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Original Research Article

Integrated application of fertilizer and compost on water transmission behavior and yield of wheat under different tillage systems

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The experiment was conducted in Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during 2012-2013 to investigate the integrated effect of fertilizer and compost on water transmission behavior and yield of wheat under different tillage systems. The experiment was laid out in a split-plot design with three tillage treatments in the main plots and fertilizer with compost treatments in the sub-plots. The treatments were replicated thrice. The tillage treatments include one passing of a power tiller (T_1), two passing of a power tiller (T_2) and three passing of a power tiller (T_3). Fertilizer and compost treatments were recommended dose of fertilizers (NPKSZn)(F) and 70% of F + compost at 6 t ha^{-1} (FC). The results demonstrate that the yield components of wheat except 1000-grain weight was maximum in T_3 and it also recordedthe highest grain yield (4.3 t ha^{-1}). The lowest grain yield of 3.6 t ha^{-1} was obtained in T_1. The effect on cumulative infiltration and the rate of soil water infiltration was found due to the tillage intensity, fertilizer and compost application. It can be concluded that fertilizer and compost treatments along with three passing of power tiller can be practiced to maximize the wheat yield.

Key words: Fertilizer, compost, tillage, infiltration, wheat and yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) constitutes the world's most important cereal crop ranks third after maize and rice. On a worldwide scale, wheat contributes approximately 30% of total cereal production (Fageria et al., 1997). It belongs to family Graminae which has many species including rice, barley, maize etc. It has significant role in human nutrition. In Bangladesh, it ranks next to rice (Razzaque and Hussain, 1991) and its popularity is increasing consistently. The food value of wheat is considerable. It contains 14% protein, 2.1% fat, 2.1% mineral matter and 78.11% starch (Peterson, 1965).

Bangladesh is an overpopulated country and the population is increasing day by day. To meet the growing demand, wheat can be a good supplement of rice which is main food in Bangladesh and can play a vital role to feed there population. Wheat production has been declining over recent years, from 1.51 million tons in 2002-03 to 0.844 million tons in 2007-08 (BBS, 2008). The main reason for the decline in wheat area is weather, which in recent years has been blamed for low yields. If low temperatures are prolonged in the winter season, the yield of wheat is increased. If winter is short the yield declines due to the temperature sensitivity of this crop.

Environmental factors strongly influence wheat yield, particularly grain yield, soil moisture and N, the former of which depends on irrigation water and its distribution during the growing season (Copper et al., 1987). Production and yield of wheat depend on climatic condition, variety, tillage practices etc. Tillage operations are necessary to remove weeds and prevent crust formation (Aase and Siddoway, 1982). Different tillage operations may influence the physical properties of soil such as soil bulk density, soil moisture content, soil porosity (Singh and Singh, 1996). The advantages of different tillage systems are moisture

conservation, reduction of soil erosion, less labour and energy requirement, more timely planting of crops and increased intensity of land use (Asoegwu, 1992). It also increases the cumulative infiltration and rate of infiltration. As a result soil becomes permeable, aerated and has a good physical condition for crop production. The general effect of compost on soil to improve the physical, chemical and biological properties of soil. The long term research conducted by Bangladesh Rice Research Institute reveals that the application of manure along with inorganic fertilizers improves rice productivity as well as prevents the soil resource from degradation (Bhuian, 1994).

Integrated use of manure and fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status (Namibiar, 1991). Thus we need to use manure and fertilizer in an integrated way in order to obtain economically profitable crop yields without affecting soil fertility. Considering the above fact, the present investigation was taken under involving tillage intensity, fertilizer and compost to study the water infiltration rates against the elapsed time and to investigate the effect of tillage intensity, fertilizer and compost on the yield contributing characters and yield of wheat.

MATERIALS AND METHODS

The experiment was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during the winter (Rabi) season of 2012-2013. The study was performed to evaluate the integrated application of fertilizer and compost on water transmission behavior and yield of wheat under the different tillage systems. The soil of the experimental site belongs to the Sonatala series under the AEZ of Old Brahmaputra Flood plain. The soil was silty loam in texture having particle density 2.55 g/cm^3 and it was medium high land, fairly level topography and moderately well drained. The experiment was laid out in a split-plot design with three replications. There were two sets of experimental treatments viz. (i) three tillage treatments arranged as main plot and (ii) fertilizer and compost treatments were allocated into the two sub-plots. The main plot treatments include T_1 = 1 passing of a power tiller, T_2 = 2 passing of a power tiller and T_3 = 3 passing of a power tiller and sub plot treatments include F = Recommended dose of fertilizers at 100kg N, 18kg P, 50kg K, 20kg S, 3kg Zn and 1kg B ha^{-1} and FC = 70% of N + Compost at 6 t ha^{-1}. The sources and nutrient content of N, P, K, S, Zn and B were urea (46%N), TSP (20%P), MoP (50%K), Zypsum (18%S), Zinc oxide (78%Zn) and Boric acid (17%B) respectively. The compost contains of 2.9%N, 0.05%P, 1.55%K, 0.165%S and 58 ppm Zn. Thus, the numbers of plots were eighteen and the size of unit plot was 4 m × 2.5 having spacing of plot to plot 0.5 m and block to block 1.0 m.The recommended high yielding wheat variety, Shatabdi was used as a test crop. The total amount of compost, TSP, MoP, gypsum, zinc oxide and boric acid was applied during final land preparation and urea was applied in three equal splits. The first split was applied during final land preparation, the second split at heading growth stage (30 days) and the third split at panicle initiation growth stage (55 days). Compost was applied in the plot and mixed with the soil by spade before sowing of wheat seed. Seeds of wheat were sown on 29 November, 2012 at 120 kg ha^{-1} in lines and covered with soil by hand. The line to line distance was 20 cm and the depth of furrow was about 6 cm. A strip of wheat crop was established around the experimental field as border crop. Different intercultural operations such as irrigation, weeding, pest control etc. were done as and when required. The crop was harvested on 24 March, 2013 at full maturity and the data on plant height, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, and number of grain spike^{-1} and weight of 1000 grains. The grain and straw yields were recorded and expressed as t ha^{-1} and 1000 grains in g on 14% moisture basis. All the data were statistically analyzed by F-test and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

Infiltration Rate and Cumulative Infiltration

Generally the infiltration rate is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour.

The infiltration of soil water in the field was determined with the help of double ring infiltrometer method. The cumulative infiltration was calculated and plotted on a log-log paper against the time interval to find the intercept "a" and slope "b" of the most widely used infiltration equation given by Kostiakov (1932)

$I_C = at^b$ ……. (1)

Where,

I_C =cumulative infiltration,

t = cumulative time,

a = intercept,

b=slope and

$d(Ic)/d(t) = abt^{b-1}$ = the rate of infiltration

After computing all necessary parameters the data on the rate of infiltration were then plotted on an ordinary graph paper to get the infiltration rate curve accordingly. Mean and standard deviation values were calculated and used for the infiltration curves.

RESULTS

The subject research was carried out to check the water infiltration rates against the elapsed time and to evaluate the effect of tillage intensity, fertilizer and compost on the yield contributing characters and yield of wheat. The outcome of the pilot study revealed that wheat plants height, number of tillers plant-1, spike length, number of spikelets spike^{-1}, number of grain spike-1 and weight of 1000-grains differed very significantly between application

Table 1. Effect of tillage intensity, fertilizer, compost and their interaction on the yield contributing characters and yield of wheat variety Shatabdi

Treatments	Plant height(cm)	Effective tillers plant^{-1}	Spike length(cm)	Spikelets spike^{-1}(no.)	Grains spike^{-1}(no.)	1000-grain weight(g)	Grain yield	Straw yield
Tillage intensity								
T_1	90.2b	2.4c	10.1b	18.6c	45.7c	46.9	3.6	6.3c
T_2	94.5a	2.9b	10.7ab	19.6b	50.7b	47.6	4.0	7.4b
T_3	90.8b	3.7a	11.4a	21.3a	52.5a	47.4	4.3	8.6a
Level of significance	*	**	*	**	**	NS	**	**
Lsd$_{(0.05)}$	2.166	0.124	0.245	0.294	0.872	-	0.058	0.176
Fertilizer and compost								
F	90.5	2.7b	10.3b	18.9b	48.1b	46.9	3.6	6.9b
FC	93.1	3.3a	11.2a	20.7a	51.1a	47.6	4.3	7.9a
Level of significance	NS	**	**	**	**	NS	**	**
Lsd$_{(0.05)}$	1.444	0.089	0.164	0.196	0.582	-	0.038	0.143
Tillage intensity ×Fertilizer and compost								
T_1F	85.7b	2.1	9.4	17.4e	43.2	46.7	2.9	5.9e
T_1FC	94.7a	2.7	10.8	19.7c	48.0	47.0	4.2	6.6d
T_2F	93.0a	2.6	10.5	18.6d	50.2	47.2	3.6	6.9c
T_2FC	95.9a	3.2	10.9	20.7b	51.1	47.9	4.5	8.0b
T_3F	90.0ab	3.3	10.8	20.9ab	50.8	47.1	4.3	8.1b
T_3FC	91.6ab	4.0	11.9	21.7a	54.2	47.7	4.3	9.2a
Level of significance	*		NS	*	NS	NS	**	*
Lsd$_{(0.05)}$	4.331	-	-	0.588	-	-	0.115	0.253

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

of different rates fertilizer and compost supplemented with different tillage operation intensity as shown in Table 1. The critical gathered observations and data for the above discussed parameters during the research period are appended below:

Yield attributes

The yield attributes of wheat variety Shatabdi was significantly influenced due to integrated application of fertilizer and compost under different tillage systems (Table 1). The plant height of wheat was significantly changed by different tillage treatments at 5% level of probability (Table 1). The maximum plant height (94.5 cm) was recorded in T_2 treatment and the minimum plant height (90.2 cm) was found under T_1 treatment (Table 1). Similar result was accorded with Basunia (2000). The plant height of wheat was not statistically significant by the addition of fertilizers and compost. The interaction effect of fertilizer, compost and tillage showed significant effects on plant height at 5% level of probability. It was measured that the tallest plant (95.9 cm) was obtained in T_2FC treatment combination and the shortest plant (85.7 cm) was found in T_1F treatment combination (Table 1). The highest number of effective tillers plant^{-1} (3.7) was found in T_3 treatment and the lowest number of effective tillers plant^{-1} (2.4) was obtained under T_1 treatment (Table 1). It was possibly due to absorption of more water and nutrients from the deeper soil. This result is supported by Ogbodo (2005). The maximum number of effective tillers plant^{-1} (3.3) was observed in FC treatment while the minimum number of effective tillers plant^{-1} (2.7) was recorded in F treatment (T 4.3).

The present result is agreement with Reddy et al. (2004). The interaction effect of tillage intensity, fertilizer and compost on the number of effective tillers plant^{-1} was not shown statistically significant effects. The tillage treatment T_3 produced the highest spike length of wheat (11.4 cm) and the shortest spike length of wheat (10.1 cm) was recorded in T_1 tillage treatment (Table 1). Ogbodo (2005) reported that crop growth and yield increased with tilled soil over untilled soil. it was observed that the maximum spike length of wheat (11.2 cm) was recorded under the FC treatment and the minimum spike length of wheat (10.3 cm) was observed in the F treatment. The interaction effect of tillage, fertilizer and compost was not significantly influenced the spike length of wheat. The maximum number of spikelets spike^{-1} (21.3) was found in T_3 treatment and the minimum number of spikelets spike^{-1} (18.6) was recorded in T_1 treatment. This result was also similar to Roy and Sarkar (1993). The combined effect of tillage intensity, fertilizer and compost on spikelets spike^{-1} was also significant. The maximum number of spikelets spike^{-1} (21.7) was found under T_3FC treatment combination and the minimum number of spikelets spike^{-1} (17.4) was found under T_1F treatment combination (Table 1). Bijoy et

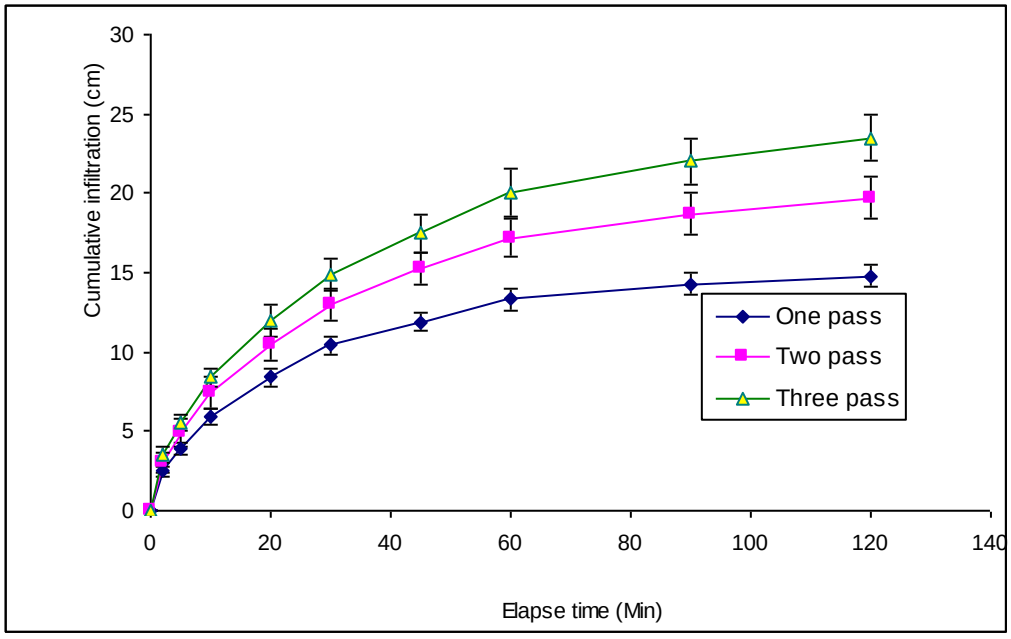

Figure 1. Cumulative infiltration as a function of elapsed time under three tillage systems
Data are the means of 3 observations; error bar indicates ±standard deviation

al. (1996) reported that the combination of manure and fertilizers application increased the number of spikelets spike^{-1} and grain yield of wheat. The highest number of grains spike^{-1} (52.5) was found under T_3 treatment. The lowest number of grains spike^{-1} (45.7) was recorded under T_1 treatment (Table 1). The result was also supported by Razzaq et al. (1997). The highest number of grains spike^{-1} (54.2) was observed in T_3FC treatment combination and the lowest number of grains spike^{-1} (43.2) in T_1F treatment. The highest 1000-grain weight of wheat (47.6 g) was found under T_2 treatment. The lowest 1000-grain weight of wheat (46.9 g) was observed in under T_1 treatment. Interaction effect of tillage intensity, fertilizer and compost was not significantly influenced 1000-grain weight of wheat.

Grain yield

The grain yield of wheat variety Shatabdi was significantly influenced due to integrated application of fertilizer and compost under different tillage systems (Table 1). The highest grain yield of 4.3 t ha^{-1} was found under T_3 treatment and the lowest grain yield of 3.6 t ha^{-1} was obtained in T_1 treatment (Table 1). This finding was supported by Ranjan et al. (2006); Ogbodo (2005); Matin and Uddin (1994); Rezaul and Ahmed (1997) and Ardell et al. (2001). Application of fertilizer and compost showed a significant influence on grain yield at 1% level of probability. The highest grain yield of 4.3 t ha^{-1} was recorded under FC treatment and the lowest grain yield of 3.6 t ha^{-1} was recorded under F treatment (Table 1) This finding was supported by Reddy et al. (2004). The interaction effect of tillage, fertilizer and compost showed significant result for producing grain yield of wheat (Table 1).The highest grain yield of 4.3 t ha^{-1} was obtained under T_3FC treatment combination. The lowest grain yield of 2.9 t ha^{-1} was found under T_1F treatment combinations (Table 1).

Straw yield

Tillage intensity influenced the straw yield of wheat significantly at 1% level of probability (Table 1). The highest straw yield (8.6 t ha^{-1}) was recorded under T_3 treatment and the lowest yield of 6.3 t ha^{-1} was found under T_1 treatment (Table 1). Application of fertilizer and compost showed significant result on the straw yield at 1% level of probability. The highest straw yield of 7.9 t ha^{-1} was recorded in FC treatment and the lowest straw yield of 6.9 t ha^{-1} was found under F treatment. The interaction effect of tillage intensity, fertilizer and compost showed significant result on straw yield. The highest straw yield of 9.21 t ha^{-1} was recorded under T_3FC treatment combination. The lowest straw yield of 5.96 t ha^{-1} was observed under T_1F treatment combination (Table 1).

Infiltration characteristics of soil as influenced by different tillage systems

The highest cumulative infiltration (23.5cm) was found under T_3 treatment and the lowest cumulative infiltration (14.8cm) was recorded under T_1 treatment at 120 min (Figure 1). Cumulative infiltration was found to be higher under three passing of a power tiller and that to be lower under one passing of a power tiller. Bear et al. (1994) found soil infiltration under conventional tillage operation was

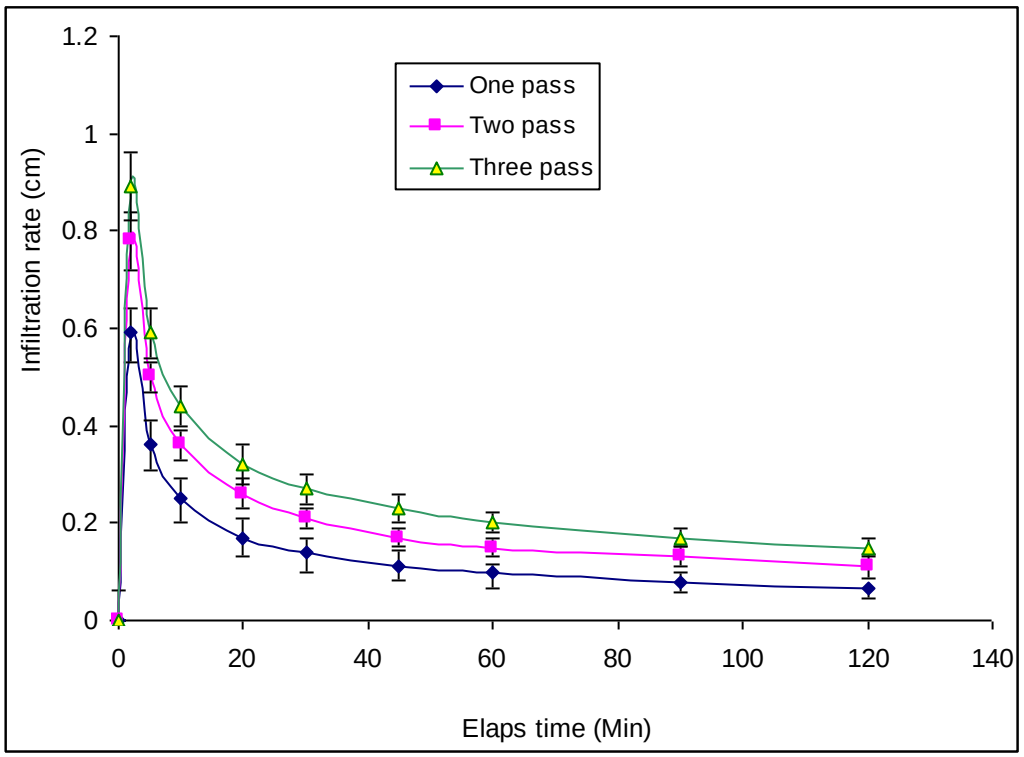

Figure 2. Rate of infiltration as a function of elapsed time (min) under three tillage systems in a wheat field Data are the means of 3 observations; error bar indicates ±standard deviation.

higher than that by no tillage treatment.

The highest rate of infiltration (0.89 cm min^{-1}) was found under T_3 treatment and lowest rate of infiltration (0.59cm min^{-1}) was found under T_1 treatment at 2.0 minutes (Figure 2). Rate of infiltration was greater under T_3 treatment than under T_1 treatment.

Tanton et al. (1996) showed that no tillage operation increased soil bulk density while it reduced soil infiltration. Rate of infiltration was found to be higher under three passing of a power tiller and lower one passing of a power tiller. It is clear that infiltration increased with the increase in tillage intensity. The result is accorded by Saha et al. (1991).

DISCUSSION

The present experiment was conducted to evaluate the integrated effect of fertilizer and compost on water transmission behavior and yield of wheat under different tillage systems. The plant height of wheat was significantly changed by different tillage treatments. At 25 DAS, the tallest plant height (23.1 cm) was found under T_3 tillage treatment and the shortest plant height (20.6 cm) was found under T_1 tillage treatment. The highest spike length (11.4 cm), spikelets $spike^{-1}$ (21.3), number of grains $spike^{-1}$ (52.5) and highest number of effective tillers $plant^{-1}$ (3.7) were observed under T_3 tillage treatment. The highest 1000-grain weight of wheat (47.6 g) was found under T_2 treatment. On the other hand, the lowest number of effective tillers $plant^{-1}$ (2.4), spike length (10.1 cm), 1000-grain weight (46.9 g), Spikelets $spike^{-1}$ (18.6) and grains $spike^{-1}$ (45.7) were observed in T_1 tillage treatment. The application of fertilizer and compost treatments, the yield contributing characters of wheat responded significantly by tillage intensity. The highest plant height (93.1 cm), number of effective tillers $plant^{-1}$ (3.3), spike length (11.2 cm), spikelets $spike^{-1}$ (20.7), number of grains $spike^{-1}$ (51.1) and 1000-grain weight (47.6 g) were recorded in FC treatment and the lowest plant height (90.5cm), number of effective tillers $plant^{-1}$ (2.7), spike length (10.3cm), spikelets $spike^{-1}$ (18.9), number of grains $spike^{-1}$ (48.1) and 1000-grain weight (46.9 g) were observed in F treatment.

The highest grain yield of 4.3 t ha^{-1}, straw yield of 8.6 t ha^{-1} and biological yield of 12.9 were recorded in T_3 tillage treatment and the highest harvest index of 35.9 was also recorded under T_2 treatment where the lowest grain yield of 3.6 t ha^{-1}, straw yield of 6.3 t ha^{-1}, biological yield of 9.8 and hervest index of 34.9 were observed in T_1 tillage treatment. In case of application of fertilizer and compost treatments, the highest grain yield of 4.3 t ha^{-1} , straw yield of 7.9 t ha^{-1}, biological yield of 12.3 and harvest index of 35.5 were observed in FC treatment where the lowest grain yield of 3.59 t ha^{-1}, straw yield of 6.96 t ha^{-1}, biological Yield of 10.6 and harvest index of 33.9 were observed in F treatment. The grain yield was found to be

significant and positively correlated with with plant height (r= 0.31*), effective tillers plant^{-1} (r =0.75**), spike length (r = 0.92**), No. of grain spike^{-1}(r = 0.74**) and 1000-grain weight (r=0.13*)

CONCLUSION

The present study was carried out to investigate the integrated application of fertilizer and compost on wheat (cv. Shatabdi) under different tillage systems. The results revealed that the effect on cumulative infiltration and the rate of soil water infiltration and the higher yield was also found due to the tillage intensity, fertilizer and compost application. The statistical data showed that the tillage treatment T_3 demonstrated better performance as compared to the other tillage treatments. The T_1 treatment showed less effective results regarding all the parameters. Hence, tillage treatment T_3 in combination recommended dose of fertilier along with compost integrated system is recommended for getting maximum yield of wheat under agro-ecological conditions of BAU farm. However, further investigation is necessary to establish the present findings in other AEZs of Bangladesh with wheat crop.

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