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EFFECT OF TILLAGE METHODS AND FERTILIZER LEVELS ON MAIZE PRODUCTION

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A field experiment was conducted at National Agriculture Research Center (NARC), Islamabad, Pakistan to observe the emergence and grain yield of maize crop under different fertilizer applications viz. 100-50-50, 150-75-75 and 200-100-100 kg ha^{-1} NPK and cattle manure 6000, 8000 and 10,000 kg ha^{-1} applied in the plots ploughed through tillage practices with deep tillage, conventional tillage and zero-tillage. The non significant interaction between fertilizers and tillage methods as well as between cattle manure and tillage methods each with three levels were found. It indicated that fertilizers and manures should be studied independently using pair wise comparison. Pair wise comparisons indicated that the fertilizer at the rate of 150-75-75 kg ha^{-1} (NPK) was suitable for best germination rate and grain yield of maize. Similarly the deep tillage was preferred over conventional and zero tillage, on the other hand, the highest level of manure (10000 kg ha^{-1}) was recommended for best germination rate and grain yield, where as 8000 kg ha^{-1} for grain weight and number of grains per cob.
Key words: Tillage, Inorganic and Organic fertilizer, Soil properties, and Grain yield.

INTRODUCTION

Maize is the most important cereal crop of the world; it is used for three main purposes as human food, feed for poultry and livestock. Maize being the highest yielding cereal crop in the world is of significant importance for countries like Pakistan, where rapidly increasing population has already out stripped the available food supplies. In Pakistan maize is third important cereal after wheat and rice. The bulk of the total production comes from two major provinces, Khyber Pakhtunkhwa (KPK) and Punjab, whereas a little amount of maize is produced in the province of Sindh and Balochistan (Anonymous, 2000). The maize crop is categorized as cereal due to the presence of starch in the grain and production of starch is the major objective of wet-milling industry. Stalks of maize are used for paper board, husk is used as filling material, and cobs are used for fuel make, charcoal and preparation of industrial solvents. Regarding as a source of animal feed, maize exceeds all other forage crops in average yield, dry matter and digestible nutrient. Green maize forage is high in vitamin A and green fodder contains 1.56% protein, 0.30% fat and 5.27% fiber (Chaudhry, 1982).

The most favorable crop production requires a suitable soil condition, which can be produced by best tillage practices as tillage has beneficial effect on plant growth. Kepner defined tillage as the mechanical manipulation of soil. The best tillage method is necessary to provide a suitable environment for seed germination, weed control, normal moisture availability and reduction of surface runoff by increasing infiltration. The degree of soil compaction, soil bulk density and soil moisture condition are important factors that influence seedling emergence and crop yield (Kepner, 1982).

Maize emergence and growth are directly and indirectly influenced by tillage operations. Most of the farmers are using a locally made plough and its continuous use which leads to form a plough pan or compact soil which hinders root growth and seed emergence. Previous studies revealed that a tillage operation has significant contribution in term of increased yield. Sheikh *et al.* (1980) reported that disc harrow and cultivator were efficient for seed bed preparation. Arora *et al.* (1991) reported that deep tillage is beneficial for maize cultivation. Kersten and Hack (1991) indicated that best results could be achieved by ploughing against no till cultivation. The aim of this study was to examine the relation between tillage methods and fertilizer levels for better crop production.

MATERIALS AND METHODS

***Experimental Site*:** This study was conducted at the experimental site in National Agriculture Research Center (NARC), Islamabad, Pakistan, in spring season 2009. The site is located at Latitude 33^0 40′ North and Longitude 73^0 08′ East. The climate data were taken during the spring season i.e. the rain fall average 0-125.8 mm, temperature 9^0C-44^0C, and humidity 22.5%-95%. The soil properties of the 0-45 cm of the experimental site are shown in Table 1.

***Experimental Design and Treatment Applications*:** Keeping in view the objectives of the study, the experiment was conducted using split plot under randomized complete block design (RCBD). A plot measuring 62 × 66 m having a total area 4092 m^2 was utilized in this study. Plots were divided into sub plots measuring equally to 20 m x 10 m, one-meter path left between each plots for turning of tractor operation, and for agronomic observation, sub plot was further divided into three equal parts measuring 6 ×10 m, so the total 54 plots were constituted. The ploughing of soil was performed with deep tillage (DT), conventional tillage (CT), and zero-tillage (ZT), with the incorporation of 100-50-50, 150-75-75, 200-100-100 NPK kg ha^{-1} and cattle manure 6000, 8000 and 10,000 kg ha^{-1}. Seeds of a maize variety "Islamabad Gold" were hand dibbled at 5 cm depth keeping row to row distance 75 cm and seed to seed distance 20 cm. Maize was sown at the rate of 10 kg per acre and the complete dose of NPK was applied at the time of sowing. The remaining dose of N was applied in two splits, the cattle manure was also applied before sowing of maize crop. Furthermore, before the first irrigation thinning process was applied to keep the plants at proper distance. Five plants were selected randomly from each plot and tagged. The agronomic observations recorded were germination, 1000 grain weight (g), number of grains cob^{-1} and grain yield. The grain data were recorded at 15 % grain moisture. The data were statistically analyzed by using Minitab-16 statistical software to see the significance differences among various levels of fertilizers.

***Standard formula for grain yield calculation*:** (Saleem, 2006)

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{FEW} \times (100 - \text{M\%}) \times 0.8 \times 10{,}000}{85 \times 1}$$

Where

FEW: Fresh ear weight in field at harvest.

M%: Grain moisture % age at harvest with moisture tester.

$\frac{100 - \text{M}}{85}$: *Conversion of grain moisture at 15% level.*

0.8: Grain/cob ratio (shelling %) i.e. for the variety planted, shelling % is 80 % grains.

$\frac{10{,}000}{1}$: *Conversion of grain yield per (1 m^2) on hectare*

RESULTS AND DISCUSSION

The analysis of experimental soil at 0-45 cm depth given in Table 1indicated that the soil was loam in texture having moisture content 9.20%, the mean bulk density and non-saline 1.5 g cm^{-3} and soil compaction 1366.33 KN m^{-2} with low organic matter (OM) with soil pH 7.31. The germination percentage, grain weight, grain per cob and grain yield parameters analysis is given in Table 2. All the interactions (Fertilizer x Tillage) were non significant. It implies that the fertilizer and tillage methods are independent and behave separately for each of the above parameters. Pair wise comparisons of fertilizer and tillage given in Table 3

Table 1. Soil properties of the experimental site at 0-45 cm of depth

Properties	Values	Properties	Values
Sand	21.00 %	N	6.11 mg Kg^{-1}
Silt	38.66 %	P_2O_5	2.63 mg Kg^{-1}
Clay	41.00 %	K_2O	59.33 mg Kg^{-1}
Moisture Content	9.20 %	Bulk Density	1.50 g /cm^3
Organic Matter	0.83 %	Soil Compaction	1366.33 KN/m^2
pH (1:2)	7.31	Texture	Loam
Electricity Conductivity	0.34 dS/m		

Table 2. ANOVA for different parameters of maize production in experiment I

SOV	df	MSS							
		Germination (%)		Grain Weight		Grains Per Cob		Grain Yield	
Block	2	1.000		17.150		155.800		0.006	
Fertilizer	2	11.445	*	264.150	**	680.700	ns	0.021	*
Error 1	4	0.945		12.703		129.925		0.001	
Tillage	2	90.780	***	701.595	***	4216.050	***	11.827	***
Fertilizer × Tillage	4	2.390	ns	12.315	ns	141.150	ns	0.003	ns
Error 2	12	0.908		7.130		113.725		0.002	

***: Significant at 0.001, **: Significant at 0.01, *: Significant at 0.05, ns: non-significant

indicated that the first fertilizer differs from fertilizer 2nd and 3rd whereas fertilizer 2nd and 3rd are non significant for germination percentage. Similar results were obtained for other three parameters as that of Siddiqui *et al*. (2006). On the other hand, pair wise comparisons for tillage levels indicated that three tillage levels were highly significant except the number of grains per cob. The 1st two tillage methods i.e. T_1 and T_2 were non significant whereas the other pairs were significant for number of grains per cob.

Table 4 revealed the effects of manure and tillage have been examined over the four parameters i.e. germination percentage, grain weight, number of grains per cob and grain yield. The analysis indicated that all the interactions (Manure x Tillage) were non-significant. It implies that manure and tillage are independent and behave separately. Pair wise comparisons of manure and tillage given in Table 5 indicated that the different levels of manure for the parameters i.e. grain weight and grain per Cob are non significant whereas the manure as well as the tillage are highly significant for all the other parameters under study. The first two manure levels were non significant and differed from its 3rd level for germination percentage whereas, for the parameter grain yield, the all three manure levels were significantly different from each other. Pair wise comparisons for tillage indicated that three tillage levels were significantly different from each other for the parameters i.e. germination (%) and grain yield whereas the first and second tillage levels are non significant for both the other parameters i.e. grain weight and number of grains per cob but significantly differ from its third tillage level with the same parameters, respectively.

CONCLUSIONS

It was concluded that deep tillage should be experienced with fertilizer 100-50-50, 150-75-75, 200-100-100 NPK kg ha^{-1} and 6000, 8000 and 10,000 kg ha^{-1} cattle manure, the most excellent results were obtained against conventional tillage and poor results were recorded at zero tillage. These results are consistent with that of the findings of Arora *et al.*

Table 3. Tukey's HSD test on fertilizer and tillage means for different parameters of maize production for experiment I

Parameters	Fertilizer			Parameters	Tillage		
	F_1	F_2	F_3		DT	CT	ZT
Germination (%)	86.3 [a]	88.6[b]	87.8[ab]	Germination (%)	90.1[a]	88.6[b]	84.0[c]
Grain Weight	217.0[a]	227.2[b]	225.2[b]	Grain Weight	230.4[a]	225.7[b]	213.3[c]
Grains Per Cob	--*---	---*--	---*---	Grains Per Cob	374.4[a]	367.9[a]	334.1[b]
Grain Yield	6.5[a]	6.6[b]	6.6[b]	Grain Yield	7.4[a]	6.9[b]	5.2[c]

Means scores across rows with the same letter are non-significantly different; *Non-significant factors are not reported

Table 4. ANOVA for different parameters of maize production in experiment II

SOV	df	MSS							
		Germination (%)		Grain Weight		Grains Per Cob		Grain Yield	
Block	2	0.334		20.335		84.000		0.001	
Manuring	2	9.335	**	121.445	ns	934.100	ns	0.041	**
Error1	4	0.500		33.945		250.450		0.001	
Tillage	2	38.780	***	548.110	***	7971.450	***	11.169	***
Manuring × Tillage	4	2.110	ns	10.890	ns	110.050	ns	0.002	ns
Error2	12	0.722		29.074		71.575		0.002	

***: Significant at 0.001, **: Significant at 0.01, *: Significant at 0.05, ns: non-Significant

Table 5. Tukey's HSD test on manuring and tillage means for different parameters of maize production for experiment II

Parameters	Manuring			Parameters	Tillage		
	MN_1	MN_2	MN_3		DT	CT	ZT
Germination (%)	84.1 [a]	84.8[a]	86.1[b]	Germination (%)	86.9[a]	85.3[b]	82.8[c]
Grain Weight	- -*----	---*----	---*----	Grain Weight	221.4[a]	222.2[a]	208.3[b]
Grains Per Cob	--* ---	---*---	---*----	Grains Per Cob	366.1[a]	363.6[a]	313.3[b]
Grain Yield	6.3[a]	6.4[b]	6.5[c]	Grain Yield	7.2[a]	6.9[b]	5.2[c]

Means scores across rows with the same letter are non-significantly different; *Non-significant factors are not reported

(1991) that deep tillage is beneficial for maize cultivation. Kersten and Hack (1991) also reported that more production of maize can be taken by ploughing as compared to zero till cultivation.

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