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The Performance of Wheat Varieties in Resisting the Drought at Nilphamari District of Bangladesh

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Abstract: The present study was undertaken to evaluate the performance of resisting the drought to wheat varieties at three Upazilas of Nilphamari district of Bangladesh namely, Saidpur, Nilphamari Sadar and Jaldhaka. The main objectives that the study aimed to achieve include, (i) identification of drought stress tolerant wheat varieties by the small and marginal farmers through adaptive trials thus found more productive and profitable; and (ii) demonstration of modern wheat cultivation technologies generated awareness, improved knowledge, attitude and perceived adoption of modern wheat production among the demonstrating as well as neighbouring farmers. Four separate trials for identification of drought stress tolerant varieties were planned and implemented using Split-Plot design. Crop production technologies as recommended by BARI were used in the trials. Study findings showed comparatively lower yield in 'zero' irrigation i.e. rainfed condition in all the varieties (ranging from 3.89 tons to 4.05 tons/ha, average being 3.97 tons/ha) as against single irrigation (4.07 tons-4.61 tons/ha, average being 4.32 tons/ha), two irrigation (4.11 tons–4.59 tons/ha, average being 4.41tons/ha) and three irrigations (4.56 tons–4.94 tons, average being 4.70 tons/ha). The yield difference between '0' & 1,1 & 2, and 2 & 3 irrigations did not reveal a significant difference in most of the varieties. But in most of the varieties, significant differences were observed between '0' and 3 irrigations. In '0' irrigation, all the varieties performed similar with respect to yield, but BARI Gom21 performed slightly better over the other varieties.

Keywords: Drought, Climate Change, Irrigation, Wheat Variety, Adaptive Trail

1. Introduction

The area under wheat in Bangladeshh as decreased sharply in recent years due to a change in the dominant rice-based consumption pattern. Bangladesh wheat production was at level of 1.31 million tonnes in 2017, down from 1.35 million tonnes previous year, this is a change of 2.72% [1]. Nutritionally, wheat is superior to rice and its cultivation has specific advantages over other crops grown in *Rabi* season such as: (i) low water requirement; (ii) can be grown successfully using residual soil moisture; (iii) less damage from insect pests and diseases; (iv) dependable consumer demand, easy utilization and marketing; (v) low production cost; and (vi) higher market price. There exist a huge potentiality of enhancing wheat production both horizontally and vertically using available high yielding varieties and production technologies.

The global mean temperature has risen by 7°C since 1860. Over the same period, CO2 concentrations have increased by 46 percent [2] and there have been not able changes in the pattern of temperature, rainfall, drought, flood, and salinity intrusion causing major problems to crop production. Livelihood and food security of people are now under threat owing to the erratic behaviour of climate. If current trend in human population growth and food comsumption continue crop production must be increased by 60% by mid-century to meet food demand and reduce hunger [3]. but climate change will make this task more difficult [4]. Population growing and consumption is the big challeng for the current world. Continuing population and consumption growth will mean that the global demand for food will increase for at least another 40 years. Growing competition for land, water, and energy, in addition to the overexploitation of fisheries, will affect our ability to produce food, as will the urgent requirement to reduce the impact of the food system on the environment [5]. The International Food Policy Research Institute projections indicate that world demand for wheat will rise from 552 million tons in 1993 to 775 million tons by 2020 [6]. At the same time, climate change-induced tem premature increases are likely to reduce wheat production in developing countries (where around 66% of all wheat is produced) by 20-30% [7]. The Intergovernmental Panel on Climate Change (IPCC) [8] noted that global climate change will have a major impact on crop production. CIMMYT and ICARDA [9] estimated that 20–30% wheat yield losses will occur by 2050 in developing countries as a result of a predicted temperature increase of 2–38C. On a global scale, these yield losses will not be fully compensated by yield gains in high-latitude regions (Canada, Russia, Kazakhstan and Northern USA), estimated at 10–15% [10], since major wheat producers such as France have already reported yield reductions due to increasing temperatures [11]. Due to increasing trend of drought and excessive use of ground water for irrigating *Boro* season rice during the dry period have made cultivation of rice less lucrative to the farmers in one hand and surfaced a number of environmental hazards. Immediate visible effects are (i) serious depletion of ground water level, and (ii) accumulation of arsenic and other harmful elements in the upper soil level in many parts of the country. The most direct approach has been identifying an appropriate crop maturity that maximizes growth and the accompanying yield component development. Beyond that, the improvement of response to drought has been rare [12]. Farmers are cultivating these varieties as they are getting more yields. Apart from this, many farmers are now become more interested towards wheat farming as they are facing problems in cultivation of boro paddy in the water-stress condition in the Barind area in 25 Upazilas of Rajshahi, Naogaon and Chapainawabgonj districts [13]. Time has now come to consider reduction of irrigation by using underground water and switching to crops that can give productive yield under less or non-irrigated conditions using the residual moisture. Both scientists and farmers have found wheat as an important crop that can give potentially satisfactory yield and profitability under low irrigated/rainfed condition within less than one-half time of longer duration *Boro* rice varieties. Wheat Research Centre of Bangladesh Agricultural Research Institute (BARI) has developed and released a number of high yielding wheat varieties [14] which are relatively drought and heat stress tolerant including supporting production technologies. Major challenges in a vertical increase of production centered in (i) continuous development of high yielding disease-resistant varieties suited to the needs and agro-climatic environment of the farmers; and (ii) dissemination of existing high yielding varieties and production technologies among the farmers. Prime production problems include:

i *Spikelet Sterility* due to high-temperature stress at the reproductive stage is a major problem for wheat production in Bangladesh. As most of the wheat sown in late (i.e. middle of December to late December), the crop experience high heat stress at the reproductive stage during March-April causing spikelet sterility and significant yield reduction. WRC of BARI has developed a good number of heat tolerant high yielding varieties. Sowing seed in optimum planting time i.e. from 15 November to 30 November may help in escaping high-temperature stress.

ii Small and marginal farmers mostly cultivate wheat using residual soil moisture. So, varieties which can be grown under the *rainfed condition, tolerant to moisture stress i.e. drought-likesituation* required to be identified by the farmers themselves.

Wheat varieties released by BARI in recent years are mostly heat stress tolerant thus the risk of spikelet sterility has been encountered largely. But most of the farmers still have little or no access to these recently released heat stress tolerant varieties and supporting technologies. Farmers-led adaptive trial and demonstration can help the farmers to identify their preferred varieties and supporting production technologies against spikelet sterility, drought, and cold stress.

2. Objectives

With the goal of assisting the farmers in identifying their own preferred wheat varieties that can provide satisfactory yield and productivity against *drought* stresses, the present study aimed at achieving the following objectives:

i To demonstrate that drought stress tolerant wheat varieties identified by the small and marginal farmers through adaptive trials are more productive and profitable.

ii Demonstration of modern wheat cultivation technologies generated awareness, improved knowledge, attitude and perceived adoption of modern wheat production technologies among the demonstrating as well as neighboring farmers.

3. Methodology

Varietal interaction with different levels of soil moisture stress was assessed against a number of agronomic and physiological parameters. The trial's main plots were used for four irrigation regimes i.e. no irrigation, 1 irrigation at crown root formation stage (20 days after sowing), 2 irrigations (one at crown root formation and 2nd at booting stage) and 3 irrigations (1 at crown root formation, 1 at booting and the 3rd at grain-filling stage) were applied to 6 selected wheat varieties, and 1 allotted to each Sub-Plot (5m^2 size each) against the concerned main plots. The wheat varieties included BARI Gom21, BARI Gom23, BARI Gom24, BARI Gom25, BARI Gom26 and BARI Gom27. The trial was replicated in 4 farmer's plots. Data on yield and selected yield contributing factors were collected all over the crop growing period. Weather-related data were also gathered from different sources. A split-plot design was used in setting adaptive trials for assessing the interaction of 6 modern wheat varieties against the different level of soil moisture stress as follows:

3.1. Design: Split-Plot

3.1.1. Factor A: Irrigation (I), Main Plot

I_o = No irrigation (rainfed), *full moisture stress*

I_1 = 1 irrigation at crown root initiation i.e. 20 days after sowing, *high moisture stress*

I_2 = 2 irrigations, 1st at crown root stage and 2nd at booting stage (55 days after sowing), *low moisture stress*

I_3 = 3 irrigations, 1^{st} at crown root stage, 2^{nd} at booting stage and 3^{rd} irrigation at grain filling stage (75 days after sowing), *no moisture stress*

3.1.2. Factor B: Varieties (V), Sub-plots

V1 = BARIGom 21 (Shatabdi)
V2 = BARIGom 23 (Bijoy)
V3 = BARIGom 24 (Prodip)
V4 = BARIGom 25
V5 = BARIGom 26
V6 = BARIGom 27

Size of each Sub-plot was 5 m^2

This trial was replicated in 4 farmers' fields, 2 in Saidpur and 2 in Jaldhaka Upazila of Nilphamari district. Al the trials were established from 5-9 December 2012 after harvesting T. Aman by the farmers. Inputs such as fertilizers, dollochune, and boron were used as per the recommendation of BARI.

3.2. Crop-related Data to Be Taken:

i Germination%
ii Number of tillers/m^2
iii Number of tillers/plant
iv Number of effective tillers/plant
v Total leaf area/m^2ofland
vi Leaf Area Index
vii Average plant height after 30, 45, 60 days of sowing and at harvest time
viii Number of days of first heading after sowing & No. of days of 50% heading after sowing
ix Number of days of 90% maturity after sowing
x Number of days from sowing to harvesting days
xi Number of Spikes/m^2
xii Length of each spike
xiii Number of grains/Spike
xiv Number of grains/main Spike
xv Grain yield/clump
xvi 1000grain weight
xvii Number of unfilled grain/spike
xviii The weight of Straw/ha
xix Harvest Index

3.3. Weather-related Data to Be Taken

Minimum, maximum and average temperature, humidity, daily sunshine hours, number of foggy days, rainfall etc. from 1^{st} January to 15^{th} February

4. Study Findings

4.1. Varietal Interaction with Drought StressYield

Mean yields of all the varieties obtained from adaptive trials against '0', 1, 2 and 3 irrigations are mentioned in Table 1.

Table 1. *Mean Yields (Ton/ha) of 6 selected varieties against'0', 1, 2 and 3irrigations.*

Irrigation	Varieties						
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27	AllVarieties
0Irrigation	4.05	3.95	3.95	3.97	3.99	3.89	3.97
1irrigation	4.24	4.07	4.61	4.39	4.25	4.38	4.32
2irrigation	4.11	4.39	4.59	4.47	4.45	4.43	4.41
3irrigation	4.68	4.56	4.94	4.69	4.73	4.57	4.70
LSD	0.26	0.82	0.19	0.56	0.47	1.18	
CV (%)	6.64	9.40	10.02	7.77	7.62	12.20	

Data in Table 1 revealed that BARI Gom21 gives similar yield against 0, 1 and 2 irrigations but these yields are significantly lower compared to yield obtained in case 3 irrigations. Here, third irrigation contributed to making a significant difference. Level of irrigation did not make any significant difference in yield in case of BARI Gom23 though yield obtained in'0' irrigation found as lowest. The yield of BARI Gom24 (3.95 ton/ha) was found significantly lowest in '0' irrigation compared to 1, 2 and 3 irrigations. This variety yielded highest (4.94 ton/ha) against 3 irrigations. BARI Gom24 gave statistically similar yields in case of 0, 1 and 2 irrigations though it yielded much less in case of '0' irrigation. The variety yielded significantly higher (4.94 ton/ha) against 3 irrigations compared to 2, 1 and 0 irrigation. BARI Gom25 gave statistically similar yield though yielded lowest (3.97 tons/ha) in '0' irrigation. The variety obtained significantly highest yield in 3 irrigation compared to the yield of '0' irrigation (3.97 ton/ha) but similar yield with 2 and 1 irrigation. Significantly lowest yield (3.99 ton/ha) of the variety BARI Gom26 was observed in case '0' irrigation (3.99 ton/ha) compared to the yield obtained in 3 irrigations (4.73 ton/ha). Yield observed in 1 irrigation (4.25 ton/ha) was also significantly lowest compared to the yield of 3 irrigation, but yielded no significant difference between 2 and 3 irrigation. Yields obtained in all the three irrigation regimes for BARI Gom27 were found statistically similar though it yielded lowest (3.89 ton/ha) in case of '0' irrigation and highest (4.57 ton/ha) in 3 irrigations.

4.2. Major Findings

i Yields obtained were found lower in ‘0’ irrigation, mostly significantly lower compared 3 irrigation in all the 6 varieties.
ii Yields obtained in 3 irrigations were found highest in all the six varieties.
iii The yield difference between ‘0' and 1, 1 & 2 and 2 &3 did not reveal significant difference except BARI Gom24 where yields of all the irrigation treatments differed significantly. In most cases, significant differences were observed between ‘0’ and 3 irrigations.
iv Considering all varieties and number of irrigation, BARI Gom24 yielded highest in 3 irrigations while BARI Gom27 obtained the lowest yield in ‘0' irrigation.
v BARI Gom21 performed comparatively better in ‘0’ irrigation.
vi The yield obtained in ‘0' irrigation (average of all varieties = 3.97 tons/ha) can be considered satisfactory compared to the yield potentialities of these varieties which range mostly from (3.5 to 5.0 tons/ha), *national* average yield (2.78 ton/ha) and taking account of irrigation costs.

4.3. Varietal Interaction with Drought Stress: Yield Contributing Factors

High High temperature (> 30°C) at the time of grain filling is one of the major constraints in increasing productivity of wheat in tropical and sub-tropical countries [15]. A reduction of 28.9% grain yields of wheat was reported to in response of heat stress and heat stress caused a reduction of 8.5, 7.6, 5.6 percent for canopy temperature depression in 1000-grain weight, grain filling period and membrane injury (grain filling stage) respectively [16]. With increase in stress intensity, a progressive and significant decrease was observed in yield and yield attributing traits in all wheat varieties [17]. The yield of a crop is the combined and integrated effect of some major yield contributing factors. How drought and irrigated situation affects to these yield contributing factors were assessed and mentioned in Table 2 to Table 12. One-way Analysis of Variance (ANOVA) and Duncan test for multiple means comparison was computed to see whether there exists significant difference among the mean values as well as to see the similarities and differences between the means.

Significantly highest number of Tillers/m^2 was observed in case of the variety BARI Gom26 and BARI Gom27 in 3 irrigations compared to ‘0’ irrigation. Other varieties yielded no significant difference (Table 2). No. of effective Tillers (Table 3) was found significantly highest in case of 3 irrigations in most of the varieties compared to ‘0’ irrigation. Regarding Leaf Area Index (LAI), it is significantly highest in case of 3 irrigation for varieties BARI Gom25, BARI Gom26 and BARI Gom27 (Table 4). The average height of plant at 60 days after sowing found highest in 3 irrigation compared to ‘0' irrigation (Table 5).

Table 2. *Average No .of Tillers/m^2.*

Irrigation	Varieties					
	BARIGom21	**BARIGom23**	**BARIGom24**	**BARIGom25**	**BARIGom26**	**BARIGom27**
0Irrigation	521.67b	434.44b	454.44b	489.67	502.78b	523.78b
1irrigation	765.78ab	756.00ab	721.00ab	701.44	681.89ab	946.33a
2irrigation	697.72ab	807.56ab	775.77ab	823.44	886.22a	939.67a
3irrigation	881.00a	843.22a	884.22a	831.11	891.89a	940.22a
F	2.730	2.673	3.367	1.451	3.791*	7.645**

Table 3. *Number of Effective Tillers/Plant.*

Irrigation	Varieties					
	BARIGom21	**BARIGom23**	**BARIGom24**	**BARIGom25**	**BARIGom26**	**BARIGom27**
0Irrigation	4.10b	5.20b	3.77b	4.27b	4.90	4.63
1irrigation	4.70ab	6.00b	4.87a	4.90ab	5.33	5.37
2irrigation	5.20a	6.00b	5.13a	5.20a	5.33	5.27
3irrigation	5.30a	7.37a	5.87a	5.30a	5.83	5.27
F	10.37**	3.96*	8.026**	4.457*	1.172	0.559

Table 4. *Leaf Area index (LAI).*

Irrigation	Varieties					
	BARIGom21	**BARIGom23**	**BARIGom24**	**BARIGom25**	**BARIGom26**	**BARIGom27**
0Irrigation	2.47	2.69	2.64b	2.91b	3.29	2.56b
1irrigation	2.51	3.09	3.35b	2.87b	3.64	3.27a
2irrigation	2.60	3.14	3.21a	3.72a	3.98	3.70a
3irrigation	3.18	3.29	3.04a	2.70b	3.90	3.62a
F	0.853	1.118	3.457	5.273*	1.377	3.320

Table 5. *Average Plant Height at 60 days of Sowing.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	66.60b	65.40b	61.53b	69.87	66.00b	65.47b
1irrigation	71.87b	71.77ab	70.83ab	71.83	68.07ab	68.57ab
2irrigation	75.00ab	80.40ab	77.93ab	79.90	77.50ab	78.60ab
3irrigation	91.43a	90.50a	87.40a	80.00	81.73a	83.33a
F3	3.508*	3.484*	3.189	1.102	3.112	3.634*

Table 6. *Number of Days required for 50% Heading from sowing.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	73.00	73.33	72.67	73.00a	74.67a	72.67a
1irrigation	73.67	73.00	72.00	73.12a	73.00a	72.07a
2irrigation	73.33	73.00	72.00	72.64a	74.00a	71.88a
3irrigation	71.33	73.00	72.67	67.00b	68.00b	67.67b
F	1.289	0.032	0.267	7.20**	7.651**	8.43**

Table 7. *Number of days required for 90% maturity from seed sowing.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	108.67	108.00	108.33	106.67	105.00	108.00
1irrigation	110.00	109.00	111.00	108.33	109.33	111.33
2irrigation	110.00	110.33	111.00	108.67	108.67	111.20
3irrigation	111.33	110.67	110.67	110.33	109.33	110.80
F	0.281	0.162	0.360	0.196	0.313	0.512

Table 8. *Mean length of Spike (cm).*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	13.00	11.67	13.00	12.33	11.33	12.67
1irrigation	13.33	11.67	13.33	13.33	11.00	12.67
2irrigation	12.67	12.00	13.33	13.33	11.00	13.67
3irrigation	13.33	12.33	13.67	13.00	11.67	13.67
F	0.064	0.122	0.074	0.333	0.310	0.197

Table 9. *Average Number of Grains/Spike.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	45.67	45.00	45.67	47.00a	45.67	48.33
1irrigation	45.00	48.00	50.33	36.33b	48.67	44.33
2irrigation	46.67	45.33	45.00	40.67ab	49.67	48.67
3irrigation	49.33	46.67	48.00	47.00a	55.00	47.00
F	0.305	0.139	0.615	3.903*	0.367	0.443

Table 10. *Average Weight (g) of 1000 Grains.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	46.33	48.00	56...00	51.67	49.67	46.67ab
1irrigation	54.00	49.04	52.67	49.67	45.33	45.00ab
2irrigation	52.07	46.33	52.67	61.00	43.67	40.33b
3irrigation	52.33	48.67	53.00	50.67	48.33	51.33a
F	2.069	0.387	2.301	2.526	1.629	4.268*

Table 11. *Number of Unfilled Grains/Spike.*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	12.67	8.33	10.67	8.67	11.67a	9.00
1irrigation	9.33	9.67	8.00	8.00	11.33a	8.00
2irrigation	9.33	10.00	8.33	8.67	7.67b	10
3irrigation	8.33	8.67	9.00	8.67	9.33b	8.33
F	8.062**	1.916	1.949	0.667	12.533**	2.154

Table 12. *Harvest Indices (%).*

Irrigation	Varieties					
	BARIGom21	BARIGom23	BARIGom24	BARIGom25	BARIGom26	BARIGom27
0Irrigation	33.54b	35.55	37.28b	35.16	37.73b	35.03
1irrigation	37.33a	38.15	41.28a	38.78	40.44ab	39.79
2irrigation	36.75a	37.26	40.70ab	38.92	38.82b	40.73
3irrigation	41.14a	40.79	42.66a	40.69	44.01a	42.48
F	3.280	0.600	4.100*	2.606	4.229*	1.418

Regarding days to 50% heading, varieties received no irrigation taken significantly more days to 50% heading compared to 3 irrigations in BARI Gom 25, BARI Gom 26 and BARI Gom 27. Regarding a number of days to 90%maturity (Table 7) no significant difference among the varieties and irrigation was observed. Similar is the case of Spike length (Table 8). Regarding grain number/spike (Table 9) in case of BARI Gom25, it is significantly highest in '0' and 3 irrigation compared to 1 and 2 irrigation. Regarding the weight of 1000 grains (Table 10), it is only in case of BARI Gom27 the weight is significantly highest in 3 irrigation. A number of unfilled grains (Table 11) observed highest in almost all the varieties in case of '0' irrigation. It is significantly highest in case of BARI Gom21 against '0' irrigation compared to 1, 2 and 3 irrigation. Harvest indices (Table 12) were observed significantly higher in case of 3 irrigations compared to '0' irrigation in varieties BARI Gom24 and BARI Gom26.

4.4. Major Finding

Most of the yield contributing parameters were found significantly affected by '0' irrigation and positively enhanced by the higher number of irrigations.

4.5. Relationship Between Yield and Yield Contributing Characters

Correlation analysis showing the relationship of various yield contributing characters with the yield of all the varieties is shown in Table 13. Analysis based on drought trial data showed that yield of tested 6 wheat varieties significantly (positive) correlated with number of tillers/m2, no. of tillers/plant, number of effective tillers/plant, average plant height after 60 days of sowing and at harvest, grain number/main spike, weight of straw and Harvest Indices. The significant negative relationship was observed with a number of first heading days from sowing, 50% heading days and number of unfilled grains/spike. This means that varieties headed early and have a number of unfilled grains yielded low. More or less similar trend of relationship also observed in using Cold Stress Trial data. Here, number of tillers/m2, number of tillers/plant and number of effective tillers/plant did not show a significant relationship with yield.

Table 13. Correlation analyses showing the relationship of wheat yield and Yield contributing factors.

Sl.	Yield contributing factors	'r' based on drought trial
1	No. of tillers/m^2	0.435**
2	No. of tillers/plant	0.461**
3	No. of effective tillers/plant	0.440**
4	Leaf Area Index	0.308
5	Average plant height in 60DAS	0.478**
6	Average plant height at harvest	0.232*
7	First heading days (DAS)	-0.272*
8	50% headings (DAS)	-0.318**
9	90% maturity (DAS)	0.129
10	Harvesting days (DAS)	
10	Av. No. of Spikes/m^2	0.158
11	Av. Length of each spike	0.095
12	Grain No./Spike	0.210
13	Grain No .of main Spike	0.252*
'	Grain yield/clump	-0.013
14	The weight of 1000grainweight	-0.063
15	No. of unfilled grain/spike	-.266*
16	The weight of Straw/ha	0.48**
17	Harvest Index	0.500**

Rather, Leaf Area Index (LAI), the average length of the spike, grain yield/clump, weight of straw and Harvest Index showed a significant positive relationship with yield. On the other hand, first heading days, 50% heading days, 90% maturity days, harvesting days and number of unfilled grains/spike showed a significant negative relationship with yield.

4.6. Field Days

Three field days were organized in 3 project sites where 250 farmers participated. DAE officials, officials from CSISA, local journalists also joined together with the participating farmers in sharing experiences, visiting the Trial and Demonstration plots and participating in crop cuttings. All the Field Days were full of joys, the pleasure of achieving great successes by the farmers who sent clear messages to those who have not yet started improved wheat cultivation.

4.7. Validation Workshop

Major findings of the study were finally shared with the farmers who raised Trials and Demonstration plots in a Validation Workshop organized last week of April/2013.

5. Study Outcomes

i Adaptive Trial findings showed that although irrigation increases yield of wheat but yields obtained in non-irrigated rainfed condition were also found satisfactory in all the six varieties, which are within the potential yields of the respective varieties and also higher than the national average yield.

ii Large-scale demonstration of modern wheat varieties and technologies generated huge interest and awareness among the marginal and small farmers in the project area.

6. Recommendations

The satisfactory yield of wheat can be obtained under rainfed condition using residual soil moisture. What is needed is the access of the small and marginal farmers to seeds of recently released high yielding varieties and production technologies. Availability of quality seeds and training on improved cultivation practices is very essential for these disadvantaged farmers. Based on study findings following recommendations are forwarded:

i Farmer-to-Farmer exchange of seed materials in the project area needs to be strengthened. RIB should concentrate its emphasis through Community Seed Banks now in operation in some parts of Nilphamari district.

ii DAE should also help these farmers in obtaining seed materials and organizing training programmes. Farmers should also be trained and encouraged to produce and store quality wheat seeds.

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