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Impact of Different Tillage Practices and Temporal Factor on Soil Moisture Content and Soil Bulk Density

FAIZAN-UL-HAQ KHAN, ABDUL REHMAN TAHIR AND IAN JAMES YULE†
Department of Farm Machinery and Power, University of Agriculture, Faisalabad–38040, Pakistan
†Department of Agriculture Engineering, Massy University, NewZealand

ABSTRACT

Conventional and conservation tillage behave differently towards soil physical properties. In this study, conventional tillage (mouldboard plough followed by two passes of diskharrow and mouldboard plough followed by two passes of tine cultivator) and conservation tillage (dyna drive followed by one pass of diskharrow and dyna drive followed by one pass of tine cultivator) were used to compare their effect on soil physical properties such as soil moisture content and soil bulk density. Different tillage treatments had significantly affected soil moisture retention and dry bulk density of soil. But mouldboard plough followed by two passes of tine cultivator (MBP+2TC) was found an appropriate and more profitable tillage implement in relation to soil moisture content and dry bulk density of soil.

Key Words: Conventional tillage; Conservation tillage; Soil physical properties

INTRODUCTION

Tillage is one of the fundamental practices of agricultural management. It is the procedure by which man disturbs, overturns and rearranges the soil to create favourable soil physical conditions for crop growth. The tillage operation loosen, granulate, crush, or even compact the soil particles. Any tillage operation that changes soil bulk density in turn modifies pore size distribution, water holding capacity, infiltration rate, penetration resistance and soil aeration. Since each soil type and cropping system responds differently to tillage. Tillage system desirable in one location may be a complete failure in an other location.

Different tillage practices prevail among the farming community. These practices include conventional and conservation tillage. The way they improve the aforementioned physical properties is critical in the selection of a certain tillage practice for a specific location. However, a tillage system having better impact on the soil physical properties conducive for crop growth and economic return would be an ideal one. The question now arises which one these practices should be used. Therefore, the overall objective of this study was to examine the impact of conventional and conservation tillage with time on soil physical properties such as soil moisture content and dry bulk density.

MATERIALS AND METHODS

The field experiments were conducted during the years 1991 and 1992 on two different sites at Nafferton farm, University of Newcastle Upon Tyne.

The soil at both sites have a sandy clay loam texture. The climate of the area was temperate with a mean annual rainfall of 650 mm evenly distributed throughout the year. Mean monthly minimum and maximum temperature ranged between -3°C in January and 27°C in July, respectively. The land has been cultivated for the past 60 years under a rotation of wheat, barley and grass. For this study, four tillage treatments were compared using mouldboard plough and dyna drive as primary tillage implements whereas diskharrow and tine cultivator as secondary tillage implements. Tillage treatments were followed as;
T1= One pass of mouldboard plough followed by two passes of diskharrow, T2= One pass of mouldboard plough followed by two passes of tine cultivator, T3= One pass of dyna drive followed by one pass of diskharrow, and T4= One pass of dyna drive followed by one pass of tine cultivator.

The mouldboard plough followed by two passes of diskharrow and two passes of tine cultivator (treatment 1 & 2) was regarded as conventional tillage whereas dyna drive followed by one pass of diskharrow and one pass of tine cultivator (treatment 3 & 4) was regarded as conservation tillage. Mouldboard plough was used at a depth of 25 cm whereas disk harrow, tine cultivator and dyna drive were used at a depth of 10 cm.

The study area was divided into 16 plots of 24 x 6 m for both the years. Previous condition of the field was a stubble of winter barley. Soil samples were taken randomly from three different locations of each plot at different depths (0-10, 10-20, 20-30, 30-40, 40-50 & 50-60 cm). A tube and screw augers were used to take soil samples to determine dry bulk density and soil moisture content, respectively before and after tillage operations. The gravimetric method was used to determine the soil moisture content and dry soil bulk density. Minitab was used to do the statistical analysis of the data recorded for two factor factorial in split plot.

RESULTS AND DISCUSSION

Soil moisture content. Soil moisture retention after cultivation, harvesting and during the crop growing season depends upon the soil surface conditions developed by different tillage treatments. During experiment 1, after cultivation and harvesting significantly less soil moisture content under treatments 1 and 2 than under treatments 3 and 4 (Table I) can be associated with soil surface conditions developed by mouldboard plough and dyna drive used as primary tillage implements. This is in line with Ohiri *et al.* (1990) who observed higher soil moisture content under conservation tillage than conventional tillage systems. During winter, a significantly greater soil moisture content under treatments 1 and 2 than under treatments 3 and 4 suggest that the use of mouldboard plough has improved the water holding capacity of soil.

A significantly greater soil moisture content after cultivation till crop harvesting under treatments 1 and 3 than under treatments 2 and 4 (Table I) may be associated with disk harrow and tine cultivator used as a secondary tillage implement while significantly greater soil moisture retention to a depth of 30 cm (Table II) under treatments 1 and 2 than under treatments 3 and 4 may be attributed to the combined effect of mouldboard plough and disk harrow. Moreover, change of total porosity and compaction caused by bearing area of the disk harrow can not be ignored. Below this depth variation in soil moisture content under treatments 1 and 3 than under treatments 2 and 4 can be related, more or less, to the nature and properties of soil. Soil always behaves like a sponge to carry soil moisture and at a 30 cm depth its upward and downward movement depends upon soil crop water requirement, temperature gradient and soil water potential.

Table I. Mean soil moisture content (%) for different tillage treatments observed during the crop growing season (Experiment 1)

Trts	AC	DA	AW	DES	DLS	DES	DMS	DLS	AH
T1	18.35	26.64	28.36	27.88	26.23	23.35	20.28	16.32	15.88
T2	16.35	25.98	26.77	26.79	24.74	21.49	19.75	15.62	15.87
T3	19.53	25.22	27.25	27.11	25.37	21.92	21.55	17.25	16.16
T4	18.98	25.20	26.62	27.01	24.64	21.17	19.28	16.42	16.48

Trts=Treatments; AC= After culivation; DA= During autumn; AW= After winter; DES= During early spring; DLS= During late spring; DES= During early summer; DMS= During mid summer; DLS= During late summer; AH= After harvest

Table II. Mean soil moisture content (%) for different tillage teatments observed at different soil depths (Experiment 1)

	Depth (cm)					
Trts	0-10	10-20	20-30	30-40	40-50	50-60
T1	35.92	35.96	32.41	24.91	20.10	20.85
T2	35.49	33.98	26.76	21.88	20.10	22.43
T3	35.02	32.49	25.69	24.21	23.50	22.58
T4	32.10	30.82	25.35	24.54	23.56	23.38

During experiment 2, significantly greater soil moisture content under treatments 1 and 2 than under treatments 3 & 4 after winter and early spring (Table III) throughout the depth of soil profile were related to soil surface conditions produced by mouldboard plough and dyna drive used as conventional and conservation tillage implement. During early and mid summer, and after crop harvesting significantly greater soil moisture under treatments 3 and 4 than under treatments 1 and 2 can be associated to soil surface conditions produced by set of primary and secondary tillage implements (Table III). A significantly greater soil moisture under treatment 2 than under treatment 1 throughout the crop growing season can be associated to continuity of pores developed as a result of mouldboard plough and tine cultivator than mouldboard plough and disk harrow. Similarly, greater soil moisture under treatment 3 than under treatment 4 over the crop growing season can be associated to soil surface conditions generated by dyna drive followed by disk harrow than dyna drive followed by tine cultivator. The greater soil moisture retention under treatment 2 than treatment 1 to a depth of 0-30 cm. and under treatment 4 than treatment 3 to a depth of 0-30 cm (Table IV) may be the result of diskharrow and tine cultivator used as a secondary tillage implement.

Table III. Mean soil moisture content (%) for different tillage treatments observed during the crop growing season (Experiment 2)

Trts	AC	DA	AW	DES	DLS	DES	DMS	DLS	AH
T1	15.57	25.84	28.14	30.10	25.97	20.71	17.90	16.61	15.70
T2	15.76	26.01	28.24	31.53	26.72	21.01	18.55	16.97	15.47
T3	15.56	26.73	26.45	29.52	26.38	22.08	19.83	17.66	16.26
T4	14.71	25.96	26.29	29.96	25.84	22.12	19.50	17.56	16.45

Trts=Treatments; AC= After culivation; DA= During autumn; AW= After winter; DES= During early spring; DLS= During late spring; DES= During early summer; DMS= During mid summer; DLS= During late summer; AH= After harvest

Table IV. Mean soil moisture content (%) for different tillage teatments observed at different soil depths (Experiment 2)

	Depth (cm)					
Trts	0-10	10-20	20-30	30-40	40-50	50-60
T1	36.33	34.87	27.61	23.89	23.13	23.04
T2	34.99	35.53	27.77	25.28	23.54	22.83
T3	31.86	31.22	25.57	25.27	22.83	21.93
T4	32.41	32.67	25.25	24.48	22.36	22.21

The effect of depth on soil moisture content was highly significant during crop growing season as soil moisture decreased when the depth increased. There was a highly significant interaction between tillage and depth.

Dry bulk density. Soil bulk density is a critical soil physical property as it controls the penetration resistance, water retention, aeration and hydraulic conductivity. Soil bulk density is controlled through different tillage treatments. During experiment 1 lower bulk density under treatments 1 and 2 than under treatments 3 and 4 (Table V) is associated with depth of tillage (20 cm.)and soil moisture content (Table I). This is in line with the findings of Braunack *et al.* (1991) that bulk density decreased with increase in soil moisture content. Similar result was found by Bhushan and Ghildyel (1971). A lower and greater bulk density under treatments 1 and 2 and treatments 3 and 4, respectively, can be associated with mouldboard plough and dyna drive used as primary tillage implements. This confirms the results forwarded by Unger *et al.* (1991) that lower bulk density at a depth of 150-300 mm was found with mouldboard plough. Tillage treatments had affected 20 to 30 cm soil layer depending upon the nature of primary and secondary tillage implements used (Table VI & VIII). Below this depth the effect of tillage treatments was not observed. Heard *et al.* (1988) mentioned that no differences in dry bulk density among different tillage treatments were found below the tillage zone.

During experiment 2, a significantly greater soil bulk density under treatments 2 and 4 as compared to treatments 1 & 3 immediately after cultivation (Table VII) suggest that secondary tillage implements had suppressed the effect of primary tillage implements used. After winter, greater soil bulk density under treatments 3 and 4 than treatments 1 and 2 suggest that the effect of secondary tillage did not persist whereas primary tillage had affected dry bulk density of soil. After crop harvesting increase in bulk density suggests that effect of secondary tillage had completely deminished (Table VII).

Table V. Mean dry bulk density of soil (gm cm^{-3}) observed for different tillage treatments during crop growing season at depth of 20 cm. (Experiment 1)

	gm cm^{-3}		
Trts	AC	AW	BH
T1	1.20	1.16	1.44
T2	1.27	1.24	1.49
T3	1.34	1.32	1.47
T4	1.37	1.36	1.48

Trts=Treatments; AC= After culivation; AW= After winter; BH= Before harvest

Table VI. Mean dry bulk density of soil (gm/cm3) observed after different tillage treatments at various soil depths after cultivation (Experiment 1)

	Depth (cm)					
Trts	0-10	10-20	20-30	30-40	40-50	50-60
T1	1.16	1.24	1.57	1.70	1.74	1.79
T2	1.24	1.29	1.59	1.68	1.72	1.78
T3	1.32	1.37	1.56	1.68	1.72	1.77
T4	1.36	1.38	1.56	1.67	1.72	1.78

Increase in bulk density was observed during the crop growing season (Table VII). Natural consolidation with time through the impact of rainfall, summer drying and harvest traffic affected the bulk density of soil. Increase

Table VII. Mean dry bulk density of soil (gm cm^{-3}) observed for different tillage treatments during crop growing season at depth of 20 cm. (Experiment 2)

	gm cm^{-3}		
Trts	**AC**	**AW**	**BH**
T1	1.22	1.30	1.45
T2	1.32	1.35	1.42
T3	1.31	1.37	1.44
T4	1.35	1.39	1.44

Trts=Treatments; AC= After culivation; AW= After winter; BH= Before harvest

Table VIII. Mean dry bulk density of soil (gm cm^{-3}) observed after different tillage treatments at various soil depths after cultivation (Experiment 2)

	Depth (cm)					
Trts	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**
T1	1.18	1.25	1.48	1.66	1.72	1.77
T2	1.29	1.34	1.55	1.67	1.71	1.74
T3	1.32	1.31	1.60	1.68	1.73	1.75
T4	1.34	1.36	1.61	1.65	1.73	1.73

in bulk density in the arable layer took place with time because of natural settlement (Pelegrin *et al.* 1990). A similar results were found by Ross and Hughes (1985) and Cassel and Nelson (1985). Generally dry densities increased with the increasing depth (Table VII) in all treatments. There are several explanation for this phenomenon. Primarily, movement of smaller soil fraction into the lower soil layers makes them denser. Secondly, the higher density of lower soil layers could be the result of tractor-implement induced compaction.

CONCLUSIONS

1. After different tillage treatments, a significant effect of tillage was observed on soil moisture content and dry bulk density of soil in both the years.

2. Mouldboard plough followed by two passes of tine cultivator is found an appropriate and more profitable tillage implement with respect to soil moisture content and dry bulk density of soil. In brief, the effect of tillage on dry bulk density with time disappeared as the crop growing season progressed.

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