Effects of Depth of Tillage and Manures on Soil Physical Properties, Root Growth and Yield of Rice

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Abstract
A field experiment was conducted at the Bangladesh Agricultural University Farm to evaluate the effects of tillage depth and manures on soil physical properties, root growth and yield of rice. The tillage treatments were; (T_0); no tillage, (T_1) ; shallow tillage (0-15 cm) and (T_2) ; deep tillage (0-30 cm) and the manuring treatments were; recommended dose of fertilizers @ 82.8, 48, 42, 10 and 3.6 kg N, P, K, S and Zn ha^{-1}, respectively (M_1), 1/2 M_1+cow dung 5 t ha^{-1} (M_2), 1/2 M_1+rice straw 2.5 t ha^{-1} + cowdung 2.5 t ha^{-1} (M_3) and 1/2 M_1+ rice straw 5 t ha^{-1} (M_4). Deep tillage (0-30 cm) showed the lowest bulk density and the highest values of moisture content, air-filled porosity and rice root growth. The treatment combination T_2M_2 was found to be the best treatment combination for creating better physical condition of soil. The highest root growth and yield were recorded in T_2M_1 followed by T_2M_2. For sustenance of better physical condition of soil, manuring with fertilizers may be practised for economic crop production in suitable soil environment.

Introduction

Tillage and manuring create improved physical condition of soil that brings about better nutrient and water relations. Different tillage operations may influence the physical properties of soil such as bulk density, soil moisture content, soil porosity and hydraulic conductivity (Singh and Singh, 1996). Deep tillage facilitates easy uptake of water as well as nutrients by the roots from the deeper soil depths efficiently, which consequently increases the root growth and density. Organic matter is a key factor for sustainable soil fertility and crop productivity as it acts as a buffer medium for making favourable soil environment to obtain higher yield of crops. Root growth is closely related to soil compactness, which is related to the proper tillage practices. Though proper organic matter management in a suitable tillage system has drawn the attention of agriculturists in the world, no such work was carried out in Bangladesh condition. In view of above facts, the present study was undertaken to evaluate the changes in soil physical properties as influenced by depth of tillage and manures and their effects on root growth and yield of rice.

Materials and methods

The experiment was conducted at the Bangladesh Agricultural University Farm during 1 August to 18 December, 2002. It was laid out in a split plot design with three replications. It consisted of 3 main plot tillage treatments such as (T_0); no tillage, (T_1); shallow tillage (0-15 cm) and (T_2); deep tillage (0-30 cm) and 4 subplot manuring treatments were; (M_1); recommended dose of fertilizers @ 82.8, 48,,42, 10 and 3.6 kg N, P, K, S and Zn ha^{-1}, respectively, (M_2); 1/2 M_1+cow dung 5 t ha^{-1}, (M_3) ; 1/2 M_1+rice straw 2.5 t ha^{-1} + cowdung 2.5 t ha^{-1} and (M_4). ; 1/2 M_1+ rice straw 5 t ha^{-1}. Soil bulk density was measured by core sampler method (Black,1965). Air-filled porosity was measured by using a standard formula. Soil moisture content was determined by gravimetric method. Root growth was measured by using an auger like sampler of 7cm diameter as recommended by Schurman and Goodwaagen (1971). The collected data were analyzed following the ANOVA technique and the mean values were adjusted by Duncan's Multiple Range Test whenever necessary.

Results and Discussion

Effect of depth tillage and manures on physical properties of soil:

Table 1 showed that before panicle initiation stage, the highest bulk density of 1.76 g/cc was recorded under no tillage (T_0). Similar results were also observed by Matin and Uddin (1994) and Molla *et al.* (2000). The lowest bulk density was found in M_2 treatment. Before panicle initiation stage, the highest value (49.1%) of soil moisture was found under deep tillage (Table 2). Addition of organic matter in soil increased soil moisture content Before panicle initiation stage, deep tillage (T_2) gave the highest (12.02%) air-filled porosity (Table 3). In manuring treatments, the highest (12.84%) and the lowest (9.04%) values of air filled porosity were found in M_2 treatment and M_4 treatment, respectively.

Table 1. Effect of depth of tillage and manuring on the bulk density (g/cc) of soil

Treatment	Bulk density (g/cc) before panicle initiation			Bulk density (g/cc) after harvest		
	Depth of soil (cm)			Depth of soil (cm)		
	0-10	10-20	20-30	0-10	10-20	20-30
Tillage treatment						
T_0	1.2 a	1.65 a	1.76 a	1.33 a	1.67 a	1.82 a
T_1	0.98 b	1.29 b	1.65 b	0.91 b	1.35 b	1.51 b
T_2	0.75 c	0.95 c	1.39 c	0.78 b	0.92 c	1.46 c
SE (±)	0.03	0.07	0.01	0.03	0.05	0.05
Manuring treatment						
M_1	1.25 a	1.48 a	1.69 a	1.34 a	1.53 a	1.67 a
M_2	0.75 c	1.10 c	1.49 c	0.66 c	1.12 b	1.34 c
M_3	0.97 b	1.29 b	1.63 ab	0.94 b	1.41 a	1.52 b
M_4	0.93 b	1.32 b	1.59 b	0.96 b	1.38 b	1.66 b
SE (±)	0.04	0.04	0.03	0.05	0.06	0.03

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT

Table 2. Effect of depth of tillage and manuring on the moisture content of soil

Treatment	Soil moisture (%) before panicle initiation			Soil moisture (%) after harvest		
	Depth of soil (cm)			Depth of soil (cm)		
	0-10	10-20	20-30	0-10	10-20	20-30
Tillage treatment						
T_0	44.92 c	33.65 c	27.88 c	42.30 b	30.91 b	26.33 c
T_1	48.03	35.02 b	31.77 b	40.76 b	33.53 a	30.38 b
T_2	49.21 a	36.53 a	32.64 a	48.76 a	34.99 a	31.65 a
SE (±)	0.04	0.11	0.05	0.91	0.45	0.04
Manuring treatment						
M_1	47.30 c	34.23 d	30.11 d	46.31 a	32.77 a	28.25 c
M_2	48.62 a	35.72 a	31.56 a	47.04 a	34.31 a	30.10 a
M_3	48.36 a	35.31 b	30.92 b	41.27 b	32.10 a	29.42 b
M_4	47.93 b	35.00 c	30.48 c	44.47 a	33.39 a	29.44 b
SE (±)	0.10	0.10	0.06	0.88	0.83	0.08

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT

Table 3. Effect of depth of tillage and manuring on the air-filled porosity of soil

Treatment	air-filled porosity (%) before panicle initiation			air-filled porosity (%) after harvest		
	Depth of soil (cm)			Depth of soil (cm)		
	0-10	10-20	20-30	0-10	10-20	20-30
Tillage treatment						
T_0	10.88 b	9.46 c	8.57 b	10.95 c	9.67 d	8.57 b
T_1	11.73 s	10.42 b	9.99 a	11.72 b	10.88 a	10.09 a
T_2	12.02 s	11.75 a	9.79 a	12.22 a	11.54 a	10.89 a
SE (±)	0.17	0.22	.29	0.02	0.28	0.25
Manuring treatment						
M_1	10.45 c	9.92 c	8.65 c	10.51 d	10.33 b	10.79 d
M_2	12.84 a	11.08 a	10.46 a	12.99 a	11.54 a	10.10 b
M_3	12.22 b	10.69 ab	9.62 b	12.44 b	10.56 b	10.92 a
M_4	10.68 c	10.49 b	9.07 bc	10.78 c	10.36 b	9.58 c
SE (±)	0.19	0.16	0.25	0.11	0.27	0.16

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT

Effect of depth of tillage and manures on root mass density of rice:

Root mass density of rice increased with the increase in depth of tillage (Table 4). The maximum root mass density of 3.26 mg/cc was recorded under deep tillage (T_2), which was statistically not similar to those observed in the other treatments. No tillage (T_0) gave the lowest root mass density of 0.14 mg/cc. This finding is accorded with Matin (1996), Vars *et al*. (1998) and Adeaye (1982). Root mass density was statistically significant by manuring treatment. The highest root mass density (3.09 mg/cc) was measured in the M_1 treatment. It might be happened due to the readily available nutrients supplied from full dose of chemical fertilizers. The treatments M_1 and M_2 gave statistically similar result.

Table 4. Effect of depth of tillage and manuring on the root mass density of BRRI dhan 30

Treatment	Root density (mg/cc)		
	Depth of soil (cm)		
	0-10	10-20	20-30
Tillage treatment			
T_0	2.16 c	0.59 b	0.14 b
T_1	2.76 b	1.30 a	0.22 a
T_2	3.26 a	0.67 b	0.15 b
SE (±)	0.11	0.03	0.01
Manuring treatment			
M_1	3.09 a	1.08 a	0.22 a
M_2	2.99 a	0.90 b	0.18 b
M_3	2.73 b	0.78 c	0.14 c
M_4	2.20 c	0.65 d	0.14 c
SE (±)	0.10	0.01	0.01

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT

Effect of depth of tillage and manuring on yield contributing characters:

The highest tillers hill^{-1} (13.38) were found in T_2 treatment and lowest tillers hill^{-1} (9.83) were found in T_0 treatment (Table 5). In manuring treatment, maximum number of tillers was found in M_1 treatment. Plant height and panicle length were increased with increase of tillage depth and highest values of plant height and panicle length were found in T_2 treatment. The shortest plant and panicle were found in M_3 treatment. Deep tillage (T_2) gave the highest number of grain panicle^{-1}. No tillage gave the lowest number of grain panicle^{-1}. In manuring treatment, recommended does of chemical fertilizers gave the highest number of grain panicle^{-1}. Thousand-grain weight was not significantly affected by depth of tillage and manuring.

Table 5. Effect of depth of tillage and manuring on the root mass density of BRRI dhan 30

Treatment	Number of tillers per hill	Plant height (cm)	Panicle length (cm)	Number of grains per panicle	1000-grain weight
Tillage treatment					
T_0	9.83 c	89.36 c	20.37 c	92.18 b	24.42
T_1	11.88 b	93.10 b	22.28 b	98.12 a	25.17
T_2	13.38 a	95.06 a	29.92 a	99.15 a	26.25
SE (±)	0.23	0.40	0.36	0.80	NS
Manuring treatment					
M_1	12.33 a	97.02 a	23.56 a	99.19 a	25.67
M_2	11.43 b	93.44 b	21.97 b	97.84 a	24.44
M_3	11.90 ab	86.22 c	21.16 b	96.73 a	24.67
M_4	11.11 b	93.35 b	22.06 b	92.18 b	23.67
SE (±)	0.26	1.01	0.32	0.85	NS

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT.

Grain and straw yield:

Deep tillage (T_2) gave the highest (3.53 t ha^{-1}) grain yield (Table 6). Deep tillage increased grain yield by 23.89% more than control. In manuring treatment, the recommended chemical fertilizers gave the highest grain yield. The second highest yield was recorded in M_2 treatment. The highest and the lowest grain yield were found in T_2M_1 and T_2M_4 treatment combinations, respectively. Straw yield ranged from 4.34 t ha^{-1} to 5.36 t ha^{-1}. The highest straw yield (5.36 t ha^{-1}) was recorded in T_2 treatment with M_1 manuring treatment. The highest and lowest straw yields were found in T_2M_1 and T_0M_4 respectively.

Table 6. Effect of depth of tillage and manuring on grain and straw yield of BRRI dhan 30

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1}
Tillage treatment		
T_0	2.69 b	4.34 b
T_1	3.52 a	35.31 a
T_2	3.53 a	35.36 a
SE	0.03	0.06
Manuring treatment		
M_1	3.59 a	5.32 a
M_2	3.32 b	5.24 a
M_3	3.17 b	5.06 b
M_4	2.91 c	4.63 c
SE	0.07	0.07

Means followed by common letters within tillage and manuring treatments do not differ significantly at 5% level of DMRT.

Conclusion

Deep tillage increased soil moisture content, air-filled porosity and root mass density and reduced soil bulk density. No tillage gave the highest value of soil bulk density. Manuring with chemical fertilizers substantially improved soil physical properties. The treatment combination T_2M_1 gave the highest yield of rice. The second highest yield was recorded in the treatment combination T_2M_2. Therefore, to maintain sustainable soil fertility and to get economic crop yield manuring with chemical fertilizers should be practised in a deep tillage system. These results were found in a short-term tillage and manuring experiment but long-term study would be of considerable value to establish the above results.

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