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Impact of Selected Soil Physical Properties on Emergence of Maize Crop in Peshawar Valley

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Abstract

A research experiment was conducted to investigate the impact of selected soil physical properties on emergence of maize crop in Peshawar valley. Two research trials were carried out during the year 2011-12 at the Malakandhir Farm of the University Agriculture Peshawar. Nine treatments were arranged in RCBD with 4 replications with a total of 36 plots. The maize variety *Jalal* was planted using a maize planter having a seed rate 50 $kg.ha^{-1}$. The maximum penetration resistance at 0-20 cm depth of 243.70 N cm^{-2} was recorded in plots prepared by cultivator twice followed by planking while minimum penetration resistance of 234.70 Ncm^{-2} was recorded in plots prepared by mould board plough followed by rotavator. Mean values for tractor passes showed that maximum penetration resistance of 242.79 $Ncm^{-2}$was noted in plots that received four tractor pass while minimum penetration resistance of 238.28 $Ncm^{-2}$was noted in plots that received zero tractor passes. Maximum bulk density of 1.35 $g.cm^{-3}$ was recorded from plots prepared by cultivator twice followed by planking while lower bulk density of 1.27 $g.cm^{-3}$ was recorded from plots prepared by mold board plough followed by rotavator. Mean values for tractor passes showed that lower bulk density of 1.28 $g.cm^{-3}$ were noted from plots that received zero passes while maximum bulk density of 1.34 $g.cm^{-3}$ were recorded from plots that received 4 tractor passes. Maximum days to emergence of 5.56 were recorded from plots prepared by cultivator twice followed by planking while fewer days of 5.45 were recorded for emergence of maize in plots prepared by mould board plough followed by rotavator. Mean values for tractor passes showed that more days of 6.13 were noted for emergence of maize in plots that received four tractor pass while less days 5.20 were observed with in plots that received zero tractor passes. More number of plants of 9.90 m^{-2} of maize emerged in plots prepared by mould board plough followed by rotavator while fewer plants of 9.66 m^{-2} of maize emerged in plots plough by cultivator twice followed by planking. Mean values for tractor passes showed that maximum emergence of 10.00 m^{-2} of maize plants were noted from plots that received zero tractor pass while maximum emergence of 9.26 m^{-2} of maize plants were noted from plots that received four passes of tractor.

Keywords：Penetration Resistance, Bulk Density, Emergence, Tillage, Compaction, Maize

INTRODUCTION

Tractors with tillage, sowing and harvesting equipments threshing and tube wells for abstracting water from below the ground is beneficial in terms of time savings and labors. However, these also brought about some negative changes as well. In order to address these issues, it is important to identify all those through some expert's opinion. The rapid development in science and technology arise to the development in industrial revolution throughout the world. Like others field of life, the agricultural field has also been received a lot of benefits in terms of mechanization. Soil Compaction is caused by the use of agricultural machinery, pressure from tires tillage implements, grazing of animals, less use of organic matter, regular use of artificial fertilizers and continues plowing at the same depth for many years. Retard plant emergence, weak stem, thin tillers, irregular growth, small grain spike abnormal rooting patterns and reduced nutrients concentration are reflection of the singe of compaction. In mechanized agriculture, soil compaction is one of the serious problem which affects many soil properties and on crop yield (Van Lynden, 2000). The use of farm machines along with its proper management can help to avoid soil compaction which adversely affects the plant growth (Raghavan *et al.*, 1990).The pressing of soil particles which decreases the porosity, increase the force for root penetration, reduce the movement of water in soil and the soil structure. (Soane and Ouwerkerk,1994).Soil compaction is the change in textural parts of the soil (sand, silt and clay particles), destruction of soil aggregates and diminishing of air pores (Coder. 2000)

Very little information is available about the soil compaction and its response to crop yield. Therefore it is an important to study the effects of tillage induced hard pan impact on soil properties and crop growth and yield. The effects of sub soil compaction on bulk density, penetration resistance and yield of wheat, nutrients and water infiltration rate on crops have been reported by (Ishaq *et al.,* 2000). Compaction has often resulted in crop yield reductions while both sub surface and sur face soil compaction contribute to these reduction due to compaction in plough layer crop yield is severally damaged (Hakansson and Reeder, 1994).

The livestock's roaming and grazing which impedes oxygen into the different soils seriously affect the growth. More ever in the irrigated regions, the top and sub soil are compacted differently. Unlike the upper soil, the sub soil is not cultivated or broken easily. So a uniform compacted layer is created. Subsoil compaction is due to driving of heavy tractors on the subsoil during ploughing and harvesting. (Hughes et *al*., 2001). Compaction affects plant growth which can be observed in the experimental fields from front view. More compaction causes reduction in plant emergence rates, stunt plant height and less crop yield. Excessive soil compaction restricted root development and therefore Plant's ability is badly affected to take up nutrients and water accordingly. Soil compaction can lead to stunted plants due to decreased root growth in dry years (Hughes, *et al* 2001).
Crop yield up to 50% is decreased due to compaction because of increased resistance to root penetration, reduced aeration, poor sub soil removal of water or drainage and scare supply of plant nutrients as reported by (Richard and Lowery, 2008).Mostly in Pakistan, the tillage operations by farmer are generally performed with bullocks and tractor drawn cultivators to the depth of 10 to 15 cm. Continues use of cultivator create plough sole at about of 15 cm depth which impedes the movement of water and air and restricted the growth of plant roots (Hassan and Gregory, 1999).Keeping in view that farm machinery have deep relation with soil physical properties like, bulk density, soil resistance which have their influences on crop production. The tillage and soil compaction affect crop yield due to intensive use of farm machinery. Pakistani soils have greatly been affected by these activities. Number of passes of tractor at the surface, cultivator and desi plough at the certain depths are creating hard pan by compacting agricultural land which affects root growth to reduce crop yield. In this regard, no research study has been performed in Khyber Pakhtunkhwa. The study was conducted to address these problems by adopting certain measures to resolve it. In Pakistan, very few researchers have attempted to address these issues to document the degree of damage to various crops. Keeping in view the development in mechanization through the activities of tillage and the soil compaction affect on crop growth, the present study was conducted to evaluate their deleterious effects on crop yield. To find out the effect of different tillage practices and compaction (number of tractor passes) due to soil selected physical properties of Bulk Density and penetration resistance on emergence of maize crops.

MATERIALS AND METHODS

The field experiments were conducted to determine the impact of selected soil physical properties on emergence of maize crop in Peshawar valley for period of two years. These crops were grown in the year 2011-12 at the new Developmental Farm of the University of Agriculture Peshawar.
For crop growing irrigation was applied to the selected field plots one week before its sowing. Seed beds were prepared by ploughing when the fields reached to field capacity. Different artificial compaction levels were applied to the fields with the help of Ford tractor 65 Hp, having its weight 5610 Kg after the operation of different selected tillage practices were just before sowing. However, control treatments had received no compaction at all. The corn variety *Jalal* was planted using a maize planter having a seed rate 50 $kg.ha^{-1}$. The first experiment on maize crop was conducted on June 25, 2011. The second experiment was repeated in on June 25, 2012 by sowing the same variety. Fixed irrigations and other basic inputs were applied equally in terms of quality and quantity. The following factors were taken into consideration as main factors and others as given below:
In Factor A the T 1, T 2 and T 3 are cultivator twice followed by planking, cultivator four times followed by planking and mould board plough followed by rotavator whereas in Factor B the P0, P2 and P4 are zero pass, 2 passes and 4 passes of tractor. The combinations of the treatments were T1P0, T1P2, T1P4, T2P0, T2P2, T2P4, T3P0, T3P2 and T3P4

Experimental Design

In Field a total of nine treatments, 4 replications and 36 plots were studied according to randomized complete block design (RCBD). Each plot had a size of 30×4 m^2. The maize crop was sown with the help of planter in lines 75 cm apart and plant to plant distance of 20 cm was maintained. Prior to planting the seed was treated with vitavix. A basal dose of 170 kg ha^{-1} of nitrogen and 60 to 70 kg ha^{-1} of phosphorous was applied. Half of nitrogen and full dose of phosphorous was being applied before sowing and half dose of nitrogen was applied before tasseling the crops.
The data were recorded on the following parameters

Penetration resistance at 0-20 cm depth

The soil strength was measured by using hand cone Penetrometer Eijkelkamp in each treatment after tillage and compaction at 0-20 cm depth during the growing season 2010-2011. Cone base area of 1 cm^2 was used for taking penetrometer reading in each plot (Lampurlane and Cantero-Martı´nez.2003). The cone index was calculated by using the following equation.

$$Ci = F/A$$

Where Ci is the Cone index ($N.Cm^{-2}$ or $Lb.in^{-2}$), F is the Normal force (N or Lb) and A was the Base area of the cone (cm^{-2} or in^{-2}).

Soil bulk density at 0-20 cm depth

For determining of soil bulk density, soil samples from 0-20 cm were taken before sowing and after harvesting. These samples were placed in oven at 105 °C for 24 hours to remove all the moisture contents from the sample. Soil samples were collected with the help of Core Sampler after digging the soil through Auger to the required depth. For this purpose, the inert materials from the surface of soil were removed by hand. The core sampler of 5 cm diameter was driven into the soil from 0-20 cm depth to fill the inner metal cylinder. The care was taken to stop any compaction of the soil during the process. The sampler was carefully removed to ensure and intact sample. Soil extending beyond each end of inner cylinder was removed. Soil samples were taken at 5 different places in each plot and soil bulk densities were determined by the formula.

$$\rho b = Ms / Vt \qquad (1)s$$

Where ρb was the bulk density (g.cm^{-3}), Ms was the mass of oven dried soil (g) and Vt was the total volume of soil (cm^3)

Days to emergence

Data on days to emergence were recorded by counting the number of days from sowing till 90 percent of seedlings are emerged in the entire experimental plots and there means were calculated**.**

Emergence (m^2)

Emergence m^{-2} was worked out by counting number of plants at 5 different places in 50 cm long row and was converted into plants m^{-2}.

$$\text{Emergence m}^{-2} = \frac{\text{Total no. of seedling emerged}}{\text{No. of rows x (R-R distance) x (Row length)}}$$

Statistical Analysis

The data was statistically analyzed by using RCBD as described by Steel and Torrie (1997) and mean were compared using LSD test subject to significant F value**.**

RESULTS AND DISCUSSION

Penetration resistance (Ncm^{-2})

Statistical analysis of the data for maize crop in 2011-2012 indicated that maximum penetration resistance of 243.70 N cm^{-2} was recorded in plots prepared by cultivator twice followed by planking while minimum penetration resistance of 234.70 Ncm^{-2} was recorded in plots prepared by mould board plough followed by rotavator. Mean values for tractor passes showed that maximum penetration resistance of 242.79 Ncm^{-2}was noted in plots that received four tractor pass while minimum penetration resistance of 238.28 Ncm^{-2}was noted in plots that received zero tractor passes (Table.1). Interaction between T x Y showed that minimum penetration resistance of 233.58 Ncm^{-2} was noted from plots that were ploughed with mould board plough followed by rotavator in year 2012 while maximum penetration resistance of 243.50 N cm^{-2} was recorded from plots that were ploughed cultivator four times followed by planking in year 2012. Y x T x P interaction showed that minimum penetration resistance 231.75 N cm^{-2} was recorded in plots prepared with mould board plough followed by rotavator with zero tractor passes in year 2012 while maximum penetration resistance 246.50 Ncm^{-2}was recorded in plots prepared with cultivator four times followed by planking receiving four tractor passes (Table. 1).

Penetrometer resistance significantly increased with tractor passes and decreased with tillage practices for corn fields (Table 1). Tractor's 4 passes produced a greater Penetrometer resistance increase than did the remaining passes in both fields. The reason may be the upper surface of soil become more compacted due to high weight of ford tractor which pressed the soil particles together and removed the pores spaces which resulted the decrease in the volume of pores. Kamaruzaman (1991) observed similar results with a heavier and unloaded tree harvester. Greater Penetrometer resistance differences were seen in the upper 4-12-cm depth as compared to other depths. Compaction causes unfavorable changes in soil bulk density, porosity and Penetrometer resistance as reported by Soane et al., 1988. Penetrometer resistance in the layer of uncultivated land was greater than the plots which were prepared by mould board plow below 10 cm depth reported by Ellis et al .,(1997).

Table 1 Penetrometer resistance (Ncm^{-2}) as affected by tillage and soil compaction for Maize Crop

Years	Tillage implements	Number of passes 0	2	4	Mean
	Cultivator twice + planking	231.00	234.75	237.00	234.25
	Cultivator four times + planking	228.50	231.75	233.75	231.33
2011	Mould board plow + rotavator	228.50	225.75	225.25	226.50
	Cultivator twice + planking	228.50	232.25	234.75	231.83
	Cultivator four times + planking	226.50	229.75	231.75	229.33
2012	Mould board plow + rotavator	225.50	224.00	223.25	224.25
	Cultivator twice + planking	229.75	233.50	235.88	233.04
	Cultivator four times + planking	227.50	230.75	232.75	230.33
	Mould board plow + rotavator	227.00	224.88	224.25	225.38
2011		229.33	230.75	232.00	230.69
2012		226.83	228.67	229.92	228.47
Mean		228.08	229.71	230.96	
LSD for tillage		1.09	LSD for passes		1.09
LSD for year		0.89	LSD for T x P		1.88

Means followed by different letters of the various categories are significantly different at 5% level of probability using least significant difference (LSD) test.

Bulk density (gcm^{-3})

Mean values for year showed that higher bulk density of 1.32 $g.cm^{-3}$ was recorded in 2012 while lower bulk density of 1.31 $g.cm^{-3}$ was noted in 2011 (Table. 2).

Mean values for tillage implements revealed that higher bulk density of 1.35 $g.cm^{-3}$ was recorded from plots prepared by cultivator twice followed by planking while lower bulk density of 1.27 $g.cm^{-3}$ was recorded from plots prepared by mold board plough followed by rotavator. Mean values for tractor passes showed that lower bulk density of 1.28 $g.cm^{-3}$ were noted from plots that received zero passes while maximum bulk density of 1.34 $g.cm^{-3}$ were recorded from plots that received 4 tractor passes (Table. 2).

Interaction between T x Y showed that minimum bulk density of 1.26 $g.cm^{-3}$ was noted from plots that were ploughed with mould board plough followed by rotavator in year 2012 while maximum bulk density of 1.37 $g.cm^{-3}$ was recorded from plots that were ploughed cultivator four times followed by planking in year 2012. Y x T x P interaction showed that lower bulk density of 1.22 $g.cm^{-3}$ was recorded in plots prepared with mould board plough followed by rotavator receiving zero tractor passes in year 2012 while higher bulk density of 1.40 $g.cm^{-3}$ was recorded in plots prepared by cultivator twice followed by planking with four passes of tractor in 2012 (Table. 2).

Table 2 Bulk density of soil ($g.cm^{-3}$) affected of tillage and soil compaction for maize crop

Years	Tillage implements	Number of passes 0	2	4	Mean
	Cultivator twice + planking	1.30	1.34	1.39	1.34
	Cultivator four times + planking	1.31	1.31	1.38	1.33
2011	Mould board plow + rotavator	1.25	1.28	1.32	1.28
	Cultivator twice + planking	1.32	1.35	1.40	1.36
	Cultivator four times + planking	1.32	1.32	1.39	1.35
2012	Mould board plow + rotavator	1.24	1.27	1.30	1.27
	Cultivator twice + planking	1.31	1.34	1.39	1.35
	Cultivator four times + planking	1.31	1.32	1.39	1.34
	Mould board plow + rotavator	1.24	1.27	1.31	1.27
2011		1.29	1.31	1.36	1.32
2012		1.29	1.31	1.36	1.32
Mean		1.29	1.31	1.36	
LSD for tillage		0.01	LSD for passes		0.01
LSD for year		0.01	LSD for T x P		0.02

Means followed by different letters of the various categories are significantly different at 5% level of probability using least significant difference (LSD) test.

Bulk density significantly increased with tractor passes and decreased with tillage practices for wheat crop. Tractor's 4 pass produced increase in Bulk density as compared to the remaining passes in both fields. The reason may the upper surface of soil become compacted more due to high weight of ford tractor which pressed the soil particles together and removed the pores spaces which caused the decrease in the volume pores. Bulk density at 0-20 cm depth was greatly affected due to tillage and compaction effect. Compaction causes unfavorable changes in soil bulk density, porosity and Penetration resistance as reported by Soane and ouwerkerk 1994. The upper surface received compaction therefore significant difference among different treatments ware observed. Similar results were also reported by Flowers and Lal. (1998) who examined the effect of uniform soil surface compaction on crop growth and yield. Deep tillage treatments were more suitable for breaking, inverting and pulverizing the soil as compared to shallow tillage treatments and reducing the bulk density of the soil as reported by Ahmad and Mauryia .1988.

Days to emergence

Mean values for year showed that more days of 5.57 for emergence of maize were observed in the in 2012 while fewer days of 5.25 for emergence of maize were noted in 2011 (Table. 3).

More days of 5.56 were recorded from plots prepared by cultivator twice followed by planking while fewer days of 5.45 were recorded for emergence of maize in plots prepared by mould board plough followed by rotavator. Mean values for tractor passes showed that more days of 6.13 were noted for emergence of maize in plots that received four tractor pass while less days 5.20 were observed with in plots that received zero tractor passes (Table. 3).

Interaction between T x Y showed that days of 5.33 were noted from plots that were ploughed with cultivator four times followed by planking in year 2011 while more days of 5.90 were noted from plots that were ploughed with cultivator four times followed by planking in year 2012. Y x T x P interaction showed that fewer days of 5.00 were recorded for emergence of maize in all plots prepared with each implement used with zero tractor passes in year 2011 and 2012. More days of 6.26 for emergence of maize were recorded in plots prepared by cultivator twice followed by planking with 4 passes of tractor in 2012 (Table. **3**). Days to emergence significantly increased with tractor passes and decreased with tillage practices for both wheat and corn (Table 3) fields. Tractor's 4 passes produced a greater increase in days to emergence as compared to the remaining passes in both fields. Days to emergence were greatly affected due to tillage and compaction effect. Days to emergence may be influenced by soil fertility, bulk density, porosity, as well as climatic condition. Days to emergence were affected significantly by compaction treatments. The interaction effects (tillage and compaction) remained significant (Table 3). As compaction was given to the soil upper surface, therefore bulk density and total porosity of upper surface varied significantly. Significant differences between the values of days to emergence of the two years may be attributed also the upper surface which showed significant differences during this research study. These results are in agreement with the results produced by Oussible et al., 1992 who found that speed of emergence was affected by change in bulk density and aggregate size. Tillage practices showed significant differences on days to emergence of wheat seeds as reported Sorour et al 1995.

Table 3.Days to emergence as affected by tillage and soil compaction for maize crop

		Number of passes			
Years	**Tillage implements**	0	2	4	Mean
	Cultivator twice + planking	5.00	5.00	6.00	5.33
	Cultivator four times + planking	5.25	5.50	6.50	5.75
2011	Mould board plow + rotavator	4.00	5.00	5.75	4.92
	Cultivator twice + planking	5.00	5.00	7.00	5.67
	Cultivator four times + planking	5.25	5.50	7.00	5.92
2012	Mould board plow + rotavator	4.00	5.00	6.00	5.00
	Cultivator twice + planking	5.00	5.00	6.50	5.50
	Cultivator four times + planking	5.25	5.50	6.75	5.83
	Mould board plow + rotavator	4.00	5.00	5.88	4.96
2011		4.75	5.17	6.08	5.33
2012		4.75	5.17	6.67	5.53
Mean		4.75	5.17	6.38	
LSD for tillage		0.19	LSD for passes		0.19
LSD for year		0.15	LSD for T x P		0.33

Means followed by different letters of the various categories are significantly different at 5% level of probability using least significant difference (LSD) test.

Emergence (m^{-2})

Mean values for the year showed that maximum emergence of 9.72 m^{-2} for maize was observed in 2012 while minimum emergence of 9.69 m^{-2} was noted in 2011 (Table. 4).

More number of plants of 9.90 m^{-2} of maize emerged in plots prepared by mould board plough followed by rotavator while fewer plants of 9.66 m^{-2} of maize emerged in plots plough by cultivator twice followed by planking. Mean values for tractor passes showed that maximum emergence of 10.00 m^{-2} of maize plants were noted from plots that received zero tractor pass while maximum emergence of 9.26 m^{-2} of maize plants were noted from plots that received four tractor passes (Table. 4).

Interaction between T x Y showed that minimum emergence of 9.56 m^{-2} was noted from plots that were ploughed with cultivator twice followed by planking in year 2012 while maximum emergence of 9.91 m^{-2} was noted from plots that were ploughed with mould board plough followed by rotavator in year 2011. Y x T x P interaction showed that minimum emergence of 9.00 m^{-2} were recorded in plots prepared with plough followed by rotavator with four tractor passes in year 2011 while maximum emergence of 10.00 m^{-2} for maize were recorded in plots ploughed by mould board plough followed by rotavator receiving zero tractor passes in year 2012 (Table. 4).

Table 4. Emergence (m^{-2}) as affected by tillage and soil compaction (m^{-2}) for maize crop

		Number of passes			
Years	**Tillage implements**	0	2	4	Mean
	Cultivator twice + planking	10.00	10.00	9.25	9.75
	Cultivator four times + planking	10.00	10.00	9.00	9.67
2011	Mould board plow + rotavator	10.00	10.00	9.00	9.67
	Cultivator twice + planking	9.75	9.25	8.50	9.17
	Cultivator four times + planking	9.25	9.00	8.50	8.92
2012	Mould board plow + rotavator	10.00	9.25	9.00	9.42
	Cultivator twice + planking	9.88	9.63	8.88	9.46
	Cultivator four times + planking	9.63	9.50	8.75	9.29
	Mould board plow + rotavator	10.00	9.63	9.00	9.54
2011		10.00	10.00	9.08	9.69
2012		9.67	9.17	8.67	9.17
Mean		9.83	9.58	8.88	
LSD for tillage		0.23	LSD for passes		0.23
LSD for year		0.19	LSD for T x P		0.40

Means followed by different letters of the various categories are significantly different at 5% level of probability using least significant difference (LSD) test.

Emergence m^{-2} may be affected by soil properties 1ike bulk density, tillage and compaction conditions. Emergence m^{-2} was affected significantly by tillage and compaction treatments). Comparison of years as well as the interaction (Tillage and Compaction) remained significant as the upper surface received compaction and germination takes place in the upper surface of soil, therefore significant differences among different treatment means were observed. Different soil condition at the time of emergence during the experiment is the reason for significant variation between emergence m^{-2} of the two years. Similar findings have been recorded by Malhi and Nyborg, 1993 who reported that emergence was affected by change in bulk density mid aggregate size. Tillage practices showed significant differences on emergence.m^{-2} of wheat seeds as reported Sorour et al 1995.

CONCLUSIONS

Crop yield decreased with increasing numbers of tractor passes. There were different yield-losses responses to compaction for maize .The problems of soil compaction was significantly increased causing potential yield reductions during the research study. Penetration resistance, bulk density, days to emergence and emergence m^{-2} of maize crop were significantly affected. The maximum value of above parameters were recorded for T3P1 (control) and the minimum for T1P3. Almost all parameters showed a decreasing trend with increasing the level of soil compaction. Shallow tillage with cultivator twice followed by 4 times of soil compaction gave less crop yield as compared deep tillage for both wheat crop.The tillage practices i.e. mould board plough followed by rotavator, produced maximum yield results. The yield of maize was less recorded even cultivator twice followed zero pass of tractor and cultivator 4 times followed zero pass of tractor (control) as compared to mould board plough followed by rotavator with zero pass of tractor (control) the reason is that the latter combination ploughs the soil deeply as compared to first two controls which produced more yield of cultivated crops.

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