ICAR-National Rice Research Institute: Genesis and Evolution

D Panda and H Pathak

SUMMARY

People of India have been cultivating rice for about last 7000 years. It is the staple food for more than two thirds of the Indian population. Prior to 1950, rice cultivation was mostly monsoon dependent. Major abiotic stresses like drought and flood were often occurring due to deficit or excess rainfall. These abiotic stresses caused widespread crop failures, starvation deaths and even famines including the Great Orissa Famine (*Na' Anka Durbhiksha*) of 1866 with death toll of about 10 lakhs of people. Loss of rice crop in large areas due to pest and disease epidemics also caused famines, most disastrous of which was the Great Bengal Famine of 1943 with a death toll of about 20 lakhs of people. This famine broke out due to epiphytotic of brown spot disease of rice, adverse impact of the Second World War on the economy of the British Empire and failure of civil administration to mobilize food to the affected areas. At the backdrop of this famine, the Government of India decided to establish a Central Institute for Rice Research and appointed Dr. K. Ramiah as the Officer-on-Special Duty to select a suitable site for locating the Institute. He visited several rice growing states and shortlisted two sites-one at Coimbatore and the other at Cuttack. Having got aware about the list, Maharaja Krushna Chandra Gajapati, the then Prime Minister of Orissa promptly decided to hand over the State Agricultural Farm, Cuttack to the Central Government for establishment of the rice institute. Dr. Pranakrushna Parija, the then Director of Agriculture, Orissa placed full justification before Dr. Ramiah regarding suitability of Cuttack for locating the Institute. Finally, on the recommendation of Dr. K. Ramiah, the Government of India established the Central Rice Research Institute (CRRI) at Cuttack in 1946. Initially, the main objective of the Institute was to carry out basic and applied research on all aspects of rice leading to the development of better rice varieties and technology for enhancement of per hectare rice yield in the country. The other objectives of CRRI were to act as a centre of authoritative information and to train rice researchers, farmers and other stakeholders on all matters related to rice production.

The Institute started functioning by taking possession of the State Agricultural Farm, Cuttack, which was locally famous as Bidyadharpur farm. Initially the focus was laid on recruitment of personnel including 10 scientists, renovation of the existing infrastructure and creation of additional physical facilities for facilitating rice research. The research work was organized in 5 Divisions namely Botany, Chemistry, Agronomy, Entomology and Mycology. In due course of time, the numberof Divisions/Sections of research were

increased to twelve, which were again reorganized to 5 Divisions namely Crop Improvement, Crop Production, Crop Protection, Crop Physiology & Biochemistry and Social Science. A laboratory wing was created in 1958. Besides, a new administrative-cum-laboratory building was constructed in the early 1980s. The Institute was renamed as ICAR-National Rice Research Institute (NRRI) in 2015. Further infrastructure development has been made in 2018-19 with construction of a well-furnished Central Genomics and Quality Laboratory; Building for Social Sciences Division; Building for Krishi Vigyan Kendra at Santhapur, Cuttack; and an Auditorium. The sanctioned strength of scientists has been increased and now stabilized at 110.

In order to expand location-specific research two sub-stations namely, Central Rainfed Upland Rice Research Station at Hazaribag in Jharkhand and Regional Rainfed Lowland Rice Research Station at Gerua in Assam were established in 1980 and 1986, respectively. With a view to educate, empower and enhance income of the farmers two Krishi Vigyan Kendras-one at Santapur in Cuttack district of Odisha and the other at Jainagar in Koderma district of Jharkhand are functioning under NRRI.

During the entire period of 73 years of its existence, the Institute has developed 133 high-yielding rice varieties, several crop production & protection technologies and farm implements. With the contribution of researchers, extension workers and policy makers and hard work of the farmers, the rice production in the country has increased from 20 Million tonnes (Mt) in 1950 to 112Mt in 2017-18. The country is now annually exporting about 10 Mt of rice and earning about Rs. 50,0000 crores annually.

1. INTRODUCTION

Rice is being cultivated in India for at least 7000 years. A report by Zong et al. (2007) suggests that the history of domestication and cultivation of rice in China is as old as 7,700 years. Since there is a rich diversity of rice landraces in a vast region comprising of north-east India, adjoining parts of Burma, Thailand, Vietnam and South China, this region is believed to be the primary centre of origin of cultivated rice. Similarly, as there is a large diversity of landraces in Jeypore tract of undivided Koraput district of Orissa, it is considered as the secondary centre of origin of rice (Roy, 2017).

Rice is the most important food crop that sustains human life in India and many other countries of Asia and Africa. Recognising the importance of rice crop, the Imperial Council of Agricultural Research (presently the Indian Council of Agricultural Research), since its inception in 1929, had sponsored many rice breeding stations and research projects scattered over rice growing states of India to stimulate and foster rice research. However, the total production of rice was invariably short of the country's requirements during pre-independence era and even two decades after independence. Since rice

production was mostly monsoon dependent, the crop production was adversely affected in unfavourable years of deficit or excess rainfall.The natural disasters such as drought, flood and cyclone had been resulting in shortage of food, starvation of people and even horrifying famines. Besides the abiotic stresses, biotic stresses such as incidence of insect pests and diseases, sometimes in epidemic dimensions, drastically decreased rice production bringing a lot of miseries to the people of India during the pre-independence period. Between 1860 and 1910 there were more than 20 famines. Most devastating of these famines was the Great Orissa Famine (*Na' Anka Durbhikshya*) of 1866 with death toll of about 10 lakh people that was about one third population of Cuttack, Puri and Balasore districts of Orissa. This famine occurred due to premature cessation of rain in September and October, lack of irrigation as well as defective colonial administration. All these famines became an eye opener for the Government of India to take remedial measures. Hence, many rice breeding and research stations were established all over India to undertake rice research, evolve improved rice varieties and to develop and adopt rice production technologies.

2. TRAGEDIES OF THE GREAT BENGAL FAMINE

The Great Bengal Famine broke out in 1943 due to very low production of rice in the previous year, 1942 in the then Bengal Province which comprised of West Bengal and the present country of Bangladesh. The shortfall in rice production in 1942 was mainly attributed to the epidemic of brown spot disease of rice crop caused by the fungal pathogen, *Helmionthorporium oryzae* Breda de Haan [*Cocliobolus miyabeanus (Ito* & *Karibayashi*) Drechsler *ex* Dastur] in Bengal province (Padmanabhan, S.Y. 1973). Comparison of weather parameters during the kharif season of 1942 with those of 1941, 1943 and 1944 revealed that the kharif season of 1942 had excessive rainfall in September, uniformly favourable temperatures of 20-30°C continuously for two months, unusual cloudy weather, higher rainfall and a higher minimum temperature in November. These unusual weather conditions were favourable for the occurrence of the brown spot epidemic in rice in the undivided Bengal.

Old Building of CRRI

New Building of CRRI

The Great Bengal Famine was so devastating that about two million people died of starvation. On the aftermath of epidemic of brown spot disease which was mainly responsible for outbreak of the famine, Dr. S.Y. Padmanabhan was appointed as Mycologist in Bengal in October, 1943. During his travel in Bengal he could observe dead bodies, starving and dying persons all along the way from Bahudurabad Ghat on the Brahmaputra to Dacca. This severe famine continued throughout October, November and December, 1943 in and around the important cities in Bengal, especially Calcutta and Dacca. The problem of acute food shortage was further aggravated due to the Second World War (1939-1945) involving many countries of the world including the British empire. The economy of the British Empire almost crumbled in the Second World War. As a result, the civil administration of British India failed to cope up with the wide spread severe food shortage. Due to the negligible marketable surplus of rice from 1942, price of rice in market went on increasing and it was beyond the reach of common people to purchase staple food grain. So, most of the rural people migrated to cities in search of employment. As they failed to get employment and food either in villages or in cities, they slowly succumbed to death due to starvation.

3. ESTABLISHMENT OF CENTRAL RICE RESEARCH INSTITUTE (CRRI)

Low production of rice in the country as a whole, outbreak of the Great Bengal Famine and unbearable tragedies of acute hunger and starvation of millions of common people during the early 1940's, in particular, prompted the Government of British India to actively consider establishment of Central Rice Research Institute at a suitable site in the rice belt of the country immediately after the second World War was over. There were several rice breeding and research stations functioning independently without any links with each other in different provinces of the country to meet demands of the local needs.The research facilities available in regional breeding stations and research centres were also inadequate to meet the challenges of low productivity and to deal with multidisciplinary research on all aspects of rice production at national level. In order to intensify rice research in the country, the Government of India at one time contemplated setting up of a Central Rice Committee to be financed by a cess on the crop. As the public opinion did not favour levying of cess on a major food crop like rice, the idea of establishing a separate Commodity Committee for rice was abandoned. Government of India finally took a decision in 1945 to establish Central Rice Research Institute under its auspices (CRRI, 1946).

In an immediate follow up action, the Government of India appointed Dr. Krishnaswamy Ramiah as the Officer on Special Duty in the Imperial Council of Agricultural Research to select a suitable site for locating the CRRI on the basis of his befitting contribution in rice research. A detailed biodata of Dr. Ramiah, popularly known as 'Rice Ramaiah', is available in the Annual Report of NRRI (2017-18).

As ascertained from the discussion with Dr. S. Patnaik, former Director, CRRI, Cuttack who served the Institute for 38 years (1952-1990), the following historical events and eminent personalities facilitated the process of site selection and establishment of the Central Rice Research Institute at Cuttack in 1946. Maharaja Krushna Chandra Gajapati became the Chief Minister of Orissa and created a Department of Agriculture which was earlier under the Directorate of Development. He appointed the eminent Botanist, Dr. Prana Krushna Parija as Director of Agriculture. Dr. Parija was simultaneously holding the position of Vice-Chancellor of the Utkal University. Both Dr. Parija and Dr. Ramiah were the alumni of Cambridge University. Maharaja K.C. Gajapati was also the Secretary General of Princes' Forum and Maharaja Sayaji Rao Gaikward of Baroda was its Chairman. As the Secretary General of the Princes' Forum, Maharaja Gajapati had several occasions to interact with members of the Executive Council of the Viceroy of India in connection with development affairs of the country. Sir C. N. Trivedi was the only Indian Member of this Executive Council. Subsequently, Sir C. N. Trivedi was appointed as the first Indian Governor of Orissa. At that time, the site selection process was almost at final stage. Dr. K. Ramiah selected two sites – one at Coimbatore and the other at Cuttack. When it was brought to the knowledge of Maharaja K. C. Gajapati, he impressed upon the Executive Council of the Viceroy to establish the Central Rice Research Institute at Cuttack and offered to transfer the State Agricultural Farm at Cuttack, popularly known as Bidyadharpur Farm with land area of 60 hectares and the existing infrastructure free of cost to the Government of India for establishing the Central Rice Research Institute.

Dr. P. K. Parija emphasized that Cuttack was more suitable for establishing the rice institute than the other shortlisted site because rice was the dominant food crop in high rainfall regions of eastern India including states of Assam, Orissa, West Bengal, south Bihar, Chhatisgarh, Jharkhand, eastern Uttar Pradesh and parts of south India including north Andhra Pradesh. Cuttack was receiving more than 1000 mm of rainfall during monsoon season from June to September. It was also receiving some more showers of rainfall in October and first fortnight of November. During monsoon season, no crop other than rice could successfully be grown in low and medium lands of Orissa and adjoining states. Moreover, Cuttack is situated in the heartland of rice belt of India. On the contrary, Coimbatore was receiving less than 800 mm

Founding Fathers of Central Rice Research Institute, Cuttack.

From left: Dr. KrishnaswamiRamiah, OSD, Site Selection for CRRI; Dr. Prana Krushna Parija, Director of Agriculture, Orissa; Maharaja Krushna Chandra Gajapati, Prime Minister of Orissa.

of rainfall spread over entire year and rice was mostly irrigated because of inadequacy of rain water. On the basis of this justification given by Dr. Parija and immediate willingness of the Government of Orissa to transfer the State Agricultural Farm at Cuttack free of cost to Government of India for establishing the Institute, Dr. K. Ramiah finally recommended Cuttack to be the suitable site for establishment of Central Rice Research Institute. This recommendation was accepted by the Executive Council of Viceroy of India. The Government of India finally accepted the recommendation to establish the Central Rice Research Institute at Cuttack in 1946 and appointed Dr. K. Ramiah as its Director in August, 1946 for a period of 5 years.

4. FUNCTIONING OF CRRI IN THE FORMATIVE YEARS (1946-1951)

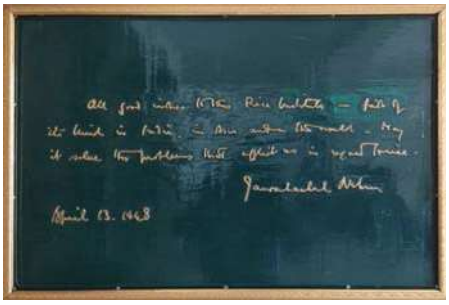
Dr. Ramiah joined the Institute on 27th of September1946 as its founder Director. The State Agricultural Farm, Cuttack in Orissa with its land area of 60 hectares, buildings and other infrastructure was taken over and arrangements were made afterwards to acquire additional land, contiguous to the existing farm. In the beginning, attention was devoted to fencing of the farm, constructing threshing floors, implement sheds, store rooms and preparation of plans and estimates for construction of laboratories and staff quarters. The layout of experimental fields with irrigation and drainage channels, roads and foot paths was also simultaneously undertaken. The necessary livestocks and deadstocks were also acquired.

Recruitment of scientific staff for the Institute was met with some difficulty. However, with the partition of the country into India and Pakistan, men became available out of the group of displaced persons who were previously working as agricultural scientists in areas which went over to Pakistan. The work of the Institute was organized under five divisions, viz. Botany, Chemistry, Agronomy, Entomology and Mycology, fully coordinated to address the researchable issues of rice production system from the all possible relevant angles.

Pandit Jawaharlal Nehru, the Honourable First Prime Minister of India visited the Institute on April 13, 1948 and gave his esteemed remarks "all good wishes to this Rice Institute - first of its kind in India, in Asia and in the world. May it solve the problems that afflict us in regard to rice". The plaque inscribed with these lines has been installed in the entrance of the main building of the Institute (*Please see below*).

The Institute had the opportunity to receive Pt. Nehru for the 2nd time on January 3, 1962 during which he visited the residential colony (Nehru Colony) and the Childrens' Park (Nehru Childrens' Park).

In Botany Division, focus was initially laid on rice germplasm collection of cultivated, semi-wild and wild species of *Oryzae* from various states.



Fortunately, the germplasm maintained by Dr. K. Ramiah in earlier years at the Paddy Breeding Station, Coimbatore was made available which were brought to start-up genetic stock at CRRI, Cuttack. Simultaneously, the conservation of the genetic stock and their utilization in plant breeding were undertaken. Regular yield trials were conducted with all the improved varieties collected from all over India including those available at Cuttack. It was from these trials the excellent performance of T 141 of Orissa was brought to light. In addition to selection and hybridisation, genetic studies were also undertaken mainly to determine linkage groups. Initially, in breeding new varieties, earliness of maturity and non-sensitivity to photoperiod were focused on. Experiments on response of rice varieties to chemical fertilizers with and without organic manures were also conducted. Plots for permanent manurial trials were laid out. The Chemistry Division of the Institute started investigations on the Chemistry of submerged soils and placement of fertilizers in reduced zone of waterlogged soil which was a pioneering work in India. Work in the Entomology Division was concentrated on two of the most important insect pests, the stem borer and gall fly, and their control. In the Mycology Division, work was concentrated on two fungal diseases, blast and brown spot. The Division also undertook work on screening of genetic stocks for disease resistance and hybridization to evolve resistant varieties.

As a member of the Standing Advisory Committee in Agriculture of FAO, Dr. Ramiah attended its annual conferences in different countries of the world in 1946, 1947 and 1948. The FAO decided to start an International Rice Commission (IRC) under its auspices for improvement of rice production in Asia and the far East. Representing India, Dr. Ramiah attended annual meetings of the IRC during 1948 to 1951. At the Burma meeting of IRC in 1950, his proposal to start an International Cooperative Rice Breeding Project was accepted by FAO and work was initiated at CRRI. Under this project an intensive programme of hybridizing *japonica* with *indica* rice was undertaken and the F_2 seeds were despatched to the different cooperating centres and rice research stations to select the most suitable types for their conditions. This programme brought limited success. However, from the seeds of hybridized population, sent from CRRI to different countries of the world and Institutions within India, the Regional Research Station, Aduturai in Madras state

identified a promising culture and released it as ADT-27. In addition, rice varieties viz. Mahsuri and Malinja in Malaysia and Circna in Australia were identified from this programme and were released for cultivation. The FAO recognised the CRRI as an official centre for training persons selected from different countries in rice breeding. The Institute has been maintaining close contact and cooperation with the IRC of FAO since its inception. The IRC also recognised CRRI as one of the main centres for maintenance of rice germplasm of the world.

During 1946-1951, a scheme was initiated for popularising the use of chemical fertilizers for rice in Orissa. Although, canal water was available up to the end of April in major irrigation command areas, the land was left fallow and growing of a second crop (Rabi) of rice was unknown before. In such areas, suitable varieties of rice were successfully grown in Rabi season and the practice has since taken a deep root and made great progress (CRRI, 1956). In early 1960s, the Institute took up breeding for non-lodging types using the stiff strawed *javanica* and developed CR-1014; a super fine grain variety yielding 3-4 t ha^{-1} in intermediate deep water stagnation conditions from the cross between T90 and Urang Uragan (Roy, 2017). This variety became widely popular in many states of India.

5. LOCATION, SITE AND SOIL CHARACTERISTICS OF THE INSTITUTE

The Institute is situated at Cuttack in Orissa (now Odisha) with $20^0$25′ N latitude, 85^0 55′ E longitude and elevation of 23 m from mean sea level. It is located adjacent to the Cuttack-Paradeep State Highway, at a distance of 7 km from Cuttack Railway Station and 35 km from Bhubaneswar airport. The climate of the place is hot sub-humid with average annual rainfall of around 1500 mm. The rainfall during kharif season is more than 1000 mm.

The fields of the Institute farm are fairly level with less than 1% slope. The land has shallow ground water level. Thirty seven soil profile pits dug all over the farm showed that even at the end of May, sub-surface water appeared at a depth in the range of 0.45 m to 1.5 m. It has poor surface drainage as well as internal drainage. The farm is comprised of low and medium lands with negligible area of upland.

As per USDA Soil Taxonomy, 1999, soils belong to the order, Ínceptisols' sub-order, Áquepts' and great group, Endoaquepts. At soil series level, the soils of CRRI farm are classified as Typic Endoaquepts, Vertic Endoaquepts and Aeric Endoaquepts. As per FAO classification system, the soils are classified as Eutric Gleysols (Sarkar et al. 2003).

As soils of the Institute farm are of alluvial origin developed in the Mahanadi river delta, they are very deep. They are fairly fertile with medium to high organic matter content.

6. OBJECTIVES OF THE INSTITUTE

The Institute was established with the following major objectives:

1. To carry out research on basic and applied aspects in all disciplines of rice culture in order to develop rice production technologies for optimising per hectare yields of rice.
2. To conduct, co-ordinate and encourage adoptive research in rice growing tracts of the country before making site specific recommendations for use by the rice farmers.
3. To serve as a centre of authoritative information on all matters concerning rice production, protection and rice germplasm at national level.
4. To identify production constraints in regions through surveys and to suggest appropriate technologies for production.
5. To participate in communication and transfer of technology in respect of rice.
6. To train research and extension workers on rice production technologies in the country.

Retaining the basic theme of the original mandate, the objectives of the Institute have undergone slight modifications from time to time with the growth of the Institute. Currently, the research policies are guided by the recommendations of the Research Advisory Committee (RAC), Quinquennial Review Team (QRT) and the Institute Research Council (IRC). It also has an Institute Management Committee (IMC) to support implementation of its plans and programmes. In recent years greater attention has been paid on sustainable rice production technology development which includes productivity enhancement in quantity and quality of produce, profitability, feasibility, acceptability by farmers, environmental security and overall welfare of the farmers keeping in view the recent climate change events caused due to global warming.

7. GROWTH OF THE INSTITUTE

The land area of the experimental farm increased from the 60 ha to 117 ha with the acquisition of additional land contiguous to the farm area. The Institute initially started with 10 scientists, and later the strength increased to 40 in 1960s, 170 in 1980s, then reduced to 140 in 1990s, and 118 during 2000s. As on 2018-19 the strength is 100.

With the recruitment of scientific personnel as well as expansion and intensification of research, the demand for additional laboratory facilities grew and a laboratory wing was created in 1958. In due course of time, the infrastructures such as net houses, farm godown, and Engineering Workshop

were constructed. The other facilities namely one conference hall, an auditorium, a committee room, a display hall (Museum), one library, a dispensary, a club house, one guest house, one farmers' hostel, one International Students Hostel, and Scientists' Home were created. The Institute also has other amenities like Post Office, Police Outpost, a pay counter of State Bank of India and service facilities for maintenance of civil, electrical and water supply structures. Besides, the new administrative-cum-laboratory building was constructed in early 1980s. Additional staff quarters were also constructed to accommodate nearly about 300 staff families belonging to various categories.

In order to cater to the needs of contemporary advanced research in 1990s, sophisticated instruments such as automatic amino acid analyser, ultra centrifuge, gas chromatograph, atomic absorption spectrophotometer, atomic mass spectrometer, liquid scintillation counter, aerobic chamber, liquid chromatography, infrared gas analyzer, infrared spectrophotometer, respirometer, fluorescent microscope, computers and many other commonly used equipments were installed over years. In addition, several externally aided projects including Asian Rice Biotechnology Network (ARBN), Rockefellor Foundation, Ford Foundation, Colombo Plan, Methane Emission, SARP, IRRI-CRRI collaborative CREMNET project, Indo-US collaborative project on N use efficiency, AP Cess Fund schemes and NATP projects were operated and many more advanced equipments were installed using funds available in these schemes and projects.

In the recent years from 2011-2019, further expansion of laboratories with instrumentation and other physical facilities has been made to carry out advanced rice research comparable to that of any national or international Institute. To cite a few such sophisticated laboratories, the construction of new Genomics Laboratory and Central Quality Control Laboratory buildings, well furnished and equipped with ultra-modern equipments, are worth mentioning. Since the existing auditorium and conference hall are not spacious enough to accommodate large number of participants of national and international symposia and farmer-scientist interaction meetings, the need for construction of a larger auditorium was recognised by the ICAR. For organizing such national and international conferences, symposia and farmers' meetings, a new auditorium to accommodate 500 participants is currently on the verge of completion in 2019.

The first sub-station of CRRI, Central Saline Rice Research Sub-Station was established in the heart of saline area of West Bengal at Port Canning in 1959 with the objective of developing suitable techniques for breeding salinity resistant rice varieties, to work out the physiology of resistance to salinity and to develop appropriate agronomic practices. This station was however later merged with the Central Soil Salinity Research Institute of ICAR in 1969 as one of its sub-stations, specifically meant for rice research in coastal saline areas (CRRI, 1996).

In order to expand location specific research on rainfed rice, two sub-stations, viz. Central Rainfed Upland Rice Research Station (CRURRS) at Hazaribag in Bihar (now Jharkhand) and Central Rainfed Lowland Rice Research Station (CRLRRS) at Kharagpur in West Bengal were established in 1980 and 1986, respectively. Subsequently, the CRLRRS was shifted to Gerua in Assam to cater to the typical lowland rice research needs of the north eastern region of the country.

Since multi-location rice research was considered essential mainly for testing the breeders' materials for yield and for assessing the resistance of the breeding materials to biotic stresses, the All India Coordinated Rice Improvement Project (AICRIP) was commissioned at Hyderabad in 1965. The AICRIP initially functioned as a part of CRRI for quite some years. Subsequently, the project Directorate of AICRIP was renamed as Directorate of Rice Research (DRR) which operated directly under ICAR as an independent Institute. The CRRI has been a major participant of the coordination. The DRR has further been renamed as Indian Institute of Rice Research in recent years.

With a view to educating, empowering and enhancing income of the farmers three Krishi Vigyan Kendras (KVKs)-one at Santapur, Cuttack district, the second at Annapurnapur, Kamakshanagar, Dhenkanal district and the third at Kalipad, Angul district were established in mid 1990s, which functioned directly under CRRI. Subsequently, out of these three KVKs, two KVKs one in Dhenkanal district and the other in Angul district were transferred to the administrative control of Orissa University of Agriculture Technology. The KVK at Santapur in Cuttack district has been functioning under CRRI since its inception. Recently, a lot of infrastructure development work in this KVK has been completed with the construction of new office building and well furnished laboratory buildings with provision of necessary physical facilities including laboratory equipments. Besides, one more KVK has been established at Jainagar of Koderma district in Jharkhand under the Central Rainfed Upland Rice Research Station (CRURRS) of CRRI. It caters to the needs of farmers of the concerned district in regard to their empowerment, enhancement of income and welfare of the farmers through integrated approach. The CRRI also carried out research and extension activities in Operation Research Projects, Lab to Land and Institute-Village Linkage (IVLs) programmes on transfer of technologies as out-reach programmes. In this connection, the Farmers First programme is currently in operation under NRRI.

The CRRI carried out on-farm research to develop and fine tune agricultural technologies for different rice-based cropping systems in various agro-ecological situations through the World Bank funded National Agricultural Technology Project (NATP) during the period from 1998-2003. CRRI functioned as the nodal agency for 35 on-farm research projects on Rainfed Rice-Based Production System (RRPS) at 35 main centres and more than 150 cooperating centres throughout the country. For this purpose, a separate NATP cell was

created in CRRI and a Facilitator was identified and appointed by ICAR from among the senior Principal Scientists or the Director of the Institute to coordinate all these RRPS projects.

The Institute has also been pursuing academic and innovative research in different disciplines of rice science which would have far reaching impact on future rice crop improvement, crop production and protection programmes. The Institute has been recognized by several universities, as a centre for advanced research leading to award of doctoral degree. Hundreds of students and research fellows have been awarded with Ph.D. degrees through such innovative research in different disciplines under the guidance of scientists of the Institute including that of the sub-station CRURRS in Jharkhand. The Institute scientists have also published a large number of peer reviewed research papers in national and international journals of high repute. Besides, scientists of the Institute have also received several prestigious national and international awards and recognitions.

Although there were only five Divisions/Sections at the inception of the Institute, subsequently the number of Divisions/Sections increased to twelve viz. Plant Breeding and Genetics, Genetic Resources, Agronomy, Soil Science and Microbiology, Agricultural Engineering, Entomology, Plant Pathology, Physiology, Biochemistry, Agricultural Economics, Statistics and the Division of Extension, Communication and Training. As per the decision of ICAR, the Institute has again been reorganised into five Divisions viz. (i) Crop Improvement, (ii) Crop Production, (iii) Crop Protection, (iv) Plant Physiology and Biochemistry and (v) Social Science with the merger of related disciplines. Hence, currently there are five Heads of the Divisions in the Institute. Division-wise research achievements, impacts and aspirations are separately dealt in greater details in the subsequent chapters of this book.

8. IMPACTS OF RICE RESEARCH AND DEVELOPMENT DURING 1958-1984

During the period from 1950 to 1984, the rice production in India was increased by nearly 300% from about 20 Mt in 1950 to 60 Mt in 1983-84. Although rice has been cultivated in India for at least 7,000 years, more progress in improving production has been achieved in the last 35 years. The progress has been triggered off by a proper blend of (i) science-based technology developed by CRRI, SAUs and IRRI including provision of irrigation, fertilizers, and quality seeds of high yielding varieties, pesticides, farm implements through public and private sectors, (ii) credit through Cooperative and Banking sectors, (iii) favorable Government policies, and above all the farmers' sincere efforts which stimulated production.

The establishment of the IRRI in the Philippines in 1960 helped promote the concept of improving the plant type in *indica* rices based on the use of a

gene for semi-dwarfing from a Taiwan variety. This helped in breeding high-yielding varieties capable of responding to higher levels of fertilizer application and good management. During the International Rice Year in 1966 the ICAR laid out one thousand national demonstrations to show that the century's old stagnation in *indica* rice yields can be broken. This marked the beginning of an accelerated advance in the improvement of the production and productivity of rice (Swaminathan, 1985). T.T. Chang (1961), the geneticist at IRRI, had come from Taiwan and he knew all about the success achieved by the breeders there in evolving TN1 and other high-yielding *indica* varieties of rice. Chang suggested the IRRI plant breeding scientists that they should introduce some of these semi-dwarf *indica* rice varieties from Taiwan for use as parental lines in their hybridization programme. The IRRI rice breeders, however, initially wasted little time in procuring seeds of these varieties. Subsiquently, Dr. P. R. Jennings, Head of varietal improvement programme made a series of crosses involving one of the semi-dwarf *indica* parental lines introduced from Taiwan.

9. CRRI AND GREEN REVOLUTION IN INDIA

Dr. H. K. Jain (2010), former Director of Indian Agricultural Research Institute, New Delhi vividly reviewed all aspects of rice revolution in his book "The Green Revolution: History, Impact and Future". As the plant breeders in the FAO sponsored *Indica-Japonica* Hybridization Project were struggling to achieve a major advance in *indica* rice yields in India and other countries, scientists in Taiwan had forged ahead in developing the world's first group of fertilizer responsive, semi-dwarf, high-yielding varieties of *indica* rice. The origin and development of these *indica* rice varieties have been reviewed by Athwal (1971). It all started with a traditional variety called Dee-geo-woo-gen, which farmers in Taiwan were growing in early years of the 20th century. It was very different in plant type showing dwarf stature, high tillering and stiff straw, which came to the notice of scientists at the Taiwan Agricultural Experiment Station much later. They used this variety in breeding programme. One of the products of these crosses, involving Dee-geo-woo-gen and Tsai-Yuan-Chung, was the variety Taichung Native 1, perhaps the first semi-dwarf, fertilizer responsive, high-yielding rice variety which became the prototype of a whole generation of *indica* rice varieties in many countries of Asia including India. The IRRI became a catalyst in this endeavour to revolutionise rice production through a change of direction of rice research in CRRI, SAUs of India and in many other countries of Asia.

The Government of India came to know about the progress of research in IRRI regarding development of rice varieties using Dee-geo-woo-gen through Sri K. K. Damle, the then Secretary, Ministry of Agriculture who was a Member of the Board of Trustees of IRRI. Further, Robert F. Chandler Jr., the first Director of IRRI during his regular visits to India had also briefed the Union Minister of Agriculture Sri C. Subramanium and the senior officers of the Government on

this issue. One of the officers he briefed to was Sri B. Sivaraman, who later became the Secretary in the Ministry of Agriculture. Prior to his appointment in the Ministry of Agriculture, he had been the Chief Secretary of Orissa and visited CRRI, Cuttack to observe rice research programmes. One of the scientists he came in contact with was Dr. G.V. Chalam, Economic Botanist of Orissa who later became Deputy Director in the State's Department of Agriculture in the 1950s. Dr. Chalam was deputed to IRRI in 1964 for study in rice improvement programme. While at IRRI, he learnt about the outstanding performance of Taichung Native 1 and asked for 2 kg seeds of this variety for testing in India. The trial with Taichung Native 1 which Dr. Chalam organized was successful. Then the Ministry of Agriculture arranged to procure from IRRI one tonne seed of Taichung Native 1 with help of Dr. R.W. Cummings, the Field Director of the Rockefeller Foundation in New Delhi. When Dr. Chalam became the Chairman of National Seed Corporation, he managed to procure 5 tonnes of seeds of TN 1 in October 1965 and subsequently to import 60 tons of seeds of TN 1 and implemented distribution of these seeds for up-scaling coverage in India especially during dry season when the incidence of pests and diseases were less.

Dr. Robert F. Chandler, the first Director of IRRI, drew attention to Chang's contribution towards this new direction to the IRRI's rice breeding programme. He reported that TN 1 was released in Taiwan in 1956 and by 1960 it was widely grown by farmers there with an yield of 6-8 t ha^{-1} following good agronomic management including irrigation and application of large doses of fertilizers. Subsequently, the rice breeders in IRRI made several crosses in 1962 using the semi-dwarf varieties received from Taiwan as one of the parental lines. One of the crosses, to be specific the 8th cross, was made between Dee-geo-woo-gen and Peta, a tall *indica* variety of Indonesian origin, known for its resistance to insect pests and diseases. After the required number of generations and yield trials, it was released from IRRI as IR 8. In India a set of 303 varieties and advanced generation lines were also received from IRRI at CRRI, Cuttack and also at Hyderabad. Dr. Seetharaman, the then Head of Genetics and Plant Breeding in CRRI found that 15 of the entries of the IR series recorded calculated yields around 9 t ha^{-1}. The entries which recorded the highest yield were those of the IR 8 series.

Taichung Native 1 introduced by Dr. G.V. Chalam in 1964 was the first high-yielding semi-dwarf variety which covered large rice area in India. It was however quickly replaced by IR 8 of IRRI. The scientists of CRRI had crossed TN 1 with a number of improved Indian varieties of tall type. One of these crosses made by Sh. M. J. Balakrishna Rao involved T141 and TN 1. A product of this cross was the semi-dwarf high-yielding variety Padma which was released by the Government of India in 1968. Padma (CR 28-25, IET 953) was of 120 days duration, short bold, medium resistance to blast and other major diseases and pests with yield of 3.5-4.0 t ha^{-1}. The Institute celebrated the Golden Jubilee of release of Padma in 2018 by releasing a golden plaque. The

second variety named Jaya was developed by Dr. S.V.S. Shastry and his associates in AICRIP at Hyderabad. The variety Jaya became more successful and covered large areas in India replacing IR 8. These two varieties Jaya and Padma were more acceptable to farmers because of better grain quality and resistance to diseases and pests.

Dr. R. Seetharaman, Head of Plant Breeding and Genetics Division of CRRI organized a major research programme in early 1960s following the introduction of TN 1 and IR 8. Subsequently, the CRRI scientists including Dr Seetharaman, Dr Gangadharan and Dr B.K. Rao with their team developed 18 high-yielding semi-dwarf varieties which were released by Government of India. The varieties performed well not only in irrigated areas with favourable conditions but also suited well to various ecologies like upland, rainfed lowlands with intermediate and semi-deep water conditions. By the end of 20th century CRRI developed 59 high-yielding varieties of rice, many of them carrying the semi-dwarf gene. A number of CRRI varieties also became popular in other countries, viz. Afghanistan, Nepal, Pakistan and many countries of sub-Saharan Africa. By then, CRRI escalated its gene bank collection over 16,000 landraces and local varieties which were evaluated as sources of resistance to stresses. These donors of resistance were made available to rice breeders all over the country for use in their varietal development work.

Simultaneously Dr. S. Patnaik, former Director, CRRI, who was earlier invited to participate in the International Conference on Mineral Nutrition of Rice Plant at IRRI in 1964, collected 3 packets of seeds of semi-dwarf rice varieties: TN 1, Taiwan 3 and Chianung from Dr. A. Tanaka, Plant Physiologist of IRRI. On his return to CRRI, he multiplied them in the wet season of 1965. Dr. G. V. Chalam, the then Agricultural Commissioner of the Government of India and Dr. W. H. Freeman, Representative of Rockefellor Foundation in India visited CRRI, Cuttack and were impressed with the performance of these varieties at maturing stage in the field. Dr. Chalam requested to keep seeds of these varieties for minikit trials in India. In a follow up action, a total of 800 bags of 1 kg each of these 3 varieties (400 bags of TN 1, 200 bags of Taiwan 3 and 200 bags of Chianung) were collected by Dr. Chalam through his technician and were distributed in Orissa, West Bengal, Andhra Pradesh and Tamil Nadu for trials in agricultural farms and selected farmers' fields in 1966.

Dr. Chalam introduced the first high-yielding semi-dwarf rice variety TN 1 in India in 1964 for cultivation in Government Agricultural farms and farmers' fields. This was, however, not that TN 1 had found its way into India. In early 1960s, 67 rice varieties were received at CRRI, Cuttack from Taiwan under germplasm exchange program. Those were evaluated by Dr. R. H. Richharia, who was the then Director of CRRI. Interestingly TN 1 was one of these varieties included in this collection. Dr. Richharia was very much concerned about the susceptibility of these varieties to many pests and diseases. He was however, interested to use them as genetic resource for development of high yielding

varieties of his own with a degree of resistance to pests and diseases. For him TN 1 was an important genetic resource rather than a readymade variety to be grown in farmers' fields. Dr. Richharia is best remembered for the vast collection of land races and traditional varieties of rice, which he made at CRRI (Richharia, 1979). However, the concerns of Dr. Richharia regarding the possible large incidence of pests and diseases in newly introduced semi-dwarf rice varieties were subsequently considered and intensive programmes of screening of land races and traditional varieties for resistance to various biotic and abiotic stresses were undertaken in CRRI, AICRIP and all other research stations of India under the network. The resistant enties were utilized in breeding programme. The resultant cultures were tested at various locations and finally different promising varieties having high yield potential and resistance to biotic and abiotic stresses were released. This has revolutionised rice production in the country. The evolution of IR 36 variety of rice in later years justified the concerns of Dr. Richharia because valuable resistance genes from landraces and traditional varieties have been incorporated in this high-yielding variety at IRRI.

10. CRRI- A SAVIOUR OF COASTAL ODISHA FARMERS POST-SUPERCYCLONE (1999)

The super cyclone occurred in Odisha during 28-30 October, 1999 with severe cyclonic wind and incessant rainfall. It caused a great loss of human life, loss of property and total loss of rice and other crops including plantations in the coastal Orissa. Sea water ingressed into the land area up to 20 km from the coast. All the affected people placed strong demands before the State and Central Government for immediate relief and long-term agricultural rehabilitation. The farmers were of the opinion that not even a blade of grass would grow on their land due to deposit of salts which was also confirmed by a research institute located at Bhubaneswar. So, Government of Orissa sent one S.O.S. letter to CRRI to survey the affected land area of the coastal belt, assess soil and water salinity and give recommendations for agricultural rehabilitation. The CRRI assigned this challenging job to a team of 3 scientists headed by Dr. D. Panda, who surveyed the entire affected land area including crop fields. A large number of soil and surface water samples from crop fields and ground water samples from tube wells, were collected and analysed in the laboratory. The scientific investigation revealed that soils and surface water of 93% of the area were non-saline i.e. normal, while only 7% of the area were saline, especially in depressions and ponds. The ground water collected from tube wells closer to sea coast were, however, saline. Most of the area remained non-saline because of incessant heavy rainfall for 24 hours following return of high tide to sea , which flushed off the deposited salts. Based on these results, a detailed report containing the analytical data, recommendations for cropping pattern and the package of practices of crop production was communicated to the Government of Odisha for implementation at farmers' level. The farmers followed the recommendations in their fields and harvested more than 4 t ha^{-1} of rice during

Rabi season, which partly compensated the crop loss in Super Cyclone. In fact, the soil fertility rather improved due to Super Cyclone because a thick layer of algae which was deposited during forceful inundation of the land with tidal water. Based on subsequent instructions from ICAR, CRRI undertook agricultural rehabilitation work extensively for a long period of about 5 years after Super Cyclone using Institute funds, by implementing NATP projects and also in collaboration with Ramakrishna Mission for economic upliftment of the farmers of the affected coastal belt of Orissa. When Sunami occurred in coastal Tamil Nadu in 2004, the Government of Tamil Nadu took help from the experiences of CRRI to deal with the situation.

11. A SUCCESSFUL 73-YEARS JOURNEY OF CRRI

In its illustrious journey of 73 years from 1946 to 2019, the Institute has been functioning as a light house radiating the knowledge generated from its basic, applied and adaptive rice research projects. More importantly, it has also been functioning as a rice research and development industry making its products of research available to the farmers and other stakeholders throughout the country and abroad. It has been made possible with the visionary leadership of 15 Directors including Padmabhushan Dr. K. Ramiah, the founder Director of CRRI and the dedication of the researchers, all supporting and administrative staff.

A brief account of history, development and the research achievements made during the initial period of ten years from 1946 to 1956 have been compiled in a booklet published by CRRI in 1956 (CRRI,1956). With the initiative of Dr. M.S. Randhawa, the former Vice President of Indian Council of Agricultural Research, the first book entitled "Rice in India" was written by Drs. R.L.M. Ghose, M. B. Ghatge and V. Subramanian which was published by ICAR in 1956. The second revised edition of this book was published in 1960. Dr. S.Y. Padmanabhan, the former Director of CRRI compiled an updated version of the book entitled "Rice Research in India" which was published by ICAR in 1985. Thereafter, the research achievements made in CRRI and other rice institutions of the country during the period of 40 years from 1960 to 2004 were compiled in 36 Chapters of the book entitled "Rice in Indian Perspective" contributed by various authors and edited by Sharma and Nayak (2005). Dr. H. Pathak, the current Director and his colleagues in 2018 compiled the contributions of CRRI and rice researchers in their book 'Rice Research for Enhancing Productivity, Profitability and Climate Resilience'. Besides, the details of the research programmes and the achievements made by the scientists of the Institute are regularly documented in the Annual Reports of the Institute.

The classical and innovative research carried out in the Institute include (i) *indica* x *japonica* hybridization leading to release of ADT 27 in India, Mahsuri and Malinja in Malyasia and Circna in Australia, (ii) collection of a large number of germplasm, their evaluation, conservation and utilization in rice

breeding, (iii) pioneering work on water management in rice fields, (iv) Pankaj x Jagannath crosses for development of varieties in rainfed lowlands, (v) development of irrigated rice variety Ratna using genes from semi-dwarf rice variety and a tall *indica* rice variety, (vi) incorporation of *Sub-1* gene into rice variety Swarna and development of submergence tolerant variety Swarna *Sub-1* in collaboration with IRRI, (vii) knowledge development on chemistry of submerged soils, chemical kinetics of nutrient transformation, (viii) development of full proof technologies of efficient nutrient management in rice crop production and (ix) integrated management of pests and diseases in Crop Protection Division, (x) development drought and blast tolerant resilient varieties for special ecology of rainfed uplands, (xi) efficient P nutrition management through native microbial support system in acid soils of rainfed uplands (Ramiah,1971;Padmanabhan, 1973; Mohanty and Patnaik, 1976;Rao, 1978;Richharia, 1979; Vamadevan and Jha, 1985; Panda, 2005; Roy, 2017; Pathak et al. 2018).

Since the Institute was established at the backdrop of the Great Bengal Famine, it had the sacred mission of alleviation of hunger, elimination of starvation death and eradication of famine from India by providing rice research support to the nation. There had been many paradigm shifts in rice research, especially with the introduction of semi-dwarf rice varieties from Taiwan. Many semi-dwarf high-yielding rice varieties were developed from CRRI, IRRI and other rice research Institutions. Adoption of these varieties and technologies of scientific management of water, soil, manures, fertilizers and bio-fertilizers as well as scientific management of pests and diseases resulted in breakthroughs in rice productivity and production during the period from late 1960s to early 1980s. Due to the concurrent advancements in rice research in CRRI and wheat research in IARI, the era of green revolution ushered in India. Thus, the mission of self-reliance in food front has been achieved in our country.

During the last few decades, CRRI (presently NRRI) has played a pivotal role not only in ensuring food security to all the people of our country, but also in transforming it from a food importing country to a food exporting country. The Institute has developed 133 improved and high-yielding rice varieties including hybrids with stress tolerance till 2017-18. Very recently in March, 2019 the Institute has developed 9 more new high-yielding rice varieties with tolerance to drought, flood and cyclonic wind. Currently, rice is grown in about 43 Mha in India as compared to that of 28 Mha in 1950. About 85% of the area is now covered with high-yielding varieties. The annual rice production of the country has increased from 20 Mt in 1950 to 112 Mt in 2017-18 with the concerted efforts of researchers, farmers, extension agencies and policy makers. The country is annually exporting about 10 Mt of rice. Rice has now become one of the major foreign exchange earners.

We need not, however, be complacent with these achievements because rice yield and for that matter, yield of any crop is a function of gene and

environment. Yield potential of any high-yielding rice variety developed even by the innovative breeding, can be realized only through sustainable management of land, soil, water, manures and fertilizers, adequate plant nutrition and protection of the crop from abiotic and biotic stresses. In this regard, Dr. M. S. Swaminathan has rightly said "The earth is a space ship with limited resources which, we may squander or pollute". Disproportionately higher crop production in intensive agriculture is normally associated with environmental degradations. As a consequence, the researchers and farmers are facing new challenges of climate change, low nutrient use efficiency, poor soil health, low water availability, lowering of the ground water table in semi-arid areas, increased emergence of pests and diseases and accumulation of pesticide residues in agricultural products. Besides, farmers are facing the problems of low profitability. Hence, NRRI is currently implementing the various research programmes in order to address the emerging problems and challenges.

In recognition of the outstanding contribution in the field of agricultural research and extension, several awards including Sardar Patel Outstanding ICAR Institution Award (2008) and ICAR-Best Annual Report Award (2016-17) were bestowed on the Institute. ICAR-NRRI is now progressing at an accelerated pace in respect of research infrastructure development as well as innovative rice research, keeping in view the farmers welfare.

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