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RESPONSE OF MAIZE TO TILLAGE AND NITROGEN MANAGEMENT

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ABSTRACT

Best nitrogen management practices are the pre-requisite to warrant high maize yield. Thus, experiments were conducted to study the "effect of tillage and split application of nitrogen on hybrid maize" under semi-arid conditions of Pakistan, during fall 2008 and 2009. The experiments were laid out in randomized complete block design with split-plot arrangement, replicated three times in a net plot size of 4.5m x 10m at the Agronomic Research Area, University of Agriculture, Faisalabad. Three tillage treatments (conventional tillage (2-cultivation), tillage with mouldboard plough + 2-cultivation and tillage with chisel plough + 2-cultivation) were kept in main plots, while nitrogen application at different growth stages (Whole at sowing, ½ at sowing + ½ at V_5 (5-leaf stage), ½ at sowing + ½ at tasseling, ½ at V_5 + ½ at tasseling, $^1/_3$ at sowing + $^1/_3$ at V_5 + $^1/_3$ at tasseling) in sub-plots. Tillage methods improved the plant height, biomass yield, harvest index and shelling percentage during both the years while nitrogen application had no effect on plant height and harvest index but had significant effect on shelling percentage and biomass yield of maize. Chisel ploughed plots produced tallest plants, higher biomass, harvest index and shelling percentage while mould board plough resulted to shortest plants, lower biomass, harvest index and shelling percentage during both the years. Nitrogen application in three splits produced highest biomass yield and shelling percentage during 2008 and 2009. Variation in biomass yield in maize suggested temporal nitrogen management practices in maize grown by ploughing the soil with chisel plough followed by cultivator under semi-arid climatic conditions.

Key words: Tillage, Maize, Harvest Index, Shelling Percentage, Biomass yield.

INTRODUCTION

The production of maize in Pakistan is low as compared to developed countries. The low yield of maize may be due to improper management practices of which most important are tillage and time of nitrogen application. Tillage plays a significant role in improving crop yield by breaking the hard subsoil layer which is created due to repeated tillage practices at the same depth year after year. The presence of hard pan had negative impact on soil bulk density, soil nutrient status, penetration resistance and soil porosity which directly or indirectly affects the yield of crops by decreasing soil porosity and increasing soil bulk density (Ahmad *et al*., 2009). Significantly highest biological yield (Gul *et al*., 2009) was obtained in case of conventional tillage as compared to no tillage or reduced tillage which showed less biological and grain yield due to high weed density (Gul *et al.,* 2009). In contrast, maize grain yield was increased up to 15% grown under deep tillage using mould board plough. This increase in yield occurred due to decreased soil bulk density, reduced soil strength, increased moisture conservation and higher cumulative infiltration (Khattak *et al.,* 2004). Subsoiling upto 50-55 cm resulted to highest average plant height and about 9.7-13.5% increase in yield (Borghei *et al*., 2008). Similarly subsoiling with chisel plough resulted to higher grain yield in maize compared with mouldboard plough which resulted in lower yield (Wasaya *et al.,* 2011).

Nitrogen is an important plant nutrient and lost in the form of leaching, denitrification or volatilization if not managed properly. Nitrogen application in splits proved to be a best practice in the sense that it reduced various losses and resulted to higher dry matter accumulation and plant height in maize as compared to sole application (Harikrishna *et al*., 2005). Nitrogen application in splits viz. at planting, first irrigation and at knee height resulted to maximum plant height and grain yield as compared to sole application (Rizwan *et al.,* 2003). Similarly, N application in three splits i.e. at sowing, at 25 DAS and 55 DAS resulted to higher grain yield due to efficient uptake of N by the maize (Saleem *et al*., 2009).

The presence of hard pan created due to repeated tillage practices at same depth had adverse effect on crop yield which may be removed through deep ploughing. Removal of hard pan may lead to improved crop yield by improving soil structure. Similarly, split application of nitrogen reduces nitrogen losses and may improve NUE. Keeping this in view, the present study was therefore, designed with the objective to find out the best and economical tillage method and best time of nitrogen application to obtain higher biomass yield under the semi-arid conditions of Faisalabad.

MATERIALS AND METHODS

Response of maize to tillage and nitrogen management was studied through field experiments conducted at the Agronomic Research Area, University of Agriculture, Faisalabad (Pakistan) during 2008 and repeated in 2009. The site of experimental area is located at longitude 73° East and latitude 31° North. The altitude of site is 135 meters above the sea level.

The experimental treatments comprised of three tillage methods (conventional tillage, tillage with mould board plough followed by 2-cultivations (with cultivator) and tillage with chisel plough followed by 2-cultivations (with cultivator) and five nitrogen application timings (Whole at sowing, ½ at sowing + ½ at V_5 (5-leaf stage), ½ at sowing + ½ at tasseling, ½ at V_5 + ½ at tasseling, 1/3 at sowing + 1/3 at V_5 + 1/3 at tasseling). The experiments were laid out in RCBD with split plot arrangements with three replications in a net plot size of 4.5m × 10m. Before the experiment, the wheat was grown in the field and harvested in last week of April, and field kept fallow for three months prior to maize sowing. Tillage treatments were applied to main plots and split application of nitrogen applied to sub-plots. Field was cultivated through tractor mounted cultivator in case of conventional tillage. Two cultivations were done followed by planking. In second treatment the soil was cultivated with mould board plough upto a depth of 0.30m followed by 2-cultivations and planking. In third tillage treatment the soil was ploughed with chisel plough at the depth of 0.40m followed by 2-cultivations and planking. Before the maize sowing, soaking irrigation of 100mm was applied and final seedbed was prepared when field reached at 50% field capacity after six days of soaking irrigation. The soil samples were randomly collected from the field and were analyzed for different soil physico-chemical properties. The experimental soil was sandy clay loam containing sand 57% & 60%, silt 21.2% & 18% and clay 21.8% & 20% during 2008 and 2009, respectively.

Maize hybrid pioneer-31R88 was sown on August 16, 2008 and August 10, 2009. A seed rate of 25 kg ha^{-1} was used by keeping a line to line distance of 75 cm and a plant-plant distance of 20 cm. The crop was sown with the help of dibbler by dropping two seeds per hill and then one plant per hill was maintained by thinning at three-leaf stage. Phosphorus and Potassium were applied at sowing time at the rate of 100 kg ha^{-1} each in the form of SSP and SOP, respectively and nitrogen was applied at the rate of 150 kg ha^{-1} at different growth stages in the form of Urea according to the treatments. Five irrigations were applied for the whole crop season and weeds were controlled through manual hoeing at five-leaf stage.

Data for different parameters such as plant height, harvest index, shelling percentage and biomass yield was collected to find out the best treatment. Ten plants from each subplot were randomly selected at physiological maturity and their height was measured with the help of meter rod from base of stem to the tip of tassel and then averaged to find out plant height per plant. The plants from the middle two rows of each sub-plot were manually harvested and sundried. The weight of air dried plants with cobs was recorded on per plot basis in kg per plot and then converted into Mg ha^{-1}. Harvest index (%) was computed by using the formula as proposed by Beadle (1987) as followed.

$$H.I.\,(\%) = Grain\ Yield/Biological\ yield \times 100$$

However, shelling percentage (%) was worked out by using the formula as suggested by Beadle (1987).

$$S.P = (Total\ grains\ weight/Total\ cobs\ weight) \times 100$$

Statistical analysis: The data recorded were statistically analyzed by using computer software MSTAT-C (Freed and Scott, 1986). Analysis of variance technique was used to test the significance and LSD at 5% probability level was used to compare the treatment's means (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Plant height (cm): Crop growth can also be measured in terms of plant height which is an important and directly contributing parameter to biomass production. Different tillage systems significantly affected plant height (Table-1). Deep tillage (chisel plough) positively affected plant height during both years of experimentation. Taller plants were observed when maize grown under conventional tillage practices or chisel ploughed plots while shorter plant height was recorded in plots cultivated with mould board plough during 2008. During 2009, the tallest plants were observed in plots ploughed with chisel plough while shorter plants were observed in case of conventionally tilled as well as mould board ploughed plots. Increased plant height with increasing tillage may be due to decreased soil bulk density (data not shown) which increased proliferation of roots for the uptake of nutrients as well as moisture. Similarly, taller plants in deeply tilled (disc ploughed) plots were recorded by Aikins and Afuakwa (2010).

Split application of nitrogen is an important nutrient management practice used for increasing nutrient use efficiency. Different form of nitrogen losses can be reduced if nitrogen is applied in splits. Data revealed that nitrogen application in splits showed significant effect on plant height during both experimental years. However, numerically taller plants were found when nitrogen applied in three splits at different growth stages viz. $^1/_3$ at sowing + $^1/_3$ at V_5 + $^1/_3$ at tasseling and shorter plants were observed when nitrogen was applied in two splits i.e. ½ at V_5 and ½ at tasseling in 2008. During 2009, non-significant effect of nitrogen application timing on plant height was observed. These results are in close association with Rizwan *et al.* (2003) and Harikrishna *et al.* (2005) who reported a non-significant effect of nitrogen application timings on maize plant height. A non-significant effect of split applied nitrogen on plant height in cotton was also reported by Hallikeri *et al.* (2010). These results are not in line with the Amanullah *et al.* (2009) who reported increase in plant height with increasing number of nitrogen splits. These contradictory results may be attributed to variation in climatic condition and soil fertility status of the area as well as the cultivar used.

Year had significant effect on plant height. Taller plants were obtained in 2009 as compared to 2008 (Table-1). Taller plants obtained in second year of study were due to favourable environmental conditions. In the first year higher rainfall of about 62mm occurred at crop emergence i.e. 2DAE (days after emergence) which had negative impact and thus stunted the crop growth. But in second year less but frequent rainfall occurred during the whole crop season and had positive impact on plant height. More plant height in second year may be attributed to fluctuation in the weather conditions (Amanullah *et al.*, 2009).

A non-significant interaction between tillage practices and nitrogen application timings was observed (Table-1).

Biomass yield (Mg ha^{-1}): Tillage systems significantly affected maize biomass yield during both experimental years (Table-1). During first year, biomass yield from chisel ploughed plots was 12.5% higher compared with mould board plough. In second year biomass yield with chisel plough was about 5.7% and 16.0% higher than with conventional tillage and mould board plough respectively. The highest biomass yield may be attributed to more plant height and dry matter production in chisel tilled plots. These results strongly relate with Astier *et al.* (2006), Diaz-Zorita (2000) and Al-Kaisi and Licht (2004), who reported that biomass yield of maize improved due to good soil conditions provided to crop for better growth and development by loosening the soil with deep tillage implements.

Biomass yield of maize was significantly ($p < 0.05$) affected by time of nitrogen fertilization. The highest biomass yield was observed in plots treated with nitrogen in three splits followed by nitrogen application in two splits (½ at sowing + ½ at tasseling) while the lowest yield was recorded with N_4 (½ at V5 + ½ at tasseling) during 2008. The similar trend was observed during 2009. The slight decrease in TDM was observed when N was delayed to 8-leaf stage due to variable effect of N uptake (Jokela and Randall, 1989). The highest biomass yield with more nitrogen splits may be attributed to extension of maize growth phase which resulted in production and translocation of more photosynthates in response to longer growth period (Amanullah *et al.*, 2009). These results are in agreement with the findings of Arif *et al.* (2010), who reported the highest biomass yield of maize when nitrogen was applied in three splits compared with two splits or sole application of nitrogen.

The combined analysis indicated that biomass yield of maize was significantly ($p < 0.05$) affected by the year. About 4.38% more biomass yield was observed during 2009 compared with 2008. The higher biomass yield during second year may be attributed to more favourable environmental conditions for crop growth which led to higher biomass yield. Arif *et al.* (2010) also stated the significant year effect on biomass yield.

A non-significant interaction between tillage systems and time of nitrogen application was observed in both years (Table-1). A non-significant interaction of nitrogen splits on maize biomass yield was also reported by Arif *et al.* (2010).

Harvest index (%): The data showed substantial effect of different tillage systems on maize harvest index (H.I.) during 2008, while, the effect was non-significant during 2009. In 2008, maize gained maximum harvest index when grown with chisel plough while minimum harvest index was observed in mould board plough which was at par with conventional tillage (Table-1). More, H.I. in chisel plough treated plots may be attributed to more individual grain size and grain yield (data not shown). These results are closely associated with the findings of Patil and Sheelavantar (2009), who observed the highest H.I. of sorghum when grown in deeply tilled plots.

Time of nitrogen application at different growth stages had non-significant effect on maize harvest index during both years. Interaction between tillage systems and N timings was found significant during both years. These results are in close association with the findings of Amanullah and Shah (2010) and Rizwan *et al.* (2003), who reported a non-significant effect of split applied N on H.I.

Perusal of the data indicated that the year had significant effect on harvest index. Harvest index during 2009 was about 7.66 % higher compared with 2008 (Table-1). A significant year effect may be attributed to more favourable ecological conditions in second experimental year which improved grain yield and resulted in higher H.I.

Shelling percentage (%): Tillage systems had no significant effect on shelling percentage during 2008 while the effect was significant in 2009. The higher shelling percentage was observed with chisel plough which was at par with conventional tillage. The lower shelling percentage was observed with mould board plough. A significant effect of nitrogen application timing on shelling percentage was observed. Significantly ($p < 0.05$) higher shelling percentage was obtained with N_3 (½ at sowing + ½ at tasseling) and was at par with N_2 and N_5.

Minimum shelling percentage was observed in N_1 (whole at sowing) during 2008. In 2009, significantly ($p < 0.05$) the higher SP was obtained with N_5 which was at par with N_3 while the lowest SP was obtained with N_4.

A significant interaction was observed between tillage systems and nitrogen application timing during 2009 (Table-2), while the effect was non-significant in 2008. The highest shelling percentage was observed with nitrogen application in three splits under chisel plough while the less was observed with N_4 (½ at V_5 + ½ at tasseling) under mould board plough. These results are inconsistent with the findings of Amanullah and Shah (2010), who observed a non-significant effect of split application of nitrogen on shelling percentage. The contradiction in results may be due to genotype or climatic variations of the experimental sites. Perusal of the data indicated a significant year effect and about 8.23% more shelling percentage was obtained in 2009 compared with 2008.

Table-1: Impact of tillage and split application of nitrogen on maize during 2008 and 2009.

Treatments	Plant height (cm)		Biomass yield ($Mg\ ha^{-1}$)		H.I. (%)		SP (%)	
Tillage	2008	2009	2008	2009	2008	2009	2008	2009
T_1	211.88a	219.03b	15.02a	15.78b	37.49b	41.68	73.31	78.95a
T_2	203.80b	213.04b	13.77b	14.06c	37.45b	40.82	68.58	75.26b
T_3	209.54a	230.47a	15.74a	16.73a	40.06a	42.04	72.48	79.45a
LSD ($p < 0.05$)	3.40	7.59	0.95	0.44	2.22	NS	NS	1.64
(B) Nitrogen timings (N)								
N_1	207.79	220.04	14.23d	15.32 b	37.93	41.26	69.9b	77.12bc
N_2	209.68	220.33	14.69c	15.33 b	38.38	41.55	72.01ab	77.09bc
N_3	208.12	221.69	15.36b	15.76 b	38.81	41.78	73.31 a	78.97ab
N_4	205.37	222.00	14.07d	14.51 c	38.00	41.27	70.10 b	76.20c
N_5	211.07	220.16	15.87a	16.70 a	38.54	41.70	71.87ab	80.05a
LSD ($p < 0.05$)	NS	NS	0.45	0.63	NS	NS	2.26	1.91
Year	208.4b	220.8a	14.84b	15.52a	38.33b	41.51a	71.45b	77.89a
LSD ($p < 0.05$)	2.82		0.35		0.92		2.09	
Interaction (T×N)	NS	NS	NS	NS	NS	NS	NS	*

Means not sharing the same letters in the column differ significantly at $p \leq 0.05$ NS= Non-significant

T_1: Conventional Tillage (2-Cultivation), T_2: Tillage with mould board plough + 2-Cultivation, T_3: Tillage with Chisel plough + 2-Cultivation, N_1: Whole at sowing, N_2: ½ at sowing + ½ at V_5, N_3: ½ at sowing + ½ at tasseling, N_4: ½ at V_5+ ½ at tasseling, N_5: $^1/_3$ at sowing + $^1/_3$ V_5 + $^1/_3$ at tasseling.

Table-2: Interactive effect of tillage and time of nitrogen application on shelling percentage (%) in maize during 2009.

Treatments	T_1	T_2	T_3
N_1	77.09 bcd	74.75 de	79.50 ab
N_2	77.82 bcd	74.87 cde	78.59 abc
N_3	79.66 ab	77.31 bcd	79.93 ab
N_4	78.49 abcd	72.65 e	77.46 bcd
N_5	81.67 a	76.74 bcd	81.74 a
LSD ($p < 0.05$)		3.31	

Means not sharing the same letters in the column differ significantly at $p \leq 0.05$.

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