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Effects of tillage and irrigation on the growth and yield of wheat

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Abstract: An experiment was conducted at the Bangladesh Agricultural University (BAU) farm, Mymensingh during rabi season of 2007-2008 to observe the effects of tillage and irrigation on the growth and yield of wheat (cv. Shatabdi) in a split plot design with tillage operation in the main plot and irrigation level in the sub-plot. The tillage operations were T_1= one passing, T_2= two passing, and T_3= three passing of a power tiller, and the irrigation treatments were I_0 = no irrigation, I_1= one irrigation, I_2 = two irrigation and I_3 = three irrigation. Each plot received an equal amount of fertilizers and manure @ 100 kg N, 18 kg P, 50 kg K, 20 kg S, 3 kg Zn, 1 kg B and 5 t decomposed rice straw per hectare. In case of plant characters such as plant height, effective tillers hill^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, and 1000-grain weight, the highest result was recorded with T_3 and I_0 treatments, and the minimum with T_1 and I_0 treatments. These plant parameters had reflected the grain and straw yield showing the highest yield by T_3 (3.46 t ha^{-1} grain and 6.24 t ha^{-1} straw) and I_3 (3.53 t ha^{-1} grain and 6.35 t ha^{-1} straw) treatments, and the lowest yield by T_1 (3.14 t ha^{-1} grain and 5.91t ha^{-1} straw) and I_0 (3.04 t ha^{-1} grain and 5.80 straw). The interaction effects of tillage and irrigation showed that T_3I_3 treatment combination produced the higher grain and straw yield where as lowest was found in T_1I_0. Overall results indicate that tillage and irrigation helped an improvement of soil physical and chemical properties which in turn had impacted on the increased wheat yield.

Key words: Tillage, Irrigation, Growth, Yield, Wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the major cereal crops of the world ranking first both in acreage and production among the seed crops. In some countries, it is the main food item. In Bangladesh it is the second most important staple food crop after rice (Razzaque and Hossain, 1991). Bangladesh produces 16, 05,760 metric tons of wheat per annum from 7, 41,830 hectares of land (BBS, 2004). Bangladesh is an over populated country and the food production of this country is not increasing that much to keep pace with that of population growth. As the land is limited, the only option to increase total production of wheat on unit area basis. Yield of wheat depends on many factors like soil fertility, climatic condition, variety, tillage, intercultural operations etc. Tillage is the first step of crop production. It is the mechanical manipulation of soil, to optimize the condition for seed germination, emergence and seedling establishment (Abodorrahmani *et al.*, 2005). Different tillage operations may influence physical properties of soil such as soil bulk density, soil moisture, soil porosity and air filled porosity (Vulloid *et al.*, 2006). Tillage, among various crop production factors contributes 20% of crop production (Ahmad *et al*., 1996). The tillage is also considered to be a cause of low yield of wheat and it may cause the yield reduction up to10 % along with weed competition. In Bangladesh wheat is grown in rabi season and the duration extends from the month of November to March. The rainfall during rabi season is characteristically scanty and uncertain. About 42.78% of the total wheat cultivated area in the country is irrigated rest of the area of wheat cultivation is cultivated under rainfed condition (BBS, 2004). Insufficient water affects the germination of seeds and uptake of nutrients from soil. Moreover, movement of nutrients through the plant body by physiological activities is also associated with soil water (Tisdale *et al.*, 1985). But as a matter of fact, irrigation water in Bangladesh is a limited resource of underground water and hence irrigation practices must be rationalized if irrigation is provided at critical growth stages of wheat. Therefore, when water supply is limited, it is necessary to take into account the critical stages of crop growth with respect to soil moisture level. Under the conditions of irrigation, with an improvement in the irrigation amount, the yield of winter wheat was increased (Quanqi *et al*. 2008). In view of the above circumstances, the present study was undertaken with the objective to study the growth and yield of wheat as influenced by different levels of tillage and irrigation practices.

Materials and Methods

The experiment was conducted at Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh, during the winter (Rabi) season in the year of 2007-2008. The soil belongs to the "Old Brahmaputra Floodplain" agro ecological zone (UNDP and FAO, 1988). The experimental field was a medium high land belonging to the non-calcareous dark gray floodplain soil followed by fallow-wheat cropping pattern. The soil texture of experimental site was silt loam with low organic matter content and slightly acidic in reaction. Details of the nutrient status of initial soil were pH - 6.30, organic matter (%) -1.76, total N (%) - 0.075, available P (ppm) - 9.98, exchangeable K (c mol kg^{-1}) - 0.073, available S (ppm) - 1.47. The experiment was laid out in a split-plot design consisting of two sets of experimental treatments viz., (i) three tillage practices arranged in main plot and (ii) the four irrigation levels allocated into the sub-plots. Tillage treatments include T_1: land prepared by one passing of a power tiller, T_2: land prepared by two passing of a power tiller and T_3: land prepared by three passing of a power tiller where as irrigation treatments include I_0: no irrigation, I_1: one irrigation at crown root initiation stage i.e., 21 DAS, I_2: two irrigation, one at crown root initiation stage, another at heading stage i.e., 45 DAS and I_3: three irrigation, one at crown root initiation stage, another at heading stage and final at the grain filling stage i.e., 76 DAS. The treatments were replicated three times and thus forming 36 unit plots. The unit plot size was 4m X 2.5m having spacing of plot to plot 0.5m and block to block 1.0m. The land was first plowed on 22 November, 2006 with the help of a power tiller and it was further plowed followed by laddering on 24 and 25 November, 2007 as

per tillage treatment to prepare finally for sowing seeds of wheat. Recommended doses of fertilizers @ 100 kg N ha^{-1}, 18 kg P ha^{-1}, 50 kg K ha^{-1}, 20 kg S ha^{-1}, 3 kg Zn ha^{-1}, 1 kg B ha^{-1} were applied through urea, TSP, MP, gypsum, ZnO and boric acid source respectively. TSP, MP, gypsum, ZnO and boric acid were applied as basal during final land preparation but nitrogen was applied in three equal splits. The first split of urea was applied during final land preparation, the second split at heading stage and the third split at panicle initiation stage. Due to low nutrient status of the soil, well decomposed rice straw @ 5 t ha^{-1} was also applied two weeks before sowing of wheat seed. Seeds of wheat were sown manually @ 120 kg ha^{-1} in the lines at the depth of 4-5 cm and maintained the line to line distance of 20 cm. Care was taken to avoid the damage of seeds and emerging seedling by birds. To ensure and maintain the normal growth, intercultural operations were done in time. Two hand weeding was done one at 28 DAS and another was done at 50 DAS by the help of nirani. Irrigation was applied as per treatment and care was taken to avoid the control plots from water during irrigation. The pests (cut worm and mole cricket) were controlled by the application of Tricosale 20 EC mixed with rice bran and chita gur and broadcasted in the field. The crop was harvested at full maturity and done on 29 March 2008. Ten plants were selected randomly from each plot for sampling and keep records on yield contributing characters like plant height, number of tillers $hill^{-1}$, spike length, number of spikelets $spike^{-1}$, number of filled grains $spike^{-1}$ and weight of 1000 grains. The grain and straw obtained from each unit plot were dried and weighed carefully and the results were recorded and expressed as t ha^{-1} and 1000 grains weight in gram on 14% moisture basis. The data were analyzed statistically (Gomez and Gomez, 1984) to examine whether the treatment effects were significant. The mean comparisons of the treatments were evaluated by DMRT (Duncan's Multiple Range Test). The analysis of variance for different parameters was done by a computer package program "MSTAT-C".

Results and Discussion

Effects of tillage and irrigation and their interaction on the yield and yield contributing characters of wheat

Plant height: The plant height of wheat was significantly changed by the impact of tillage and irrigation practices (Table 1). The plant height ranged from 78.16 cm to 83.21 cm. The highest plant height 83.21 cm was recorded in T_3 and the lowest plant height 78.16 cm was recorded in T_1 treatment respectively. The similar result was accorded with Basunia (2000). In case of irrigation practices, the tallest plant (86.57 cm) was found in I_3 and the shortest plant (74.53 cm) was found under the treatment I_o. The result was also supported by Abodorrahmani *et. al.* (2005). The interaction effect of tillage and irrigation showed non- significant effects on plant height. From the table 2, it was clear that the tallest plant (89.85 cm) was found under T_3I_3 treatment combination and the shortest plant (72.21 cm) was found under T_1 I_o treatment combination respectively.

Table 1. Single effects of tillage and irrigation and their interaction on yield contributing characters and yield of wheat

Factors	Plant height (cm)	Effective tillers $hill^{-1}$	Spike length (cm)	Spikelets $spike^{-1}$	No. of grains $spike^{-1}$	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Tillage treatments								
T_1	78.16c	3.80c	9.68c	14.75c	28.22c	36.14	3.14c	5.91
T_2	80.60b	3.95b	10.22b	15.32b	32.60b	40.54	3.23b	6.13
T_3	80.21a	4.03a	10.79a	16.22a	35.16a	45.48	3.46a	6.24
Level of sign.	**	**	**	**	**	NS	**	NS
$LSD_{(0.05)}$	0.611	0.072	0.036	0.338	0.221	-	0.0004	-
Irrigation treatments								
I_0	74.53d	3.08d	8.39c	12.82d	29.77d	37.83	3.04d	5.80c
I_1	78.33c	3.66c	9.81b	15.34c	30.44c	40.46	3.19c	6.07b
I_2	83.19b	4.32b	10.92a	16.27b	32.07b	40.84	3.34b	6.14b
I_3	86.57a	4.63a	11.20a	17.41a	35.69a	43.76	3.53a	6.35a
Level of sign.	**	**	**	**	**	NS	**	**
$LSD_{(0.05)}$	1.499	0.099	0.318	0.339	0.537	-	0.044	0.076

Means followed by common letters do not differ significantly, NS = Not significant, ** = Significant at 1% level of probability, * = Significant at 5% level of probability

Number of effective tillers $hill^{-1}$: Tillage influenced significantly the number of effective tillers $hill^{-1}$ of wheat (Table 1). The highest number of effective tillers $hill^{-1}$ (4.03) was recorded in T_3 treatment whereas the lowest number of effective tillers $hill^{-1}$ (3.8) was found under T_1 treatment. Effective tillers $hill^{-1}$ and grain yield was found to be statistically significant. It is possible due to absorption of more water and nutrients from deeper soil. The number of effective tillers $hill^{-1}$ was also significantly influenced by irrigation (Table 1). Maximum number of effective tillers $hill^{-1}$ (4.63) was observed in I_3 and minimum numbers of effective tillers $hill^{-1}$ (3.08) was recorded in I_o treatments respectively. The result was accorded with the findings of Jamal *et al.*, (2004). The interaction effects of tillage and irrigation on the effective tillers $hill^{-1}$ was statistically

significant (Table 2). The treatment combination $T_3 I_3$ gave the highest number (4.94) of effective tillers hill^{-1} and $T_1 I_o$ treatment combination gave the lowest number (2.93) of effective tillers hill^{-1}.

Spike length: Tillage and irrigation practices significantly influenced spike length of wheat (Table 1). The treatment T_3 produced the tallest spike (10.79 cm). The shortest spike length (9.68 cm) was recorded in T_1 treatment. From table it was also observed that the tallest spike (11.20 cm) was found under the treatment I_3 and the shortest spike length (8.39 cm) was found under the treatment I_0, which was correlated with the findings of Singh *et al.* (2006) and Hefni *et al.* (1983). The interaction effects of tillage and irrigation was non significant (Table 2). The tallest spike of 11.88 cm was found under T_3I_3 treatment combination and the shortest spike of 7.57 cm was found under T_1I_o treatment combination respectively.

Table 2: Interaction effects of tillage and irrigation and their interaction on yield contributing characters and yield of wheat

Factors	Plant height (cm)	Effective tillers hill^{-1}	Spike length (cm)	Spikelets spike^{-1}	No. of grains spike^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Tillage and irrigation treatments								
T_1I_0	72.21	2.93h	7.57	12.13g	27.22h	33.96	2.88f	5.54f
T_1I_1	76.93	3.80e	10.07	15.00e	27.05h	35.04	3.01e	5.97de
T_1I_2	79.96	4.11d	10.56	15.00e	28.39g	35.33	3.25d	6.01de
T_1I_3	83.54	4.36c	10.51	16.87bc	30.20ef	40.24	3.41c	6.11cd
T_2I_0	74.98	3.16g	8.45	12.20g	29.97f	35.11	3.03e	5.88e
T_2I_1	78.21	3.67ef	10.23	15.20e	31.00e	40.97	3.19d	6.03d
T_2I_2	82.87	4.36c	10.99	16.47c	30.98e	41.58	3.25d	6.21c
T_2I_3	86.32	4.59b	11.21	17.40ab	38.44a	44.50	3.44c	6.39b
T_3I_0	76.39	3.16g	9.16	14.13f	32.11d	44.41	3.21d	5.98de
T_3I_1	79.84	3.51f	10.91	15.84d	33.26c	45.36	3.36c	6.21c
T_3I_2	86.74	4.49bc	11.21	17.33b	36.85b	45.61	3.52b	6.21c
T_3I_3	89.85	4.94a	11.88	17.97	38.44a	46.55	3.74a	6.55a
Level of sign.	NS	**	NS	**	**	NS	*	*
$LSD_{(0.005)}$	-	0.172	-	0.587	0.930	-	0.077	0.133

Means followed by common letters do not differ significantly, NS = Not significant, ** = Significant at 1% level of probability, * = Significant at 5% level of probability

Number of spikelets spike^{-1}: The number of spikelets spike^{-1} was influenced by the impact of different tillage and irrigation (Table 1). The maximum number of spikelets spike^{-1} was (16.22) recorded in T_3 and the minimum number of spikelets was (14.75) found under T_1 treatment. This result was also similar to Roy and Sarker (1993). Irrigation significantly influenced the number of spikelets spike^{-1}. The maximum number of spikelets spike^{-1} was (17.41) recorded in I_3 and the minimum number of spikelets spike^{-1} (12.82) was recorded in I_o treatments respectively. The combined interaction effects of tillage and irrigation were also significant to the number of spikelets spike^{-1} (Table 2). The highest number of spikelets spike^{-1} (17.97) was observed under T_3I_3 treatment combination and the lowest number (12.13) was observed under T_1 I_o treatment combination respectively.

Number of grains spike^{-1}: Various tillage and irrigation treatments influenced the number of grains spike^{-1} significantly (Table 1). The highest number of grains spike^{-1} (35.16) was obtained in T_3 and the lowest number (28.22) was found under T_1 treatment. Considering the irrigation treatment, the highest number of grains spike^{-1} (35.69) was observed in I_3 and the lowest number (29.77) was observed in I_o treatments respectively, which was correlated with the findings of Abodorrahmani *et. al.* (2005) and Rajput and Pandey (2004). The interaction effects of tillage and irrigation on grains spike^{-1} was also significant. The highest number of grains spike^{-1} (38.44) was observed in T_3I_3 treatment combinations whereas the lowest number of grains spike^{-1} (27.05) was found in the T_1 I_o treatment combinations respectively (Table 2).

1000- grain weight: Tillage and irrigation did not affect 1000- grain weight significantly (Table 1). The highest 1000- grain weight was (45.48 g) found in T_3 and the lowest 1000- grain weight (36.14 g) was found under T_1 treatments respectively. The maximum weight of 1000- grain (43.76 g) was also found under I_3 and the minimum weight of 1000- grain (37.83 g) was found in I_o treatment. This result was in agreement with Rajput and Pandey (2004) and Wang *et. al.* (2001). Interaction effects of tillage and irrigation treatment combination of T_3I_3 produce the highest weight of 1000-grain and the lowest weight of 1000-grain (33.96 g) was produced by T_1 I_o treatment combination (Table 2).

Grain yield: Different tillage and irrigation practices resulted a significant grain yield (Table 1). Maximum grain yield of (3.46 t ha^{-1}) was found under T_3 and minimum grain yield (3.14 t ha^{-1}) was obtained in T_1 treatment. More tillage intensity favored better root

growth and nutrient uptake, as a result yield became maximum. Matin and Uddin (1994), and Siritanu *et. at.* (2002) observed similar findings. In irrigation practices, the highest grain yield (3.53 t ha^{-1}) was achieved in I_3 and the lowest grain yield (3.04 t ha^{-1}) was found in I_o, which is correlated with Rahman *et. al.* (2006) and Rajput and Pandey (2004). Irrigation increase the availability of nutrients thus plants uptake more nutrients and finally yield increased. The interaction effects of tillage and irrigation showed significant result for producing grain yield of wheat. The highest yield (3.74 t ha^{-1}) was found under T_3I_o treatment combination, which was statistically identical with T_1I_o (2.88 t ha^{-1}) treatment combination (Table 2).

Straw yield: Straw yield was not significantly influenced by tillage. The highest straw yield (6.24 t ha^{-1}) was obtained under T_3 and the lowest straw yield (5.91 t ha^{-1}) was obtained under T_1 treatment respectively (Table 1). Under T_3 treatment, soil was looser that permitted the penetration of the roots into the deeper soil layer for uptaking water and mineral nutrients. Positive physiological and metabolic activities of wheat were probably influenced by tillage operation. Thus the grain and straw yields were increased. Irrigation showed significant result on the straw yield of wheat (Table). The highest straw yield of 6.35 t ha^{-1} was recorded under I_3 treatment and the lowest straw yield of 5.80 t ha^{-1} was recorded in I_0 treatment. Rahman *et. al.* (2006) was observed similar findings. The interaction effects of tillage and irrigation showed significant result on the straw yield (Table 2). The highest straw yield (6.55 t ha^{-1}) was found under T_3I_3 treatment combination and the lowest straw yield (5.54 t ha^{-1}) was found under T_1I_0 treatment combination.

From the results, it may be concluded that higher grain and straw yield of wheat (cv. Shatabdi) were recorded in the treatments where higher tillage and irrigation practices were applied. In general, it was believed that higher grain and straw yield of wheat observed due to the improved soil physical and chemical conditions with the increase of tillage and irrigation at the critical stages of crops.

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