Pak. j. sci. ind. res., vol. 37, no. 5, May 1994

EFFECT OF TWO TILLAGE SYSTEMS ON SOIL PHYSICAL PROPERTIES, ROOT GROWTH AND THE YIELD OF RICE AND MAIZE

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(Received July 28, 1991; revised December 7, 1993)

To investigate the effect of tillage on soil physical properties and crop yield field experiments using rice and maize were carried out at the Bangladesh Agricultural University farmland during the autumn and winter seasons of 1989 and 1990. The rice cultivars BR11 and Pajam were used in the autumn season of 1989, while during the winter of 1990, BR2 rice and maize (Barnali) were cultivated. Results revealed that the bulk density values were greater due to tilling by country plough than power tiller except in the experiment with BR11 rice. Soil bulk density increased significantly with an increase of soil depth. Root density of different crops was generally greater with power tiller as compared to country plough and it decreased significantly with an increase in soil depth. There were no significant differences in rice yield and straw due to power tiller and country plough. However, maize grain yield and ear length were significantly greater with country plough as compared to power tiller.

Key words: Plough pan, Bulk density, Soil resistance.

Introduction

The major purposes of tillage are to reduce bulk density and soil strength and to control pests and weeds. Tilling soil under wetland condition during rice cultivation leads the development of a plough pan or dense layer at 7-10 cm below the surface. Such layer restricts root penetration because of high soil strength and bulk densities [1-5]. Poor results of corn have been obtained with reduced tillage practices mainly because of high bulk densities and resistance to penetration [6,12].

Increase yields have been attributed due to deep disruption that increase root exploration [13,14]. However, some researchers [15-17] did not find significant yield differences within tillage treatments.

This research study was carried out to investigate the effect of different tillage practices on soil physical properties, and consequently their effect on root growth and yield of rice and maize crops.

Materials and Methods

Experiments were carried out at the Bangladesh Agricultural University farm during the autumn and winter seasons of 1989 and 1990 to compare the effect of different tillage practices on the growth and yield of rice and maize. Tillage treatments under investigation were: (a) conventional tillage (ploughing five times using country plough to a depth of 10cm) and (b) tillage by power tiller (five times ploughing to a depth of 15 cm).

The rice varieties BR11 (a high yielding variety) and Pajam (a local high yielding variety) were used in the autumn season of 1989. During the winter season of 1990, BR2 (a high yielding variety) rice and maize (cv. Barnali) were grown. The texture of the soil was silty loam. The particle density ranged from 2.21 to 2.51 g/cm^3. Experiment was organized in randomized complete block design using five replications. Plot size was 4 x 3m. Triple superphosphate and muriate of potash were applied @ 26 and 33 kg/ha as P and K, respectively during land preparation. For rice and maize urea was added @ 80 kg N/ha in three equal splits.

Autumn and winter rice were planted on August 2 and February 3, 1989 and 1990, respectively. The maize was sown on December 17, 1989. Rice was transplanted at a distance of 25 x 20 cm spacing, but in case of maize row to row and plant to plant distance was 75 and 25 cm, respectively. Weeding, irrigation and insecticide applications were done whenever necessary.

Root growth was measured just prior to panicle initiation stage using an auger-like sampler of 7 cm diameter as recommended by Schuurman and Goodewaagen [9]. Four samples were taken from one side of a hill at 6 cm interval (0-6, 6-12, 12-18 and 18-24 cm) down to 24 cm from each hole. Soil was washed out using 20 mesh (aperture of 0.0331 INS or 20 openings per square inch) and 200 mesh (apertures of 0.0029 INS or 200 openings per square inch) seives to obtain root samples for each depth. Root samples thus collected from all plots were kept in plastic containers and dried in the laboratory under room temperature for several days. The results were expressed as mg dry matter/cm^3.

After harvest of the crop, bulk density was determined using a core sampler of known volume [10]. The sample was collected from each plot at 6 cm interval down to 24 cm depth (0-6, 6-12, 12-18 and 18-24). A vertical pit was dug in each plot and soil resistance were measured by a pocket penetrometer at 6 cm interval down to 24 cm depth.

Autumn and winter rice were harvested on December 2, 1989 and June 17, 1990, respectively. The maize crop was harvested on May 6, 1990. The grain and straw of rice were dried in the sun and the yields recorded. The grain and straw yields of the maize crop were also recorded after drying in the sun. The ear length of maize was also measured.

Results and Discussion

Power tillage rsulted in a statistically significant greater bulk density (1.53 g/cm^3) in the BR11 rice experiment as compared to conventional tillage. However, there was no difference in bulk densities of the soil due to these tillage methods when rice varieties Pajam and BR2 and maize were used as test crops (Table 1). The bulk density values were higher due to tilling by country plough than power tiller except when BR11 was used as test rice variety.

Soil bulk density significantly increased with depth in all trials. It is very interesting to note that the higher bulk densities (1.73, 1.70 and 1.68 g/cm^3) were found at 12-18 cm soil depth in the rice (BR11 and BR2) and maize fields. In the layer of top soil (0-6 cm), the highest bulk density (1.42 g/cm^3) was recorded in the maize experiment (Table 1). Islam *et al.* [2] also found similar trends in densities with the depth in the same profile both under power tiller and country plough treatment.

Soil resistance in the autumn rice fields were higher in the soil tilled by country plough than power tiller (Table 2) but the differences were nonsignificant. The soil resistance increased significantly with depth, with the maximum soil resistance values measured at 12-18 cm depth (Table 2). In the deeper depth i.e. at 18-24 cm depth, the soil resistance decreased. The lowest values of 0.72 and 0.87 kg/cm^2 were recorded in the top layer of soil. The high soil resistance values in the subsoil were associated with the high bulk density values. Higher bulk density and soil resistance indicate the presence of plough pan (or dense layer) formation that restrict root penetration and hamper root growth.

As regards the root develop variable root growth was observed owing to the different tillage operations. Root density of Pajam was significantly higher due to tillage operation by the power tiller (Table 3). This trend was also observed with BR11, BR2 and maize but the differences were not significant (Table 3). The root densities of rice and maize (1.73, 1.46, 1.86 and 7.92 mg/cm^3) were greatest in the 0-6 cm layer and root density significantly decreased with depth (Table 3). the lowest root densities of BR11, (0.16, 0.19 and 0.16 mg/cm^3) Pajam and BR2 were observed at 18-24 cm soil depth, but in case of maize, the lowest root density (0.34 mg/cm^3) was found at 12-18 cm depth. The decline in root densities was associated with the increase in bulk densities and penetration resistance with depth (Tables 3 and 1). These results agree with the

TABLE 1. EFFECT OF TWO TILLAGE SYSTEMS ON SOIL BULK DENSITY AFTER HARVEST OF RICE AND MAIZE GROWN DURING AUTUMN AND WINTER SEASONS.

	Bulk density (g/cm^3)			
	Rice			Maize
Treatment	Autumn		Winter	Winter
	BR11	Pajam	BR2	Barnali
TILLAGE SYSTEMS				
Power tiller	1.53	1.38	1.48	1.95
Country plough	1.44	1.41	1.60	1.96
LSD (0.05)	0.06	NS	NS	NS
SOIL DEPTH (cm)				
0–6	1.23	1.18	1.19	1.42
6–12	1.36	1.25	1.45	1.68
12–18	1.73	1.57	1.70	1.68
18–24	1.63	1.59	1.61	1.50
LSD (0.05)	0.14	0.13	0.16	0.11

NS = Non-significant..

TABLE 2. EFFECT OF TWO TILLAGE SYSTEMS ON SOIL RESISTANCE AFTER HARVEST OF AUTUMN RICE.

Treatment	BR11(kg/cm^2)	Pajam(kg/cm^2)
TILLAGESY STEMS		
Power tiller	2.07	2.26
Country plough	2.42	2.57
LSD(0.05)	NS	NS
SOIL DEPTH (cm)		
0–6	0.72	0.87
6–12	1.04	1.24
12–18	3.74	3.97
18–24	3.47	3.58
LSD(0.05)	0.68	0.23

NS = Non-significant.

TABLE 3. EFFECT OF TWO TILLAGE SYSTEMS ON THE ROOT DENSITY OF RICE AND MAIZE GROWN DURING AUTUMN AND WINTER SEASONS.

	Root density (g/cm^3)			
	Rice			Maize
Treatment	Autumn		Winter	Winter
	BR11	Pajam	BR2	Barnali
TILLAGE SYSTEMS				
Power tiller	0.83	0.84	0.77	3.55
Country plough	0.73	0.58	0.80	2.59
LSD (0.05)	NS	0.20	NS	NS
SOIL DEPTH (CM)				
0–6	1.73	1.46	1.86	7.92
6–12	0.83	0.76	0.80	1.16
12–18	0.39	0.42	0.32	0.34
18–24	0.16	0.19	0.16	0.39
LSD (0.05)	0.37	0.25	0.23	1.20

NS = Non-significant.

TABLE 4. EFFECT OF TWO TILLAGE SYSTEMS ON THE MEAN YIELD OF RICE GROWN DURING AUTUMN AND WINTER SEASONS.

Tillage systems	Grain yield			Straw yield		
	Autumn		Winter	Autumn		Winter
	BR11	Pajam	BR2	BR11	Pajam	BR2
	— kg/ha —					
Power tiller	4629	4669	3821	6955	6704	5298
Country plough	4386	4365	3771	6437	6377	4459
LSD (0.05)	NS	NS	NS	NS	NS	NS

NS = Non-significant.

TABLE 5. EFFECT OF TWO TILLAGE SYSTEMS ON THE GRAIN AND STRAW YIELD AND EAR LENGTH OF MAIZE GROWN DURING WINTER SEASON.

Tillage systems	Yield (kg/ha) Grain	Straw	Ear length (cm)
Power tiller	5105	4311	16.09
Country plough	5913	4241	18.19
LSD (0.05)	567	NS	1.70

NS = Non-significant.

reports given by Brammer [1], although according to Singh *et al.* [3] little is known about the response of rice roots to increased bulk density and the information is conflicting. In examining root response to soil physical properties, mechanical impedance measurements have been more useful than bulk density values [4].

The effect of different tillage treatments on rice grain and straw yield is presented in Table 4. The results show that there were no significant differences in the yield of grain and straw due to conventional tillage and power tiller. Phillis [11] stated that if percolation losses are low and weeds can be controlled by appropriate herbicides puddling may not be necessary. Similar reports have been given by Mittra [7], Seth *et al.* [8] and Islam *et al.* [2]. However, the higher grain and straw yields were obtained with puddling by power tiller than country plough (Table 4).

Tilling soil by country plough significantly increased the maize grain yield (5913 kg/ha) and ear length (18.19 cm) as compared to power tiller (Table 5). Maize stalk yield was not affected by tillage treatments. However stalk yield was higher with power tiller than with country plough treatment. Islam *et al.* [2] reported contradictory results where in he obtained lower yield with power tiller than the conventional tillage.

The findings leads to the conclusions that hard pan existed in the soil due to which bulk density and penetration resistance were greater at greater soil depth as compared to shallower soil depth. Short term tillage by country plough and power tiller did not show any significant difference on paddy yield as the root growth was little affected due to almost similar penetration resistance under conventional tillage and the power tiller. Tilling soil by country plough gave higher maize grain yield than by tillage with power tiller. However, long term effect of these tillage practices needs to be investigated on soil physical properties and crop production.

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