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EFFECT OF MULCH, IRRIGATION AND SOIL TYPE ON NUTRIENT UPTAKE OF FORAGE MAIZE

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A pot experiment was conducted to evaluate the effect of mulch and irrigation on nutrient uptake of forage maize using clay and loam soils during Autumn 2002. Two mulch levels, i.e. 0 (control) and 6.7 Mg ha^{-1} of wheat straw were used. Three irrigation levels viz. 100 %, 80 % and 60 % of total crop water requirement (CWR) was determined at 30 mm deficit. Maize plants were harvested twelve weeks after sowing and shoots were analyzed for N, P and K concentration and their uptake was calculated. Results revealed that there was no effect of wheat straw mulch on nutrient concentration and their uptake while N concentration and uptake in shoot significantly increased in clay than loam soil. Phosphorus concentration and uptake was more in loam soil. Interaction between mulch and soil texture was statistically significant as increase in potassium concentration in shoot was observed.

Key words: Mulch, irrigation, texture, potential evapotranspiration, forage maize, concentration, uptake, shoot

INTRODUCTION

Maize is the third most important cereal crop in the world after wheat and rice. Maize grains have great nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% sugar and 1.7% ash (Chaudhary, 1983). In Pakistan it is cultivated on an area of 961.7 thousand hectares with an annual production of 1652 thousand tons (Anonymous, 2000). Adequate N promotes vigorous vegetative growth, increases the plumpness of grains and their protein contents and the integral component of the chlorophyll. Phosphorus is the second major nutrient essential for plant growth and plays a vital role in the several key physiological processes, viz. photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement, etc. Potassium is very important in water use and plants with an adequate supply of K are less susceptible to water stress.

Agricultural crop production in Pakistan is facing serious water shortage. About 10.24 million hectare meter is diverted to canals, which is not enough, to fulfill the 15.54 million hectare meter water requirement (Anonymous, 2002). Assuming 35% conveyance losses, only 65.39 million hectare meter remains available at farm gate, thus resulting in 90.07 million hectare meter water deficit.

Now irrigated agriculture is entering an "age of management" in which crop water deficit may not be totally avoided but instead, favourably controlled. So, there is need to adopt management practices that limit evaporation losses. Among these practices one of them is mulching. The practice of spreading plant residue or any other material like straw on the soil surface to reduce water evaporation losses is called mulching. Mulching has been found effective in conserving soil water, regulating soil temperature and preventing crust formation. Mulches can also be used for soil water conservation on moderately sloping arable lands. Chaudhary *et al.* (1988) observed the response of gram to the application of wheat straw, maize stover and rice straw mulches. Their study showed that mulch treatment moderated soil temperature, improved water retention in the soil, increased biomass and enhanced crop yield. Texture also directly affects water-holding capacity of a soil. Irrigated silty soil increased 29 - 74% higher soil water around seed when mulch was applied (Tisdall and Adam, 1986). Therefore, the effect of mulch on improvement of plant available water in different textured soil is modified. Keeping these aspects in mind, a study under wire house conditions was carried out during the year 2002 to study the effect of mulch, irrigation and soil type on nutrient uptake of forage maize.

MATERIALS AND METHODS

For this study, two soils of different textures, i.e. loam and clay having sand (27.9, 45.8 %), silt (31.2, 28.2 %), clay (40.9, 25.9 %) were collected from the surface (0-15 cm) layer of cultivated fields of the University Research Farm and Nandipur near Daska, respectively. Soil samples were air-dried, ground, passed through a 2 mm sieve and were filled @ 10 kg pot^{-1} in earthen pots having thin plastic sheet placed inside. A basal recommended dose of fertilizers [150 mg N, 100 mg P_2O_5 and 50 mg K_2O per kg of soil as urea, single superphosphate and muriate of potash, respectively] was applied in solution form at the time of sowing except N fertilizer, which was applied in two split doses.

Mulch levels selected for the experiment were 0 (control) and 6.7 Mg ha^{-1} of wheat straw and were

applied at the time of sowing. Crop water requirement was determined by Modified Penman Model (Doorenbos and Pruitt, 1977). Then three irrigation levels viz. 100 % (I_0), 80 % (I_1) and 60 % (I_2) of total crop water requirement (CWR) were selected at 30 mm deficit. So there were 12 treatments combinations, each replicated six times. Hybrid maize variety R-2205 was sown and seedlings were thinned to four per pot. Plants were harvested twelve weeks after sowing and shoots were analyzed for N, P and K concentration and their uptake was calculated.

Statistical analysis was carried out following ANOVA technique and DMR test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Nitrogen concentration (%) in maize shoot

The data regarding N concentration in maize shoot listed in Table 1, which showed that effect of wheat straw mulch had a statistically no effect with respect to this parameter.

As regard effect of mulch on N percentage, data revealed that nitrogen concentration was similar in shoot, i.e. in the mulched soil it was 1.37% as against 1.33% in the non-mulched soil. Regarding the effect of soil texture on N concentration in shoot, it affected significantly as higher mean values for N-percentage were observed in T_2 (clay), i.e. 1.61% and for T_1 (loam) 1.12% in case of mulched soil compared to 1.57% for T_2 (clay) and 1.08% nitrogen for T_1 (loam) in non-mulched soil. Nitrogen concentration noted in shoot were higher (1.61 and 1.57 %) in case of T_2 (clay), compared to T_1, i.e. loam soil. These results of nitrogen percentage in shoot with respect to texture are in line with those of Siddique and Hassan (1991). As regard the effect of irrigation level, these had statistically significant effect on N-percentage of shoot. The highest mean nitrogen (%) in case of maize shoot was observed in I_2 (60 % CWR) having 1.66 %, followed by I_1 (80 % CWR) with 1.4 and 0.99 % in I_0 (100 % CWR).

Table 1. Effect of mulch, soil texture and irrigation level on nitrogen concentration (%) in maize shoot

Irrigation level	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	0.70	1.05	0.87	1.34	0.99 c
I_1	0.99	1.08	1.10	1.69	1.40 b
I_2	1.57	1.28	1.40	1.82	1.66 a
Mean	1.08	1.57	1.12	1.61	
Mean	1.33		1.37		

Mean sharing same letter(s) are statistically non-significant at 5% probability

Phosphorus concentration (%) in maize shoot

The data pertaining to P concentration in shoot are given in Table 2. Analysis of variance clearly indicated that mulch had a significant effect on P concentration in shoot of maize. Higher mean value was obtained in non-mulched soil having 0.12% compared to 0.10% in the mulched soil.

There was a significant effect of soil texture on P concentration in shoot of maize. In case of shoot the higher mean values of P concentration were observed in non-mulched soil, i.e. 0.13 and 0.11 % and 0.10 and 0.09 % in case of clayey soil. These results are in agreement with those obtained by Ahmad *et al.* (1992). They reported that availability of P to plants is affected by soil texture, pH, clay contents and clay mineralogy. Similar results were observed by Nakos (1987) who reported a significant and positive correlation between P adsorption and clay contents.

Table 2. Effect of mulch, soil texture and irrigation level on phosphorus concentration (%) in maize shoot

Irrigation levels	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	0.14	0.11	0.12	0.09	0.11
I_1	0.12	0.11	0.11	0.09	0.11
I_2	0.14	0.85	0.10	0.08	0.10
Mean	0.13	0.10	0.11	0.09	
Mean	0.12		0.10		

Mean sharing same letter(s) are statistically non-significant at 5% probability

Potassium concentration (%) in maize shoot

The data regarding K concentration in shoot are presented in Table 3, which shows that mulch has statistically no effect on K concentration in shoot. In case of shoot data both the non-mulched and mulched soils have no difference in mean values, i.e. 2.89 % and 2.88 % K.

As regard soil texture, it was observed that soil texture had a statistically significant effect on K concentration in shoot only. In shoot data higher mean K concentration was observed, i.e. 3.14 and 2.91 % for clay and loam soil, respectively, while 2.63 and 2.66 % for loam and clay in case of non-mulched and mulched soil, respectively. These results are in corroboration with those of Ramadan *et al.* (1986) who reported that the effect of soil type on nutrient availability was variable in soybean. Interactive effect of mulch with soil texture was statistically significant.

Data pertaining to irrigation level shows that it had a significant effect on K concentration in case of shoot. The highest mean value was observed in I_2 (60% CWR) with 3.11%, followed by I_1 (80% CWR) having 2.88 % and then 2.66 % in I_0 (100% CWR).

Table 3. Effect of mulch, soil texture and irrigation level on potassium concentration (%) in maize shoot

Irrigation level	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	2.35	3.03	2.77	2.52	2.66
I_1	2.69	3.03	2.77	3.03	2.88
I_2	2.86	3.37	3.20	3.03	3.11
Mean	2.63	3.14	2.91	2.86	
Mean	2.89		2.88		

Mean sharing same letter(s) are statistically non-significant at 5% probability

Nitrogen uptake (mg pot^{-1}) in maize shoot

The data regarding N uptake by shoot are given in Table 4. Analysis of variance clearly indicates that wheat straw mulch had a statistically no effect on N uptake in shoot. In case of shoot higher mean value was noted in the mulched soil (i.e. 499.8 mg pot^{-1}) compared to 450.4 mg pot^{-1} in case of non-mulched soil.

As regard soil texture, it was observed that soil texture had a statistically significant effect on N uptake of shoot. However, higher mean values were noted at T_2 (clay) in case of the shoot, i.e. 570.5 mg pot^{-1} and 429.1 mg pot^{-1} for T_2 (clay) and T_1 (loam) in case of mulched soil and 502.2 mg pot^{-1} and 398.7 mg pot^{-1} for T_2 (clay) and T_1 (loam), respectively in case of non-mulched soil. Nitrogen uptake in shoot, both the higher mean values (570.5 and 502.2) were recorded for clayey soil. These results are in corroboration with those of Siddique and Hassan (1991) who reported that nitrogen movement and uptake recorded was higher in clay loam than sandy loam soil. These results have some similarity with those of Iqbal *et al.* (1999) who observed that soil texture affected N, P and K uptake in maize shoot.

It was noted that irrigation level had a significant effect on nitrogen uptake of shoot. In case of shoot, the highest mean value was noted in I_2 (60% CWR) with 559.6 mg pot^{-1} followed by 436.9 mg pot^{-1} in I_0 (100% CWR) and 429.0 in I_1 (80% CWR).

Table 4. Effect of mulch, soil texture and irrigation level on nitrogen uptake (mg pot^{-1}) in maize shoot

Irrigation level	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	300.3	527.1	327.0	592.8	436.8 b
I_1	360.9	395.5	411.3	548.1	428.8 b
I_2	534.7	583.9	548.9	570.5	559.5 a
Mean	398.7	502.2	429.1	570.5	
Mean	450.4		499.8		

Mean sharing same letter(s) are statistically non-significant at 5% probability

Phosphorus uptake (mg pot^{-1}) in maize shoot

The data pertaining to P uptake by maize shoot are listed in Table 5, which shows that wheat straw mulch had a statistically no effect on P-uptake of shoot. Higher mean P-uptake value was noted in non-mulched, i.e. 43.33 mg pot^{-1} than that of 40.12 mg pot^{-1} in mulched soil for shoot uptake. These results are in contradiction with those of Black (1972) who noted that as residue levels increased soil water storage increased and grain yield was also increased significantly.

Data regarding soil texture, texture had a statistically significant effect in shoot for P uptake. More uptake of P was observed in non-mulched soil, i.e. 51.06 for T_1 (loam) and 35.60 mg pot^{-1} for T_2 (clay) compared to mulched soil, i.e. 44.73 and 35.52 mg pot^{-1} for T_1 and T_2, respectively in case of shoot. Therefore, both the higher mean values, i.e. 51.06 and 44.73 mg pot^{-1} of uptake were observed in case of loam soil.

As regard data pertaining to irrigation level, these have statistically significant effect for shoot of P uptake. The highest mean P-uptake value was noted in I_0 (100% CWR) with 51.31 mg pot^{-1} followed by I_2 (60 % CWR) with 38.73 mg pot^{-1} and 35.14 mg pot^{-1} in case of I_1 (80 % CWR).

Table 5. Effect of mulch, soil texture and irrigation level on phosphorus uptake (mg pot^{-1}) in maize shoot

Irrigation level	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	60.91	56.09	47.56	40.67	51.31 a
I_1	42.87	23.96	44.21	29.53	35.14 b
I_2	49.41	26.76	42.40	36.37	38.73 b
Mean	51.06	35.60	44.73	35.52	
Mean	43.33		40.12		

Interactive effect of mulch and irrigation level on phosphorus uptake (mg pot^{-1}) in maize shoot

Irrigation levels	Non-mulched (M_0)	Mulched (M_1)
I_0	58.50 a	44.12 b
I_1	33.42 c	36.87 bc
I_2	38.08 bc	39.39 bc

Mean sharing same letter(s) are statistically non-significant at 5% probability

Potassium uptake (mg pot^{-1}) in maize shoot

The data regarding K uptake by maize shoot are given in Table 6. Analysis of variance clearly indicates that mulch had statistically no effect on K-uptake by maize shoot. The highest mean value was noted in mulched,

i.e. 1109.9 mg pot^{-1} as compared to 1020.9 mg pot^{-1} in case of non-mulched soil.

As regard soil texture, it was noted that soil texture had also statistically no effect. Higher mean values (1117.2 and 1102.6 mg pot^{-1}) were calculated in mulched for T_1 (loam) and T_2 (clay) as compared to 1084.5 and 957.4 mg pot^{-1} in non-mulched soil in case of shoot for T_2 and T_1. Interaction between wheat straw mulch and soil texture was found statistically non-significant.

It was concluded that irrigation level had a significant effect on shoot uptake of K. The highest mean value was noted in I_0 (100 % CWR) with 1154.6 mg pot^{-1} followed by 1136.3 mg pot^{-1} in I_2 (60 % CWR) and 905.4 mg pot^{-1} in I_1 (80% CWR).

CONCLUSION

There was no effect of wheat straw mulch on nutrient concentration and their uptakes. Nitrogen concentration and uptake in shoot significantly increased in clay than loam soil while P concentration and uptake in shoot increased in loamy soil. Interaction between mulch and soil texture was statistically significant as increase in K concentration in shoot was noted. Modified Penman Model was valid only up to one week after the establishment of the crop. So the Modified Penman Model under wire-house conditions cannot be used.

Table 6. Effect of mulch, soil texture and irrigation level on potassium uptake (mg pot^{-1}) in maize shoot

Irrigation level	Non-mulched (M_0)		Mulched (M_1)		Mean
	T_1	T_2	T_1	T_2	
I_0	1012.0	1502.5	1033.1	1070.5	1154.5 a
I_1	906.3	693.2	1030.6	991.4	905.4 b
I_2	953.9	1057.7	1287.8	1245.9	1136.3 a
Mean	957.4	1084.5	1117.2	1102.6	
Mean	1020.9		1109.9		

Interactive effect of mulch and irrigation level on potassium uptake (mg pot^{-1}) in maize shoot

Irrigation level	Non-mulched (M_0)	Mulched (M_1)
I_0	1257.3 a	1051.8 b
I_1	799.7 c	1011.0 b
I_2	1005.8 b	1266.9 a

Interactive effect of soil texture and irrigation level on potassium uptake (mg pot^{-1}) in maize shoot

Irrigation level	Loam (T_1)	Clay (T_2)
I_0	1022.5 bc	1286.5 a
I_1	968.4 bc	842.3 c
I_2	1120.8 ab	1151.8 ab

Mean sharing same letter(s) are statistically non-significant at 5% probability

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