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Technological interventions to enhance rice productivity and profitability in rainfed lowlands of Asom

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ABSTRACT

Improved technological interventions are important to sustain production and productivity of rice. A study was conducted by Regional Rainfed Lowland Rice Research Station, ICAR–National Rice Research Institute, Gerua, Kamrup in four districts of lower brahmaputra valley and north bank plains agro-climatic zones of Asom during *boro* seasons from 2012–13 to 2016–17 to enhance productivity of *boro* rice through introduction of latest rice varieties and application of improved production technology. Performance of open-pollinated varieties, viz. Naveen, Chandrama and CR Dhan 909, and hybrids, viz. Ajay and Rajalaxmi under application of improved production technology were demonstrated. At all the locations, application of improved technologies showed superior results in terms of growth, yield attributes, productivity and profitability over local checks under farmers' practice. Rice varieties with application of improved production technologies, increased mean grain yield by an average of 38.8% and extra earning of ₹18137/ha over existing farmer's practice with only ₹3632/ha extra expenditure on inputs. The mean gap indices,viz.extension gap (1.56 t/ha), technology gap (0.96 t/ha), technology index (14.5%) and mean B:C (4.99) clearly indicated the superiority of technological demonstrations over farmers' practices. The study also lays emphasis on the framing intensive technology transfer programmes like technological demonstrations on field to motivate the farmers for higher adoption rate of improved rice production technology.

Key words: *Boro* rice, Front line demonstrations, Improved production technology, Productivity, Profitability, Rice varieties

Rice (*Oryza sativa* L.) is the main staple food grain for people of upper to lower Brahmaputra valley region of Asom. Rice accounts for more than 90% of the total cultivated area of the foodgrain crops in the state which is 5.7% of the total rice area of the country while its share in national rice production is only 4.9% (GOI 2017). The total rice production in Asom is estimated to be around 5.14 million tonnes with average productivity of 2.1 t/ha, which is lower than the national average of 2.4 t/ha (GOI 2017). Thus, there exists a wide gap in the available improved crop production techniques and its actual adaptation by the farmers which gets reflected through poor yield of rice in the farmer's fields in the region (Harish *et al.* 2017). The main reason of low productivity is poor crop management practices like use of aged seedlings, low and imbalanced use of fertilizers and weed infestation. Moreover, the popular rice varieties such as *Baismuthi*, *Chinaboro, Kanaklata* and other local landraces are grown during early *ahu* season (*boro*) which are long duration (>180 days) or poor yielder. *Boro* rice is known for high productivity (5 to 6 t/ha) in shallow lowlands of Asom, where productivity has traditionally been very poor (<1 t/ha) during the *kharif* (Singh 2002). This is mainly because *boro* is more manageable than the *kharif* rice. But the productivity of *boro* rice under shallow lowland in north-eastern states is 2.1 t/ha which is comparatively lower than that of the national average productivity of 3.2 t/ha (GOI 2011).Technological interventions are the prime mover of change and thus, technology fatigue and technology gap should be avoided (Choudhary and Suri 2018a). It is important to have technology breakthrough in rice which could push the production trajectory path upwards and achieve a higher and sustainable growth rate in rice as well as sustaining food security (Choudhary and Suri 2013; Dass *et al.* 2016). Thus, there is tremendous scope of increasing the production and productivity of rice by adopting medium duration rice variety and improved production technologies (Singh 2002; Choudhary and Suri 2014a, 2014b; Harish *et al.* 2017). Only a little new knowledge percolates to the farmer's field, hence, a vast gap has been observed between knowledge production and knowledge utilization (Choudhary and Suri 2014a, 2014b). Hence, front line demonstrations (FLDs) on rice varieties released by ICAR–National Rice Research Institute have been conducted during *boro* and *kharif* seasons during 2012–13 to 2016–17 with the aim: (i) to improve the productivity and profitability

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of rice farmers through technological interventions of high yielding rice varieties with recommended package of practices and (ii) to analyse the technological gaps in rice farming in the region.

MATERIALS AND METHODS

FLDs on high yielding rice varieties along with improved production technology were conducted on 289 farmers' fields covering 115 ha area in 14 villages of four districts of Asom, viz. Champupara Pathar and Laruajan of Kamrup; Galdighala, Ghoga, Burlutpar, Sunger Bari and Mukhkuchi of Nalbari; Gelaidingi, No. 2 Mazgaon, Naogaon and Gorakhat of Darrang; Hokradoba, Luisgaon,Puroni Hapagaon of Udalguri from 2012–13 to 2016–17 in partially irrigated lands in *boro* season.The climate of the region is characterised by heavy monsoon downpours reducing summer temperatures and affecting foggy nights and mornings in winters whereas, moderate rainfall and temperature during spring (March-April) and autumn (September-October). The soils of the region are light black to sandy clay loam in texture, low in available N and P and medium in available K.The constraints in rice production in the region were identified through participatory rural appraisal, farmer meetings and training programmes, field survey and field diagnostic visits during crop growth period in the previous years following the procedures as followed by Choudhary and Rahi (2018) and Choudhary and Suri (2018a). It was found that the low yield of rice conceived is due to lack of suitable medium-duration rice variety, imbalanced use of fertilizers, aged seedling, infestation of weeds and improper crop geometry. Based on the problems identified, FLDs were conducted at farmer's field while using high yielding rice varieties, viz. Chandrama, Naveen and CR Dhan 909 and hybrids, viz. Ajay and Rajalaxmi. The most important characteristics of rice varieties and hybrids are depicted in Table 1.The plot size under each demonstration was 0.2 to 0.4 ha. Seed @ 30 kg/ha, fertilizers @ 80:40:40 kg/ha N–P_2O_5–K_2O and pre-emergence herbicide (Pretilachlor) @ 1.0 kg a.i/ha were provided to the farmers' as critical inputs with improved crop production technologies as intervention during the course of FLD programme.The seeds were treated with Carbendazim @ 2 g/kg seed. Nursery was raised between last week of December and second week of January in

Table 1 Description of rice varieties used in the demonstrations.

Cultivar	Pedigree/parentage	Source	Characteristics
Naveen	Sattari/Jaya cross	ICAR-National Rice Research Institute, Cuttack	Semi-dwarf plant type (100 to 115 cm) with 10-15 bearing tillers and long panicle (24-25 cm). Resistant to blast, gall midge biotype 5 and 1 and stem borer, and tolerant to brown spot disease. Medium bold grain size with 66.5% head rice recovery and elongation ratio of 1.76. Matures in 120 days (*kharif/sali*); 145-150 days (*boro/ahu*)
Chandrama	ARC 6650/CR 94-721-3	RRLRRS, ICAR-National Rice Research Institute, Gerua, Asom	Semi-dwarf plant type (105 to 115 cm) with 12-15 bearing tillers and long panicle (22-25 cm). Tolerant to leaf and neck blast, bacterial leaf blast, rice tungro disease and sheath blight. Cold tolerant during vegetative stage Matures in 135–140 days (*kharif/sali*); 170–175 days (*boro/ahu*) Medium bold grain size with 67% head rice recovery. Potential yield >5 t/ha (*sali/kharif*); 6.5–7 t/ha (*ahu/boro* season)
CR Dhan 909	Pankaj/Padumoni	RRLRRS, ICAR-National Rice Research Institute, Gerua, Asom	Suitable for rainfed shallow lowland and irrigated ecology Aromatic short grain Matures in 135–140 days (*kharif/sali*) Potential yield 4.5–5.5 t/ha (*sali/kharif*)
Ajay (Hybrid)	CRMS 31 A x IR 42266-29-3R	ICAR-National Rice Research Institute, Cuttack	Medium tall plants (110-115 cm) Duration: 125–130 days (*sali*); 155-160 days (*Boro*) Long panicle, spikelet fertility >85%, long slender grains Good milling (62%), cooking and eating quality Tolerant to leaf blast, brown leaf blight and stem borer Potential yield 5–6 t/ha (*sali/kharif*); 6.5–7.5 t/ha (*ahu/boro*)
Rajalaxmi (Hybrid)	CRMS 32 A x IR 42266-29-3R	ICAR-National Rice Research Institute, Cuttack	Medium tall plants (110–115 cm) Duration- 125–130 days (*sali*); 155-160 days (*boro*) Long panicle, spikelet fertility >87%, long slender grains Good milling (60%), cooking and eating quality Tolerant to leaf blast, brown leaf blight and stem borer Potential yield 5–6 t/ha (*sali/kharif*); 6.5–7 t/ha (*ahu/boro*)

boro season every year. Rice seedlings of 40–45 days were transplanted in the field during second fortnight of February every year. The FLDs were regularly monitored from nursery raising to harvesting. In case of local check (control plots), existing farmers' practices were followed (Table 2). Recommended dose of fertilizers were applied as urea, di-ammonium phosphate and muriate of potash. Full dose of P_2O_5, 1/3rd of N and 3/4th of K_2O was applied as basal at the time of transplanting. Remaining N was applied in 2 equal splits at maximum tillering and panicle initiation stages, 1/4th of K_2O was applied as top-dressing at panicle initiation. A thin film (2-5 cm) of water was maintained during dry period of February-March and April onwards frequent pre-monsoon showers met the water requirement of crop almost every year.

An off-campus training programme was organized before conducting the demonstrations for the selected farmers of the respective villages to impart technological knowledge on improved rice production techniques. All other steps like site selection, layout of demonstrations, farmers' participation etc. were followed as suggested by Choudhary and Suri (2014a, 2014b). The observations on plant growth and yield attributes were recorded from 10 representative hills from five different locations of five farmers' fields from each village (Rana *et al.* 2014). Grain yield of demonstrations and farmers' practice were recorded through crop cutting technique from net plot size of 25 m^2 area of five farmers' fields of each location following standard procedures as suggested by Rana *et al.* (2014). The crop was harvested between last week of May and second fortnight of June every year. The various indices of gap analysis were derived from the grain yield and economic returns as suggested by Choudhary and Suri (2014a, 2014b) and Yadav *et al.* (2015). The details of these indices are given below:

Technology gap (t/ha) = Potential yield (P1) – Demostratd yield (D1)

Extension gap (t/ha) = Demonstrated yield (D1) – Farmer's practice yield yield (F1)

Technology index (%) = (P1 – D1)/P1 × 100

Additional return (₹/ha) = Demonstrated return (Dr) – Farmer's practice return (Fr)

Effective gain (₹/ha) = Additional return (Ar) – Farmer's practice return (Fr)

Benefit cost ratio (B : C) = Additional return (Ar)/ Additional cost (Ac)

RESULTS AND DISCUSSION

Maturity, growth and yield attributes: The maximum demonstrations (171) were of Naveen variety covering 70 ha area followed by Chandrama. The main reason of having more demonstrations on Naveen was due to its suitability in the region as it took minimum duration in maturity, i.e. 152 days and harvested in the last week of May every year which helps escape the crop from early flash floods at time of maturity. Chandrama with farmers' practice generally suffered flooding during harvesting in the mid-June at Nalbari and Kamrup districts demonstrations. Chandrama and local checks of farmers practice took the maximum duration (165–168 days) in maturity followed by the hybrids. But it was observed that if Chandrama was transplanted between the last week of January and first week of February, it resulted in highest grain yield and also escaped from flash floods. The maximum plant height (124.3 cm) was recorded in CR Dhan 909 followed by Rajalaxmi and Chandrama, respectively. However, local checks recorded minimum plant height. The average values of yield attributing characteristics, i.e. number of tillers,

Table 2 Technological interventions and gap between improved demonstrations and farmers'practice in rice

Particulars	Technological interventions in demonstrations	Farmers practice	Technology gap
Farming situation	Well irrigated and light black to sandy clay loam	Well irrigated sandy clay loams	No gap
Land preparation	3–4 ploughings	3–4 ploughings	No gap
Fertilizer doses (kg/ha)	80:40:40 ($N–P_2O_5–K_2O$)	60:30:20 ($N–P_2O_5–K_2O$)	Partial gap
Variety	Naveen, Chandrama, Ajay, Rajalaxmi and CR Dhan 909	Luit and Baismuthi China *boro* (Local)	Full gap
Seed rate (kg/ha)	30.0	45–50	Higher
Seed treatment	Bavistin @ 2g/kg seed	Nil	Full gap
Age of seedlings	40 days (*boro*)	70–80 days (*boro*)	Higher
Planting method	Line transplanting (20 × 15 cm)	No line transplanting	Full gap
Plant population (m^{-2})	34 hill	45–48	
Weed management	Pre-emergence Pretilachlor @ 1.0 kg a.i./ha	Partial one hand weeding at 40–50 days after transplanting	Partial gap
Plant protection	Need based application of Carbofuran 3G @ 25 kg/ha	No plant protection measures	Full gap
Water management	Maintain thin film of water up to panicle initiation (mention depth)	Flooding during the crop growth period and irrigation water at flowering stage	Partial gap

Table 3 Growth and yield attribute of rice varieties under front line demonstrations and local checks (average of all locations over the years)

Variety	No. of demonstrations	Area (ha)	Yield potential (t/ha)	Maturity duration (days)	Plant height (cm)	Tillers (m^2)	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/ panicle
Naveen	171	70	6.5	152	114.6	419.7	25.7	131.85	27.2
Chandrama	51	18	6.5	168	115.2	399.4	25.5	149.2	22.6
CR Dhan 909	21	7	6.0	155	124.3	366.5	25.3	136.4	23.6
Ajay (Hybrid)	25	10	7.5	160	112.5	416.2	25.6	158.2	23.6
Rajalaxmi (Hybrid)	21	10	7.0	160	116.2	408.5	25.8	152.8	21.9
Local checks	-	-	-	165	102.8	312.6	23.6	114.3	21.5

panicle length, filled and unfilled grains per panicle were quite higher than that of local checks of farmers practice (Table 3).The average maximum number of tillers (m^2) was recorded with Naveen followed by Ajay and Rajalaxmi hybrids, respectively. However,panicle length of all demonstrated varieties was almost similar except CR Dhan 909. Both hybrids recorded higher number of filled grains per panicle and lower unfilled grains per panicle which was closely followed by Chandrama. Whereas, Naveen recorded lower number of filled grains per panicle and higher number of unfilled grains per panicle but higher number of tillers per m^2 might have compensated the grain yield. Local checks in farmers' practice recorded the minimum values of tillers, panicle length, filled and unfilled grains per panicle which resulted in lower grain yield. The differences in growth and yield attribute parameters might be due to varietal characteristics (Jiang *et al.* 2007). However, all demonstrated varieties were found superior in terms of growth and yield attributes over local checks of farmers' practice. Choudhary and Suri (2014a, 2014b) and Yadav *et al.* (2015) also recorded higher values for growth and yield attributes from demonstrations over local controls in various crops.

Grain yield and gap analysis: The productivity of demonstrated rice varieties with improved production technology ranged from 5.1 to 6.2 t/ha with overall 5.6 t/ha whereas, local checks of farmers' practices recorded grain yield from 3.4 to 4.4 t/ha with overall mean of 4.1 t/ha (Table 4). The maximum grain yield of 6.2 t/ha and 4.4 t/ha was recorded during 2012–13 season whereas, during 2016–17 minimum grain yield of 5.1 t/ha and 3.4 t/ha was obtained from demonstrations and local checks of farmers' practices, respectively. It was mainly due to favourable weather parameters and rice hybrids in 2012–13. The yield advantage over farmers' practice ranged from 28.6 to 50.8% with an overall mean of 38.8% which proved the superiority of demonstrations with improved production technologies over local farmers' practices. These results are in corroboration with the findings of Yadav *et al.* (2015) and Rahi and Choudhary (2014, 2016). Increase in grain yield might be attributed to optimum utilization of all the production factors in the demonstrations accelerating better growth and yield parameters (Choudhary *et al.* 2010; Seema *et al.* 2014; Choudhary and Rahi 2018). The results of the demonstrations clearly indicate the impact of FLDs over the farmers' practices towards enhancing the yield of rice in rainfed lowland ecology of Asom (Choudhary and Suri 2014a, 2014b).

An extension gap of 1.19 to 1.83 t/ha in grain yield was found between demonstrated technology and farmers' practices during various years. The average extension gap of 1.56 t/ha was noticed which might be attributed to rice varieties and adoption of improved production technology in the demonstration plots which resulted in higher grain yield than the existing farmers' practices (Choudhary and Suri 2018a, 2018b). Higher values of extension gap emphasized to convince the farmers to adopt improved production technologies alongwith latest rice varieties to achieve higher productivity and profitability (Choudhary and Suri 2013, 2018a). The technology gaps ranged from 0.7 to 1.2 t/ha with overall average of 0.96 t/ha which indicates 14.5% lower grain yield of mean yield potential of

Table 4 Grain yield and gap analysis of improved technological demonstrations on rice at farmers' field (average of all rice varieties)

Year	Potential yield (t/ha)	Demonstred yield (t/ha)	Farmers' practice yield (t/ha)	Increase over Farmers' practices (%)	Extension gap (t/ha)	Technology gap (t/ha)	Technology index (%)
2012-13	7.0	6.2	4.4	41.7	1.83	0.80	11.3
2013-14	6.5	5.3	4.2	28.6	1.19	1.20	17.9
2014-15	6.5	5.6	4.3	33.6	1.42	0.90	13.5
2015-16	6.5	5.8	4.2	39.4	1.64	0.70	10.8
2016-17	6.3	5.1	3.4	50.8	1.70	1.20	19.2
Average	6.6	5.6	4.1	38.8	1.56	0.96	14.5

rice varieties. The minimum technology gap (0.7 t/ha) was obtained during 2015-16 whereas the maximum values of technology gap was estimated during 2013–14 and 2016–17 which indicates that local climate was more favourable in 2015–16 than that of 2013–14 and 2016–17. The variability in the technology gap might be due to variability in soil fertility, variability in adoption of crop management practices and local climatic conditions while minimum technology gap showed proper adoption of technology and favourable local climatic conditions (Paul *et al.* 2011; Yadav *et al.* 2015). Technology index is also very important index which indicates the feasibility of the demonstrated improved technology at farmer's field (Choudhary and Suri 2014a, 2014b). The technology index varied from 10.8 to 19.2% during course of study. On an average, technology index observed was 14.5% which indicates the efficacy of all rice varieties and technological interventions (Pooniya *et al.* 2015). Higher technology indexes (19.2% and 17.9%) during 2016–17 and 2013–14 reflected the inadequate efficacy of rice varietiesand technological interventions while lower technology indexes (10.8% and 11.3%) during 2015-16 and 2012-13 showed the feasibility of the technology, respectively (Choudhary and Suri 2014a, 2014b). Similar findings on extension gap, technology gap and technology index for field demonstrations were also reported by Yadav *et al.* (2015) and Rahi *et al.* (2014, 2016).

Economic analysis: The economic viability of improved production technology over farmers' practices was calculated on the basis of prevailing price of input and output cost (Table 5). It was observed that the cost of rice production under improved production technologies ranged from ₹ 45470 to 48150/ha with an average of ₹ 47008/ha as against ₹ 41550 to 44800/ha with an average of ₹ 43376/ha under local check of farmers' practice. The improved production technologies incurred an additional cost of production ranged from ₹2720 to 5970/ha with an average of ₹3632/ha over local check. The total cost of production (₹47520/ha) and additional cost of production (₹5970/ha) of demonstrations was at higher side during 2012–13 which was mainly due to higher cost of hybrid seeds. The gradual increment in the cost of production was due to increase in input costs and labour wages. The average additional cost (₹3632/ha) increased additional returns (₹18137/ha).The maximum values of total returns, net returns, additional returns and effective gain were calculated for 2015–16 season. However, minimum values for same were recorded during 2013–14 which was due to yield differences in the respective season. The maximum B:C ratio (7.39) was calculated during 2016–17 which might be due to better performance of demonstrations under stress conditions as compared to local check of farmers' practices. Nirmala and Muthuraman (2009) and Yadav *et al.* (2015) also reported that adoption of latest varieties alongwith improved production interventions by the farmers in rice resulted in higher economic returns.

Extension and feedback mechanism: The present study revealed that cultivation of rice with improved technologies has been found more productive and grain yield might have

Table 5 Economic analysis of improved technological demonstrations on rice (average of all varieties)

Year	Cost of production (₹/ha)		Sale price (MSP) of rice grains (₹/t)	Total Returns (₹/ha)		Net Returns (₹/ha)		Additional cost in demons. (₹/ha)	Additional return (₹/ha)	Effective gain (₹/ha)	B:C
	Technological demonstration	Farmer's practice		Technological demonstration	Farmer's practice	Technological demonstration	Farmer's practice				
2012–13	47520	41550	12500	77625	54792	30105	13242	5970	16863	10893	2.82
2013–14	45470	42750	13100	69889	54365	24419	11615	2720	12804	10084	4.71
2014–15	46550	43580	13600	76500	57256	29950	13676	2970	16274	13304	5.48
2015-16	47350	44200	14100	81780	58656	34430	14456	3150	19974	16824	6.34
2016-17	48150	44800	14700	75161	47040	27011	2240	3350	24771	21421	7.39
Average	47008	43376	13600	76191	54422	29183	11046	3632	18137	14505	4.99

increased due to rice varieties and timely and balanced use of inputs. To strengthen the research, the feedback from farmers was taken during the course of study. Most of the farmers liked the rice varieties along with improved production technology as most of the varieties were high yielding and of medium duration in comparison to their own local varieties. Among the varieties, Naveen was highly appreciated as it is shorter in duration and has slight drought tolerant characteristics. Timely weed management through pre-emergence herbicide and fertilizer management are highly appreciated by the farmers. During the course of study, 8 field days were organized at different locations involving all line departments for further extension of technology. The main indirect outcome of these demonstrations was the use of major part of the produce (except in case of hybrids) as seed. Institute also facilitated farmers to get their seed certified from Asom State Seed Certification Agency. Farmers sold their produce as certified seed to Asom State Seed Corporation and to the local farmers. Thus, intensive extension methodologies led to better technology adoption among the farmers in the study area (Choudhary *et al.* 2013; Choudhary and Suri 2018a; Choudhary and Rahi 2018).

It can be concluded that cultivation of recent and high yielding rice varieties with improved production technology may reduce the extension and technology gaps among practising farmers to a considerable extent and thus,may lead to increased rice productivity in the region. With adoption of improved production technologies, farmers can increase their rice grain yield by 38.8% with an additional return of ₹18137/ha by incurring additional cost of ₹ 3632/ha on the improved production technology/inputs. The high erextension gap also laid emphasis on motivating the farmers to adopt latest rice varieties coupled with improved rice production technology in the region. Thus, the FLD programme is highly effective extension tool in changing the attitude, skills and knowledge of resource-poor farmers and motivating them to adopt the improved package of practices of high yielding rice varieties.

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