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IDENTIFICATION OF FACTORS INFLUENCING YIELD GAPS IN MUSTARD, POTATO AND RICE IN SOME SELECTED AREAS OF BANGLADESH AND STRATEGIES TO MINIMIZE THE GAPS

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Abstract

On-farm trials funded by Krishi Gobeshona Foundation (KGF) were conducted at Shibganj(Bogra), Mithapukur (Rangpur), and Ulipur(Kurigram) upazilas to determine and minimize yield gaps in mustard, potato, boro, and T.Aman rice of Mustard/Potato-Boro-T.Aman rice cropping pattern during 2011-12. To conduct the trials, one bigha (1200 sq.m) land was divided into two- where trial plots received the recommended technology and farmers' plots (control) traditional technology. The trials were carried out with mustard, boro, and T.Aman rice at Shibganj and potato, boro, and T.Aman at both Mithapukur, and Ulipur locations. Fertilizers were applied according to BARC Fertilizer Guide, 2005 and plant protection measures taken following IPM techniques in trial plots. Traditional practices were followed in farmers' plots. Data on yield and yield components were taken and analyzed statistically using paired t-test. Gross return and gross margin were calculated based on production & variable costs and prevailing market price of the produces. The yield of mustard in trial plots was 49.7% (yield gap) higher than that in farmers' plots. The yields of potato in trial plots were 37.66% and 33.96% (yield gap) higher over farmers' plots at Mithapukur and Ulipur sites, respectively. Likewise, yields of boro rice at Shibganj, Mithapukur and Ulipur in trial plots were 16.67%, 22.03%, and 17.61% (yield gap) higher compared to those of farmers' plots. At all three locations, yields of T.Aman in trial plots were also 17.37%, 21%, and 23% (yield gap) higher over farmers' plots. In addition, gross return, gross margin, and BCR in trial plots were found higher than those of farmers' plots. Results revealed that yield gaps varying from 16.67% to 49.7% exist in boro, T.Aman rice, potato and mustard. The gaps could be attributed to difference in the use of variety and management practices in fertilizers and pests between trial and farmers' plots. The yield gaps might be minimized by using HYVs of crops and improved management practices, especially in fertilizers and pests at field level. It is, therefore, necessary to explore the scope to increase the yields of the crops by minimizing yield gaps using improved technologies. The support of extension agencies through demonstrations, field visits and monitoring is essential to minimize the yield gaps.

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Introduction

The concept of yield gaps in crops originated from different constraint studies carried out by International Rice Research Institute (IRRI) during the seventies. The yield gap comprises at least two components. The first component-Yield gap I is the difference between experiment/research station yield and the potential farm yield. The component is not exploitable. The second component of yield gap II is the difference between the potential farm yield and the actual average farm yield (Alam, 2006).The yield gap II is exploitable and can be minimized by deploying research and extension approaches and government interventions, especially institutional issues. The yield gap II in this paper has been discussed as the 'yield gap".

In Bangladesh, despite the technology developed by different National Agricultural Research System (NARS) institutes and extension agencies to disseminate the technologies, yield gaps exist in different crops of Bangladesh, such as rice, wheat, potato, oilseeds, pulses, etc. that range from 19% to about 64% of the potential yield (Alam, 2006; OFRD, 2007-2008, 2008-2009; Roy, 1997; Mishra, 2007.; Mondal, 2011).The yield gaps were also observed in rice, mustard and cotton in India (Aggarwal, 2008). It is, therefore, essential to minimize the yield gaps and increase the productivity of the crops to feed the growing population of the country. The present study was undertaken to identify the major reasons of yield gaps in rice, potato, and mustard in Potato/Mustard-Boro-T.Aman rice cropping pattern and suggest measures to minimize the yield gaps and thereby enhance the productivity of these crops.

Materials and Method

On-farm trials were conducted at the selected locations of three upazilas of Shibganj, Bogra; Mithapukur, Rangpur and Ulipur, Kurigram district. Potato-Boro-T.Aman is a major cropping pattern in Mithapukur, Rangpur, and Ulipur, Kurigram, while Mustard-Boro-T.Aman in Shibganj, Bogra. Trials were conducted in the fields of 15 farmers selected earlier. One bigha (1200 sq. m) of land was selected for each farmer to run the trials. The land was divided into two where trial plots received recommended technology and farmers' plots (control) traditional technology.

Shibganj, Bogra

On-farm trial was conducted at Shibganj, Bogra with mustard, boro, and T.Aman of Mustard-Boro -T.Aman rice cropping pattern during 2011-2012. The mustard variety BARI Sharisha-14 was used in the trial plots and local Tori-7 in farmers' plots. Seeding was late due to late harvest of T.Aman. The seeds were sown on 27 November 05 December 2011. The fertilizers applied were 85.3-15-37-13.3 kg/ha NPKS in farmers' plots whereas 80.6-26-23.5-10-1.6-0.5 kg/ha NPKSZnB

in trial plots. Half of N and all other fertilizers were applied during final land preparation. Rest of N fertilizer was used as top dress at 25 days after sowing. Irrigation was applied at 25 days after sowing only in trial plots. Karate (Lambda-Cyhalothrin) 25EC @ 1ml/l of water was sprayed at 3 days after germination (DAG) to control flea beetle and Rovral @2g/l at 40 DAG to control Alternaria blight in trial plots. No pesticide was applied in farmers' plots. The crop was harvested during 22-25 February 2012. At harvest, 10 randomly selected mustard plants from each plot were carefully uprooted to record the plant height, number of siliquae/plant and number of seeds/siliqua.

In Boro rice, BRRI dhan 28 was used in both trial and farmers plots. Thirty to thirty five days old seedlings were transplanted in the plots on 25-29 February 2012 at the spacing of 20 cm × 20 cm. Boro was planted late due to the late harvest of the previous crop (mustard). Fertilizer doses were 104-18-37.5-13.5 kg/ha NPKS in farmers' plots against 113-16-73-10-1.1 kg/ha NPKSZn in trial plots. The full amount of TSP, 2/3 of MoP, and full Gypsum were applied as broadcast and incorporated with soil during final land preparation. Rest 1/3 of MoP was applied in 5-7 days before panicle initiation stage. Urea was applied in three equal splits at 10 days after transplanting, at rapid tillering, and 5-7 days before panicle initiation stage. Virtako 40 WG @1.5g/10 l of water was sprayed at 40 DAT (days after transplanting) to control stem borer in both the plots. Irrigations were applied seven days after transplanting up to 25 days before harvest in both trial and farmers' plots. The crop was harvested during10-19 May 2012. At harvest, 10 plants from each plot were selected randomly to record data on plant height, no. of panicles per hill, and no. of grains/panicle. Thousand-grain weight was also recorded from each plot.

In T.Aman, variety BR11 was used in farmers' plots and BRRI dhan 49 in trial plots. Twenty five days old seedlings were transplanted in the plots on 24-31 July 2012 at the spacing of 25 cm × 25 cm. The fertilizers were applied @ 108-22.4-37.5-13.5 kg/ha NPKS in farmers' plots against 69-7-30-9 kg/ha NPKS in trial plots. The full amount of TSP, 2/3 of MoP, and Gypsum were applied as broadcast and incorporated with soil during final land preparation. Rest 1/3 of MoP was applied at 5-7 days before panicle initiation stage. Urea was applied in three equal splits at 10 days after transplanting, at rapid tillering, and 5-7 days before panicle initiation stage. Tilt@ 0.5 ml/l was sprayed at 40 DAT to control sheath blight and Virtako 40 WG@ 1.5g/10 l of water was sprayed at 45 DAT to control stem borer in both the plots. Supplementary irrigation was applied after 60 DAT in trial plots. The crop was harvested during 8-19 November 2012. At harvest, 10 plants from each plot were selected randomly to record data on plant height, no. of panicles per hill, and no. of grains/panicle. Thousand-grain weight was also recorded from each plot.

Mithapukur, Rangpur and Ulipur, Kurigram

For potato, the varieties Asterix and Cardinal were used in farmers' plots and Cardinal in trial plots in both the locations. Potato was planted on 2-5 December 2011. Late planting was due to delayed harvesting of previous T.Aman crop. Fertilizer doses were 140-30-90-10 kg/ha NPKS in farmers' plots whereas 115-70-150-20-4-2 kg/ha NPKS Zn B in trial plots at Mithapukur. Fertilizers were applied at 130-30-80-10 kg/ha NPKS in farmers' plots against 115-70-150-20-4-2 kg/ha NPKSZnB in trial plots at Ulipur. Half of N and all other fertilizers were applied during final land preparation. Rest of N fertilizer was used as top dress at 25 days after planting. Irrigation was applied two times at 20-25 and 45-50 days after planting at both the locations. Pesticides (Asataf @2g/l and Admire@ 0.5ml/l water) were used in trial plots 3 times up to 35 days after planting at 10 days interval against aphid. In case of farmers' plots, no insecticide was applied for controlling the insect. Fungicides (Dithane M @4g/l and Acrobat MZ@2g/l water) were used in trial plots six times up to 30 days after planting at seven days interval against late blight disease. In case of farmers' plots, fungicide (Indofil @5g/l) was used several times up to 30 days after planting at 5 days interval against late blight disease. Irrigation was applied twice at 20-25 and 45-50 days after planting. The crop was harvested during 1-3 March 2012 at both the locations. At harvest, 10 plants were selected randomly from each plot to record number of tubers/plant and weight of tubers/plant.

In Boro rice, variety BRRI dhan 28 was used in both farmers' and trial plots at both Mithapukur and Ulipur. Thirty to 35 days old seedlings were transplanted on 2-7 March 2012 at the spacing of 20 cm × 20 cm. Boro was planted late due to the late harvest of the previous crop. Fertilizer doses were 100-0-0-0 kg/ha NPKS in farmers' plots whereas doses were 115-0-40-15-0 kg/ha NPKSZn in trial plots in both the locations. The full amount of Gypsum and MoP were applied broadcast and incorporated with soil during final land preparation. Urea was applied in three equal splits at 10 days after transplanting, at rapid tillering, and 5-7 days before panicle initiation stage. Virtako 40 WG @1.5g/10 l of water was sprayed at 40 DAT to control stem borer in trial plots. Several irrigations were applied seven days after transplanting up to 25 days before harvest in both trial and farmers' plots at both the locations. The crop was harvested during 28 to 30 May 2012. At harvest, 10 plants from each plot were selected randomly to record plant height, no. of panicles per hill and no. of grains per panicle. Thousand-grain weight from each plot was also taken.

In T.Aman, variety BR11 was used in farmers' plots and BRRI dhan 49 in trial plots. Thirty to thirty three days old seedlings were transplanted in the plots on 16-20 July 2012 at the spacing of 25 cm × 25 cm. The fertilizers were applied @100-0-0-15 kg/ha NPKS in farmers' plots whereas doses were 69-7-20-7 kg/ha NPKS in trial plots at both the locations. The full amount of TSP, MoP, and

Gypsum were applied as broadcast and incorporated with soil during final land preparation. Urea was applied in three equal splits at 10 days after transplanting, at rapid tillering, and 5-7 days before panicle initiation stage. Folicur@ 2 ml/l and Tilt@ 0.5 ml/l were sprayed at 45 DAT to control sheath blight and Virtako 40 WG@ 1.5g/10 l of water was sprayed at 50 DAT to control stem borer in trial plots. In case of farmers' plot, Virtako 40 WG@ 1.5g/10 l of water was sprayed at 45 DAT to control stem borer in both the locations. Supplementary irrigation was provided after 60 DAT in trial plots only. The crop was harvested during 6-10 November 2012. At harvest, 10 plants from each plot were selected randomly to record plant height, no. of tillers per hill, and no. of grains per panicle. Thousand-grain weight from each plot was also noted.

Intercultural operations were done as and when necessary. Recommended management practices were followed in trial plots and traditional practices in farmers' plots at all locations. Fertilizers were applied according to the BARC Fertilizer Recommendation Guide, 2005 in trial plots. Plant protection measures were taken following IPM techniques in trial plots. Yield per plot was noted plot-wise and converted into yield/ha. Data on yield and yield component were taken and analyzed statistically using paired t-test. Gross return, gross margin, and benefit cost ratio (BCR) were calculated based on production cost and prevailing market price of the produces.

Results and Discussion

Site: Shibganj, Bogra

Seed yield of 1.55 t/ha in mustard was obtained from trial plots against 0.78 t/ha from farmers' plots. Yield was 49.7% higher (yield gap) in trial plots compared to that of farmers' plots (Table 1). Increase in yield of mustard in trial plots could be explained by higher number of seeds/siliqua and 1000- seed weight that might be accounted for by the use of quality seeds (BARI Sharisa 14), balanced fertilizers and better pest management, especially against aphid and Alternaria leaf blight. On the other hand, farmers used low yielding traditional variety Tori-7 and did not apply any Boron fertilizer that was vital for seed formation and seed yield in mustard (Hossain *et al.,* 2011). Besides, no pesticide was used by the farmers to control the pests. Similar yield gaps were noticed in mustard in earlier studies (OFRD, BARI 2007-2008, 2008-2009; Roy, 1997; Aggarwal, *et al.,* 2008 and ORC, BARI, 2002). Economic analysis showed that gross return and gross margin in trial plots were higher than those of farmers' plots. Benefit cost ratio (BCR) was as well higher compared to that of farmers' plots (Table 2).

Yield of Boro rice (variety BRRI dhan 28) in trial plots were 16.67 % (yield gap) higher compared to that of farmers' plots (Table 3). Higher yield in trial plot might be due to higher no. of panicles/hill, no. of grains/panicle, and 1000-

grain weight. It may also be pointed out that the variety BRRI dhan 28 was used in both trial and farmers' plots that might account for relatively low yield gaps at this site. Gross return, gross margin, and BCR were also found higher compared to those of farmers' plots (Table 4).

Table 1. Yield and yield contributing characters and yield gap of mustard in trial and farmers' plots at Shibganj, Bogra.

Treatment	Plant height (cm)	No. of siliquae/ plant	No. of seeds/ siliqua	1000-seed wt (g)	Average seed yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	84.62	90.57	25.29	2.46	1.55	2.55		
Farmers' plot	56.99	220.6	10.66	2.20	0.78	1.50	0.77	49.7
t value	16.39	56.86	12.04	4.51	27.09	12.38		
Level of significance	**	**	**	**	**	**		

Table 2. Economic analysis of mustard in trial and farmers' plots at Shibganj, Bogra.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	77500	2550	80050	42172	37878	1.90	31165
Farmers' plot	39000	1500	40500	33787	6713	1.20	

Market price of Mustard @ 50 Tk/kg, straw @ 1.0 Tk/kg

Table 3. Yield and yield contributing characters and yield gap of boro rice in trial and farmers' plots at Shibganj, Bogra.

Treatment	Plant height (cm)	No. of panicles/ hill	No. of grains/ panicle	1000-grain wt (g)	Average grain yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	100.2	15.20	79.59	19.98	5.76	5.87		
Farmers' plot	97.42	13.83	66.33	18.86	4.80	4.92	0.96	16.67
t value	7.18	5.8	7.19	2.03	8.51	10.33		
Level of significance	**	**	**	ns	**	**		

Yields and yield attributes of T.Aman rice at the site are shown in Table 5. Results showed that yield of T.Aman in trial plots was 17.37 % (yield gap) higher over that of farmers' plots. Higher yield of T.Aman in trial plot might be accounted for by the use of modern rice variety BRRI dhan 49, application of supplementary irrigation, and the balanced doses of fertilizers P and K in

particular. It may be mentioned that farmers used BR11 variety of T.Aman in their plots. None of the farmers applied supplementary irrigation due mainly to resource constraint. The results are in conformity with the findings of Alam (2006); Aggarwal (2008), KGF (2012), and Mondal (2011). Economic analysis for T.Aman is shown in Table 6. At this location also, gross return, gross margin, and BCR in trial plots were higher than those of farmers' plots.

Table 4. Economic analysis of boro rice in trial and farmers' plots at Shibganj, Bogra.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	86400	5870	92270	59607	32663	1.55	13148
Farmers' plot	72000	4920	76920	57405	19515	1.34	

Market price of paddy @ 15 Tk/kg, straw @ 1.0 Tk/kg

Table 5. Yield and yield contributing characters and yield gap of T.Aman rice in trial and farmers' plots at Shibganj, Bogra.

Treatment	Plant height (cm)	No. of panicles /hill	No. of grains/ panicle	1000-grain wt (g)	Average grain yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	100.6	13.49	107.4	23.5	4.95	5.12	0.86	17.37
Farmers' plot	103.3	11.81	102.5	22.0	4.09	4.29		
t value	2.30	0.223	3.06	0.264	2.18	0.18		
Level of significance	*	ns	**	ns	*	ns		

Table 6 . Economic analysis of T.Aman rice in trial and farmers' plots at Shibganj, Bogra .

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	76810	5120	81930	39445	42485	2.04	18014
Farmers plot	63495	4290	67785	43314	24471	1.56	

Market price of paddy @ 15 Tk/kg, straw @ 1.0 Tk/kg

Site: Mithapukur, Rangpur

Table 7 indicates that the tuber yield of potato in trial plot was 37.66 % (yield gap) higher over farmers' plots. Higher yield in potato in trial plot might be attributed by the higher no. of tubers/plant, higher weight of tubers/plant which in turn might be due to the use of quality seeds, balanced fertilizers, and proper pest management against late blight and aphid in particular. It was further observed that farmers applied lower doses of K fertilizer that was necessary for tuber formation in potato. Similar yield gaps in potato were found by Roy (1997), Mondal (2011), and Mishra *et al.* (2007). Economic analysis showed that gross return, gross margin, and BCR in trial plot were higher than those of farmers' plots (Table 8).

Table 7. Yield and yield contributing characters and yield gap of potato in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	No. of tubers/plant	Wt of tubers/plant (kg)	Average tuber yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	7.46	0.355	29.58	11.14	37.66
Farmers' plot	5.33	0.281	18.44		
t value	7.50	6.09	12.53		
Level of significance	**	**	**		

Table 8. Economic analysis of potato in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	Gross return (Tk /ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
Trial plot	295800	160350	135450	1.84	74700
Farmers' plot	184400	123650	60750	1.49	

Market price of potato @ 10 Tk/kg

Yield of Boro rice (variety BRRI dhan 28) in trial plots was 22.03% (yield gap) higher compared to that of farmers' plots (Table 9). Higher yield in trial plot might be due to higher no. of panicles/hill, no. of grains/panicle, and 1000-grain weight. Farmers did not use any PKS fertilizers that might account for low yield in their plots. At this location also, variety BRRI dhan 28 was used in both trial and farmers' plots that might explain relatively low yield gap. Economic analysis shown in Table 10 indicates that gross return, gross margin, and BCR were higher than those of farmers' plots.

Table 9. Yield and yield contributing characters and yield gap of boro rice in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	Plant height (cm)	No. of panicles /hill	No. of grains/ panicle	1000-grain wt (g)	Average grain yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	100.0	17.41	169.43	25.92	5.90	5.98		
Farmers' plot	98.1	15.93	127.98	25.81	4.60	4.82	1.30	22.03
t-value	4.90	0.335	3.76	0.0167	0.284	10.42		
Level of significance	**	**	**	ns	**	**		

Table 10. Economic analysis of boro rice in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	73750	5980	79730	50750	28980	1.57	15660
Farmers' plot	57500	4820	62320	49000	13320	1.27	

Market price of paddy@ 12.5 Tk/kg, straw @1.00 Tk/kg

Table 11. Yield and yield contributing characters and Yield gap of T. Aman rice in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	Plant height (cm)	No. of panicles/ hill	No. of grains/ panicle	1000-grain wt(g)	Average grain yield (t/ha)	Straw Yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	110	16.33	123.03	25.00	4.97	5.74		
Farmers' plot	108	14.55	108.88	24.05	4.05	5.86	0.92	20.21
t value	3.17	8.57	7.21	0.127	0.173	2.77		
Level of significance	ns	ns	**	ns	**	ns		

Table 12. Economic analysis of T.Aman rice in trial and farmers' plots at Mithapukur, Rangpur.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	62125	5740	67865	42580	25285	1.59	9920
Farmers' plot	50625	5860	56485	41120	15365	1.37	

Market price of paddy@ 12.5 Tk/kg, straw @1.00 Tk/kg.

Yields and yield attributes of T.Aman rice (variety BRRI dhan 49) at the site are shown in Table 11. Yield in trial plot was 20.21 % (yield gap) higher over that of farmers'. Higher yield of T.Aman in trial plot might be accounted for by the use of modern rice variety BRRI dhan 49, application of supplementary irrigation, and the balanced doses of fertilizers. At this location also farmers used BR11 variety of T.Aman in their plots. Farmers did not apply supplementary irrigation due mainly to resource constraint. The results are in conformity with the findings of Alam (2006); Aggarwal,(2008), KGF (2012), and Mondal (2011). Economic analyses on the crop is presented in Table 12. Results showed that gross return, gross margin and BCR in trial plot was higher compared to that of farmers' plots.

Site: Ulipur, Kurigram

At this site, the tuber yield of potato in trial plot was 33.96 % (yield gap) higher over farmers' plots (Table 13). Higher tuber yield in trial plot might be explained by the higher no. of tubers/plant, higher weight of tubers/plant and that in turn might be due to the use of quality seeds, balanced fertilizers, and proper pest management against late blight and aphid. It was further observed that the farmers at this site applied lower doses of K fertilizer that was necessary for tuber formation in potato. Similar yield gaps in potato were found by Mishra *et al.* (2007). Economic analysis presented in Table 14 indicates that gross return, gross margin, and BCR in trial plot were higher than those of farmers' plots.

Table 13. Yield and yield contributing characters and yield gap of potato in trial and farmers' plots at Ulipur, Kurigram.

Treatment	No. of tubers/plant	Wt of tubers/plant (kg)	Average tuber yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	9.94	0.419	27.06	9.19	33.96
Farmers' plot	6.79	0.279	17.87		
t value	18.92	13.54	12.7		
Level of significance	**	**	**		

Higher yield of 17.61% in Boro rice (variety BRRI dhan 28) in trial plot was observed over that of farmers' plots (Table 15). Higher yield in trial plot might be due to higher no. of panicles/hill, no. of grains/panicle, and 1000-grain weight. At this location as well, farmers did not apply any PKS fertilizer that might account for low yield in their plots. Gross return, gross margin, and BCR were also found higher in trial plots than those of farmers' plots (Table 16).

Table 14. Economic analysis of potato in trial and farmers' plots at Ulipur, Kurigram.

Treatment	Gross return (Tk/ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
Trial plot	270600	161050	109550	1.68	53400
Farmers' plot	178700	122550	56150	1.46	

Market price of Potato @ 10 Tk/kg

Table 15. Yield and yield contributing characters and yield gap of boro rice in trial and farmers' plots at Ulipur, Kurigram.

Treatment	Plant height (cm)	No. of panicles /hill	No. of grains/ panicle	1000-grain wt (g)	Average grain yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	100.5	19.97	143.96	25.93	5.85	5.92	1.03	17.61
Farmers' plot	98.3	17.01	123.79	25.00	4.82	4.89		
t-value	5.68	0.67	7.64	0.142	0.253	10.13		
Level of significance	**	**	**	ns	**	**		

Table 16. Economic analysis of boro rice in trial and farmers' plots at Ulipur, Kurigram.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	73125	5920	79045	51750	27295	1.53	12855
Farmers' plot	60250	4890	65140	50700	14440	1.28	

Market price of paddy @ 12.5 Tk/kg, straw @ 1.00 Tk/kg.

Yield and yield attributes of T.Aman rice (variety BRRI dhan 49) at the site are shown in Table 17. Yield of T.Aman rice in trial plot was 23.0 % (yield gap) higher over those of farmers' plots. Higher yield in trial plot might be accounted for by the use of modern rice variety BRRI dhan 49, application of supplementary irrigation and the balanced doses of fertilizers. Here also farmers transplanted BR11 variety of T.Aman in their plots and did not apply supplementary irrigation. The results are in conformity with the findings of Alam (2006); Aggarwal (2008), KGF (2012), and Mondal (2011). Economic analysis

was also carried out for the crop. In this case as well, gross return, gross margin, and BCR in trial plot were higher than those of farmers' plots (Table 18).

Higher economic returns in trial plots observed at all three locations might be explained by higher yields due to the use of modern varieties (BARI Sharisa 14 in mustard, BRRI dhan 49 in T.Aman rice and Cardinal in potato) and proper management practices, especially in pest and water management (KGF, 2012).

Table 17. Yield and yield contributing characters of T. Aman rice in trial and farmers' plots at Ulipur, Kurigram.

Treatment	Plant height (cm)	No. of panicles/ hill	No. of grains/ panicle	1000-grain wt (g)	Average grain yield (t/ha)	Straw yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Trial plot	111	16.52	125.03	25.0	5.06	5.86		
Farmers' plot	107	14.05	106.26	24.0	4.02	5.20	1.04	23.00
t value	3.53	8.83	7.44	0.132	0.195	3.87		
Level of significance	**	ns	**	**	**	ns		

Table 18. Economic analysis of T.Aman rice in trial and farmers' plots at Ulipur, Kurigram.

Treatment	Gross return (Tk/ha)			Cost of production (Tk/ha)	Gross margin (Tk/ha)	BCR	Gross margin over farmer's practice (Tk/ha)
	Grain	Straw	Total				
Trial plot	63250	5860	69110	42230	26880	1.64	12290
Farmers' plot	50250	5200	55450	40860	14590	1.36	

Market price of paddy@ 12.5 Tk/kg, straw @1.00 Tk/kg

Recommendations

- Yield gaps exist in mustard, potato, Boro, and T.Aman rice of mustard/potato-Boro-T.Aman cropping pattern at all locations of the trial. It is, therefore, recommended to explore the scope to promote yields of the crops by minimizing the yield gaps using HYVs and improved management practices.
- Frequent interaction between researchers and extension personnel of the trial sites is essential for minimizing yield gaps in these crops. The researchers should develop appropriate technology package and extension personnel at the same time ensure adoption of such technology package by the farmers.

- Results of the on-farm trial conducted at different locations reveal that the farmers apply low and imbalanced doses of fertilizers and pesticides due mainly to resource constraints, It is, therefore, suggested that the farmers are supported by adequate credit facility in time from different institutional sources with easy terms and conditions.
- Farmers should be offered training on the importance of the use of balanced fertilizers, especially Boron and Potash ones in mustard and potato, respectively, for higher yield. They should as well be given training on different areas of pest and water management of the crops.
- It is also essential that adequate funds are released in time for organizing farmers' training programmes and field days on the production technology of the crops.

Conclusion

Results of the on-farm trials conducted at all locations clearly revealed that yield gaps varying from16.67% to 49.70% exist in Boro, T.Aman rice, potato, and mustard. The gaps could be attributed to difference in the use of variety and management practices in fertilizers and pests between trial and farmers' plots. The yield gaps might be minimized by using HYVs of crops and improved management practices, especially in fertilizers and pests at field level. Lower yield gaps obtained in Boro and T.Aman rice might be explained by the fact that farmers at all locations used modern varieties (BRRI dhan 28 and BR11). However, the trials have to be repeated for few more years to confirm the findings (yield gaps) obtained so far.

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