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TILLAGE PRACTICES AND SOWING METHODS AFFECT YIELD AND RELATED ATTRIBUTES OF MAIZE

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ABSTRACT

Adequate tillage practices and sowing of crops at suitable time with proper sowing methods are among the main factors that regulate the crop growth and ultimate yield. This experiment was conducted to assess the effects of different tillage practices and sowing methods on maize hybrid ‘32T16’ that was grown under field conditions where treatments were assigned in split plot arrangement by keeping tillage practices (conventional tillage, minimum tillage and deep tillage) in main plots while sowing methods (flat sowing, ridge sowing and bed sowing) in sub-plots and repeated thrice. Conclusively, tillage practices and sowing methods significantly improved maize growth, yield and yield contributing traits. Ridge sowing under deep tillage resulted in maximum grains and grain weight per cob, 1000-grain weight, grain and biological yield as well as harvest index. Regarding economics of the crop, maximum marginal rate of return (2232.79%) was recorded in ridge sown maize under conventional tillage.
Keywords: Maize, Tillage, Sowing methods, Growth, Yield

INTRODUCTION

Field crops depend largely on soil conditions to show their full potential regarding growth and yield. For improving soil condition, tillage plays a crucial role in improving maize production. A compacted soil, due to its high strength and low porosity, limits the crop roots in the upper layer and decreases the soil volume that can be searched by the plants for water and nutrients (Lipiec et al., 2003). Among different crop production factors, tillage contribution is up to 20% in crop production (Ahmad *et al*., 1996). Tillage is very effective farm activity for improving the soil physical condition and soil tilth, which enhances nutrient uptake and ultimately good final yield of crops (Bahadar *et al*., 2007). For a double cropping system, reducing tillage is very important due to short time for seedbed preparation and also to keep the low cost of production (Limon-Ortega *et al.,* 2002). Most economical, feasible and time saving cultural practices are required for raising the maize crop. Moreover, Tillage practices affect evaporation and also dry out soil to tillage depth. No till soils reduces surface residue incorporation and ultimately soil aeration in to soil. Soil disturbance and tillage activity usually can cause an increase in the residue decomposition, soil aeration, organic nitrogen mineralization and accessibility for plant to use nitrogen (Dinnes *et al*., 2002). For the remediation of subsoil compaction, deep tillage and crop rotations with the help of deep-rooted crops are best management options (Motavalli *et al*., 2003). Due to low soil organic matter percentage and poor crop establishment, maize grain yield is very low (Amanullah *et al*., 2010). Tillage breaks the hard subsoil layer that is formed due to repetitive tillage practices on the same depth for year after year. The presence of hard subsoil layer had bad impact on soil bulk density, penetration resistance, nutrient status and soil porosity that directly or indirectly disturbs the crop yield by lowering soil porosity and increasing bulk density of soil (Ahmad *et al*., 2009).

Sowing method is another key factor which has important role in maize crop production. The sowing methods which are mostly being used in Pakistan are ridge sowing, bed sowing and flat sowing. There are so many disadvantages of old broadcast method i.e. irregular seed distribution, uneven seed depth and seed picking up by the birds. Ashique *et al*. (1997)

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found several reasons for low production of maize in Pakistan among them high weed infestation, poor weed management practices and improper planting methods are common problems. Low yield potential of maize is due to many constraints like cultivar selection, late sowing, use of traditional sowing methods, improper plant protection measures and poor crop establishment. Proper sowing method has several benefits like improved inter-culturing, uniform irrigation, weeding, pest management and mechanical harvesting (Memon *et al*., 2007). Among the various agronomic practices, planting technique is of considerable importance because of optimum plant population and also proper use of the land and input resources (Ali *et al*., 1998). Improper sowing methods result in unproductive plants while improved sowing methods are important to get the maximum potential of maize hybrids (Alias *et al*., 2003). So, the aim of the study was to assess the variation in yield and yield contributing factors due to various tillage practices and sowing methods.

MATERIALS AND METHODS

The proposed study was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan (31.25°N latitude, 73.09°E longitude, altitude 184 m). Experimental soil belongs to Lyallpur soil series (Haplargid, hyperthermic Ustalfic, Aridisol-fine-silty, mixed according to USDA classification). The prevailing environmental conditions during crop growing period are presented in the fig. 1. Randomized complete block design (RCBD) with split plot arrangement was used to layout the experiment in three replications with a net plot size of 9.0 m × 4.8 m. Three different tillage practices i.e., TP_1: Conventional tillage (Disc harrow twice + cultivator once + planking), TP_2: Minimum tillage (Cultivator twice + planking) and TP_3: Deep tillage (Chisel plough twice + cultivator once + planking) were kept in main plots while three sowing methods i.e., SM_1: Flat sowing (R × R = 60 cm), SM_2: Ridge sowing (R × R = 60 cm) and SM_3: Bed sowing (Bed = 120 cm) were kept in sub-plots. The experiment was hand planted using 30 Kg ha^{-1} seed rate of maize hybrid 'Pioneer-32T16', intending to achieve good stand establishment. Two seeds were dropped per hill and the space between two adjusted hills within each row was 20 cm. Thinning was done at four leaves stage, to adjust the population. NPK was applied @ 250:125:125 kg ha^{-1}. Crop was irrigated when required and necessary plant protection measures were practiced to avoid pest attack. The crop was harvested manually on 16th June, 2012 and cobs (sun dried) were shelled with the help of a maize sheller to detach grains from pith. Data were recorded by using standard procedures and statistically analyzed by using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability level was used to compare treatment means (Steel *et al.,* 1997) whereas marginal analysis was done to calculate the net benefits and marginal rate of returns according to procedures devised by CIMMYT (1988).

RESULTS AND DISCUSSION

Plant population at maturity

Tillage practices and sowing methods did not affect plant m^{-2} at maturity (Table 2). Moreover, Interaction between tillage practices and sowing methods for plant population was also found non-significant. This might be due to maintaining plant population after germination of crop through thinning and using uniform seed rate to maintain plant to plant distance in all plots. These results are supported by Amin *et al.* (2006) who concluded that plant population was not significant under different sowing techniques.

Cob length (cm)

Cob length affected appreciably by various sowing methods while there were non-significant differences in cob length when maize hybrid was sown by different tillage practices (Table 2). Maximum cob length was observed under deep tillage while minimum cob length was recorded in minimum tillage but they were not varying up to the level of significance. Furthermore, maximum cob length was observed in bed sowing that was similar with ridge sown maize while minimum was recorded in flat sowing. This might be due to more moisture conservation and better crop stand in ridge sowing method because crop can get more porous soil on ridges than soil surface. The interactive effect of various tillage practices and sowing methods on maize cob length was also found to be non-significant (Table 2). Khan *et al.* (2010) by supporting these results concluded that maize ridge sowing influenced the cob length more as compared to other sowing methods.

Cobs per plant

The individual and interactive effect of various tillage practices and sowing methods on cobs per plant was found non-significant (Table 2). It might be a reason that the number of cobs per plant is a genetic character of maize hybrid which is not affected by cultural practices. Planting methods did not affect the number of cobs per plant considerably (Bakht *et al.*, 2011).

Cob length (cm)

Cob length as affected appreciably by various tillage practices and sowing methods (Table 2) which further illustrated that there were non-significant differences in cob length when maize hybrid was sown under different tillage practices. Maximum cob length was observed deep tillage while minimum cob length was recorded in minimum tillage but they were not varying up to the level of significance. Furthermore, maximum cob length was observed in bed sowing that was similar with ridge sown maize while minimum was recorded in flat sowing (17.76 cm). This might be due to more moisture conservation and better crop stand in ridge sowing method because crop can get more porous soil on ridges than soil surface. The interactive effect of various tillage practices and sowing methods on maize cob length was also found to be non-significant. Khan *et al*. (2010) by supporting these results concluded that maize ridge sowing influenced the cob length more as compared to other sowing methods.

Grain rows per cob

Non-significant difference regarding number of grain rows per cob was recorded when maize hybrid was sown under different tillage practices. Maximum number of grain rows per cob was observed when deep tillage was practiced while minimum grain rows per cob were recorded in minimum tillage but they were not varying up to the level of significance. Moreover, highest number of grain rows per cob was observed in ridge sowing that was statistically similar with bed sown maize while minimum grain rows were recorded in flat sowing. However, the interactive effect of various tillage practices and sowing methods on number of grain rows per cob was found to be non-significant (Table 2). These results were supported by Shahzad and Khan (2003) who reported that ridge sown maize significantly increased number of grain rows per cob as compared to other sowing methods.

Grains per cob

A significant interaction between tillage practices and sowing methods regarding grains per cob was observed (Table 2). In conventional tillage, maize sown on ridges and beds produced maximum number of grains per cob against flat sown maize. Similar trend was recorded in minimum tillage. Under deep tillage, maize ridge sowing performed best and produced maximum number of grains per cob that was statistically similar with bed sowing while flat sown maize produced minimum number of grains per cob which was statistically at par with bed sowing. Bakht *et al.* (2007) concluded that sowing methods had a significant effect on the number of grains per cob and they obtained maximum grains per cob in ridge sowing method as compared to other sowing methods.

Grain weight per cob (g)

Combined effect of various tillage practices and sowing methods on grain weight per cob was found to be significant (Table 2). Grain weight per cob was highest in ridge sown maize under deep tillage while lowest was recorded in flat sowing under minimum tillage. At conventional tillage, bed sown maize produced maximum grain weight per cob that was statistically alike with the ridge sown maize while flat sown maize gave minimum grain weight per cob. Under deep tillage, maize ridge sowing performed best and produced maximum grain weight per cob that was statistically alike with bed sowing while flat sown maize produced minimum grain weight per cob. Our results are corresponding to Shahzad and Khan (2003) who reported that maize ridge sowing increased grain weight per cob significantly as compared to other sowing methods.

1000-grain weight (g)

The significant interaction (tillage practices × sowing methods) revealed that 1000-grain weight was highest in ridge sown maize under deep tillage while the lowest was recorded in flat sowing under minimum tillage while conventional tillage, bed sown maize produced maximum1000-grain weight that was statistically at par with the ridge sown maize. In minimum tillage, maize on beds produced higher 1000-grain weight while flat sown maize produced lower 1000-grain weight. Similarly under deep tillage, maize on ridges produced higher 1000-grain weight however flat sown maize produced lower 1000-grain weight (Table 2). In sum, all tillage practices were found statistically similar regarding 1000-grain weight in case of ridge and bed sowing followed by flat sown maize. Anjum *et al*. (2014) and Bakht *et al.* (2007) supported these results and found maximum 1000-grain weight in ridge sowing method as compared to other sowing methods.

Grain and biological yield (t ha^{-1})

All tillage practices were found statistically similar regarding grain and biological yield of maize in case of ridge followed by bed sowing but differs in flat sown maize. Flat sown maize yielded less than ridge and bed sown maize. Over all the effectiveness of all three tillage practices were: deep tillage > minimum tillage > conventional tillage, while for sowing methods, it may be stated as: Ridge sowing > bed sowing > flat sowing. The higher grain yield of maize on ridges might be ascribed to more number of grains per cob with higher grain weight than the crop sown with other planting methods. These results were supported by Musambasi *et al.* (2003) who stated that maize sowing on ridges provided the maximum grain yield. Anjum *et al.* (2014) also reported that ridge sowing method significantly enhanced the biological yield than other sowing methods.

Harvest index (%)

The interaction of tillage practices and sowing methods explicated that harvest index was higher in ridge sown maize under deep tillage while lower was recorded in flat sowing under minimum tillage. At conventional tillage, bed sown maize furnished maximum harvest index found statistically allied to ridge sowing while flat sown maize gave minimum harvest index. All the sowing methods including flat, ridge and bed sowing showed statistically non-significant difference regarding harvest index at minimum tillage. However under deep tillage, all the sowing methods showed substantial differences regarding harvest index. At deep tillage, ridge sown maize produced maximum harvest index followed by bed sowing while flat sown maize produced minimum harvest index. Balasubramaniyan *et al*. (2001) and Graybill *et al*. (1991) also reported that harvest index was affected significantly by sowing methods.

Dominance and marginal analysis

Final recommendation for the production technology cannot be specified only on the basis of net field benefit (NFB) as NFB does not indicate the rate of return in relation to investment. Domination is the mechanism for identification of good alternatives. Data presented in table 3 revealed that NFB of some treatments were less with lowering cost and as a result these treatments were dominated (D). The remaining (un-dominated) treatments were further considered for the marginal analysis. It is clear from the table 3 that the treatments in which flat sowing was practiced under conventional and deep tillage were dominant due to their lower net field benefits as compared to other treatments.

As real differences were found in the yield among different treatments, therefore a marginal analysis was done. Table 3 presents the marginal analysis of un-dominated treatments. Maximum marginal rate of return of 2232.79% was obtained in treatment where maize sown on ridges under conventional tillage. It is clear from the results that farmers with poor resources can accomplish maximum benefits by sowing the maize hybrid on ridges under conventional tillage system.

CONCLUSION

Conclusively, ridge sowing after deep tillage proved better regarding growth and yield of maize and provided higher net returns as compared to other tillage practices and sowing methods. Hence, maize could be planted on ridges after deep ploughing to get maximum benefits.

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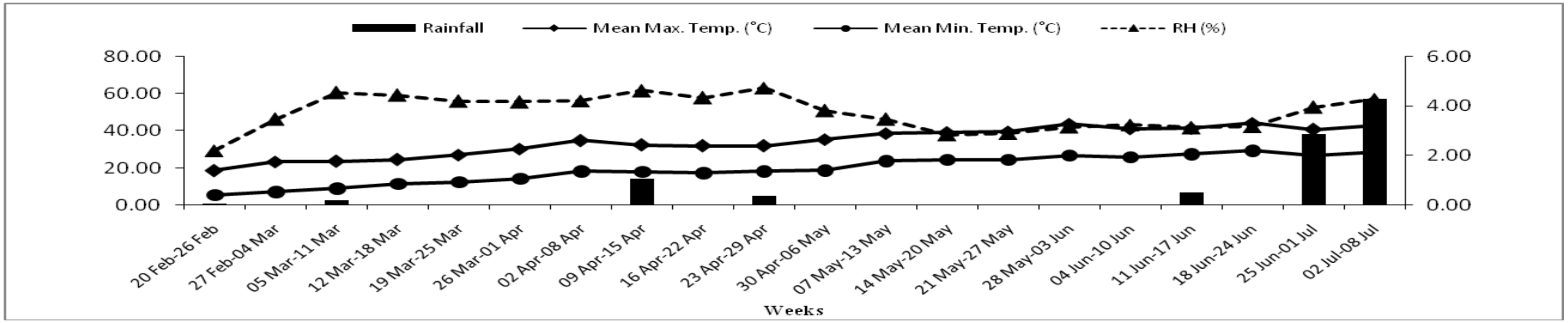

Figure 1. Mean maximum temperature (˚C), Mean minimum temperature (˚C), Relative humidity (%) and Rainfall (mm) during the growth period of crop.

Table 1 Affect of different tillage practices and sowing methods on yield and yield related attributes of maize

Treatments	**Plant population at maturity**	**Cob length (cm)**	**Number of cobs per plant**	**Number of grain rows per cob**	**Number of grains per cob**	**Grain weight cob (g)**	**1000-grain weight (g)**	**Biological yield ($t\ ha^{-1}$)**	**Grain yield ($t\ ha^{-1}$)**	**Harvest index (%)**
TP_1	6.9	18.83	1.0	15.53	534.3 B	129.8 B	242.4 B	16.30 B	5.82 B	35.68 A
TP_2	7.0	18.45	1.0	15.39	485.5 C	124.2 C	231.8 C	15.87 B	5.44 C	34.28 B
TP_3	7.0	18.85	1.1	15.80	590.9 A	134.0 A	256.5 A	17.18 A	6.08 A	35.39 A
LSD($p\leq0.05$)	**NS**	**NS**	**NS**	**NS**	**11.12**	**3.47**	**5.08**	**0.44**	**0.13**	**0.92**
SM_1	6.4	17.76 B	1.0	15.19 B	505.3 B	123.9 B	234.8 B	15.80 C	5.43 C	34.33 B
SM_2	7.6	19.14 A	1.1	15.84 A	555.0 A	132.2 A	247.3 A	16.92 A	6.05 A	35.74 A
SM_3	6.9	19.23 A	1.0	15.69 A	550.5 A	131.9 A	248.6 A	16.63 B	5.87 B	35.28 A
LSD($p\leq0.05$)	**NS**	**0.96**	**NS**	**0.36**	**11.29**	**2.18**	**3.88**	**0.24**	**0.06**	**0.49**
$TP_1\times SM_1$	6.3	17.73	1.0	15.13	507.6 b	125.1 b	236.8 b	15.83 b	5.52 b	34.87 b
$TP_2\times SM_1$	6.3	17.90	1.0	15.06	433.0 b	115.7 b	225.9 b	14.83 c	5.04 c	33.96 a
$TP_3\times SM_1$	6.7	17.66	1.1	15.40	575.4 b	130.8 b	241.8 b	16.73 b	5.72 c	34.17 c
$TP_1\times SM_2$	7.7	19.20	1.1	15.86	548.7 a	132.0 a	242.6 ab	16.67 a	6.01 a	36.04 a
$TP_2\times SM_2$	7.3	18.66	1.1	15.46	513.6 a	127.9 a	233.4 a	16.62 a	5.74 a	34.55 a
$TP_3\times SM_2$	7.7	19.56	1.0	16.20	602.6 a	136.8 a	265.9 a	17.47 a	6.40 a	36.62 a
$TP_1\times SM_3$	6.7	19.56	1.0	15.60	546.6 a	132.3 a	247.9 a	16.40 a	5.92 a	36.13 a
$TP_2\times SM_3$	7.3	18.80	1.0	15.66	510.1 a	128.9 a	236.1 a	16.17 b	5.55 b	34.34 a
$TP_3\times SM_3$	6.7	19.32	1.1	15.80	594.7 ab	134.4 ab	262.0 a	17.33 a	6.13 b	35.37 b

LSD(p≤0.05)	**NS**	**NS**	**NS**	**NS**	**19.54**	**3.78**	**6.72**	**0.42**	**0.11**	**0.86**

Means not sharing a letter in a common within a column differ significantly ($p \leq 0.05$); NS: Non-Significant**.** TP_1: Conventional tillage (Disc harrow twice + cultivator once + planking), TP_2: Minimum tillage (Cultivator twice + planking) and TP_3: Deep tillage (Chisel plough twice + cultivator once + planking); SM_1: Flat sowing (R × R = 60 cm), SM_2: Ridge sowing (R × R = 60 cm) and SM_3: Bed sowing (Bed = 120 cm)

Table 2 Economic and dominance analysis of tillage practices and sowing methods of maize

Treatments		**Variable cost (Rs. ha^{-1})**	**Marginal cost (Rs. ha^{-1})**	**Net field benefits (Rs. ha^{-1})**	**Marginal net benefits (Rs. ha^{-1})**	**Marginal rate of return (%)**
Minimum Tillage	Flat Sowing	19110	--	153823	--	--
	Bed Sowing	21112	2002	164344	10521	525.52
	Ridge sowing	21635	523	167030	2686	513.57
Conventional Tillage	Flat Sowing	25180	3545	145610	**D***	**D**
	Bed Sowing	26880	1700	159193	13583	799
	Ridge sowing	27127	247	164709	5515	2232.79
Deep Tillage	Flat Sowing	29730	2602	156183	**D**	**D**
	Bed sowing	31457	1727	167002	10819	626.46
	Ridge Sowing	32200	742	173788	6785	914.42

*D = Dominance

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