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Impact of Tillage Intensity, Fertilizer and Manuring on Soil Physical Properties

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Abstract: A field experiment was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during aman season of 2013, to study the impact of tillage intensity, fertilizer and manuring on soil physical properties, water conservation and yield of rice. The experiment was laid out in a split-plot design with three tillage treatments in main plot and four fertilizer and manuring treatments in sub plots and replicated thrice. The unit plot area was 4 m x 2.5 m. The maximum bulk density of 1.61 g cm^{-3}and the minimum bulk density of 0.87 g cm^{-3}were observed in P_1 at 10-20 cm depth and by P_3 at 0-10 cm soil depth. The highest soil moisture content of 51.68% was found under P_3 at 0-10 cm depth and the lowest value of 37.91% in P_1 at 10-20 cm depth. The highest air-filled porosity of 12.16% was found under P_2 at 0-10 cm soil depth. Considering tillage treatment, the highest number of tillers hill^{-1} (11.80), number of grains panicle^{-1} (106.97), 1000-grain weight (21.58 g) and grain yield (4.40 t ha^{-1}) were observed in P_3 treatment. The lowest straw yield (4.18 t ha^{-1}) and grain yield (3.64 t ha^{-1}) was found in P_2 treatment. The soils were manipulated with different tillage operations thereby reduced compactness of soil and increased the number of pore spaces, which decreased soil bulk density. As a result, yield of rice increased.

Key words: Tillage Intensity · Fertilizer · Manuring · Yield · Rice (*Oryza sativa* L.)

INTRODUCTION

Agriculture is the most important sector of the economy of Bangladesh. Rice *(Oryza sativa* L.*)* is the leading cereal crop in the world and staple food crop in Bangladesh. Agriculture contributes about 19.82% of her gross domestic products (GDP). Rice is grown in about 80% of total cropped area. The total area and production of rice in Bangladesh are about 10.28 million hectare and 25.157 million metric ton, respectively, with the average yield of around 2.43 ton per hectare [1]. Although, rice is the major food crop in Bangladesh and the agro-climatological condition is favorable for its cultivation all the year round, yet the per hectare yield of this crop is low compared to other rice growing countries like Australia, Japan, China and South Korea due to declining soil fertility status and lack of proper tillage practices.

Generally crop production is a combined impact of soil factors, management and environmental factors. Lal [2] defined tillage as physical, chemical or biological soil manipulation to optimize conditions for seed germination, emergence and seedling establishment. Tillage is the practices of working the soil for the purpose of bringing about more favorable condition for plant growth.

Tillage practices suppress weeds, presents a suitable seedbed for crop-plants and incorporates organic matter into the soils, thereby, the physical and chemical condition of soil play a key role in growth and development of root by controlling air and water movement to a certain extent and nutrient supply to the roots of the growing plants. Tillage intensity influence soil properties and thus the mineral nutrition and yield of wetland rice. Tillage improves soil physical condition by altering the aggregates size distribution.

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By altering the aggregates size distribution, tillage also affects the physical and chemical properties of the soils, which in turn affect plant growth [3].

The magnitude of tillage impacts varies with the use of tillage implements. Power tiller is used for deep ploughing sub soiling and rotating the soil make better than that of country plough. Deep tillage decreases the bulk density and increases the soil porosity, infiltration rate and hydraulic conductivity. As a result soil becomes permeable, aerated and have a good physical condition for crop production. On the other hand, shallow tillage increases the bulk density, soil resistance and mechanical impedance of soil for poor physical condition may be developed.

The general Impacts of organic matter are to improve soil physical, chemical and microbial properties. The importance of organic manures for improving soil environmental has been well recognized. The organic matter content of cultivated soils of the tropics and sub-tropical is comparatively low due to high temperature, alternate rainfall and microbial activity. Thus organic manures act as a buffer medium for making favorable soil environments to obtain higher yield of crops. Addition of organic matter in light soil increases porosity and water holding capacity of the soil. It makes heavy soils more friable and easy for tillage operation.

Tillage operation influences soil physical properties, crop yield, water conservation, root growth, nutrient availability and distribution. No tillage is not suitable for crop production. Though it resists the soil from erosion, conserve moisture and reduces energy but weed, insect and disease become a common phenomenon in the soil. So, uses of proper tillage practices have a big role in crop production.

MATERIALS AND METHODS

The experiment was laid out in a split plot design. There were two sets of experimental treatments *viz.* (i) three tillage treatments arranged as main plot and (ii) fertilizer and manuring treatments allocated into the subplots. The treatments were replicated three times. Thus the total number of plots was thirty six. The unit plot area was 4 m x 2.5 m having spacing of plot to plot 0.5 m and block to block 1 m. The experiment consisted of 3 main plot treatments and 4 subplot treatments. The treatments were as follows:

Main Plot Treatment:

Treatment	Tillage treatment applied to the experiment
P_1	One passing of a power tiller
P_2	Two passing of a power tiller
P_3	Three passing of a power tiller

Sub Plot Treatment:

Treatment	Fertilizer and manure applied to the experiment
Fmo	Recommended dose of fertilizers @ 85 kg N, 14 kg P, 32 kg K, 8 kg S, 2 kg Zn ha $^{-1}$as Urea, TSP, MOP, Gypsum and $ZnSO_4$. $2H_2O$ (BARC, 2005).
FM_1	60% of N plus rest of recommended dose of fertilizers + cowdung@ 5 t ha^{-1}.
FM_2	60% of N plus rest of recommended dose of fertilizers +rice straw @ 5 t ha ^{1}.
FM_3	60% of N plus rest of recommended dose of fertilizers +cowdung @ 2.5 t ha^{-1} + rice straw @ 2.5 t ha^{-1}.

RESULTS

Soil Moisture (Before Panicle Initiation Stage of Growth): Tillage intensity influenced soil moisture content significantly (Table 1). The highest soil moisture content of 51.68% was found under P_3 tillage treatment at 0-10 cm soil depth, while the lowest value of 37.91% was recorded by P_1 tillage treatment at 10-20 cm soil depth (Table 1). Fertilizer and manuring treatments also influenced soil moisture content significantly (Table 1). The highest moisture content (51.46%) was recorded in FM_1 treatment at 0-10 cm depth, whereas the lowest value (38.76%) was recorded in FM_2 treatment at 10-20 cm soil depth. The interaction of impact of tillage, fertilizer and manuring was non-significant on soil moisture content. The highest amount of soil moisture (53.54%) was found in P_2FM_1 treatment combination. The lowest amount of soil moisture (35.20%) was found in P_1FM_o treatment (Table 1).

Soil Moisture (After Harvest): The soil moisture content showed statistically significant results in different tillage treatments at 10-20 cm depth but non-significant at 0-10 cm. The maximum soil moisture content (46.01%) was found under P_3 tillage operation at 0-10 cm soil depth, while the minimum moisture content (32.91%) was measured under P_1 tillage treatment at 10-20 cm soil depth

Table 1: Effect of tillage intensity, fertilizer, manuring and their interaction on the moisture content of soil.

	Soil moisture content (%)before panicle initiation stage		Soil moisture content (%) after harvest	
Treatment	0-10 cm depth	10-20 cm depth	0-10 cm depth	10-20 cm depth
Tillage treatment				
P1	47.91c	37.91b	44.73	32.91c
P2	50.76b	40.76ab	45.28	35.76b
P3	51.68a	41.24a	46.01	36.36a
LSD 0.05	0.64	0.611	NS	0.636
Fertilizer and manuring treatments				
FM0	48.95	38.95	44.68	33.95b
FM1	51.46	41.32	46.14	36.47a
FM2	49.22	38.76	45.09	33.76b
FM3	50.82	40.85	45.43	35.85b
LSD 0.05	0.693*	NS	NS	0.758*
Tillage ×Fertilizer and manuring treatments				
P1FM0	45.20	35.20	42.65c	30.20
P1FM1	48.56	38.56	44.62abc	33.56
P1FM2	48.16	38.16	44.76abc	33.16
P1FM3	49.72	39.72	46.89a	34.72
P2FM0	51.28	41.28	45.04abc	36.28
P2FM1	53.54	43.54	47.80a	38.54
P2FM2	48.72	38.72	43.32bc	33.72
P2FM3	49.50	39.50	44.95abc	34.50
P3FM0	50.38	40.38	46.37ab	35.38
P3FM1	52.29	41.85	46.01ab	37.33
P3FM2	50.77	39.39	47.20a	34.39
P3FM3	53.25	43.35	44.46abc	38.35
LSD 0.05	NS	NS	1.674*	NS

NS= Non significant

* = significant at 5% level probability

(Table 1). The moisture content in soil was significantly influenced by fertilizer and manuring at 10-20 cm depth but non-significant at 0-10 cm depth. The highest moisture content (46.14%) was observed at 0-10 cm in FM_1 treatment, while the lowest moisture content (33.76%) was found at 10-20 cm depth in FM2 treatment (Table 1). There was a significant impact of tillage, fertilizer and manuring on soil moisture content at 0-10 cm depth but non-significant at 10-20 cm. The maximum (47.80%), while the minimum (30.20%) moisture content was found at P_2FM_1 and P_1FM_0 treatment combination under 0-10 and 10-20 cm soil depth (Table 1).

Bulk Density (Before Panicle Initiation Stage of Growth): The bulk density of soil showed significant results under three tillage treatments at 10-20 cm depth but non-significant at 0-10 cm. The highest bulk density of 1.61 g cm^{-3} was recorded under tillage treatment P_1 at 10-20 cm soil depths, while the lowest bulk density of 0.87 g $cm^{-3}$was observed by P_3 tillage treatment at 0-10 cm soil depth (Table 2). The bulk density was positively correlated (r = 0.297 NS) with grain yield (Fig. 1). Bulk density was increased significantly with increasing soil depth. The bulk density of soil was also significantly influenced by fertilizer and manuring treatments. The highest bulk density of 1.57 g $cm^{-3}$was observed under FM_2 treatment at 10-20 cm depth, while the lowest bulk density of 0.85 g cm^{-3} was recorded in the treatment FM_1 at 0-10 cm depth (Table 2). It may be due to the application of organic manures, which improved granulation of soil. The interaction impacts of tillage, fertilizer and manuring were significant (Table 2). The highest bulk density of 1.72 g cm^{-3} was observed in the P_1FM_o treatment at 10-20 cm depth of soil, while the lowest bulk density of 0.73 g cm^{-3} was observed in the P_2FM_1 treatment combination at 0-10 cm soil depth.

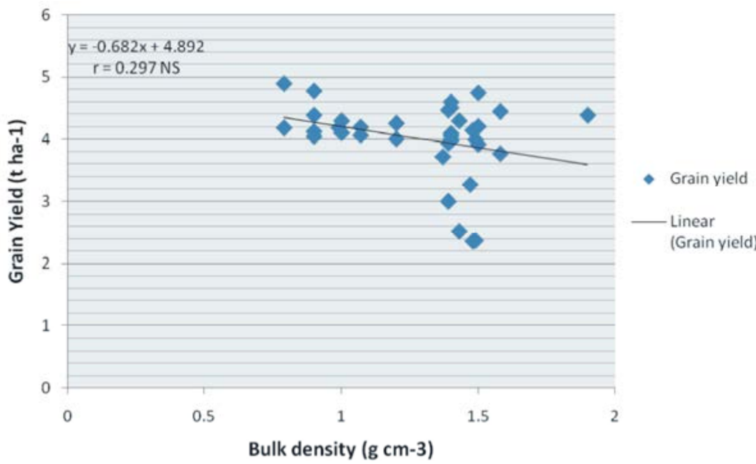

Fig. 1: The relationship between grain yield and bulk density (g cm^{-3}).

Table 2: Effect of tillage intensity, fertilizer and manuring and their interaction on the bulk density (g cm^{-3}) of soil.

	Bulk density (g cm^{-3}) before panicle initiation stage		Bulk density (g cm^{-3}) after harvest	
Treatment	0-10 cm depth	10-20 cm depth	0-10 cm depth	10-20 cm depth
Tillage treatment				
P_1	1.01	1.61a	1.08	1.47a
P_2	0.92	1.35b	0.99	1.19b
P_3	0.87	1.30b	1.02	1.21b
LSD	0.034	0.043	0.040	0.049
Level of sig	NS	**	NS	*
Fertilizer and manuring treatments				
FM_0	0.97ab	1.43ab	1.08	1.36ab
FM_1	0.85b	1.25b	0.95	1.07b
FM_2	1.00a	1.57a	1.10	1.42a
FM_3	0.90b	1.43ab	0.99	1.31ab
LSD	0.035	0.057	0.049	0.052
Level of sig	*	**	NS	**
Tillage ×Fertilizer and manuring treatments				
P_1FM_0	1.24a	1.72a	1.24	1.66a
P_1FM_1	1.02bc	1.70a	1.03	1.37a
P_1FM_2	0.93cde	1.54a	1.07	1.43a
P_1FM_3	0.81de	1.47ab	0.98	1.41a
P_2FM_0	0.78de	1.11c	0.93	1.02b
P_2FM_1	0.73e	0.96c	0.85	0.86b
P_2FM_2	1.18ab	1.71a	1.17	1.43a
P_2FM_3	0.97cd	1.63a	1.00	1.47a
P_3FM_0	0.89cde	1.46ab	1.07	1.40a
P_3FM_1	0.80de	1.08c	0.95	0.99b
P_3FM_2	0.89cde	1.46ab	1.07	1.40a
P_3FM_3	0.91cde	1.21bc	1.00	1.06b
LSD	0.104	0.172	0.147	0.157
Level of sig	**	**	NS	**

NS= Non significant

* = significant at 5% level probability

* * = significant at 1% level probability

Table 3: Effect of tillage intensity, fertilizer and manuring and their interaction on air-filled porosity (%) of soil.

	Air filled Porosity (%) before panicle initiation stage		Air field porosity (%) after harvest.	
Treatment	0-10 cm depth	10-20 cm depth	0-10 cm depth	10-20 cm depth
Tillage treatment				
P_1	10.23c	9.95b	10.93	10.64
P_2	12.16a	10.98a	11.39	11.08
P_3	11.62b	10.67ab	11.41	10.89
LSD	0.311	0.185	0.378	0.101
Level of sig	*	*	NS	NS
Fertilizer and manuring treatments				
FM_0	10.98b	10.12b	10.97b	10.69b
FM_1	12.26a	11.06a	11.57a	11.14a
FM_2	12.43a	11.01a	11.51a	11.19a
FM_3	9.67c	9.94c	10.91b	10.46b
LSD	0.242	0.198	0.176	0.171
Level of sig	**	**	*	**
Tillage ×Fertilizer and manuring treatments				
P_1FM_0	8.28e	9.21d	10.38d	9.76d
P_1FM_1	8.99e	9.37d	10.74cd	10.51bcd
P_1FM_2	11.43cd	9.96cd	11.26bcd	10.99abc
P_1FM_3	12.22bc	11.27ab	11.33a-d	11.29abc
P_2FM_0	13.87a	11.47ab	11.40a-d	11.32ab
P_2FM_1	14.35a	12.21a	12.32a	11.60a
P_2FM_2	11.87cd	10.94bc	11.13bcd	11.11abc
P_2FM_3	8.56e	9.29d	10.70cd	10.30cd
P_3FM_0	10.81d	9.69d	11.14bcd	10.99abc
P_3FM_1	13.46ab	11.60ab	11.64abc	11.31ab
P_3FM_2	14.00a	12.12a	12.13ab	11.46ab
P_3FM_3	8.23e	9.27d	10.72cd	9.80d
LSD	0.726	0.595	0.529	0.512
Level of sig	**	**	*	**

NS= Non significant

* = significant at 5% level probability

** = significant at 1% level probability

Bulk Density (After Harvest): Tillage intensity influenced soil bulk density significantly at 10-20 cm depth but non-significant at 0-10 cm depth. The highest value of 1.47 g cm^{-3} was recorded under (P_1) tillage treatment at 10-20 cm depth of soil, while the lowest value of 0.99g cm^{-3} was observed in P_2 treatment at 0-10 cm soil depth, which was significantly different from P_1 and P_2 treatments (Table 2). Bulk density showed significant result to fertilizer and manuring treatments at 10-20 cm depth. The highest bulk density of 1.42 g cm^{-3} was found in FM_2 fertilizer and manuring treatment at 10-20 cm soil depth, while the lowest bulk density of 0.95g cm^{-3} was found in FM_1 fertilizer and manuring treatment at 0 -10 cm soil depth (Table 2). The interaction Impact of tillage, fertilizer and manuring was also significant at 10-20 cm depth but non-significant at 0-10 cm. The highest (1.66 g cm^{-3}), while the lowest values (0.85 g cm^{-3}) of bulk density were found in P_1FM_o and P_2FM_1 treatments, respectively.

Air-filled Porosity (Before Panicle Initiation Stage of Growth): Tillage intensity significantly influenced the soil air-filled porosity. The highest air-filled porosity of 12.16 and the lowest air-filled porosity of 9.95% were found under P_2 treatment at 0-10 cm and P_1 treatment at 10-20 cm soil depth, respectively (Table 3). Air-filled porosity means a space occupied by air in the soil. From the data it is clear that more loosen soil is present under P_3 treatment and can allow more air into the soil. Fertilizer and manuring also significantly influenced the air-filled porosity. The highest value of air-filled porosity (12.43%), while the lowest value of air-filled porosity (9.67%) were found in FM_2 treatment at 0-10 cm and FM_3 treatment at 0-10 cm soil depth respectively. The interaction impact of tillage, fertilizer and manuring on soil air-filled porosity was significant. The highest value of air filled porosity of 14.35% was recorded at 0-10 cm depth, while the lowest value of 8.23% was recorded at 0-10 cm depth in treatment P_2FM_1 and P_3FM_3 (Table 3).

Air-filled Porosity (After Harvest): Different tillage practices non-significantly influenced the soil air-filled porosity at both depth. The highest air-filled porosity of 11.41% was found in P_3 treatment at 0-10 cm soil depth while the minimum value of 10.64% was found in P_1 treatment at 10-20 cm soil depth (Table 3). After harvest air-filled porosity of soil was slightly increased from the air-filled porosity at before panicle initiation stage of growth of rice. With respect of fertilizer and manuring, soil air-filled porosity was significantly influenced by different fertilizer and manuring treatment. The highest value of air-filled porosity (11.57%) was recorded in FM_1 treatment 0-10 cm soil depth, while the lowest value (10.46%) was found in FM_3 treatment at 10-20 cm soil depth (Table 3). Interaction impact of tillage, fertilizer and manuring on soil air-filled porosity was significant. The highest value of air-filled porosity (12.13%) was found in P_3FM_2 treatment, while the lowest value of air-filled porosity (9.76%) was found in P_1FM_0 treatment of 10-20 cm depth (Table 3).

DISCUSSION

The tillage intensity influenced grain yield of rice significantly (Table 2). The highest grain yield of 4.40 t ha^{-1} was found under P_3 treatment, while the lowest yield of 3.64 t ha^{-1} was obtained in P_2 treatment (Table 4.4). This finding was supported by [4-8].

Application of fertilizer and manuring showed significant result on grain yield. The highest yield of 4.33 t ha^{-1} was recorded, while applying the different fertilizers as a recommended dose at FM_o treatment. This finding was supported by ……..[9] and…. [10]. The lowest grain yield of 3.52 t ha^{-1} was recorded under FM_3 treatment.

Rice yield depends largely on tillers $hill^{-1}$, grains $panicle^{-1}$ and bulk density. Grain yield has a positive relationship with tillers $hill^{-1}$, grains $panicle^{-1}$ and 1000-grain weight. Positive relationship indicates the increase of grain yield was dependent on increase of tillers $hill^{-1}$ and grains $panicle^{-1}$ and 1000 grain weight. On the other hand, Grain yield has a negative relationship with bulk density. Negative relationship indicates that grain yield will decrease with the increase of bulk density. Because high bulk density restricted root growth that affected the yield contributing characters of rice.

Tillage intensity influenced the straw yield of rice. The highest straw yield of 4.51 t ha^{-1} was recorded in P_1 treatment. The lowest straw yield of 4.18 t ha^{-1} was obtained under P_2 treatment. Under P_3 treatment soil were looser (Table 2) which permits the penetration of the roots into the deeper layer for up taking of water and mineral nutrients. Positive physiological and metabolic activities of rice were probably influenced by tillage operation thus grain and straw yields of rice were increased.

CONCLUSION

Based on the study the following conclusions may be Tillage intensity, fertilizer and manuring treatments improved the physical properties of soil i.e. reduced the bulk density of soil, increased the air-filled porosity. Tillage intensity and recommended dose of fertilizers along with manure led to better rice yield. Fertilizer and manuring treatments showed a positive impact on soil physical properties and increased the yield contributing characters and yield of rice.

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