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YIELD AND N USE EFFICIENCY OF WHEAT AS INFLUENCED BY BED PLANTING AND N APPLICATION

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Abstract

Wheat *(Triticum aestivum* L.) was planted as winter crop using raised bed and conventional planting system with four N levels at Regional Wheat Research Station, Rajshahi (latitude 28°75′ N and longitude 92°58′ E), during November to March in 2002 and 2003 to study N content in grain and straw, uptake of total nitrogen, N use efficiency, fertilizer recovery percentage and grain yield. The highest N content in grain and straw were obtained from bed planting system with Shatabdi at 150% N treatment. Maximum total N uptake by the plants was found in bed elevation as compared to conventional planting system. The highest N use efficiency was observed at N zero treatment as compared to applied N levels. Shatabdi noticed highest N use efficiency among the crop varieties. The maximum fertilizer recovery percentage was noted in Shatabdi under bed planting system. The highest grain yield (2,555 kg/ha) was produced from bed planting system. Significantly the highest grain yield (2,929 kg/ha) was found in Shatabdi. The highest grain yield (3,746 kg/ha) was found when 150% N was applied. In bed planting system, the highest grain yield (3,323 kg/ha) was produced when 150% N was applied. The lowest grain yield (1,177 kg/ha) was obtained in zero N treatment. Among the varieties, Shatabdi was the best performer in bed planting system due to maximum nitrogen and protein content in grain and straw, maximum N use efficiency and fertilizer recovery percentage.

Key Words: Bed planting, N content, N use efficiency and fertilizer recovery percentage.

Introduction

Wheat *(Triticum aestivum* L.) is the first ranking cereal crop globally and it is grown from temperate irrigated to dry and high rainfall environments. It can be cultivated in areas where the winter is cool and the summer is comparatively hot. The optimum temperature for the growth of this crop is 10-20^{0}C (Fischer, 1981). Sayre (1998) noted that the average wheat yield was higher in bed planting system than conventional planting tillage. Use of those practices has increased dramatically in the last decade in high yielding irrigated wheat growing areas in Mexico (Meisner *et al.*, 1992). The use of permanent raised bed system is an

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alternative practice in wheat that allows for timing of nitrogen fertilizer application to increase N use efficiency and to lower production cost. CIMMYT's scientists are strongly convinced that bed-planting (with or without tillage) offers a very sound method for planting wheat and other crops under high rainfall conditions where excessive moisture can cause water logging (Sayre, 1998). Bed sowing could be a good alternative for Bangladesh where wet culture is more dominant and this experiment was aimed to investigate the interaction among wheat varieties and method of sowing (tillage option) among varying nitrogen fertilizer applications.

Materials and Method

The trial was carried out at the Regional Wheat Research Center (WRC), Rajshahi to find out the suitable variety(s) for bed planting system, nitrogen use efficiency and fertilizer recovery percentage. The experimental field was a medium high land with loam to silty loam textured soil having a p^H value 7.56. The initial soill N percent and bulk density of the experimental field were 0.084% and 1.40 g/cm^3, respectively. The design was strip split plot having three replications. Varieties used were Shatabdi, Gourab, Protiva and the check variety Kanchan. There were 3 factors having 32 treatments. Methods of sowing, a) conventional *i.e.,* flat bed and b) raised bed, 15 cm above from the soil surface, which was made by taking the soil from the furrows maintaining 25 cm spacing between row to row and 75 cm spacing from furrow to furrow, that was placed in the main plot. Nitrogen doses viz., 0, 50%, 100%, 150% of the recommended N (100 kg N/ha), which were placed in sub-sub plots. Two-thirds of N was applied as basal mixing well with soil in conventional one and in bed planting, along with furrows. The remaining one-third N was applied as broadcast in between the rows at crown root initiation (CR1) stage of the crop. The unit plot size was 3m × 4m. A blanket dose of PKS @ 60-40-45 kg/ha was applied in the form of Triple Super Phosphate, Muriate of Potash and Gymsum (FRG, BARC, 2005). Nitrogen was applied as urea. The seeds were sown on 3 December 2002-2003. Three samples of l m^2 of each plot were harvested for collecting data on yield by using method as described by Bell and Fisher (1994). The grain and straw were weighed separately for each treatment after proper sun drying. Five plants were randomly collected from each treatment for recording data on yield contributing characters (Bell and Fisher, 1994).

Determination of N% in grain and straw

Grain and straw samples were collected from each plot. Approximately 10 g of samples of each plot were preserved separately in polythene bags for chemical

analysis to determine grain and straw nitrogen. Nitrogen content in wheat grain and straw was determined by the standard micro Kjeldahl method (Total nitrogen estimation method, AOAC, 1980). Total nitrogen uptake was estimated by multiplying oven dry weight of the sample with N content in respective sample. Nitrogen use efficiency (Physiological) was calculated as the ratio of grain yield to the total N uptake by the plants. Fertilizer recovery percentage was calculated as the ratio of N use efficiency to the N applied of each treatment multiplied by 100. All the data including yield and yield components were statistically analyzed following computer package MSTAT-C. The means were separated by using DMRT (Gomez and Gomez, 1984) at 5% level of significance.

Results and Discussion

Nitrogen content (%) in grain and straw

Highest nitrogen content in grain (2.13%) and straw (0.33%) was found in bed planting system as compared to the conventional planting system due to more uptakes of nitrate nitrogen and accumulation of carbon dioxide and solar radiation in bed planting system (Table 1). Among the varieties, the maximum nitrogen content in grain (2.18%) and straw (0.35%) was observed in Shatabdi followed by Gourab, Protiva, and Kanchan (Table 1). Interaction of crop varieties and bed elevation has led to highest N content in Shatabdi variety (2.23% in grain and 0.40% in straw) grown under raised bed condition (Table 2). The results are in agreement with the findings of Ciobanu *et al.* (1995), Kumar *et al.* (1995) and Alom *et al.* (2004). Interaction of sowing method and nitrogen level had also significant effect on nitrogen content in grain and straw (Table 3). The highest nitrogen content in grain (2.25%) and straw (0.48%) was found under raised bed at 150% N application followed by 100% N and 50% N application. The lowest nitrogen content in grain (1.88%) and straw (0.21%) was found under conventional bed with no application of N (Table 3).

Total nitrogen uptake

The highest nitrogen uptake by the plants was in bed planting (40.99 kg/ha system as compared to the conventional planting system may be due to higher uptake of nitrogen (Table 1). Among the crop varieties, the maximum uptake of N was obtained in Shatabdi (41.26 kg/ha) followed by Kanchan, Protiva, and Gourab (Table 1). At 150% N applicable maximum total uptake of nitrogen was noticed (100.7 kg/ha). Interaction of crop vatieties and bed elevation has led to the highest uptake of N in Shatabdi (79.62 kg/ha) as compared to consentient planting system (Table 1). Combined effect between sowing method and N

doses, 150% N application noticed highest total uptake of N by the plants (106.04 kg/ha in bed elevation as compared to conventional planting.

Table 1. Effect of sowing method, variety and N level on N content, N use efficiency and fertilizer recovery percentage (Pooled over two **years).**

Sowing method	Nitrogen content of straw (%)	Nitrogen content of grain (%)	Total N uptake (kg/ha)	N use efficiency (kg grain/ha per kg uptake of N)	Fertilizer recovery percentage
Bed planting	0.33a	2.13a	71.06a	40.99a	69.89a
Conventional planting	0.29b	2.03b	63.28b	38.67b	64.34b
Shatabdi	0.35a	2.18a	75.09a	41.26a	78.33a
Gourab	0.31b	2.lla	67.12b	38.70d	65.65h
Protiva	0.29b	2.03b	63.38c	39.67c	62.37c
Kanchan	0.29b	2.Oc	63.09c	39.69b	62.12c
$N_{0\%}$	0.23d	1.95d	28.12d	42.09a	-
$N_{50\%}$	0.25c	2.OOc	56.31c	41.45b	I 12.Oa
$N_{100\%}$	0.35b	2.13b	83.62b	38.54c	83.62b
$N_{150\%}$	0.42a	2.23a	100.7a	37.23d	71.26c
CV(%)	0.33	4.94	0.39	0.11	0.32

Nitrogen use efficiency

The highest nitrogen use efficiency (physiological) (63.38 kg grain/kg N uptake) was observed in bed planting system followed by conventional system (50.85 kg grain/kg N uptake). Among the varieties, Shatabdi showed maximum N use efficiency (41.26 kg grain/kg N uptake) (Table 1). At zero N treatment, the maximum N use efficiency was found (42.09 kg grain/kg N uptake) followed by 50% N, 100 % N and 150 % N application (Table 1). Interaction of crop varieties and method of sowing, Shatabdi showed the highest (42.74 kg grain/kg N uptake) nitrogen use efficiency in bed planting system followed by Gourab (Table 2). Combined effect of sowing method and nitrogen level had significant effect on nitrogen use efficiency. The highest nitrogen use efficiency (43.24 kg grain/kg N uptake) was found at zero N treatment in conventional planting system compared to rest of the N levels applied. The lowest nitrogen use efficiency (36.55 kg grain/kg N uptake) was found at 1500%) N treatment in bed planting system (Table 3). Thakur *et al.* (1998), Tripathi *et al.* (2004) and Alom *et al.* (2005) reported similar results in wheat.

Table 2. Effect of sowing method and variety on N content (%), N use efficiency and fertilizer recovery percentage (Pooled over two years).

Sowing method X Variety	Nitrogen content of straw (%)	Nitrogen content of grain (%)	Total N uptake (kg/ha)	N use efficiency (kg grain/ha per kg uptake of N)	Fertilizer recovery percentage
Raised bed					
Shatabdi	0.40a	2.23a	79.62a	42.74a	78.08a
Gourab	0.31b	2.16b	71.05b	37.21b	69.86b
Protiva	0.31b	2.llc	66.89c	39.79e	66.Olc
Kanchan	0.30c	2.llc	66.72c	38.93f	651.2c
Conventional bed					
Shatabdi	0.31b	2.09a	70.56 b	40.56b	78.58a
Gourab	0.29b	2.08a	63.23d	40.19d	61.45d
Protiva	0.28d	1.94c	59.87e	38.77g	58.73e
Kanchan	0.28d	2.04b	59.47e	40.46c	58.63e
CV(%)	0.33	4.94	0.39	0.11	0.32

Columns having the dissimilar letter/letters indicate significant differences at 0.05 levels of significance (Duncan's test).

Fertilizer recovery percentage

Maximum fertilizer recovery percentage (69.89%) was obtained from bed planting system due to more uptake of N. Among the crop varieties, Shatabdi noticed highest fertilizer recovery percentages (78.33%) might be due to high response to N fertilizer followed by Gourab. Due to N levels, the highest fertilizer recovery percentage (112.0%) was found at 50% N application followed by 100% N and 150% N applications due to more leaching and volatilization loss for increasing rate of N doses (Table 1). The lowest fertilizer recovery percentage (71.26%) was found at 150%N application (Table 1). Combined effect of sowing method and crop varieties had significant effect on fertilizer recovery percentages. The highest fertilizer recovery percentage was found in Shatabdi (78.08%) in bed planting system, which was identical with conventionally planting Shatabdi. The lowest fertilizer recovery percentage was found in Protiva and Kanchan in conventional planting system (Table 2). Interaction effect of sowing method and nitrogen level had also significant effect on fertilizer recovery percentage due to nitrogen doses. The highest fertilizer recovery percentage (120.03%) was found at 50% N application followed by 100% N and 150% N applications in bed planting system (Table 3). The lowest fertilizer recovery percentage was obtained at 1 50% N application in bed planting system.

Table 3. Effect of N and sowing method on N content, N use efficiency and fertilizer recovery percentage (Pooled over two years).

Sowing method X Nitrogen level	Nitrogen content of straw (%)	Nitrogen content of grain (%)	Total N uptake (kg/ha)	N use efficiency (kg grain/ha per kg uptake of N)	Fertilizer recovery percentage
Raised bed					
$N_{0\%}$	0.24f	2.O6abc	30.32dg	40.95c	-
$N_{50\%}$	0.27e	2.O3bcd	60.02e	40.08d	120.Oa
$N_{100\%}$	0.37c	2.l7ab	67.85c	37.lOg	87.85c
$N_{150\%}$	0.48a	2.25ab	106.04a	36.55h	70.69f
Conventional bed					
$N_{0\%}$	0.21h	1.88d	25.90h	43.24a	-
$N_{50\%}$	0.23g	1.95cd	52.59f	42.82b	105.l8b
$N_{100\%}$	0.33d	2.09ab	79.38d	39.98e	79.38d
$N_{150\%}$	0.38b	2.23a	95.26b	37.91f	7l.8le
CV(%)	0.33	4.94	0.39	0.11	0.32

Yield and yield components

Effect of sowing method

Higher number of tillers (2.51) was obtained in bed planting system as compared to conventional planting system (2.46 no.) (Table 4). Longer period (106 days) was required for physiological maturity at bed planting system compared to conventional planting system (101 days). More spikes (234 no./m^2) were found in bed planting system and minimum (210/m^2) in conventional planting system. Highest number of spikelets per spike (17.27) was produced from bed planting system and lower from conventional planting system (16.77). The weight of 1000-grain (41g) was higher in raised bed compared to conventional planting system (40g). Higher grain yield (2,555 kg/ha) was recorded from bed planting system due to the maximum tillers, highest number of grains per spike and higher 1000-grain weight and lower grain yield (2359 kg/ha) was found in conventional planting (Table 4).

Effect of variety

Among the varieties, the highest number of tillers per plant was obtained in Shatabdi (2.53) followed by Protiva (2.41) (Table 4). Shatabdi required maximum period (107) for physiological maturity and Gourab required minimum number of days. Shatabdi produced maximum number of spikes (249m^2) and minimum in Protiva. The highest spikelets per spike was observed in Shatabdi (19.47) and lowest in Gourab (16.79). Maximum number of grains per spike was

observed in Shatabdi (45) followed by Gourab. Shatabdi produced the highest 1000-grain weight (42g) among the varieties studied. Shatabdi produced significantly the highest grain yield (2,929 kg/ha). This was due to the maximum expression of important yield attributes like number of litters per plant, spikelets per spike, grains per spike and 1000-grain weight in bed planting system followed by conventional p1aiting system and lowest grain yield (2,445 kg/ha) was obtained in conventional planting system with Kanchan (Table 4).

Table 4. Effect of sowing method, variety and N **level on yield and yield components (Pooled over two years) of wheat.**

Sowing method	Tillers/ plant	Days to maturity	Spike/m^2	Spike-lets/ spike	Grains/ spike	1000-grain wt (g)	Yield (kg/ha)
Bed planting	2.51a	106a	234a	17. 27a	42a	41.00a	2555 a
Conventional planting	2.46b	l01b	210b	16.77b	39b	40.00b	2359b
Variety							
Shatabdi	2.53a	107a	249a	19.37a	45a	42.46a	2929a
Gourab	2.37bc	l01c	239b	16.79c	44b	40.83b	2559b
Protiva	2.41b	103b	225c	18.91b	43bc	37.50c	2530c
Kanchan	2.19c	104b	237b	18.l6b	42c	38.92bc	2445d
Nitrogen level							
$N_{0\%}$	1.32c	98d	153d	14.29c	32d	38.00c	l177d
$N_{50\%}$	2.05b	102c	205 c	1.46be	40c	39.00c	2326c
$N_{100\%}$	2.47b	105b	279b	16.88ab	44b	41.00b	32l5b
$N_{150\%}$	3.16a	107a	313a	18.2lab	47a	44.00a	3746a
CV(%)	9.76	0.31	0.95	1.85	3.30	2.25	0.46

Columns having the dissimilar letter/letters indicate significant differences at 0.05 levels of significance (Duncan's test).

Effect of nitrogen level

Highest numbers of tillers were found at 150% N (3.16 no.) being followed by 100% N and 50% N. Maximum number of days (107 days) were required when 150% N was applied for physiological maturity followed by 100% N and 50% N (Table 4). Maximum number of spikes per m^2 (313 no.) was obtained when 150% N was applied compared to remaining doses of N and minimum in stress nitrogen treatments. Spikelets per spike differed significantly among the N treatments and highest value was observed at 150% N (1821 no.) and lowest at N stress treatment (1429). Maximum number of grains per spike was observed at 150% N (47 no.) and lowest at N stress condition. At 150% N treatment, highest 1000-grain weight (44.00) was obtained among the treatments combinations. The highest grain yield of 3,746 kg/ha was recorded under highest level of N application (150% N) due to the highest N response to the crops and its use

efficiency resulting significantly the maximum tillers, highest 1000-grain weight (44g) and higher number of grains per panicle (47). The lowest grain yield was obtained (1,443 kg/ha) from the stress nitrogen treatment due to poor tiller number per plant, lowest 1000-grain weight and minimum number of grains per spike. Maximum days were required for physiological maturity at 150 kg N compared to 100% N and 50% N (Table 4).

Interaction effect of variety and sowing method

The interaction effects of sowing method and wheat varieties on yield and most yield contributing components were significant (Table 5). Highest number of tillers per plant was obtained from Shatabdi (2.93 no.) in bed planting system followed by conventional planting. Shatabdi required maximum number of days (107 days) in bed planting system for physiological maturity followed by conventional planting. Shatabdi produced maximum number of spikes (228/m^2) in bed planting system than remaining varieties and minimum was in Kanchan with conventional planting. Spikelets per spike differed significantly among the varieties and the highest was observed in Shatabdi (20.10) and lowest in Gourab (16.15). Maximum number of grains per spike was observed in Shatabdi (45 no.) in bed planting system followed by (41 no.). Shatabdi produced highest 1000-grain weight (44g) among the varieties. Shatabdi produced significantly the highest grain yield (2,918 kg/ha) in bed planting system. This might be due to the maximum expression of important yield attributes (maximum number of tillers, spikelets/spike, grains/spike, and 1000-grain weight) followed by conventional methods of sowing and lowest grain yield (2,205 kg/ha) was obtained in conventional planting system with Kanchan (Table 5).

Table 5. Effect of sowing method and variety on yield and yield components (Pooled over two **years) of wheat.**

Sowing method X Variety	Tillers/ plant	Days to maturity	Spikes/m^2	Spike-lets/ spike	Grains/ spike	1000-grain wt (g)	Yield (kg/ha)
Bed planting							
Shatabdi	2.93	107a	228a	20.l0a	45.00a	44.34a	2918a
Gourab	2.64	105c	213b	16.15c	41.00c	42.45bc	2575c
Protiva	2.32	106b	204bc	17.03bc	42.00bc	39.43e	2390d
Kanchan	2.30	106b	208bc	18.04b	42.00bc	40.lScd	2338d
Conventional planting							
Shatabdi	2.65	106b	213b	17.l0bc	44.00b	42.37ab	2660b
Gourab	2.36	105c	198cd	17.l5bc	42.00bc	41.38bc	2353d
Protiva	2.07	105c	198cd	17.05bc	42.00bc	39.85e	2219e
Kanchan	2.03	106b	196d	17.07bc	42.00bc	40.34de	2205e
CV(%)	2.41	1.15	10.10	1.85	3.30	2.25	1.26

Interaction effect of sowing method and N level

Highest numbers of tillers per plant was produced at 150% N (3.30 no.) in bed planting system followed by 100% N and 50% N. Maximum number of days were required when 150% N was applied (109 days) for physiological maturity in bed planting system followed by 100% N and 50% N. Maximum number of spikes (258/m^2) was produced when 150% N was applied compared to remaining doses of N and minimum in stress nitrogen in conventional planting. The highest spikelets per spike was observed at 150% N (19.54) and lowest (5.83) at nitrogen stress condition. Maximum number of grains per spike (46) was observed at 150% N and the lowest at nitrogen stress condition. At 150% N treatment, highest 1000-grain weight (44.18) was obtained among the treatments combination. The highest grain yield (3,323 kg/ha was obtained at 150% N application might be due to the maximum spikes per m^2, highest 1000-grain weight, and maximum number of tillers per plant followed by conventional planting system The lowest grain yield (1,418 kg/ha) was obtained at zero nitrogen treatment with conventional planting system (Table 6). These results are similar with the findings of many other authors (Tripathi *et al.*, 2004; Hossain *et al* 2004, and Sakartono *et al.*, 2004).

Table 6. Effect of sowing method and N Level on yield and yield components.

Sowing method X level	Tillers/ plant	Days to maturity	Spike/m^2	Spike-lets/ spike	Grains/ Spike	1000-grain wt (g)	Yield (kg/ha)
Bed planting							
$N_{0\%}$	1.64 d	l0ld	167g	15.83d	35d	38.64d	14691f
$N_{50\%}$	2.40c	106c	201e	16.66c	40c	39.54c	2485d
$N_{100\%}$	2.71b	108b	225c	17.58bc	44b	42.19b	2943b
$N_{150\%}$	3.30a	109a	258a	19.54a	46a	44.18a	3323 a
CV(%)	9.76	1.15	10.10	1.85	3.30	2.25	1.26

Columns having the dissimilar letter/ letters indicate significant differences at 0.05 levels of significance (Duncan's test).

Conclution

It is revealed from the study that maximum yield potential of wheat can be achieved from the soil of Wheat Research Center, Rajshahi by growing the variety Shatabdi in raised bed (15 cm above the soil surface) and applying N at 150% N of the recommended doses.

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