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Influece of Tillage and Mulching Practices on Soil Physical Properties under Semi-Arid Environment

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Abstract
Impact of tillage practices and mulching on the yield of maize crop under semi-arid environment was studied at Malakandher Farm, The University of Agriculture, Peshawar during Kharif, 2012. The experiment was laid out in factorial experiment with randomized complete block design having nine treatments, four replication and 36 plots.Three tillage practices (Cultivator 4 times followed by planking, mould board plough followed by rotavator and cultivator twice followed by planking) and three mulching levels (wheat mulch, barseem mulch and control) were used. Tillage practices were alloted to main plots and mulching levels to subplots.Tillage practices had a significant effect on bulk density (g cm^{-3}), moisture contents (%),soil porosity (%) and penetration resistance.Maximum bulk density at 0-20 cm depth (1.25 g cm^{-3}), bulk density at 21-40 cm depth (1.46 g cm^{-3}), moisture contents at 0-20 cm (18.50 %), moisture contents at 21-40 cm depth (17.55 %), soil porosity (49.50 %) and penetration resistance (233.35 Ncm^{-2}). Mulching has also a significant effect on bulk density (g cm^{-3}), moisture contents (%), soil porosity (%) and penetration resistance. Similarly, due to mulching practices there is a maximum bulk density of 1.29 g cm^{-3} at 0-20 cm depth, a bulk density of 1.50 g cm^{-3} at 21-40 cm depth, moisture contents at 0-20 cm (17.13 %), moisture contents at 21-40 cm depth (17.43 %), soil porosity (51.53 %) and penetration resistance (238.29 Ncm^{-2}). It was concluded that the combination of wheat straw mulch and mould board plough fallowed by rotavator were proved fruitful in improving soil physical properties under semi-arid environment.
Keywords: Tillage, Mulching, Bulk Density, Moisture Contents, Soil Porosity, Penetration Resistance

INTRODUCTION

Tillage plays an important role in the crop growth and production. However, every one known about the effect of various tillage implements on soil physical properties. A soil tillage practice improves soil physical properties and enables the plant to show their full potential and growth. Soil tillage techniques are used to provide a good seed for root growth and development, control weeds, manage crop residues, reduce soil erosion and level the surface for planting, irrigation; drainage and incorporation of organic and inorganic fertilizers in the soil (Teasmeter et al., 2001).Since continuous uses of soil tillage practices strongly affect the soil physical properties. It is important to use proper tillage practices in the soil to avoid the degradation of soil structure, maintain crop yield as well as fauna and flora stability in the soil (Lal, 1981a,b, Greenland et al.,1981).

Suitable tillage practices break up high density soil layers, improve water infiltration and movement in the soil, enhances root growth and development, and increase crop production potentials. To meet the food requirement of ever increasing human population, there is a great need of high crop productivity rate, which is only possible when soil is properly ploughed in the rain-fed areas and to conserved moisture in the subsoil. Proper tillage practices and moisture conservation is required for good yield in semi arid zone. About 70 % of land in the tribal areas is rain-fed only one crop i.e. Wheat is raised. But there is need to grow more food crops in arid zone due to explosive increase in population in tribal belt as well as Khyber Pakhtunkhwa. This is a 21st century which is the century of economic growth and development, education and social uplift of the people which lead to a sustainable and prosperous society (Ramzan et al., 2012).

Mulching is a desirable management practices used to regulate and enhances crop growth, production and soil temperature (Khan, 2001). It is a recent and important non-chemical weed control method, reduce leaching and transpiration from the soil surface (Liu *et al*., 2000). Mulching practices conserve soil moisture, increase soil organic matter and reducing nutrient losses due to run off (Roldan *et al*., 2003: Smart and Bradford, 1999). The main advantages of mulching are organic matter and nutrient supply for the plant growth. Mulch is a protective covering which maintain even soil temperature, prevent soil erosion, control weeds and enrich the soil (Becher *et al*. 2005). Mulch addition increased the total porosity in more compacted soil under reduced tillage. Ghuman and Sur (2001) confirmed that residue mulch decreased bulk density in rather compacted soils particularly in no tillage system what can be ascribed to higher soil carbon content and biotic activity.

Keeping in view the importance of different tillage and mulching practices for improving soil physical properties under semi-arid environment is the need of today food crises in rain-fed areas which is a global issue. Therefore on this issue the study was conducted in semi-arid environment in the Malakandher Farm, The University of Agriculture, Peshawar to combat the shortages of food requirement.

Proper amount of water is required for normal growth of plants and yield of crops. Less irrigation applied to crops leads to stunted growth and thus results reduction in yield. In rain-fed areas there is deficiency of soil moisture especially for maize crop. Therefore there is a need of proper moisture conservation for maize crop in semi-arid environment. The present study was designed to conserve the moisture through different mulching Practices in semi-arid environment in The University of Agriculture, Peshawar-Pakista

MATERIALS AND METHODS

Field experiment was conducted at New Developmental Farm, The University of Agriculture Peshawar during Kharif 2012. Available maize variety "Azam" for sem-arid environment was sown on well prepared seed bed with row to row and plant to plant distance of 75 and 20 cm respectively. Prior to planting the seeds were treated with vitavix. A basal dose of 170 kg ha^{-1} of nitrogen and 60 kg ha^{-1} of phosphorous was applied. Half of nitrogen and full dose of phosphorous were applied before sowing while half dose of nitrogen was applied to the crops before tesseling. The combinations were T1M1, T1M2, T1M$_o$, T2M1, T2M2, T2M$_o$, T3M1, T3M2 and T3M$_0$ respectively.

The tillage practices were cultivator 4 times followed by planking, mould board plough followed by rotavator and cultivator twice followed by planking. The crop residues application as a mulching were wheat, barseem and no mulch respectively.

Soil Bulk density

Soil samples were taken at five different places from each plot and bulk density was determined by the following formula

$$\rho_b = \frac{M_s}{V_t}$$

Where ρb is the bulk density (g.cm^{-3}) M_s is the mass of oven dried soil (g) & V_t is the total volume of soil (cm^3).

Moisture content

The moisture content in soil was determined by taking soil sample from 0-20 cm and 21-40 cm, placing fresh soil in an oven at 105C^o for 24 hours. Any loss in soil sample weight after drying was considered as moisture content.

$$\text{Moisture content \%} = \frac{(\text{Wet soil weight})-(\text{Oven dry soil weight})}{\text{Oven dry soil weight}} \times 100$$

Porosity

Porosity was determined by the ratio of volume of pores (cm^3) to its total volume of the soil (cm^3).

$$f = V_f / V_t$$

Where f is the Porosity of the soil (fraction), V_f is volumes of pores (cm^3) and V_t is total soil volume (cm^3).

Penetration resistance

The soil strength was measured by using hand cone penetrometer in each treatment after tillage and mulching practices during maize growing season. Cone base area of 1 cm^2 was used for taking penetrometer reading in each plot (Lampurlane, 2003).The cone index was calculated by using the following equation.

$$Ci = F/A$$

Where Ci is the cone index (N.Cm^{-2}), F is the normal force(N) and A was the base area of the cone(Cm^{-2})

Statistical Analysis

The recorded data for each trait were subjected individually to the ANOVA technique by using MSTATC computer software (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Bulk density at 0-20 cm depth

Statistical analysis of the data (Table 1) indicated that at 0-20 cm depth there was noticed a significant influence of tillage and mulches on soil bulk density. Highest bulk density (1.33 g cm^{-3}) results in cultivator twice and the minimum soil bulk density (1.25 g cm^{-3}) in mould board plough followed by rotavator. The maximum bulk density (1.31 g cm^{-3}) was observed in no-Mulch followed by barseem straw mulch (1.29 g cm^{-3}) and minimum in wheat straw mulch (1.26 g cm^{-3}). The interactive effect of tillage and mulch on bulk density was significant. The interaction of cultivator twice and no mulch treatment showed maximum bulk density (1.35 g cm^{-3}) while the minimum bulk density (1.23 gcm^{-3}) was resulted in wheat straw mulch and mould blow plough followed by rotavator. The lower bulk density of the soil is due to the reason that the upper soil surface received tillage and mulching therefore significant differences were noted in different treatments. The present results clearly showed that mould board plough was proved more suitable option for decreasing soil bulk density which break, invert and pulverize the deep soil as compared to other tillage treatments like cultivator twice or 4 times. More over wheat and barseem straw mulch were also found affective for decreasing bulk density.

Table 1. Bulk density (g cm^{-3}) after harvesting at 0-20 cm soil depth as affected by tillage and mulching practices.

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow +Rotavator	Cultivator twice	
Wheat mulch	1.26	1.23	1.31	**1.26 c**
Barseem mulch	1.28	1.25	1.33	**1.29 b**
No-mulch	1.30	1.27	1.35	**1.31 a**
Mean	**1.28 b**	**1.25 c**	**1.33 a**	

Bulk density at 21-40 cm depth

The tillage mean data of Table-2 showed that the maximum soil bulk density (1.53 g cm^{-3}) was resulted in cultivator twice while the minimum (1.46 g.cm^{-3}) was observed in mould board plow followed by rotavator treated plots. Likewise the Bulk density decreased significantly by mulches as maximum bulk density (1.52 g cm^{-3}) resulting in no-mulch followed by barseem mulch (1.50 g cm^{-3}) and minimum was noticed in wheat straw mulch (1.49g cm^{-3}). The mean interaction data of mulches and tillage showed that lowest bulk density of 1.44 g cm^{-3} from mould board plough followed by rotavator and maximum (1.55 g cm^{-3}) for no mulch and cultivator twice. The present study findings are in line with those of Mulamba and Lal (2008) that soil bulk density decrease with increasing mulching rates.

Table 2. Bulk density (g.cm^{-3}) at 21-40 cm depth as affected by tillage and mulching practices

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow + Rotavator	Cultivator twice	
Wheat mulch	1.50	1.44	1.52	**1.49 c**
Barseem mulch	1.52	1.46	1.53	**1.50 b**
No-mulch	1.53	1.47	1.55	**1.52 a**
Mean	**1.52 b**	**1.46 c**	**1.53 a**	

Moisture Contents (%) at 0-20 cm depth

Statistical analysis of the data revealed that moisture content was positively influenced by both tillage and mulching practices. The mean data of the tillage practices demonstrate that maximum soil moisture content (18.50%) was recorded in mould board plough followed by rotavator and the minimum soil moisture contents of 15.86 % was recorded in Cultivator twice as shown in Table-3. More over the mulches mean data revealed that highest moisture content (17.29 %) was noticed in wheat straw mulch while the lowest soil moisture contents (16.76%) was recorded in treatments having no-mulch. However higher moisture content is might be due to high rainfall during this season. Al-Tahan *et al*. (1992) reported that tillage practices have significant effect on soil moisture contents below few centimeters on soil surface layer.

Table 3. Moisture Contents (%) at 0-20cm depth as affected by tillage and mulching practices

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow + Rotavator	Cultivator twice	
Wheat mulch	17.04	18.72	16.10	17.29 a
Barseem mulch	16.89	18.54	15.96	17.13 a
No-mulch	16.52	18.24	15.52	16.76 b
Mean	16.81 b	18.50 a	15.86 c	

Moisture Contents (%) at 21-40 cm depth

Statistical analysis of the data showed that maximum soil moisture contents at depth of 21-40 cm was recorded 17.55 % in treatments practiced with Mould board plough followed by rotavator while minimum soil moisture content of 16.07 % were observed in cultivator twice as shown in Table-4. Similarly the moisture contents were increased significantly by mulching practices. The mulching mean data demonstrated that highest moisture content (17.58 %) was observed in wheat straw mulch followed by barseem straw mulch with moisture content of 17.43 % while lowest moisture content (15.31%) was noticed in No-mulch. Hatfield *et al*., (2001) reported that at least 34-50% reduction in soil water evaporation as a result of crop residues application on the soil surface. The results clearly showed that both tillage and mulching practices were proved more effective to conserve moisture and to maintain soil temperature for long time under non-irrigated condition.

Table 4. Moisture Contents (%) at 20-40cm depth

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow + Rotavator	Cultivator twice	
Wheat mulch	17.56	18.77	16.40	17.58 a
Barseem mulch	17.44	18.54	16.30	17.43 a
No-mulch	15.14	15.32	15.49	15.31 b
Mean	16.71 b	17.55 b	16.07 b	

Porosity

The analysis of variance indicated (table-5) that tillage and mulching practices significantly affected soil porosity. The porosity was positively affected by both mulches and tillage techniques. The maximum soil porosity (49.50 %) was recorded in treatments practiced with mould board plough followed by rotavator and minimum soil porosity of 46.12 % in cultivator twice treatments. Similarly the mean data for mulches showed that porosity increased significantly by mulches, maximum porosity of 52.22% was observed in wheat straw mulch followed by Barseem straw mulch (51.31%) and minimum value for porosity (40.79%) was recorded for No-mulch. The interaction data revealed that maximum porosity (52.48%) resulted in mould board plough followed by rotavator and wheat straw mulch while the minimum porosity (34.14%) was observed in Cultivator twice and no mulch treatments plots. These result also clearly showed that mould board plough and straw both are more suitable for soil porosity. Total soil porosity increased with increase mulch rate. The present research findings are in close proximity with those of Oliveria and Merwin 2001.

Table 5. Soil Porosity (%) as affected by tillage and Mulching practices

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow + Rotavator	Cultivator twice	
Wheat mulch	52.45	53.58	50.65	52.22 a
Barseem mulch	51.78	52.54	49.61	51.31 b
No-mulch	41.88	42.38	38.10	40.79 c
Mean	48.70 b	49.50 a	46.12 c	

Penetration resistance

Data regarding Soil Penetration Resistant is presented in table-6. Statistical analysis of the data revealed that penetration resistance at 0-20 cm depth was positively influenced by both tillage and mulching practices. The mean data of the tillage practices demonstrate that maximum penetration resistance (244.55) Ncm^{-2} was recorded in those plots which prepared by cultivator twice followed planking while minimum penetration resistance of (235.33 Ncm^{-2}) was recorded in mould board plough. More over the mulches mean data revealed that highest penetration resistance (243.27 Ncm^{-2}) was noticed in no-mulch while the lowest soil penetration resistance (238.29 Ncm^{-2}) was recorded in treatments having wheat mulch.

Table 6. Soil Penetration resistance (%) as affected by tillage and Mulching practices

Treatments	Tillage			Mean
	Cultivator 4 times	MB plow + Rotavator	Cultivator twice	
Wheat mulch	239.52	233.58	241.77	238.29 c
Barseem mulch	241.88	234.04	243.80	239.90 b
No-mulch	243.34	238.36	248.10	243.27 a
Mean	241.58 b	235.33 c	244.55 a	

CONCLUSION

For the discussion of foregoing results it was concluded that both tillage and mulching practices positively influenced soil physical properties under semi-arid environment. Both practices decreased bulk density and penetration resistance, while increasing soil moisture contents and porosity. In treatments combinations wheat straw mulch along with mould board plough followed by rotavator was proved superior in decreasing bulk density and penetration resistance while enhance moisture contents and soil porosity under semi-arid environment.

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