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FACTORS RESPONSIBLE FOR YIELD GAP OF WHEAT AT FARMERS' FIELD IN TWO DISTRICTS OF BANGLADESH

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ABSTRACT

The main purpose of the research was to identify factors responsible for yield gap in wheat production. Eighteen (18) experiments were conducted in two major wheat growing districts Rangpur and Dinajpur in two consecutive years. The selected varieties for the conducted research were Prodip, Satabdi and Sourav. All the experiments were established in farmers' fields providing all recommendations for wheat production. It was observed that yield gap varied with the variety and farmers to farmers and location to location. The overall yield gap of Prodip was the highest (18.43 percent) followed by Sourav (18.15 percent) and Satabdi (17.45 percent). Yield gaps of all the wheat varieties under study were higher in Rangpur site than Dinajpur site. The practice gap was the highest in gypsum application (69 percent) followed by boron (67 percent), sowing time (40 percent). Practice gaps in the application of MoP, TSP and irrigation were almost equal, 40 percent, 37 percent, and 36 percent respectively. Late sowing, non use of dolomite and micro nutrients (zinc and boron) in wheat yield with sub-optimal doses of phosphatic and potash fertilizers were the main reasons for yield gap. Adoption of short duration T. aman variety and optimal doses of chemical fertilizers with micro nutrients in wheat field could minimize this gap to a greater extent. Preventive measures against bird attack after sowing of seeds for optimum plant population would have impact in narrow down this yield gap as well.

Key Words: Yield gap, Wheat, Bangladesh

INTRODUCTION

Wheat is one of the main cereal crops is the world as well as in Bangladesh. It is considered to very important crop in several ways. It is grown in more than 240 million hectares in the world, an area larger than that of any other crop (Hanson *et. al.,* 1982). It is important cereal crops with respect to both acreage and production and currently it ranked second among the cereals in Bangladesh. It contributes more calories and protein than any other food crop. Presently, it constitutes about 15 percent of the staple cereal food of Bangladesh and it is the staple food for about one million people in as many as 43

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countries, providing 20 percent of the total food calories (Taslim, 1999). The annual production of wheat in Bangladesh is about 0.90 million tons which is cultivated in 0.38 million hectares of land with an average yield of 2.39 t/ha (BBS, 2011). This yield is very low compared to the yield obtained by the popular varieties in the research stations as well as the farmers' field demonstrations.

Generally adoption of modern technology and production practices vary across the farmers. Performances of varieties vary significantly from research station to farmers' field, even wide variations in yields are observed among the farmers. The factors of production are not used properly at farmers' level. Variation in different items of production package is mainly responsible for such kind of yield gap. Amount and quality of different inputs used and other management vary form one farmer to another. Thus, the potential yield level at farmers' field is not achieved in many cases. Sometimes farmers are found to be interested to cultivate crops with traditional management practices. Farmers cultivating HYVs of different crops also do not follow the recommended practices. As a result, the differences between potential yield and yield under farmers' practice are widened. The management practices and input use are likely to be influenced by various socio-economic factors. Keeping these facts in mind, the present study has been undertaken to fulfill the following specific objectives:

i. To quantify the yield gaps of wheat between achievable yield at researcher supervised farmers' plot and non-supervised plot;
ii. To identify the management related factors responsible for yield gap of wheat with their relative contribution; and
iii. To ascertain constraints faced by the farmers in cultivating wheat.

METHODOLOGY

In order to compare the wheat yield between maximum attainable yield and farm-level yield, in addition to research data, the empirical field data were also collected from two selected major wheat growing areas for two consecutive years. The wheat growing areas were the Sadar Upazila of Dinajpur district and Gangachara Upazila of Rangpur district. In total of 18 research plots were set up in farmers' field in order to assess the achievable yield of the wheat varieties. Nine research plots were set up in Dinajpur Sadar Upazila of Dinajpur district, while 09 research plots in Gangachara Upazila of Rangpur district. The wheat varieties were: Shatabdi, Shourav, and Prodip. The research plots were jointly conducted, monitored and supervised by the concerned farmers, SAAOs (DAE personnel) and researchers.

In order to compare the yield between the research plots and farmers' actual yield, field data were collected from the wheat growers of the selected Upazilas. Data were, however, collected from the sample rather than population. Random sampling procedures were used for determining the proportionate samples from the population.

Measurement of yield gap

Yield gap of a variety was measured on the basis of the difference between the achievable yield (kg/ha) of research plot yield and farmer's actual yield (kg/ha) obtained at the farmers' plot and then compared it to the percentage of achievable yield. Thus, the yield gap of a variety could vary from 0 to 100%. The following formula was used in this regards:

$$\text{Yield gap of a farmer} = \frac{\sum_{i=1}^{n}(P_i - Y_i)}{P_i} \times 100$$

Where,

P_i = Achievable yield (obtained at research plots) of a particular variety; and

Y_i = Actual yield the same variety harvested by a farmer.

Determining the practice gap in wheat cultivation

Yield of any crop depends on employment of some management practices. Managing all of the practices at optimum level might produce highest yield of a certain modern rice and wheat variety. But due to socioeconomic conditions in Bangladesh, farmers are not in a position to manage all the practices in a full swing rather they often apply sub-optimal level of these practices in wheat cultivation that resulted a gap between achievable yield and farmer's actual yield. Seed rate, seed quality, sowing time, irrigation and application of fertilizers (urea, TSP, MoP, gypsum and Boron) at the recommended dozes are regarded as yield determining factors, while practice gap for each yield determining factor, however, was measured on the basis of difference between recommendation and actual application. The formula used in this regard was as follows:

$$\text{Deviation proportion G} = \frac{R - A}{R}$$

Where,

G = gap;

R = Recommended practices for the variety; and

A = Actual practices done for the same variety.

As for example, the recommended dose of seed rate of a wheat variety was 120 kg/ha. Hence, the practice gap index for seed rate of a farmer in wheat cultivation was measured by the following formula:

$$\text{Practice gap index for seed rate of wheat cultivation} = \frac{\sum_{i=1}^{n} A_i \times G_i}{\sum_{i=1}^{n} A_i} \times 100$$

Where,

A_1 = Actual seed rate of a particular variety sowing in the first plot;

A_2 = Actual seed rate of a particular variety sowing in the second plot;

A_3 = Actual seed rate of a particular variety sowing in the third plot;

G_1 = Deviation proportion for the first plot;

G_2 = Deviation proportion for the second plot; and
G_3 = Deviation proportion for the third plot.

The same formulae were followed in computing practice gap indices in wheat cultivation. Seed rate, seed quality, sowing time, irrigation and application of fertilizers (urea, TSP, MoP, gypsum and Boron) were considered for wheat production. The recommendations that were used as the basis of deviation during calculation of practice gap have been presented in Table 1.

Table 1. Recommendation used for the calculation of practice gaps in wheat cultivation

Crop	Yield determinant practices						
	Seed rate (kg/ha)	Sowing time	Urea (kg/ha)	TSP (kg/ha	MoP (kg/ha)	Gypsum (kg/ha)	Boron (Kg/ha)
Prodip	120	15th to 30th Nov	175	175	110	110	7
Satabdi	120	15th to 30th Nov.	175	175	110	110	7
Sourav	120	15th to 30th Nov.	175	175	110	110	7

Source: DAE, 2003

FINDINGS AND DISCUSSION

Yield gap of wheat at rangpur (Gangachara) and Dinajpur (Dinajpur sadar)

Nine research plots on wheat varieties of Prodip, Satabdi, and Sourav were set up in Dinajpur Sadar Upazila of Dinajpur district, while 09 research plots of these varieties were set up in Gangachara Upazila of Rangpur district. The research plot yield, farmers' actual yield, mean yield gap of these varieties along with standard deviation have been presented in Table 2.

Table 2. Achievable yield and farmers' actual yield of wheat at different locations

Research Site	Yield of wheat	Variety wise achievable yield and farmers actual average yield (kg/ha)								
		Prodip			Satabdi			Sourav		
		1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Dinajpur Site	Achievable yield (Research plot yield)	4365	4395	4380	4210	4260	4235	3965	3995	3980
	Farmers' actual yield	3629	3681	3655	3468	3568	3518	3252	3382	3317
	yield gap (%)	16.86	16.24	**16.55**	17.62	16.24	**16.93**	17.98	15.34	**16.66**
Rangpur Site	Achievable yield (Research plot yield)	4345	4379	4362	4185	4215	4200	3890	3910	3900
	Farmers' actual yield	3434	3518	3476	3416	3475	3446	3188	3080	3134
	Yield gap (%)	20.96	19.66	**20.31**	18.37	17.55	**17.96**	18.04	21.22	**19.63**
	Overall yield gap (%)		**18.43**			**17.45**			**18.15**	

The overall yield gap of Prodip was the highest (18.43 percent) followed by Sourav (18.15 percent) and Satabdi (17.45 percent). The findings of Table 2 reveals that the variety Prodip had the highest yield gap at Rangpur site than any other varieties. However, the yield gaps were reduced in 2nd years in case of all the varieties in both sites.

Practice gap in cultivation of wheat

Practice gaps in wheat cultivation by the farmers were ascertained. The findings are presented in Table 3. The findings indicate that the highest practice gap by the farmers in wheat cultivation was in case of gypsum followed by use of boron and sowing time of wheat. Practice gap in seed source was much more higher in Rangpur site than Dinajpur site; 63 percent compared to 37 per cent. This may be due to the fact that the farmers of Dinajpur probably had far better access to WRC for collecting good quality wheat seeds than the farmers of Rangpur site. The practice gaps in using gypsum, boron and MoP in Rangpur site were also higher than Dinajpur site.

Table 3. Farmers' practice gaps in wheat cultivation

Gaps in Practices	Categories	Dinajpur site		Rangpur site		Total no. and % farmers	Mean (%)	Standard deviation
		% farmers	Mean (%)	% farmers	Mean (%)			
1. Seed rate	No gap (0 %)	16	9.54	17	8.30	25.0	8.92	7.93
	Low gap (1-12 %)	58		21		50.0		
	Medium gap (13-24%)	20		10		20.0		
	High gap (25 % and above)	6		2		5.0		
2. Seed source	No gap (0 %)	28	36.66	0	62.66	14.0	21.39	27.22
	Low gap (33.33 %)	34		52		43.0		
	Medium gap (66.66 %)	38		8		23.0		
	High gap (100 %)	0		40		20.0		
3. Sowing time	No gap (0 %)	0	42.40	24	38.00	12.0	40.20	26.43
	Low gap (1-33 %)	32		22		27.0		
	Medium gap (33.01-66 %)	54		38		46.0		
	High gap (66.01 % and above)	14		16		15.0		
4. Irrigation	No gap (0 %)	32	35.08	30	36.40	31.0	35.74	31.55
	Low gap (33.33 %)	40		40		40.0		
	Medium gap (66.66 %)	18		20		19.0		
	High gap (100 %)	10		10		10.0		
5. Urea at final land preparation	No gap (0 %)	22	28.14	18	27.80	20.0	27.97	18.99
	Low gap (1-23 %)	12		18		15.0		
	Medium gap (23.01-46 %)	50		52		51.0		
	High gap (46.01 % and above)	16		12		14.0		
6. Urea top dressing	No gap (0 %)	36	14.38	34	14.06	35.0	14.44	13.24
	Low gap (1-14 %)	18		18		18.0		
	Medium gap (14.01-28 %)	26		30		28.0		
	High gap (28.01 % and above)	20		18		19.0		

Gaps in Practices	Categories	Dinajpur site		Rangpur site		Total no. and % farmers	Mean (%)	Standard deviation
		% farmers	Mean (%)	% farmers	Mean (%)			
7. TSP application	No gap (0 %)	72	36.58	70	36.84	0	36.71	22.72
	Low gap (10-40 %)	20		22		71.0		
	Medium gap (40.01-70 %)	8		8		21.0		
	High gap (70.01 % and above)	0		0		8.0		
8. MoP application	No gap (0 %)	8	38.44	8	40.88	8.0	39.66	25.83
	Low gap (1-33 %)	42		24		33.0		
	Medium gap (33.01-66 %)	36		58		47.0		
	High gap (66.01 % and above)	14		10		12.0		
9. Gypsum application	No gap (0 %)	28	68.02	28	70.10	28.0	69.06	33.87
	Low gap (1-33 %)	22		22		22.0		
	Medium gap (33.01-66 %)	50		50		50.0		
	High gap (66.011 % and above)	0		0		28.0		
10. Boron	No gap (0 %)	26	63.02	12	71.42	19.0	67.22	42.21
	Low gap (1-33 %)	14		16		15.0		
	Medium gap (33.01-66 %)	2		10		6.0		
	High gap (66.01 % and above)	58		62		60.0		

Correlation between different practice gaps in wheat cultivation and yield gaps in wheat

Correlation co-efficients were computed to ascertain the relationships different practice gaps with the yield gaps of wheat. The findings have been presented in Table 4.

Table 4. Relationships of the practice gaps in wheat cultivation by the farmers with the yield gaps in wheat

Practice gaps in wheat cultivation	Correlation co-efficient (r)
1. Seed rate	0.778***
2. Seed quality	0.576***
3. Sowing time	0.891***
4. Quantity of irrigation	0.933***
5. Urea at final land preparation	0.822***
6. Urea top dressing	0.458**
7. TSP application	0.540***
8. MoP application	0.555***
9. Gypsum application	0.464***
10. Boron	0.520***

*** Significant at P<0.001 level of probability

The findings presented in Table 3 show that all the practice gaps by the farmers in wheat cultivation had significant positive relationships with the yield gaps in wheat. This meant that yield gaps of wheat increased with the increase of practice in wheat cultivation.

Relationships of selected characteristics of farmers with yield gaps in wheat cultivation

In order to assess the relationships between the selected characteristics of wheat growers and their yield gaps in wheat, correlation co-efficients were computed. The findings have been presented in Table 5.

Table 5. Correlation between the selected characteristics of the wheat growers and their yield gaps in wheat

Selected Characteristics	Correlation co-efficients (r)
1. Age	.096
2. Level of education	-.253*
3. Family size	.074
4. Farm size	.041
5. Farming experience	-.418**
6. Agricultural Knowledge	-.381**
7. Innovativeness	.-.208*
8. Attitude towards modern agricultural technologies	-.245*
9. Use of information sources	-.421**
10. Risk orientation	-.110
11. Decision making ability	-.237*

* Significant at P<0.05 level of probability; ** Significant at P<0.001 level of probability

The findings of Table 5 shows that level of education, farming experience, agricultural knowledge, innovativeness, attitude towards technologies, and decision making ability of the wheat growers had significant negative relationships with their yield gaps in wheat production.

Yield gap influencing factors in wheat

Linear multiple regression co-efficient were computed in order to determine the influential factors leading to yield gaps in wheat. The findings have been presented in Table 6. The findings reveal that only four factors (application of irrigation, boron, urea and seed sowing gap) contributed about 84 percent variation of the yield gaps in wheat cultivation.

Constraints in wheat cultivation

As of rice similar procedures were followed to compute problem facing index (PFI) in case of wheat. The findings are presented in Table 7. The top 05 constraints as PFI were: delayed sowing due to preceding crops, high cost of quality seeds, low plant population

due to massive attack of birds, high price of fertilizers, and poor knowledge about modern wheat locality.

Table 6. Linear multiple regression coefficients of yield gap influencing factors of wheat production

Yield gap influencing factors in wheat	Unstandardized Coefficients		Standardized Coefficients	t-value	Level of significance
	B	Std. Error	Beta		
(Constant)	-3.033	1.270		-2.389	.019
1. Irrigation application gap	.207	.036	.498	5.736	.000
2. Boron application gap	.041	.014	.131	2.948	.004
3. Urea application gap at top dressing	.086	.040	.087	2.159	.034
4. Seed sowing gap	.080	.039	.161	2.044	.044
R^2 **Value = 0.839**			F= 88.72	P= 0.000	

Table 7. Constraints in wheat cultivation as mentioned by the farmers (n = 100)

Sl. No.	Statement of constraints	High	Medium	Low	Not at all	CFI
1	Delayed sowing due to preceding crops	44	32	8	16	220
2	High cost of quality seeds	40	36	12	12	216
3	Low plant population due to massive attack of birds	41	32	11	16	214
4	High price of fertilizers	38	35	12	15	211
5	Inadequate knowledge about modern wheat cultivation	37	32	15	16	206
6	Attack of rats	34	33	22	11	201
7	Insufficient cooperation of field extension workers	33	34	20	13	200
8	Inadequate moisture in soil	31	36	18	15	198
9	Insufficient credit facilities during wheat cultivation	28	34	21	17	190
10	Low market price of wheat in harvesting season	25	37	25	13	187

Farmers usually sow wheat after harvesting *aman* rice; in many cases farmers cannot sow wheat in exact due to delayed harvesting of *aman* rice. Possibly that is why this constraints appeared as the number one constraint as indicated by CFI of 220. The cost of high quality seeds WRC and BADC is relatively higher than seeds available in the local market and consequent some farmers face problems in purchasing the good quality seeds from the

WRC and BADC. Immediately after sowing of wheat seeds some small birds of course, huge in number, eat the wheat grains and consequently the wheat plant populations are reduced in number. This leads to low yield; may be due to this reason farmers opined the massive attack of birds as one of the important constraints in wheat cultivation. Further, due to high price of fertilizers many farmers cannot buy the requisite quantity of fertilizers and in the field as recommended. That is why some farmers indicated this as the constraints in wheat cultivation.

CONCLUSION

Late sowing and unavailability of quality seeds in due time appeared as the dominant factors responsible for yield gap in wheat production. The wheat seeds are planted just after of aman rice, but due to late harvest of aman rice it is not possible to release land for wheat cultivation. The introduction of short duration aman rice can minimize the problem of late sowing of wheat. On the other hand the quality of wheat seed is an important attribute for ensuring higher yield of wheat. The quality of seed production can be enhanced by two ways: firstly growing of quality seed by government agencies and secondly cultivation of wheat for seed purposes by group of farmers in a cluster. Use of good quality seeds, proper date of sowing, less use of boron, zinc, and dolomite appeared as the important factors for the yield gaps in wheat. Hence, apart from the attempt of expanding wheat acreage, motivational training should be arranged for the wheat farmers for using recommended doses of fertilizers, especially the minor and trace elements like, boron, zinc, and dolomite (Ca.Mg carbonate).

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