30-40% over continuous flooding was developed and several suitable rice-based cropping systems (RBCS) and organic farming for sustaining rice productivity recommended.
- The 8 row drum seeder is a boon to small farmer. It saves 33% of total labour requirement, 20% of seed and 25% of water which has a positive influence on farming community in adopting this low cost machine. In the event of delayed and erratic monsoon, water stress and labour scarcity which are normal constraints, drum seeder which costs Rs. 2000 only could benefit the farmers on adoption.
- For irrigated rice optimized use of irrigation water and nutrients was developed in comprehensive studies on enhancing water productivity which has an impact on sustainable water use in rice.
- The long term fertility management experiment in RBCS clearly indicated that chemical fertilizers alone cannot sustain rice productivity and soil quality and this had resulted in the use of organic manures through integrated nutrient management by many farmers across the country. Supplementary application of FYM along with concurrent RDF was found best in improving productivity by 0.2-1.0 t/ha in rice-rice and rice-wheat systems with corresponding increase in NUE, soil fertility and soil organic carbon (SOC) stocks. These integrated nutrient management studies have highlighted how crop residue, phosphate solubilising bacteria can be effectively used.
- Organic farming systems for sustaining rice productivity required 4-8 crop cycles to stabilize productivity. There was significant improvement of soil, physical, fertility and biological properties after four seasons. The benefit: cost ratio improved by fifth year to 1.99:1 with organics as compared to 1.75:1 with inorganic.
- Site specific nutrient management (SSNM) study indicated ample scope for improvement in nutrient use efficiency based on site specific nutrient supply, nutrient use efficiency and crop demand. Validation of target specific nutrient recommendations in some farm sites improved rice productivity by 5-17% over current fertilizer management practices.

- The basic research on silicon at DRR amply demonstrated its use in combating biotic and abiotic stress in rice and harnessing this information would help in reducing the pesticides and also effectively combat climate stress in coming year.
- The studies on climate change initiated revealed that 3-7^0 C increase in temperature results in 24% rice grain yield loss. One impartment reason for low fertility and high temperature was due to high osmoticum on the stigma causing improper germination of pollen grains.
- Three hybrids (KRH2, PA 6201, PA 6444) and IET 20924 have desired cumulative degree days and nycto periods for early sowing with superior yields identified for soft registration for these traits.
- Continuous monitoring of insect pests across locations revealed that the number of insect pests increased from 3 in 1965 to 19 in 2015 resulting in significant yield losses at National and regional level.
- Extensive multi-location testing under AICRIP has resulted in successful recommendation of pheromone mediated monitoring as well as mass trapping of yellow stem borer as a practical, cost effective and environmental friendly option for the farmers. Installation of 8 traps with 5 mg impregnated lures per hectare helps in monitoring of yellow stem borer populations, while installing 20 traps per hectare can mass trap male moths of yellow stem borer and help in effectively lowering population of this pest in farmers' fields.Planting of one row of Pusa Basmati 1 (PB1), an aromatic cultivar highly susceptible to yellow stem borer, for every 9 rows of any main crop reduced stem borer damage considerably giving additional income from PB1 crop.
- Identification of sources of resistance and resistant lines against major insect pests & diseases; production constraints identified through POS and course corrections suggested; new molecules for management of pest & diseases identified and incorporated in integrated pest management practices for irrigated rice.
- Every year thousands of advanced breeding lines were tested against six important diseases like blast, BLB, Sheath blight, brown spot, sheath rot and RTD across the test locations in India in five national screening nurseries and two international nurseries, hybrids and germplasm screening nurseries. Donors and multiple resistant lines identified against these diseases are being used in the varietal improvement programme. Several high yielding resistant varieties were released through the continuous effort of the Plant Pathologists all over India.
- Several new molecules tested were suggested to incorporate in integrated pest management practices for irrigated rice ecosystems.
- Various production constraints identified through POS and mid course corrections were suggested. Through this, disease distribution maps were prepared for the major rice diseases like blast, neck blast, brown spot, sheath blight, sheath rot, false smut, grain discoloration, RTD and bacterial leaf blight.

- Front Line Demonstrations (FLDs): The extension principle of "Seeing is believing" is very well epitomized at DRR. Organization of Front Line Demonstrations (FLDs) on newly released varieties/technologies is a very useful strategy for their popularization which is helping in disseminating the new technology to the farmers. DRR coordinates the Rice FLDs which is organized every year all over the country demonstrating suitable elite cultivars and appropriate crop management technologies in farmers' fields in association with SAUs and state departments of agriculture. Every year DRR organizes on an average 700 FLDs across different states covering different ecosystems. These are sponsored under Macro-management scheme of Ministry of Agriculture. Till date, 27,772 Frontline Demonstration were organized across the country that impacted 69,430 rice farmers directly. The trickle down impacts of FLDs are many. During last eight years 7007 FLDs were organized benefitting over 18318 farmers. About 2637 tonnes of seed of modern varieties, hybrids were distributed to farmers through this programme. An innovative attempt has been made to redefine the Frontline Demonstrations on Rice using digital technologies such as video extension. The FLD programme helped many stakeholders to get first hand information about newly released varieties/ hybrids that went into the value chains of Indian rice sector.



ii) Global Impact

- AICRIP has become a role model for IRRI based on which International Rice Testing Program (IRTP) was initiated with India as major partner in 1975. Later IRTP was renamed as International Network for Genetic Evaluation of Rice (INGER). This INGER program has facilitated easy and free exchange of genetic material among rice researchers across the globe.
- Rice varieties that were bred and released in India after multi-location testing in AICRIP have been directly released for commercial exploitation in many countries covering various ecosystems through INGER. Forty six Indian varieties have been released by other countries for farmers' cultivation, 25 in Sub-Saharan Africa, 10 in South Asia, 5 in Latin America and the Caribbean Islands, 3 in South East Asia, 2 in West and North Africa as well as one variety in East Africa (Table---). Utilization of Indian bred varieties around the world have covered all the rice ecosystems viz., 8 varieties in rainfed upland areas, 6 in rainfed lowlands and 32 in irrigated areas. These have been released under different names in different countries. Global acceptance and adoption of 46 rice varieties of Indian origin vindicates the strength of varietal testing program of AICRIP.
- Several elite breeding lines generated in India under AICRIP program have been widely used by many countries as donors for desirable traits such as resistance to biotic and abiotic stresses, yield and quality.

Rice Varieties developed in India and released in other Countries

Country where released	Number	Name/ designation	Cross	Source	Released region	Name given	Year of release	Ecosystem
Afghanistan	IET 1415	CR 44-11	TKM 6/IR 8	CRRI	South Asia	-	1975	Irrigated
Afghanistan	IET 355	Cauvery	TKM 6/TNI	DRR	South Asia	-	1975	Upland
Afghanistan	IET 953	Padma	Tl4l1TNI	CRRI	South Asia	-	1975	Irrigated
Benin	-	Co 38	IR 8/ Co 25	TNAU	Sub- Saharan Africa	-	-	Irrigated
Benin	-	RAU 4072-13	IR 1833-208-6-3/ Mahsuri	RAU		RAU 407	1991	Upland
Bhutan	-	Barkat	Shinci/ China 971	SKAUST	South Asia	Barkat	1992	Irrigated
Brazil	IET 2881	Seshu	IR 24/T 141	DRR	Latin America & The Caribbean Islands	-	1984	Upland
Burkina Faso	IET 2885	Vikram	IR 8/ Siam 29	DRR	Sub- Saharan Africa	-	1979	Irrigated
Burkina Faso	IET 1996	RP 4-2	T 90/ IR 8	DRR		-	1985	Irrigated
Burkina Faso	IET 1879	Vijaya	T 90/ IR 8	CRRI		-	1997	Rainfed lowland
Barundi	-	Savithri	Pankaj/ Jagannath	CRRi		-	-	Irrigated
Cambodia	IET 7435	OR 142-99	Pankaj/ Sigadis	OUAT	South East Asia	Sante Pheap 3	1992	Rainfed lowland

Country where released	Number	Name/ designation	Cross	Source	Released region	Name given	Year of release	Ecosystem
Cameron	IET 723	Jaya	TN1/ T 141	DRR	Sub- Saharan Africa	-	1977	Irrigated
China PR	-	M 114	Mahsuri mutant 3628	KAU	East Asia	8085	1981	Irrigated
Ivory Coast	IET 723	Jaya	TN1/ T 141	DRR	Sub- Saharan Africa	-	-	Irrigated
Dominican Republic	-	IR 2153-273-1-10-PR 509	IR 1541-102-6-3/ IR24*4//O. nivara	PAU	Latin America & The Carib-bean Islands	Juma 62	1986	Irrigated
Ghana	IET 2885	Vikram	IR8/ Siam 29	DRR	Sub- Saharan Africa	Afife/ GR 17	1982	Irrigated
Iran	IET 1990	Sona	GEB 24/ TN1	DRR	West Asia & North Africa	Amol 3	1982	Irrigated
Iraq	IET 8113	RP 2095-5-8-31	Vokram/ Andrewsali	DRR	Sub- Saharan Africa	-	-	Rainfed lowland
Kenya	IET 6985	AD 9246	ADT 31/AD 198	TNAU		-	-	Irrigated
Kenya	-	Basmati 217	-	-		-	-	Irrigated
Malawai	IET 4094	Kitish	BU 1/ CR 115	CRRI		Senga	1993	Irrigated
Mali	IET 1444	Rasi	TN1/ CO 29	DRR		IET 1444	1984	Rainfed lowland
Mali	IET 723	Jaya	TN 1/ T141	DRR		-	-	Irrigated
Mali	IET 1879	Vijaya	T 90/ IR 8	CRRI		-	1978	Irrigated
Mauritiana	IET 723	Jaya	TN 1/ T 141	DRR		-	-	Irrigated
Myanmar	-	Mahsuri mutant	-	-	South East Asia	Ma Naw Thu Kha	1977	Irrigated
Myanmar	IET 9221	-	M 63-83/ IRAT 8// N 22		Myanmar	Shwe Myanmar	2005	Rainfed upland

Country where released	Number	Name/ designation	Cross	Source	Released region	Name given	Year of release	Ecosystem
Myanmar	IET 7591	-	RP 1057-393-1	-	Myanmar	Yezin 3	1995	Rainfed lowland
Nepal	IET 2935	CR 123-23	Dunghansali/ Jayanthi	CRRI	South Asia	Durga	1978	Upland
Nepal	IET 1444	Rasi	TN 1/ Co 29	DRR		Bindeswari	1981	Upland
Nepal	-	K 39-96-1-1-1-2	CH 1039/IR 580-19-2-3-3	SKAUST		Khumal 3	-	Irrigated
Nepal	-	IR 2298-PLPB-3-2-1-1B	CICA 4/ KULU	PAU	South Asia	Himali	1982	Irrigated
Nepal	-	-	CR 126-42-5/ IR 2061-213	PAU	South Asia	Kanchen	1982	Irrigated
Pakistan	IET 4094	Kitish	BU 1/ CR 115	CRRI		DR 82	1984	Irrigated
Paraguay	IET 4094	Kitish	BU 1/ CR 115	CRRI	Latin America & The Carib bean Islands	CEA 1	1989	Irrigated
Paraguay	IET 5612	R 22-2-10-1	IR 22/ Sigadis	KKV		CEA 3	1989	Irrigated
Senegal	IET 1444	Rasi	TN1/ CO 29	DRR	Sub- Saharan Africa	-	1981	Upland
Senegal	IET 723	Jaya	TN 1/ T141	DRR		Jaya	-	Irrigated
Tanzania	IET 4790	BIET 360	IR 8/ CH 45	RAU		-	1986	Irrigated
Tanzania	IET 1444	Rasi	TN 1/ Co 29	DRR		-	1984	Upland
Tanzania	IET 2397	RP 143-4	IR 8/ HR 19/IR8	DRR		Katrain 1	1984	Rainfed lowland
Tanzania	IET 360	L 5P23	GEB 24/ TN1	CRRI		-	-	Irrigated
Tanzania	IET 1891	Sabarmati BC5/55	TN1/Bas.370// Bas370	IARI		Subamati	-	Rainfed lowland
Togo	IET 1444	Rasi	TN1/ CO 29	DRR		-	1978	Upland

Country where released	Number	Name/ designation	Cross	Source	Released region	Name given	Year of release	Ecosystem
Venezuela	IET 7288	PR 106	IR 8/Peta5// Belle Patna	PAU	Latin America & The Caribbean Islands	Araure3	1984	Irrigated
Vietnam	IET 723	Jaya	TN1/ T 141	DRR	South East Asia	-	-	Irrigated
Zambia	IET 7543	RTN 500-5-1	IR8/ RTN 24	KKV	Sub- Saharan Africa	-	-	Irrigated

CRRI, Central Rice Research Institute; DRR, Directorate of Rice Research; IARI, Indian Agricultural Research Institute; KAU, Kerala Agricultural University; KKV, Konkan Krishi Vidyapeeth; OUAT, Orissa University of Agriculture and Technology; PAU, Punjab Agricultural University; RAU, Rajendra Agricultural University; SKUAS&T, Sher-e-Kashmir University of Agricultural Sciences and Technology; and TNAU, Tamil Nadu Agricultural University.

VI. AICRIP-Way Forward

India has the world's largest area under rice with 42.5 million ha and is the second largest producer (106.65 million tones in 2013-14) next to China. However, productivity of rice is only 2.54 tonnes/ha of milled rice as against the global average productivity of 3.28 tonnes/ha. The country has witnessed threefold increase in rice production during last five decades (1960-2010), however it is also well documented that the rice yield growth has declined from 2.3% per year during 1970-1990 to 1.5% during 1990s and < 1.0% during the first decade of present century. On the other hand, the country's population is expected to reach 1.63 billion by 2050, which would require another 25 to 30 million tonnes of rice for maintaining the present level of food security.

In the coming years, rice production systems are likely to face major challenges in view of production constraints. In addition to the declining pace of productivity, there are very limited possibilities for arable land expansion due to rapid urbanization and industrialization. Other expected concomitant developments include scarcity of labour for agriculture as well as issues of environmental and human health concerns. Global climate change impact in terms of frequent droughts, cyclones, floods, enhanced temperature and CO_2 is another serious development needing urgent attention. Crop diversification due to rapid shrinking of water resources, deteriorating soil health, abiotic and biotic stresses as well as escalation of input costs will also be major threats to rice economy.

In view of these mounting challenges as well as needs on one hand and rapid advances in scientific research and developments on the other, the way forward should include development of roadmap for substantial revamping of AICRIP setup to meet the future demands. Transformation from routine field evaluation centers to highly efficient technology developing centers of excellence is the need of hour. Scientific developments need to be rapidly converted into adoptable technologies and validated under diverse rice ecologies. Fewer, well equipped centers would concentrate on technology development and larger voluntary centers would meet the requirement of validation of technologies. Reorienting research and technology development programmes tailoring to meet the emerging challenges and focusing on small and marginal farmers' needs is essential.

i) Thrust areas for Research

- **Pre-breeding for broadening the genetic base to enhance yield, quality and stress tolerance in rice -** Broadening of genetic base by including wild rice and other related species for exploiting the gene pool reservoir can help in overcoming limited genetic variability in the cultivated germplasm pool. This will also aid in incorporation of other desirable traits related to yield, quality and stress tolerance. It is now possible to track the variability present in the primary and secondary gene pool of rice and gainfully use them in breeding programs by adopting novel breeding strategies and modern biotechnological tools. Exploiting hybrid vigour through precision breeding of parental lines to enhance their genetic diversity for better levels of heterosis can address the varietal needs of diverse ecosystems.

- **Soil and plant health management under changing climate -** Understanding soil health impacts in relation to climate change is possible using controlled environment and long- term research experiments to assess soil health indicators affected by climate change such as aggregate stability, SOM, carbon and nitrogen cycling, microbial biomass and activity, and microbial fauna and flora diversity. This will assist in devising greenhouse gas mitigation and climate adaptive strategies across rice ecosystems.

- **Adopting resource conservation technologies -** The natural resources are under immense pressure due to population growth and intensive agriculture. Improved tillage and crop establishment practices, especially for rice, show real potential for sustainably improving the productivity and profitability of rice based cropping systems. Reduced and zero tillage can improve yields, raise input-use efficiency, reduce the intensity of machinery use and lower reduction costs. Fine tuning of efficient agronomic practices (DSR, SRI, Aerobic, AWD, micro-irrigation) for scientific management of available water resources will be one of the critical components of adaptation to climate change in near future.

- **Incorporation of abiotic and biotic stress tolerance -** The frequent occurrence of abiotic stresses such as drought and submergence has been identified as the key to the low productivity of rainfed ecosystems. Similarly, biotic constraints also cause potential losses to rice production. Conventional breeding strengthened by molecular tools such as marker aided selection and gene pyramiding with the help of molecular markers appears to be the most promising approach for evolving a broad spectrum and durable resistance mechanism to the majority of the stresses.

- **Enhanced resource use efficiency -** Development and standardization of efficient package of soil, nutrient, water and crop management practices keeping in view the nutrient dynamics, losses, crop responses to input and resource use, and land preparation, and pest/disease/weed dynamics will be the major objective of optimizing of resource and enhancing productivity. Precision agriculture management practices can significantly reduce the amount of nutrient and other crop inputs used while boosting yields. Crop diversification farming systems approach involving pulses, vegetables and oilseeds can also be suitably exploited for higher productivity, resource use efficiency and sustainability.

- **Selective mechanization to reduce human drudgery, value addition and post harvest processing -** Farm mechanization in rice aids in the timeliness of operations, reduces the human drudgery in farm operations and improves the productivity. Timely and selective mechanization also plays a key role in value addition through post harvest processing.
- **Integrated Pest Management -** The modern versatile tool of biotechnology has enough potential to develop multiple pest resistant cultivars in rapid time through thorough understanding of molecular basis of tritrophic interactions among host, insect pest and natural enemies. Diagnostic tools and Decision support systems utilizing Geographical information system (GIS) maps along with weather data will be helpful for pest risk analysis and forecasting of major pests. In the last few years, newer environment friendly chemicals with novel modes of action and effectiveness at very low doses have fitted well into rice IPM programmes. Use of bio-pesticides and other novel bio-molecules can be advocated as environment friendly components of IPM, while precise delivery systems through deployment of nano-pesticides or nano-encapsulated pesticides and development of herbicide tolerant varieties are the other potential options in ecologically sound IPM.
- **Dissemination of Technology for farmers -** The varieties/hybrids and technologies developed as a part of research and multi-location testing are validated for their suitability to various socio-economic and field conditions through FLDs. In this regard, 'Farmers First approach' can be taken up as a novel and more aggressive approach for dissemination of technologies under AICRIP. Linking technology dissemination and ICTs through model portals such as the existing Rice Knowledge Management Portal (RKMP) can expedite the transfer of technology to all classes of farmers across rice ecosystems. Some of the other activities planned for validation and transfer of technologies for years to come through include - strengthening seed chain supply, breeder seed production, capacity building and HRD programmes, impact and constraint analysis of adopted rice production technologies and appropriate follow up action.

Location specific thrust areas

S.No	Location	Thrust area
1	Aduthurai	• Breeding for high yielding quality rice varieties with pest resistance
2	Arundhutinagar	• Development of varieties for aus, aman and boro seasons
3	Bankura	• Development of drought tolerant and boro rice varieties
4	Brahmavar	• Development of gall midge resistant high yielding varieties

S.No	Location	Thrust area
5	Chatha	• Development of quality rice varieties for hills
6	Chinsurah	• Development of HYV for irrigated, rainfed / flash flood, submergence, coupled with Fe-enrichment and arsenic tolerance
7	Chiplima	• Development of drought tolerant varieties for upland areas
8	Coimbatore	• Development of varieties and hybrids with biotic stress tolerance
9	Masodha	• Development of varieties for shallow low land and saline soils
10	Gangavathi	• Development of quality rices for northern Karnataka area and varieties for inland salinity
11	Ghaghraghat	• Development of rice varieties for deep water
12	Jagdalpur	• Development of varieties for upland and lowlands
13	Jeypore	• Development of varieties for rainfed shallow low lands
14	Kanpur	• Development of varieties tolerant to sodic and saline soils
15	Karjat	• Development of varieties and hybrids for high yield and quality
16	Kaul	• Improvement of basmati rices for yield and biotic stress tolerance
17	Khudwani	• Development of high yielding cold tolerant varieties for hills
18	Kohima	• Development of nutrient and glutinous rice varieties
19	Kota	• Improvement of aromatic rice varieties
20	Ludhiana	• Breeding for high yielding quality rice varieties with biotic stress tolerance
21	Malan	• Development of varieties with cold and blast tolerance for hills
22	Mandya	• Development of varieties and hybrids with quality and resistance
23	Maruteru	• Development of varieties and hybrids for high yielding, quality and biotic stress tolerance.
24	Moncompu	• Development of varieties with biotic stress tolerance
25	Mugad	• Development of upland rice varieties
26	Nagina	• Development of Basmati quality rice varieties
27	Navsari	• Breeding high yielding rice varieties resistant to biotic stresses
28	Nawagam	• Development of high yield varieties with biotic stress tolerance
29	Pantnagar	• Development of varieties and hybrids with high yielding and quality
30	Patna	• Development of high yielding varieties for rainfed shallow lowland

S.No	Location	Thrust area
31	Pattambi	• Breeding varieties for biotic stress tolerance
32	Ponnampet	• Development of blast resistant rice varieties
33	Puducherry	• Rice varieties for kuruvai and sornavari seasons
34	Pusa	• Development of deep water rices and aromatic varieties.
35	Raipur	• Development of varieties and hybrids for rainfed shallow lands with inbuilt resistance to pests
36	Ranchi	• Development of varieties for rainfed uplands
37	Rajendranagar	• Development of varieties with quality, cold tolerance.
38	Rewa	• Development of rainfed upland varieties
39	Sakoli	• Breeding for gall midge resistant rice varieties for Vidarbha region
40	Titabar	• Development of varieties for upland and lowlands with biotic stress tolerance
41	Tuljapur	• Development of rainfed upland varieties
42	Upper Shillong	• Development of varieties for NEH region
43	Varanasi	• Development of medium duration scented varieties
44	Wangbal	• Development of biotic stress resistant varieties
45	Warangal	• Breeding for quality rice and gall midge resistant varieties

ii) Scope for review in guidelines and administrative revamp

- AICRIP is the largest research network programme wherein more than 300 scientists from more than 100 cooperating centers (45 funded and 70 voluntary) are contributing towards generation of breeding material and testing. In Golden Jubilee year *i.e.* 2015, varietal testing programme (AICRIP) was reviewed and found that a total of 24900 entries were tested under AICRIP since its inception till 2014.
- In centre wise contributions of test entries it was found that IIRR (DRR) nominated maximum entries (5389) followed by NRRI (3060) and together accounted for 34% of the total entries evaluated during last 50 years. Other top contributing centers were Raipur (1018 entries), Chinsurah (1006 entries), Masodha (925 entries), Coimbatore (906 entries), Pantnagar (799 entries), Rajendranagar (616 entries), Maruteru (616 entries) and IARI (581 entries). About 10000 entries (about 40%) were nominated together by 90% centers indicating that those centers were doing only testing and did not generate any material worth nomination in AICRIP.
- In view of the above there is an urgent need for such centers to strengthen their breeding activities in order to make significant contributions. IIRR as a AICRIP coordinating unit has to play a major role in identification of the bottlenecks rendering the centers unproductive and support the

centers by helping in material generation, advancement (off-season) and strengthening of infrastructure. All the Project Coordinating (PC)/Project Directorate (PD) units should act similar to crop based CG centers of International institutes, *e.g*. IRRI for rice.

- PC/PD units should take lead in the research efforts to break yield plateau and widen the genetic base, pre-breeding activities to tap hidden and unused variability available in landraces and wild relatives of *Oryza* at selected centers.
- Free sharing of the germplasm between institutes and countries has played major role in development and release of high yielding varieties but under new IPR regime, there is a declining trend in the sharing of germplasm which needs to be addressed on priority. Suitable mechanisms have to be put in place to encourage the movement of germplasm for ensuring food and nutritional security of future generations.
- It has been a common feature that despite the generation and regular contribution of promising material to AICRIP, Variety Identification Committee (VIC) proposals are not forthcoming from many centers mainly due to lack of interest to release the material centrally or in other states or inadequate awareness of VIC procedures or mechanisms. In order to avoid this, PC/PD/PI should be responsible for preparing VIC proposal in consultation with concerned breeder with respect to all the eligible cultures.
- Policy support and generous funding for hardcore rice breeding is the need of the hour as not much support is coming for encouraging unique breeding activities.
- Centralized data base for maintaining the details of material generation across the locations will help in avoiding duplication.
- VIC weightage system should also consider the parameters or efforts for picking / selecting material based on preference of farmers, rice millers and consumers.
- Mini-kit system to be introduced again and mini-kit data along with farmers view should be given due weightage in Central Variety Release Committee (CVRC).
- There is a need for strong Human Resource Development (HRD) component in AICRIP for need based training and international exposure of scientists across the globe.
- AICRIP research should be made demand driven and responsive with due accountability and fixation of responsibility for effective outputs and outcome.

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