Rainfed Lowland Rice:
Activities, Achievements and Aspirations

R Bhagawati, K Saikia, SK Ghritlahre, Md Azharudheen TP and B Raghavendra Goud

SUMMARY

Flood/submergence is critical constraints to rice production in lowland and deep water areas. Most traditional varieties are low yielder. These varieties can neither elongate fast nor survive inundation and suffer from lodging when water table recedes. Most of the varieties are not adapted to flash flood inundation. In North East India, low productivity of crop during rainy season is due to low incidence of solar radiation coupled with fluctuating light intensity with over cast cloudy sky coinciding mostly with reproductive stage, the most sensitive stage to low light stress. Weather related constraints, poor drainage and mostly acidic soils with iron and aluminium toxicity are also other limiting factors in realizing higher productivity of rice under rainfed lowland situation in N.E. India. Similarly in Assam during late *sali* the crop suffers from sterility due low temperature at flowering and *boro* rice suffers from cold injury during the early vegetative stage. Continuous rain during harvest cause (i) grain germination on the plant (ii) incomplete drying and (iii) high humidity mediated deterioration of grain quality.

Efforts were initiated to address these issues by specific varietal development programme with definite targeted objectives in RRLRRS, Gerua, Assam. High yielding rice varieties like Chandrama, CR Dhan 601 and CR Dhan 909 were developed at this research station suitable for both *Sali* and *Boro* seasons which have become popular preferred varieties of Assam. Similarly several numbers of advanced breeding materials were generated which are in the pipeline of varietal development. Development of required production and protection technologies for each variety suitable for the target environment are underway.

1. INTRODUCTION

Rainfed lowland rice comprises five micro agro-ecologies, which are classified based on hydrology, physiography, soil structures and landscape. These sub-ecologies, as mentioned below, strongly influence choices of cultivars and management practices.

- Shallow, favourable ecology;
- Shallow, drought-prone ecology;

- Shallow, drought-and submergence-prone ecology;
- Shallow, submergence-prone ecology;
- Medium-deep and waterlogged ecology.

In rainfed lowland landscapes, upper, middle, and lower fields tend to have distinct hydrological and soil characteristics: upper fields tend to be drought-prone, middle fields drought and submergence-prone, and lower fields submergence-prone. There is strong relationship between landforms and adoption of modern varieties. Farmers on alluvial plain riverine bed areas (with more favourable hydrology) tended to adopt modern varieties more readily than farmers of drought or flood-prone lands. The adaptation of cultivars developed for rainfed areas are now evaluated based on landform. In eastern India, for example, rainfed rice land is categorized as highlands, mediumlands, and lowlands. Farmers in this area choose varieties and use cultural practices appropriate to the category of field.

High minimum temperatures and low solar radiation directly reduces rice yield potential in many rice growing rainfed lowland areas. For instance, rainfed rice yields are low in eastern India and have not increased significantly in recent years. Researchers attribute these low yields, in part, to the area's high minimum night temperatures at tillering and floral initiation combined with low levels of solar radiation during the growing season (250-300 cal/m 2 daily). While radiation levels are stable throughout eastern India's wet season, minimum temperatures begin to drop during the late months, and crops that mature during this cooler period have higher yields. Many researchers found that rainfed lowland rice in eastern India, harvested in September had a mean yield of 3.3 t ha^{1}, but those harvested in late October had a mean yield of 4.5 t ha^{1}. While the productivity of rainfed lowland rice may be constrained by high temperatures at low latitudes, it may be limited by low temperatures at high latitudes of NE states. At latitudes greater than 17° N, temperatures are optimum for growing rainfed lowland rice only for a limited period; as minimum temperatures drop below 20ºC, immature rice crops experience poor panicle emergence and high spikelet sterility. Thus farmers must use shorter dration varieties which mature before the temperature drops. At the same time, monsoon, which is ever variable in terms of amount and pattern of precipitation, is the only source of water for rainfed lowland rice. So, varieties should mature within the normal span of monsoon whcih lasts in NE India during June to October. While there is a clear association between environmental factors and disease and insect incidence, the complexity and diversity of rainfed environments makes it difficult to provide detailed information on the occurrence of biological stresses. Currently, little or no pesticide is used in many rainfed areas. Integrated pest management can be developed for and applied in these areas before the use of pesticides becomes rampant. These rainfed areas then would avoid the problems associated with dependence on and overuse of pesticides. Host-plant resistance is an essential component of integrated pest management strategies which is being exploited for development of pest tolerant varities

There are several challenges for rainfed lowland rice farming system in Assam. More than 70% rice area in eastern India is rainfed. Threats of climate change being more prominent in rainfed ecology, it directly and adversely affects production and productivity of rainfed lowland rice. The rainfall pattern for last 10 years shows that there is a drop in rainfall amount during the month of July which affects the crop area coverage. It has been observed that there is raise in minimum temperature by 3.5ºC-4.5ºC from the mean of minimum temperature for last 10 years. In most rainfed lowlands, a single crop of rice is grown each year. This cropping pattern is typical for the less favourable sub-ecosystems, where long-duration, photoperiod-sensitive cultivars are generally grown. As population density increases, farm size decreases, marketing systems change and new technologies are adopted. Farmers are pressured to use the land more intensively, even in less favourable areas. So, the farmers need to introduce other upland crops after rice as per availability of moisture and change the rice varieties to photoperiod-insensitive HYVs beside modern cultural practices.

Regional Rainfed Lowland Rice Research Station (RRLRRS) was established in an area of 12.5 ha in village Gerua under Hajo circle of Kamrup district of Assam on Monday, the 15th September, 1997 as a regional station of ICAR-National Rice Research Institute, Cuttack with the following objectives:

- To explore, evaluate, conserve and exchange rice germplasm
- To develop high yielding rice varieties resistant/tolerant to different biotic and abiotic stresses for rainfed lowland ecosystem
- To generate appropriate agronomic and protection technologies for sustaining as well as increasing the productivity of rice-based farming system in rainfed lowlands
- To impart training to rice farmers, field functionaries, extension specialists and research workers on improved rice production technology and rice-based farming system

2. ACHIEVEMENTS

2.1. Rice germplasm

North East India being one of the centres of origin has got wide range of variation of rice cultivars. It has been estimated that at least 10,000 indigenous cultivars are prevailing in this region. Farmers have played a major role in conserving some of the traditional as well as improved varieties. The farmers of this region still grow their traditional cultivars which not only suit to their taste but also provide crop security, being highly adopted to the ecology. The NE India is also the home to many locally adapted aromatic *joha* and quality rice land races. Despite their low-yield potential, these cultivars are grown for their high market and social values. There are prominent cultivar groups within the aromatic rice gene pool of NE India.

Indian Agricultural Research Institute (IARI), New Delhi has collected 6630 accessions of rice from Assam during 1965-72 in cooperation with the International Rice Research Institute (IRRI), Philippines. That collection was known as the Assam Rice Collection (ARC), which is still in use for improvement of rice cultivars. RRLRRS has collected 803 accessions of rice germplasm from different places of Assam and NE Regions since inception and observations on days to 50% flowering, plant height and grain yield were recorded. These accessions were maintained at the station for development of new rice varieties and seed of 250 accessions were deposited in the gene bank of the ICAR-NRRI, Cuttack for conservation.

2.2. *Rice variety developed*

Central Variety Release Committee has released the rice variety Chandrama for the state of Assam in 2011. It was evolved at RRLRRS, Gerua, Assam from the cross between ARC 6650 and CR 94-721-3. Chandrama is a photo-insensitive variety which matures in 130-135 days during *kharif* season and 165-170 days during *boro* season. It has semi-dwarf plant type (105 to 115 cm) with 12-15 bearing tillers and long and compact panicle (22-25 cm). It is tolerant to leaf and neck blast, bacterial leaf blast (BLB), rice tungro disease (RTD) and sheath blight diseases. It is also having cold tolerance during vegetative stage. It has medium bold grain size with 67% head rice recovery. The variety has the potential yield of 5 t ha^{-1} during *kharif* and 6 t ha^{-1} during *boro* season.

Breeder Seed Production of Chandrama variety at RRLRRS Gerua

2.3. *CR Dhan 601*

CR Dhan 601 (CRG 1190-1; IET 18558) derived from cross Jaya/IR 64 is a highly promising rice variety under irrigated *boro* in the states of Assam, Odisha and West Bengal. It has semi-dwarf (90-95 cm) plant height with non-lodging, non-shattering and fertilizer responsiveness, produces 9-13 number of effective tillers.

It also has medium slender type grain, good cooking quality with cold tolerance at early vegetative stage. It is also having tolerant to leaf blast and RTV; moderately tolerant to brown spot and sheath rot; tolerant to yellow stem borer, green leaf hopper and leaf folder under natural conditions. It matures in 160 days during *boro* season with yield potential 5.6 t ha^{-1}.

2.3. *CR Dhan 909*

CR Dhan 909 (IET 23193; CRL 74-89-2-4-1) derived from cross Pankaj/ Padumoni is a highly promising rice variety under aromatic short grain category developed at RRLRRS, NRRI, Gerua (Assam). The culture was approved by the Varietal Identification Committee, in the 50th Annual Rice Group Meeting, for release in the states of Uttar Pradesh, Bihar, Assam and Maharashtra. It has semi-dwarf (105-100 cm) plant height, produces 9-12 number of effective tillers, 24-28 cm long panicles. It also has medium slender type grain, strong aroma, and good cooking quality with up to 70% head rice recovery. It is also having tolerant to leaf blast, neck blast, sheath rot and RTD diseases; tolerant to stem borer, leaf folder and whorl maggot under natural conditions. It matures in 140-145 days during *Sali* season with yield potential 4.5-5.0 t ha^{-1}. CR Dhan 909 yielded 5.01 t ha^{-1} as against 4.31 t ha^{-1} of local check "Ketekijoha" at village -2 No. Mazgaon under Darrang district of Assam during sali/kharif 2017. This variety was also tested at ICAR-NEH Tripura centre and its performance was better than the local check.

2.4. *Rice cultures developed*

Rice culture 'IET 23496' (CRL 2-12-7-2-3-2) yielding 5.3 t ha^{-1} in 163 days was developed for *boro* season. Another culture IET 24172 (CRL 193) has been developed which yields 5.5 t ha^{-1} and takes 165 days to mature in *boro* season.

2.5. *Advance breeding lines developed*

Advance breeding lines for the improvement of (i) *boro* rice, (ii) semi-glutinous and soft rice and (iii) short duration *ahu* rice have been developed. The range of yield performance of 124 breeding lines were 1008.33 kg ha^{-1} to 7441.67 kg ha^{-1} and few lines performed better than check Swarna-Sub1 (6635.33 kg ha^{-1}) and CR Dhan 909 (6366.67 kg ha^{-1}).

2.6. *Breeder Seed production*

Breeder seeds of Chandrama, CR Dhan 601, CR Dhan 909, Naveen and CR Dhan 310 varieties of rice have produced at RRLRRS, Gerua based on annual indent received from Department of Agriculture and Cooperation (DAC), New

Delhi. Nucleus seeds of Chandrama, CR Dhan 601 and CR Dhan 909 are maintained at the station and of Naveen and CR Dhan 310 are obtained from ICAR-NRRI, Cuttack for the production of Breeder category of seeds at Gerua, Assam.

2.7. Knowledge generation

2.7.1. Rice varieties suitable for agro-ecology of Assam

Rice varieties 'Naveen' and 'Abhishek' have been identified to be highly promising for growing as summer rice in Assam. Rice varieties 'Abhishek', 'Naveen' and 'Sahbhagi Dhan' have been identified suitable for growing as pre-flood *ahu* crop. Rice variety 'Abhishek' and 'Naveen' have been identified suitable for growing as post-flood late *sali* rice crop. Rice hybrid 'Rajalaxmi' (CRHR 5) and 'Ajay' (CRHR 7) have been identified promising for cultivation as *boro* rice in Assam. Rajalaxmi (CRHR 5) has also been identified suitable for cultivation as *sali* rice in rainfed shallow lowlands.

Optimum time of sowing of seeds for *boro* rice has been ascertained. Transplanting of Chandrama and Naveen on 25th January recorded the highest grain yield (6.45 t ha^{-1}).

The maximum grain yields of Chandrama and Naveen (6.23 t ha^{-1} and 4.73 t ha^{-1}) were observed with transplanting of 50 days old seedlings in *boro* season. Increase in the age of seedlings from 60 to 90 days showed progressive reduction in yield.

2.7.2. Plant spacing in rainfed lowlands

Transplanting of Naveen at 15 cm x 15 cm spacing recorded grain yield of 4.27 t ha^{-1} which was on a par with double transplanting at 15 cm x 15 cm spacing (4.36 t ha^{-1}) under post-flood situation in rainfed lowland ecosystem.

Normal transplanting of *sali* rice under post-flood situation in rainfed lowland ecosystem recorded higher grain yield than double transplanting and wet direct sown. Normal transplanting of Abhishek at 15 cm x 15 cm spacing recorded higher grain yield (5.60 t ha^{-1}), as compared to wider spacing and double transplanting or direct wet seeding.

2.7.3. Nutrient management in rainfed lowland ecosystem

Application of 60 kg N ha^{-1} based on LCC along with PK @ 30:30 kg ha^{-1} in late planted *sali* rice (under post-flood situation in rainfed lowland ecosystem) recorded highest grain yield of 4590 to 4650 kg ha^{-1} which is *on a par* with the treatment 50 kg N based on LCC along with PK @ 25:25 kg ha^{-1} yielded 4360 to 4480 kg ha^{-1}.

2.7.4. Ratoon crop

RRLRRS, Gerua has identified Naveen variety as suitable for ratoon, which can produce more than 50% grain yield of main rice crop in *sali* season. Results revealed that 15th February planting was optimum time for transplanting to obtain the maximum ratoon crop yield with the highest production efficiency. However, both 25% and 50% recommended doses of nitrogen provided significantly higher grain yield over control but it remained statistically at par with each other. Application of 25% recommended doses of nitrogen in ratoon crop provided higher grain yield (2.25 t ha^{-1}) of ratoon crop.

2.7.5. Cropping system

Rice (*Sali*) - rapeseed system yielded higher net return (Rs. 59396 ha^{-1}), production efficiency (35.04 kg ha^{-1} day^{-1}) and B:C ratio (2.29) as followed by rice-lentil/linseed systems. Rice-linseed cropping system in rainfed lowlands recorded maximum REGY (6.98 t ha^{-1}), net return (Rs. 56934 ha^{-1}) and B:C ratio (2.17) while production efficiency (35.04 kg day^{-1} ha^{-1}) was the maximum with rice-rapeseed cropping system which was due to shorter duration and higher productivity.

Application P_2O_5 @ 60 kg ha^{-1} in *kharif* rice of rice-rape seed system resulted the maximum grain yield of rice (4.58 t ha^{-1}), which was significantly higher over control but at par with 20 and 40 kg ha^{-1} of P_2O_5. Sulphur (S) application of 20 and 40 kg ha^{-1} S significantly increased rice yield over control but remained at par with each other while rape seed yield increased significantly up to 40 kg ha^{-1} S.

Incorporation of green manure in *sali* rice can reduce inorganic fertilizer requirement by 50%. Green manuring in rice based cropping system recorded the maximum rice equivalent grain yield (7.1 t ha^{-1}), production efficiency (32.69 kg day^{-1} ha^{-1}), net return (Rs. 60989 ha^{-1}) and B:C ratio (2.29) as compared to rice residue incorporation.

2.7.6. Integrated Farming System

An integrated rice-fish-horticulture farming system has been developed for flood-prone lowland ecosystem of Assam . The components of the integrated farming system were rice in main field, fish in refuge, trenches and rice field (at appropriate water level) and vegetables, fruits, ornamental crops and agro-forestry on pond dyke. A crop sequence of rice-*utera* linseed/ khesari-rice was followed in the main field. Rice variety Ranjit and Anjali were grown during *sali* and *ahu* season respectively. Fingerlings of catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and common carp (*Cyprinuscarpio communis*) were released in the pond @ 6000 fingerling/ha 7 days after transplanting of *sali* rice. Ducks were introduced inthe pond.

Integrated rice-fish-horticulture farming system

Vegetable crops were cultivated on pond dyke throughout the year . Interventions made were lady's finger (var. F_1 Durga), yard bean (var., Reenu) during pre-wet season and wet season, green chilli (var., Tejswini) during wet and post-wet season. French bean, cauliflower, cabbage broccoli, radish, spinach and merrygold during dry season. Interventions made on the hanging platforms were of Pumpkin (var., Arjun), Ridge gourd (var., Malika), bitter gourd (var., Vivek), spine gourd (local) during wet season, bottle gourd and country bean during dry season. Fruit trees, *viz*. coconut, arecanut, Assam lemon, guava, mango and banana and 20 timber (teak) trees have been established on pond dyke.

Interventions of integrated rice-fish-horticulture farming system

Gross income generated from half a hectare of integrated rice-fish-horti farming system in rainfed, shallow lowlands of north eastern region can sustain an average small farm family. The integrated rice-fish-horti farming system can produce 19.68 t ha1 of rice equivalent yield per annum with employment generation of 408 man days per ha. Major contribution in terms of production and income comes from horticultural component (45.7%) followed by rice (25.2%) and fish (20.6%).

2.7.7. Insect-pests of rice in lowland situations

A survey was conducted for recording the incidence of insect-pests on *kharif* rice in flood prone areas of the state. Rice leaf folder (*Cnaphalocrosis medinalis*), stem borers (*Scirpophaga incertulas* and *S. innotata*), gundhi bug (*Leptocorisa acuta*) were found to be the major insect pests of winter paddy. Mealy bug (*Brevennia rehi* (Lindinger), an uncommon pest of rice in NE India was recorded causing mild to severe damage to rice in Baksa (27 ± 11.57 bugs/tiller), Hailakandi, Kamrup (3.8±2.21 per tiller), Nalbari, Udalguri and Goalpara districts of Assam. Number of white stem borer moth on deep water paddy (1.7 nos hill^{-1}) was more as compared to yellow stem borer moth (0.5 nos hill^{-1}) at Lakhimpur. Severe incidence of rice hispa (*Dicladispa armigera*) (1-4 adults plant^{-1}) was noticed at Gogamukh in Dhemaji district and Gohpur in Sonitpur district during 2016.

Severe infestation of swarming caterpillar in Assam

Swarming caterpillar (*Spodoptera mauritia*) and ear head cutting caterpillar (*Mythimna separata*) invaded winter rice crop in Assam and affected altogether 56,768 ha of winter rice crop in 27 of the state's 35 districts during 2016. The swarming caterpillar worst-affected districts are Sivasagar and Charaideo – where the worms affected 6,747 ha of winter rice. Altogether 3.1% of the acreage (18,82,756 ha) under winter rice was devastated by swarming caterpillar and armyworm. Invasion of winter rice by the swarming caterpillar was noticed during the 1st week of September.

Rice stem borers: Four species of rice stem borer, *viz*., yellow stem borer *(Scirpophaga incertulas)* (Lepidoptera: Pyralidae), Striped stem borer *(Chilo supressalis)* (Lepidoptera: Pyralidae), White stem borer *(Scirpophaga innotata)* (Lepidoptera: Pyralidae) and Pink stem borer *(Sesamia inferens)* (Lepidoptera: Noctuidae) were found to infest rice at RRLRRS, Gerua, Assam

Rice leaf folder: Catches of leaf folder moth in light traps installed in winter paddy field started at the first week of October in the year 2016 and moth population found to gradually increase in subsequent days and reached its peak of 11 moths/trap in the first week of November. Thereafter leaf folder moth population gradually declined till the third week of November. Grain yield loss of paddy for each per cent infestation of rice leaf folder on rice variety CR Dhan 909 was 45.67 kg ha^{-1}.

2.8. *Diseases of rice in lowland situations*

Commonly occurring fungal diseases in *kharif* rice (*sali*) were found to be sheath blight and brown spot followed by bacterial leaf blight, leaf blast and sheath rot, whereas neck blast and *bakanae* are important in *rabi* rice (*boro* and early *ahu*). False smut was found to be an emerging disease. *Tungro* disease sporadically occurs in different rice varieties across the seasons.

2.8.1. Rice tungro disease

Geographical distribution of rice *tungro* disease has been mapped in parts of Assam and Tripura. Incidence of rice *tungro* disease (RTD) was recorded in twenty-two districts of Assam.

Resistance screening revealed that IR 71606-2-1-1-3-3-1-2, Pankhari 203, PTB 18, PTB 21 showed resistant reaction against rice tungro disease and CR 2482-10, CR 2643-1, CR 2644-2, CR2647-5, CR 2649-7, CR2652-14, CR 2654-17, CR 2656-11, IC 516579, IR 68068-99-1-3-3-3, IR 71606-1-5-3-4-3-3-3, Jaymati, Matiyaburushu, Swarna, Swarna*sub1*, Purnendu, Anjali, Jaya, Jaymati, Kalong, Swarna,Lalbadal and Rangabao showed moderately resistant reaction. NRRI breeding lines, *viz*., CR 2656-11, CR 2652-14, CR 2916-8 and CR 2916-10 showed field resistance against *tungro*, under artificially inoculation using viruliferous green leaf hoppers. CR 2652-14 and CR 2916-10 showed moderate resistance against the disease. Cultivars IR 20, PTB 8, PTB 18, PTB 21, Shuli 2 and Utrirajapan showed resistant reaction against Gerua isolate of *tungro* disease whereas, Balimau Putih, Habigunj DW8, Utrimerah, and Pankhari 203 showed moderate resistance

2.8.2. Sheath blight *(Rhizoctonia solani)*

1035 entries were screened for their resistance against sheath blight disease (*Rhizoctonia solani* Kuhn). None of entry was found to be resistant against sheath blight and 232 entries showed moderate resistance reaction. Genotypes IET 17886 and IET 20443 were found to be moderately resistant to sheath blight disease while IET 20755, ADT 39 and Mansarovar tolerant to sheath blight.

2.9. Insect-pest management

- IPM module comprising of seed treatment with carbendazim @ 2 g kg^{-1} seed, application of pretilachlor at 5-7 DAT, cartap hydrochloride @ 25 kg ha^{-1} at 30 DAT and need-based application of insecticide
- Seed treated with Carbenzadim @ 2 g L^{-1} of water and seedling root dip in carbendazim @ 2 g L^{-1} of water recorded the lowest incidence of bakanae disease as compared seed treatment and root dip treatment with *Pseudomonas fluorescens* @ 3 x 10^6 cfu/ml.
- Use of scirpo-lure in funnel trap @ 20 ha^{1} for YSB, application of Flubendiamide @ 50 ml/ha at 30 DAT for lef folder.
- Azoxystrobin 25 SC (Amistar) @ 1.0 ml L^{-1} of water recorded the highest (52.50-53.98%) reduction in sheath blight disease incidence.
- *Trichoderma viridae* (pest Control India) reduced sheath blight incidence 49.50 to 53.82% as compared to 42.70 to 43.66% for the treatment Validamycine 3% L.

2.10. Weed management

Broad spectrum herbicides, *viz*., Pyrazosulfuron ethyl and Chlorimuron+Metsulfuron methyl and Bensulfuron methyl, have been identified suitable for controlling the weed menace in *boro* rice.

Two hand weedings at 25 and 50 days after transplanting of *boro* rice recorded the highest grain yield (7.2 t ha^{-1}) as compared to recommended chemical control measures

Hand weeding in *boro* rice highest grain yield (4.77 t ha^{-1}) but remained statistically *on a par* with the low volume pre-emergence herbicides. Pyrazosulfuron ethyl recorded higher grain yield (4.58 t ha^{-1}) followed by ready mix Chlorimuron+Metsulfuron methyl (4.54 t ha^{-1}).

3. PUBLICATIONS

Scientist of RRLRRS, ICAR-National Rice Research Institute, Gerua has published 42 research papers in the journals of national and inter national repute. Other publications of the station were 17 popular articles, 23 Technical bulletins, 2 books, 7 book chapters, 4 Technology bulletin and 14 paperwere presented in seminar/symposium/conference.

4. EXTENSION ACTIVITIES

RRLRRS has been popularising NRRI developed HYV rice varieties for different ecologies through conduction of FLDs in Assam (Table 1) and farmers have well adopted these varieties.

State Seed Sub-Committee of Assam recently included nine rice varieties developed from NRRI based on their performance at RRLRRS, Gerua *viz.*, CR Dhan 909, Swarna Sub-1, CR Dhan 310, CR Dhan 500, CR Dhan 501, CR Dhan 505, CR Dhan 506, CR Dhan 508 and CR Dhan 601 in state seed chain of Assam in 2018. Assam Seed Co-operation Ltd, Khanapara, Guwahati, Assam Seed Certification Agency, Ulubari, Guwahati, Duarbagori Cooperative Society limited, Kuthari, Nagaon and a few progressive farmers are the regular buyer of breeder seeds from RRLRRS, Gerua to meet the demand of Foundation and Certified seed for the state Assam (Table 2).

Table 1. FLD on HYV conducted by RRLRRS in Assam.

Variety	Total FLD area (ha)				
	2014-15	2015-16	2016-17	2017-18	2018-19
Naveen	10	17.5	24	2	5
Chandrama	10		10		
CR Dhan 909				5	
CR Dhan 310			4	2	7.5
Total area (ha)	20	17.5	38	9	12.5

Table 2. Breeder seed programme at RRLRRS, Gerua, Assam

Variety	Quantity of breeder seed lifted (qtl.)				
	2014	2015	2016	2017	2018
Chandrama	0.50	25	21	4	30
Naveen		35	25	12	
CR Dhan 909		2		1	
CR Dhan 310				5	20
Total	0.50	62	46	22	50

RRLRRS has screened thousands of rice lines in AICRIP programme and contributed in developmental process of new varieties. The yield of the RRLRRS developed entry IET 23193 (CRL 74-89-2-4-1) ranked first (4908 kg ha^{-1}) and showed yield gain of 37% over the best check (LC) and Varietal Identification Committee has approved it for release.

Assam had witnessed severe incidence of swarming caterpillar and army worm on rice in 2016, which drew the attention of Directorate of Plant Protection, Quarantine and Storage, Faridabadand ICAR, New Delhi for the management of these pest menace. RRLRRS, Gerua actively participate in separate joint field visits with officials and scientists from DPPQ, NCIPM and NRRI, HQ in the affected areas and chock out strategies and advisories for the control the swarming caterpillar and armyworm on rice.

5. MAJOR PROJECTS

The following institute multi-disciplinary research programmes have been in operation at RRLRRS, Gerua to develop production and protection technologies for increasing productivity of rice in rainfed lowland,

- Development of rice genotypes for rainfed, flood prone lowlands (Completed)
- Soil and crop management for productivity enhancement in rainfed flood prone lowland ecosystem (Completed)
- Management of major rice-pests and diseases in rainfed, flood prone lowlands (Completed)
- Genetic improvement and management of rice for rainfed lowlands (on going)

6. LINKAGES

- Local Institutions: The research station has close collaboration with the Department of Agriculture, Government of Assam and Krishi Vigyan Kendras under ICAR & Assam Agricultural University for development and evaluation of varieties and farming system research.
- National Institutes and Agricultural Universities: Besides NRRI, Cuttack and the Indian Institute of Rice Research, Hyderabad, the station is collaborated with Assam Agricultural University, Jorhat (Assam) and ICAR Research Complex for NEH Region, Barapani (Meghalaya) for network research.
- International Institutes: The station is associated with the International Rice Research Institute, Manila, Philippines for evaluation and utilisation of germplasm of INGER nurseries.

- Extension & Development Agencies: The Station maintains close cooperation with Field Functionaries of the Department of Agriculture, Government of Assam and farmers of the region for transfer of technology.

7. ASPIRATIONS

Aspiration of RRLRRS, Gerua is to improve livelihood of the farming community who practices rainfed agriculture for cultivation of rice in lowlands of Assam. Low temperature at early vegetative stage in *boro* season prolonged the crop harvest and recurrent pre-monsoon flood cause heavy crop loss to *boro* and early *ahu* paddy cultivated in lowlands of Assam. Development of *boro* rice varieties of 145-160 days duration having low temperature tolerance at early vegetative stage and early *ahu* varieties of 100-120 day duration having drought tolerance with quick vegetative growth will escape pre-monsoon flood. Similarly, winter rice varieties of 130-140 days duration having medium slender grains and submergence tolerance will perform better in rainfed lowlands of Assam. Periodic soil amelioration and adoption of proper agronomic practices will definitely increase the productivity of rice in rainfed lowland of the state. Insect-pests, diseases and weeds are important constraints to rice production in rainfed lowland ecosystem and therefore development of integrated pest management strategies is equally important for enhancing rice production and productivity in Assam. The future activities of the station will focus on the following.

- Development of short duration rice varieties for pre-flood *ahu* season, medium duration, submergence tolerant varieties for *sali* season and varieties having low temperature tolerance at the early vegetative stage for *boro* season.
- Formulation of soil and crop management practices for rainfed lowlands
- Management of major and emerging biotic stresses of rice in rainfed lowland
- Dissemination of rice production technologies, inputs and capacity building of extension functionary and progressive farmers.

References

Adhya TK, Singh ON, Swain P and Ghosh A (2008) Rice in Eastern India: Causes for low productivity and available options. J Rice Res 2(1):1-5.

Mackill DJ, Cofffiman WR and Garrity DP (1996) Rainfed lowland rice improvement, International Rice Research Institute, P.O. Box 933, Manila, Philppines, pp 242.

NRRI-Annual Report 2016-17, ICAR-NRRI, Cuttack.

NRRI-Annual Report 2017-18, ICAR-NRRI, Cuttack.❄