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Quantifying yield and economics of improved rice (*Oryza sativa* L.) varieties through frontline demonstrations (FLDs) in Manipur

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Abstract
The study aimed at quantifying yield and economics of the performance of frontline demonstrations (FLDs) in terms of grain yield, extension gap, technological gap and economic gains in six improved varieties of rice in 9 districts of Manipur during 2016-17 to 2018-19. The data on selected parameters of demonstration plots as well as control plots were collected through experimental designs ('Control-Treatment') of social research. The results revealed that the average grain yield in demonstration plots of all the selected varieties of rice was higher than farmers practice with highest percent increase over the local check was recorded in var. RC Maniphou-7 (32.67%). The lowest extension gap and technology gap were observed in var. RC Maniphou-11 (7.5q/ha) and CAU-R1 (5q/ha). While the highest technology index was seen in RC Maniphou-7 (14.87%) variety of rice with respect to its potential yield. The study also shown that the highest additional income of Rs. 27325/ha in demonstration over local check was recorded in cultivation of var. RC Maniphou-13 with B:C ratio of 2.38. This was followed by var. RC Maniphou-10 (Rs. 27033/ha), RC Maniphou- 12 (Rs. 23550/ha) and CAU-R1 (Rs. 22153/ha). The results clearly indicate that the adoption of improved varieties of rice and recommended package of cultivation practices with scientific intervention by KVKs under frontline demonstration (FLD) programme contributes to increase the productivity and profitability of rice cultivation at farmers' fields in Manipur, which may be further improved by reducing the cost of cultivation, extension gap and technology gap.

Keywords: Rice variety, yield gap, frontline demonstration, extension gap, technology index.

Introduction
Rice (*Oryza Sativa* L.) is the major food crop of the Northeastern Region of India occupying an area of about 3.5 million ha with an average productivity of 1.77 t/ha which is much below the national average of 2.57 t/ha (Anon. 2018) [1]. The main problems associated with low rice productivity in the region is lack of knowledge about improved agricultural practices viz. crop establishment methods, high yielding cultivars, proper weed and nutrients management (Kumar *et al.* 2016, [10] Chatterjee et al. 2016) [4]. The poor farmers in the region lost their interest in rice cultivation due to declining in factor productivity and profitability with rise in input costs (Das *et al.* 2010) [6]. Besides, rice in the region covering around 61 per cent of gross cropped area has also wide interstate disparity in production and productivity. Over 10 million tonnes of rice is annually being imported in the region from the Central Pool to meet the food requirement of growing population. Therefore, self-sufficiency in rice production at household level and at regional level is the need of hour in Northeastern India. Farmers should be made aware of the new rice varieties and technologies through state extension personnel and news media followed by skill oriented training programmes to the farmers. In context to Manipur, livelihood of the people largely depends on agriculture and allied sectors and rice is the primary food and cultivated in an area of 236.71 thousand hectares and produced 607.82 thousand tonnes with productivity of 2.57 t/ha during 2017-18 in the state (According to Agriculture Department, Govt. of Manipur, 2018). In Manipur, rice is cultivated in 9 districts of the state, out of which 4 districts (Imphal East, Imphal West, Thoubal and Bishnupur) are under high productivity group and rest 5 districts namely; Chandel, Churachandpur, Tamenglong, Senapati and Ukhrul are in low productivity group. The triennium average area of high productivity group (yield > 2.5t/ha) of 4 districts was 1.11 lakh hectares in 2017-18

with 2.98 t/ha average productivity as against 2.23 t/ha triennium average productivity in the state. In this context, Krishi Vigyan Kendras (KVKs) in the state have been successfully conducting frontline demonstrations (FLDs) as part of their mandated activities on newly released/ proven variety(s) of rice with full package of practices on farmers' fields to showcase the production potential of the technology to participating farmers and collect the feedback information from the farmers for research system. During 2016-17 to 2018-19, a total of 329 demonstrations (FLDs) covering an area of 191.75ha were conducted by KVKs of the state at farmers' fields on selected 6 improved varieties of rice namely; CAU-R1, RC Maniphou-7, RC Maniphou-10, RC Maniphou-11, RC Maniphou-12 and RC Maniphou-13 with active participation of 380 farmers in different districts of the state. With this background, the present investigation was undertaken with the specific objectives to assess the performance of FLDs on different rice varieties in terms of grain yield, extension gap, technological gap and economic gains by the farmers so that the findings the study will be helpful to the concerned policy makers and other stakeholders to focus on the way forward for improving rice production and productivity in the state, vertically and horizontally.

Materials and methods

The analytical framework for the present investigation constituted the FLDs conducted by 9 (nine) Krishi Vigyan Kendras (KVKs) of Manipur (Imphal East, Imphal West, Thoubal, Bishnupur, Chandel, Churachandpur, Tamenglong, Senapati and Ukhrul) during 2016-17 to 2018-19 at farmer's field. In Manipur, a total of 329 demonstrations (FLDs) covering an area of 191.75 ha under selected rice varieties of CAU-R1, RC Maniphou-7, RC Maniphou-10, RC Maniphou-11, RC Maniphou-12 and RC Maniphou-13 were conducted by KVKs with active participation of 380 farmers in different districts of the state during the period (Table 1). Before conducting FLDs, a list of potential farmers was prepared by the concerned KVKs through group meeting as well as discussion with the state agriculture officials. Specific skill training was imparted to the selected farmers regarding different aspects of improved rice cultivation techniques in integrated crop management mode as suggested by Choudhary (1999) [5] and Venkattakumar *et al.* (2010) [18] as part of technological interventions. The farmer practice was considered as control plot/local check which was maintained by the farmers according to their own traditional cultivation practices with old varieties. In demonstration plots, use of quality seeds of improved varieties of CAU-R1, RC Maniphou-7, RC Maniphou-10, RC Maniphou-11, RC Maniphou-12 and RC Maniphou-13, line sowing, seed treatment, timely weeding, use of balanced fertilizers (using micro nutrient sulphur) and bio-fertilizer (Rhizobium, PSB) and plant protection measures were ensured. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale. The demonstration farmers were facilitated by KVK scientists by providing critical inputs and technical supports in performing field operations like sowing, fertilizer application, water management, insect-pests & diseases management, weed management, harvesting etc. The necessary steps for selection of site and layout of demonstration etc. were followed as suggested by Choudhary (1999) [5]. The data utilized for the analysis constituted both the secondary data as well as the primary data. The secondary data on existing state yield and potential yield of improved rice varieties were procured from the official documents and records prepared by Bordoloi *et al.* (2017) [3] and Singh *et al.* (2017) [14]. These data were utilized to assess the yield gaps at different levels such as potential level, state level, demonstration level and farmer level. Similarly, primary data were obtained both for the demonstration yield and farmer's yield of rice in the adjoining plots. The primary data were used for computing yield advantages, profitability and B:C ratio. As stated above both primary and secondary data were utilized for computation of parameters of yield gap and yield advantage. These parameters were operationalized and measured by following formula adopted by Dubey *et al.* (2018) [8] as detailed below.

Yield gap: Yield gap was the extent to which there was a difference in reported yields of rice at different levels with respect to its potential yield. It was calculated with respect to the potential yield of rice in comparison to state yield and farmers' existing yield. The yield gap was ascertained both in terms of absolute yield gap (q/ha) and in percent (%) terms using following formula separately at state level, demonstration level and farmers' level.

$$\text{Yield gap (\%)} = \sum_{i=1}^{n} (\text{Pyi} - \text{Ryi})\text{S, D, F}/\text{Pyi}$$

where, Pyi is the potential yield of ith farmer and Ryi is the reported yield for the ith farmer against the state (S), demonstration (D) and farmer (F) yield.

Yield advantage: Yield advantage was the extent of gain in the reported yield of different rice varieties at state level, farmers' level and potential level as against the average yield obtained in the demonstrations.

$$\text{Yield advantage (\%)} = \sum_{i=1}^{n} (\text{Pyi-Ryi})_{\text{S,F, P}}/\text{Dy}_i$$

where, Dyi is the demonstration yield of ith farmer and Ryi is the reported yield for the ith farmer against the state (S), farmer (F) and potential (P) yield.

The data outputs were also collected from FLD plots as well as control plots and finally the extension gap, technology gap, technology index, additional return along with the benefits-cost ratio were worked out (Table 4) as per the formula adopted by (Samui *et al*. 2000) [13] as given below:

Extension Gap = Demonstrated yield-Farmers' practice yield

Technology Gap= Potential yield- Demonstration yield

Additional Return = Demonstration return – Farmers practice return

$$\text{Technology Index (\%)} = \frac{\text{Potential yield-Demonstration yield}}{\text{Potential yield}} \text{ X } 100$$

$$\text{Benefit-cost ratio} = \frac{\text{Gross return}}{\text{Gross cost}}$$

The basic information from the farmer's field as well as feedback information were systematically recorded and analyzed to see the comparative performance of frontline demonstrations (FLDs) and farmer's practice (control) against each variety of rice.

Results and discussion

Cross-sectional analysis of existing rice productivity

The existing yield analysis of different rice varieties at state, potential, demonstration and farmer's level was worked out and the results are presented in Table 1. The results indicated that the average state yield for all the 6 varieties of rice was reported the same (3q/ha). In case of average potential yield, the var. RC Maniphou-13 was recorded with the highest yield level upto 65q/ha followed by RC Maniphou-7 (60q/ha), CAU-R1 and RC Maniphou-11 with 55q/ha each and RC Maniphou-10 and RC Maniphou-12 (50q/ha each). The highest average yield in demonstration plots was found in RC Maniphou-13 (56q/ha) which was followed by RC Maniphou-7 (51.08q/ha), CAU-R1 (50q/ha), RC Maniphou-11 (49.50q/ha), RC Maniphou-10 (46.12q/ha) and RC Maniphou-12 (43.5q/ha). While the average yield level in farmers' field (check), it was observed that the variety RC Maniphou-13 was recorded with the highest yield of 44q/ha as compared to other varieties of rice which ranged between 41.5q/ha (CAU-R1) and 37.16q/ha (RC Maniphou-12). The results clearly indicate that the overall yield level of improved varieties of rice was higher than those of the farmers practice. The findings are in conformity with that of Barma *et al*. (2018) [2]. The average per cent increment of 24.56% in yield of improved rice varieties in demonstration over local check created greater awareness and motivated the other farmers to adopt the improved package of practices of rice cultivation. These demonstrations also could establish close relationship and increased confidence level between farmers and scientists of KVKs in the state. The KVKs were successful to introduce those beneficiary farmers of FLDs to play a significant role as source of information and quality seeds of improved/ high yielding varieties of rice for further up-scaling among other farmers of nearby villages.

Table 1: Details of frontline demonstrations on improved varieties of rice (average over 3 years)

Variety	No. of demo	Area (ha)	Average Yield (q/ha)				% increase over check
			State level	Potential	Demo	Check (Farmers)	
CAU-R1 (Tamphaphou)	101	52.00	30.00	55.00	50.0	41.45	20.63
RC Maniphou-7	33	18.00	30.00	60.00	51.08	38.50	32.67
RC Maniphou-10	124	76.00	30.00	50.00	46.12	37.58	30.71
RC Maniphou-11	16	14.00	30.00	55.00	49.50	42.00	17.86
RC Maniphou-12	27	12.50	30.00	50.00	43.5	37.16	17.06
RC Maniphou-13	28	19.25	30.00	65.00	56.50	44.00	28.41
Total	329	191.75	-	-	-	-	24.56 (Av.)

Yield gap analysis

A perusal of data depicted in Table 2 revealed that the average yield gap at state level in term of percentage for all the 6 varieties of rice was calculated to be 86.11% with the highest yield gap (35q/ha=116.67%) in RC Maniphou-13 against its potential yield followed by RC Maniphou-7 (100%), CAU-R1 and RC Maniphou-11 with 83.33% each and RC Maniphou-10 and RC Maniphou-12 (66.67% each). The lowest yield gap of selected varieties of rice in demonstration field was recorded in RC Maniphou-10 (3.88q/ha=8.41%) as compared to other varieties which ranged from 5q/ha (10%) in CAU-R1 to 8.92q/ha (17.46%) in RC Maniphou-7. The average yield gap value of 12.83% in demonstration was much lower than their corresponding values of yield gaps at state level. This was perhaps due to the demonstration of selected improved varieties under close technical supervision by KVKs scientists with the trained farmers in adoption of improved cultivation practices in their specific local farming situations. While the existing farmer level yield gap with respect to potential yield was observed to be highest (21.5q/ha=55.84%) in RC Maniphou-7. The yield gaps of other remaining varieties of rice at farmer level with respect to their potential yields varied from 13q/ha (30.95%) in RC Maniphou-11 to 21q/ha (47.27%) in RC Maniphou-13.

Table 2: Yield gap analysis of frontline demonstrations on improved varieties of rice (average over 3 years)

Variety	Absolute yield gap (q/ha) w.r.t. potential yield			Percentage yield gap (%) w.r.t potential yield			Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
	SYG	DYG	FYG	SYG	DYG	FYG			
CAU-R1	25	5.00	13.55	83.33	10.00	32.69	8.5	5	9.09
RC Maniphou-7	30	8.92	21.50	100.00	17.46	55.84	12.58	8.92	14.87
RC Maniphou-10	20	3.88	12.42	66.67	8.41	33.05	8.54	3.88	7.76
RC Maniphou -11	25	5.50	13.00	83.33	11.11	30.95	7.5	5.5	10.00
RC Maniphou-12	20	6.50	12.84	66.67	14.94	34.55	6.34	6.5	13.00
RC Maniphou-13	35	8.50	21	116.67	15.04	47.27	12.50	8.5	13.08
Average	25.83	6.38	15.72	86.11	12.83	39.06	9.33	6.38	11.30

SYG- State Yield Gap, DYG- Demonstration Yield Gap, FYG- Farmer Yield Gap

The analysis of yield gap at different levels indicates that the prevailing yield level of rice varieties at state and farmer levels except demonstration against their potential yield is not convincing. This calls for more extension efforts on the part of the state agriculture personnel and other stakeholders towards dissemination of improved rice varieties and technical support to the farmers specially in hill districts of the state. The Table2 also shows that the lowest value of extension gap (6.34q/ha) was recorded in RC Maniphou-12 rice variety followed by RC Maniphou-11 (7.5q/ha), CAU R1 (8.5q/ha) and RC Maniphou-10 (8.54q/ha). The other two varieties viz; RC Maniphou-13 and RC Maniphou-7 were relatively higher in their extension gaps with 12.50q/ha and 12.58q/ha respectively as a result of higher demonstration yield. While the variety RC Maniphou-10 exhibited with the lowest technology gap of 3.88q/ha compared to other varieties of rice which ranged from 5q/ha in CAU-R1 to 8.92q/ha in RC Maniphou-7. The average technology index of 11.30% with the highest in case of RC Maniphou-7 (14.87%) clearly shows the feasibility and effectiveness of the demonstrated

technology at the farmer's field. With the calculated corresponding average values of 9.33 q/ha and 6.38q/ha in extension gap and technology gap, it implies that KVKs in the state of Manipur were successful in systematic transfer of technologies to the farmers of their respective districts through their mandated programmes and activities.

Yield advantage

Data depicted in Table 3 indicate that the highest state yield advantage with respect to demonstration yield was recorded in RC Maniphou-13 (26.6q/ha) with corresponding percent yield advantage of 88.33%. This was followed by RC Maniphou-7 with 21.08q/ha (70.26%) and CAU-R1 with 20q/ha (66.67%). The lowest state level yield advantage was seen in RC Maniphou-12 with 13.5q/ha (45%). With regard to quantitative yield advantage at farmers field, the maximum level of advantage i.e. 12.58q/ha (32.6%) was recorded in RC Maniphou-7 against its demonstration yield level of 51.08q/ha. This was closely followed by RC Maniphou-13 with 12.5q/ha (28.41%). The quantitative yield advantage of other varieties with respect to their corresponding demonstration yields ranged between 6.34q/ha (RC Maniphou-12) and 8.55q/ha (CAU-R1). Whereas negative values of results were shown in all the selected varieties of rice with respect to potential yield advantage against their corresponding demonstration yield level. As evident from the findings, it implies that there was significant scope for improvement of production and productivity of different varieties of rice at farmers' level in the state, which requires for special focus on those non-beneficiary farmers of the adjoining villages through technical interventions by KVKs on participatory mode.

Table 3: Yield advantage of improved rice varieties accrued due to frontline demonstration (average over 3 years)

Variety	Demo yield (q/ha)	Quantitative yield advantage (q/ha) w.r.t. demonstration yield			Percent yield advantage (%) w.r.t. demonstration yield		
		SYA	FYA	PYA	SYA	FYA	PYA
CAU-R1	50.00	20.00	8.55	-5.00	66.67	20.63	-9.09
RC Maniphou-7	51.08	21.08	12.58	-8.92	70.26	32.67	-14.87
RC Maniphou-10	46.12	16.12	8.54	-3.88	53.73	22.72	-7.76
RC Maniphou -11	49.50	19.50	7.50	-5.50	65.00	17.86	-10.00
RC Maniphou-12	43.50	13.50	6.34	-6.50	45.00	17.06	-13.00
RC Maniphou-13	56.50	26.50	12.50	-8.50	88.33	28.41	-13.07
Average	49.45	19.45	9.33	-6.38	64.83	23.22	11.29

SYA-State Yield Advantage, FYA-farmers Yield Advantage, PYA-Potential Yield Advantage

Economic advantage on the demonstrated technologies

The major economic indicators like gross cost (Rs/ha), gross return (Rs./ha), net return (Rs./ha), benefit-cost ratio (B:C ratio), additional gain/ profit (Rs./ha) and increase net return (%) were computed both for farmers field and demonstration plot (Table 4). The results presented in Table 4 revealed that the highest average gross return from recommended practice (FLD's) was seen in case of variety RC Maniphou-13 (Rs. 123800/ha) as compared to Rs. 92300 /ha in farmers practice of the same variety during the period of study. This yielded net return of Rs. 71800/ha in demonstration and Rs. 44475/ha in farmers practice after deducting the average gross cost of cultivation of the concerned varieties of rice. Among the five varieties, RC Maniphou-11 was observed with the lowest net return of Rs. 40000/ha, accounting B:C ratio of 1.81 in demonstration. The highest B:C ratio in demonstration field was also seen in RC Maniphou-13 (2.38), which might be due to highest yield level and high demand in markets compared to other varieties of rice in the state. While in case of farmers existing plots, the highest average net return was recorded in RC Maniphou-13 (Rs. 44475/ha) with highest B:C ratio of 1.93. This was followed by CAU-R1 (Rs. 34887/ha) and RC Maniphou-7 (Rs. 30750/ha). The net returns of other varieties varied from Rs. 23148/ha in RC Maniphou-11 to Rs. 20930/ha in RC Maniphou-10. These results are in accordance with the findings of Mitnala *et al*. (2018) [11], Gurumukhi and Mishra (2003) [9], Dhaka *et al.* (2010) [7] and Singh *et al.* (2018) [16]. Kumar *et al.* (2016) [10] on their study on productivity enhancement of rice through crop establishment techniques in Nagaland also revealed that gross returns, net returns and benefit-cost ratio was recorded significantly highest under ICM than the farmers practice. Hence, favourable benefit cost ratios proved the economic viability of the interventions and convinced the farmers on the utility of interventions. The programme of large scale frontline demonstrations could be popularized for other improved varieties of rice as well in order to increase farmers' income and to attain self sufficiency in rice production in the state.

Table 4: Economic analysis of the frontline demonstrations on improved varieties of rice (average over 3 years)

Variety	Demonstration plot (Rs./ha)				Farmer existing plot (Rs./ha)				AG (Rs./ha) in FLD's	% increase net return
	GC	GR	NR	B:C ratio	GC	GR	NR	B:C ratio		
CAU-R1	56110	113150	57040	2.02	52800	87687	34887	1.66	22153	38.83
RC Maniphou-7	55298	105000	49702	1.90	45500	76250	30750	1.60	18952	38.13
RC Maniphou-10	51912	99875	47963	1.92	47612	68542	20930	1.44	27033	56.36
RC Maniphou-11	49500	89500	40000	1.81	41007	64155	23148	1.56	16852	42.13
RC Maniphou-12	50000	95230	45230	1.90	46448	68128	21680	1.47	23550	52.07
RC Maniphou-13	52000	123800	71800	2.38	47825	92300	44475	1.93	27325	38.06

GC- Gross Cost, GR- Gross Return, NR- Net Return, AG-Additional Gain

With regard to additional gain/ profit, it was noticed that the variety RC Maniphou-13 emerged with the highest gain of Rs. 27325/ha closely followed by RC Maniphou-10 (Rs. 27033/ha) and RC Maniphou-12 (Rs. 23550/ha) due to FLDs at farmers field. The lowest additional profit (Rs. 16852/ha) due to demonstration was recorded in cultivation of RC

Maniphou-11 compared to other varieties of rice. In all, it was observed with significant feasibility and profitability in cultivation of selected improved rice varieties in all the districts of Manipur as evident from higher increase level of net returns which ranged from 38.13% in var. RC Maniphou-7 to 56.36% in var. RC Maniphou-10. The findings are in conformity with those of Singh *et al.* (2019) [17], Singh *et al*. (2017) [15] and Raj *et al.* (2013) [12].

Conclusion

The findings above revealed that all the selected varieties of rice namely; CAU-R1, RC Maniphou-7, RC Maniphou-10, RC Maniphou-11, RC Maniphou-12 and RC Maniphou-13 gave higher yield in recommended practice (FLD's) than farmers practice in the state of Manipur. There is a wide yield gap between research station technology and farmers' technology, which has resulted in lower yields in farmers' practices. The extension agencies should demonstrate effects of new technology in rice production and motivate farmers for adoption of new technology to bridge this wide yield gap between demonstration and farmers field. Economic analysis on different parameters also revealed that net returns and additional gains were recorded higher in recommended practice (FLD's), which implies that the FLD programme is an effective tool for increasing the production and productivity of rice and changing the knowledge, attitude and skill of farmers. The strategy of the Government is to focus on farmers' welfare by making rice farming viable activity. Farm viability is possible, when cost of cultivation is reduced, yield per unit of farm is increased and farmers get remunerative prices on their produce. KVKs in this state have significant role to play with widespread extension efforts towards effective transfer of appropriate rice technologies including disease-pest management strategies to farmers through their mandated activities with proper technical support. Farmers' awareness on improved technology through different innovative extension approaches including ICTs, FPOs, CIGs, FIGs, farmers' fairs/field days etc. as well as quality seeds availability of improved varieties are the key factors in increasing productivity of rice. The identified yield enhancing technology needs to be subsidized for wider adoption among the farmers in their local farming systems and enhancing production and productivity of rice in the state of Manipur.

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