INFLUENCE OF FOLIAR APPLIED POTASSIUM AND DEFICIT IRRIGATION UNDER DIFFERENT TILLAGE SYSTEMS ON PRODUCTIVITY OF HYBRIDMAIZE

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ABSTRACT: Field experiment was carried out to study the effect of different tillage systems and skipping irrigation at different growth stages along with or without foliar applied potassium on phenology, growth and yield of maize hybrid. Results revealed that maximum grains per cob (381), 1000-grains weight (281.00 g), grain yield (7.82 t ha^{-1}) and biological yield (14.78 t ha^{-1}) were observed in conventional tillage system as compared to zero tillage. Regarding the irrigation levels and potassium (K) spray maximum grains per cob (390), 1000-grains weight (309 g), grain yield (8 t ha^{-1}) and biological yield (15.33 t ha^{-1}) were recorded with full irrigation + 1% Sulphate of Potash (SOP) spray. Skipping irrigation at tasseling stage had the most negative effect on yield attributes. Foliar application of SOP at 1%with full irrigationsunder conventional tillage system significantly improved the phonological and yield attributes of autumn planted maize.

Key words: Hybrid maize, tillage systems, skip irrigation, foliar potash, growth, yield.

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INTRODUCTION

Maize is also known as "Queen of cereals" due to its versatile uses and is also considered a miracle crop (Hunje *et al*., 2011). Production potential of existing cultivars of hybrid maize is quite high but the actual farmer yield is very low in Pakistan. Major reasons for decreasing the production ofhybrid maize includedeclining soil fertility, no or low availability of water, poor tillage systems and unbalanced fertilizer application (Rosegrant *et al*., 2007).Tillage is important part of crop production and it substantially affects the soil properties and crop productivity (Torbet *et al*., 2001).Tillage is mainly carried out with an objective of development of suitable soil tilth, for increasing porosity and structure of seedbed (Srivastava *et al.,* 2006). Proper tillage operations substantially improved the soil properties and ultimately the crop yield, conversely, improper tillage operation deteriorate the soil properties, thereby the crop yield (Iqbal*etal*., 2005).

All the metabolic processes of a plant are affected by water availability and water shortage periods can severely effect productivity of a field crop (Wajid *et al.,* 2004). Drought stress has adverse effect on germination and morphological qualities i.e. leaf area, fresh and dry weight of shoots and roots which ultimately reduces the crop yield (Moghaddam *et al*., 2011). Potassium has major role in improving quality of crop because it has the ability to simulate the enzymes of different types. The application of potassium has significant role in increasing root penetration which can lessen the chances of damage under persistent drought that is why the healthy plant growth is observed under water stress. For improved grain yield of maize, crop potassium acts as a potential osmolytes which is capable of producing tolerance against drought stress at reproductive phase (Valadabadi and Farahani, 2010).

Potassium nutrition plays a crucial role in turgidity of stomata, thereby, stomatal opening and closing can be affected under potassium hanger. Moreover, Potassium also helps in photosynthates translocation from leaves to grains that results a substantial improvement in grain quality (Hussain *et al*., 2007 and Wang *et al.,* 2013). Like other nutrients, potassium supply to plants is reduced under water stress conditions and the soil application of potassium at that time will not meet immediate need of the plants. The foliar application of nutrients as a supplementary source to the soil-applied nutrients may be effective in meeting plant nutrient requirements under water stress.

Realizing the importance of potassium in plant growth under water deficit conditions and at the same time seriousness of its deficiency in soils and plants, an attempt has been made to evaluate the impact of supplemental foliar-applied potassium on maize in response to water stress at different growth stages under the conventional and zero tillage systems.

MATERIALS AND METHODS

Experimental details: The experiment reported in this study was carried out at Student Research Farm,

Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during autumn, 2015.Composite soil samples were collected from the top (0–30 cm) soil layer of the experimental site prior to sowing. Samples were analyzed using the protocols described by Homer and Pratt (1961).The soil was sandy clay loam having organic matter 0.88%, pH 8.3, electric conductivity (EC) 4.5dS m^{-1} and Nitrogen, Phosphorus, Potash and Zinc contents were 0.059%, 4.9 mg kg^{-1},and162 mg kg^{-1}, respectively.

Maize single cross hybrid DK-919 was used as a test cultivar. The experiment was performed in randomized complete block design in split plot arrangement with three replications. The tillage system treatments i.e. T_1=Conventional tillage with 4ploughing + 2 planking; T_2= Zero tillage were kept in main plots while the combination of skip irrigation and foliar application of 1% potash treatments i.e. I_1 = Full irrigation; I_2 = Full irrigation + 1% SOP spray; I_3 = Skip irrigation at 6-8 leaves + 1% SOP spray; I_4 = Skip irrigation at tasseling + 1% SOP spray; I_5 = Skip irrigation at 6-8 leaves + 1% SOP spray + Skip irrigation at tasseling stage + 1% SOP spray were kept in subplots.

Crop husbandry: Seedbed was prepared as per treatment conventional tillage with 4 ploughing and 2 planking and 75 cm apart ridges were formed while, in the zero tillage seeds were sown on the flat soil by dibbling method keeping the row to row distance 75 cm.The crop was sown on 31stJuly, 2015 using a seed rate of 30 Kg ha^{-1}.Nitrogen (N), phosphorus (P) and potassium (K) were applied at the rate of 250-115-125 Kg ha^{-1}in the form of urea, di-ammonium phosphate and potassium sulfate,respectively. All of the phosphors and potassium and 1/3 nitrogen were applied as basal dose and rest of the nitrogen was applied in three splits. Irrigation was applied with 15 days interval, according to the climatic conditions and treatments. After first irrigation, when soil reached to workable moisture level, hoeing was done to keep crop free from weeds.Crop wasaffected by shoot fly attack after 25 days of sowing. Furadan was applied for the control of shoot fly.All other agronomic practices were keptnormal and uniform to keep crop free from weeds, insects anddiseases.

Data recording: For recording the days to 50% silking and tasseling randomly selected ten plants were taken from each plot, tagged and days taken to 50% tasseling and silking was observed from the date of sowing and the average was calculated. For plant population at the time of harvesting, the plants in one square meter area were counted.Tenplants were selected randomly to determine the plant height, cob length, cob diameter, grains per cob, and grain rows per cob. 1000-grain weight was taken randomly from the grain lot of each plot. Crop was harvested on 10th November. After harvesting, the crop was put inopen place for sun drying, after that dried cobs were shelled with sheller. Later on the total yield of all the plots was calculated and finally, the harvest index (H.I) was computed using the formula, HI= (Grain yield/Biological yield) × 100.

Statistical analysis: Data was analyzed by Fisher's analysis technique and differences among the treatments were compared by Least Significant Difference (LSD) test at 5% probability level (Steel *et al.,* 1997).

RESULTS

Different tillage systems and skip irrigation with foliar application of SOP significantly affected the phonological and agronomicattributesof hybrid maize. The data revealed that the minimum days to tasseling (56.00) and 50% silking (63.06) was observed in conventional tillage while maximum days to 50% silking (67.13) and tasseling (58.67) was observed in zero tillage treatment. Regarding the irrigation levels and 1% SOP foliar application, minimum days to 50% silking (63.33) and tasseling (55.50) was observed with full irrigation+ 1% SOP spray while maximum days to 50% silking (66.17) and tasseling (58.34) was observed with I_3(Skip irrigation at 6-8 leaves + 1% SOP spray + Skip irrigation at tasseling stage + 1% SOP spray)and I_5(skip irrigation at 6-8 leaves + 1% SOP spray) treatments, respectively.The interactive effect between the different tillage systemsand skip irrigation with foliar application of SOP showed non-significant behavioror phonological attributes of hybrid maize (Table 1).

The data pertaining skip irrigation along with foliar application of SOP and different tillage systems showed significant behavior for all yield relating attributes except number of plants (per plot) and number of cobs per plant (Table 1,2). However, regarding cob length and harvest index the skipirrigation along with SOP foliar application showed non-significant behavior (Table 1, 2). Regarding different tillage systems, maximum plant height (171.7 cm), cob length (17.8 cm), cob diameter (4.2 cm), number of grains per row (33.8), number of grains row per cob (16.0), number of grains per cob (381), 1000-grains weight (281 g), grain yield (7.82t ha^{-1}), biological yield (14.78t ha^{-1}) and harvest index (67.80%)was recordedwith conventional tillage as compared with zero tillage. Regarding skip irrigationalongwith foliar application of 1% SOP, maximum plant height (176.8 cm), cob diameter (4.2 cm), number of grains per row (35.0), number of grains row per cob (16.2), number of grains per cob (390), 1000-grains weight (309 g), grain yield (8.00 t ha^{-1}) and biological yield (15.33 t ha^{-1})was observed where full irrigation + foliar application of 1% SOP was sprayed on hybrid maize while statistically minimum values for all these parameters were recorded for I_5 treatment (Skip irrigation at 6-8 leaves + 1% SOP spray + Skip irrigation at tasseling stage + 1% SOP spray). The interactive effect

between the different levels of irrigations + 1% foliar application of SOP and tillage systems showed non-significant behaviorexceptforgrains per cob and grain yield of hybrid maize (Table 2). In interactive effect maximum number of grains per cob and grain yield was recorded in conventional tillage with full irrigation+1% SOP spray, meanwhile, minimum grains per cob and economic yield was obtained in minimum tillage with irrigation skiped at tasseling stage+ 1% SOP spray (Fig.1 a and b).

Table 1: Phonological andagronomic attributesof maize influenced by foliar applied potassium at different soil moisture deficits and tillage practices

Factors	Phonological and Agronomic attributes					
	Days to 50% Silking (Days)	Days to 50% Tasseling (Days)	NOP (per plot)	PH (cm)	NOC (per plant)	CL (cm)
Tillage (T)						
Conventional tillage	63.06 B	56.00 B	179.40	171.7 A	1.19	17.8 A
Zero tillage	67.13 A	58.67 A	174.33	149.2 B	1.15	16.9 B
Irrigation Levels + Potassium spray (I)						
I_1	65.17 BC	58.00 AB	178.33	170.7 B	1.21	17.2
I_2	63.33 D	55.50 D	183.50	176.8 A	1.22	18.6
I_3	65.00 C	58.34 A	172.67	154.2 C	1.17	16.9
I_4	65.84 B	57.83 B	173.17	154.3 C	1.03	16.9
I_5	66.17 A	57.00 C	176.17	146.2 D	1.14	17.0
LSD (T) ($p \leq 0.05$)	0.34	1.72	NS	4.23	NS	0.54
LSD (I) ($p \leq 0.05$)	1.04	0.78	NS	4.26	NS	NS
T×I ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS

I_1= Full Irrigation; I_2 = Full Irrigation + 1% SOP spray; I_3 = Skip irrigation at 6-8 leaves + 1% SOP spray; I_4 = Skip irrigation at tasseling + 1% SOP spray; I_5 = Skip irrigation at 6-8 leaves + 1% SOP spray + Skip irrigation at tasseling stage + 1% SOP spray
PH = Plant height; NOP = Number of plants; NOC = Number of cobs; CL = Cob length
Any two means within a column followed by same letters are not significant at $p \leq 0.05$. NS = non-significant

Table 2: Agronomic attributes of maize as influenced by foliar applied potassium at different soil moisture deficits and tillage practices

Factors	Agronomic attributes							
	CD (cm)	NGPR	NGRPC	GPC (cm)	1000-GW (g)	GY (t ha^{-1})	BY (t ha^{-1})	HI (%)
Tillage (T)								
Conventional tillage	4.2 A	33.8 A	16.0 A	381 A	281.00 A	7.82 A	14.78 A	67.80 A
Zero tillage	3.9 B	28.8 B	14.3 B	363 B	259.00 B	7.00 B	14.37 B	66.50 B
Irrigation Levels + Potassium spray (I)								
I_1	4.2 AB	34.0 B	15.7 B	383 B	282.00 B	7.60 AB	14.85 B	65.60
I_2	4.2 A	35.0 A	16.2 A	390 A	309.00 A	8.00 A	15.33 A	70.00
I_3	3.9 C	31.0 C	14.5 D	371 C	261.00 C	7.60 AB	14.33 C	67.20
I_4	4.0 B	28.0 D	15.2 C	357 D	258.00 CD	7.20 BC	14.23 CD	65.80
I_5	3.8 D	29.5 CD	14.3 E	355 D	241.00 D	6.80 C	14.13 D	67.20
LSD (T) ($p \leq 0.05$)	0.2	2.0	0.3	15.8	14.0	0.54	0.33	1.2
LSD (I) ($p \leq 0.05$)	0.1	0.9	0.2	6.0	10.0	0.45	0.14	NS
T×I ($p \leq 0.05$)	NS	NS	NS	*Fig.1a	NS	*Fig.1b	NS	NS

I_1= Full Irrigation; I_2 = Full Irrigation + 1% SOP spray; I_3 = Skip irrigation at 6-8 leaves + 1% SOP spray; I_4 = Skip irrigation at tasseling + 1% SOP spray; I_5 = Skip irrigation at 6-8 leaves + 1% SOP spray + Skip irrigation at tasseling stage + 1% SOP spray
CD = Cob diameter; NOGPC = Number of grain per cob; NGRPC = Number of grains rows per cob; GPC = Total grains per cob; 1000-GW = 1000 grains weight; GY = Grain yield; BY = Biological yield; HI = Harvest index
Any two means within a column followed by same letters are not significant at $p \leq 0.05$. NS = non-significant

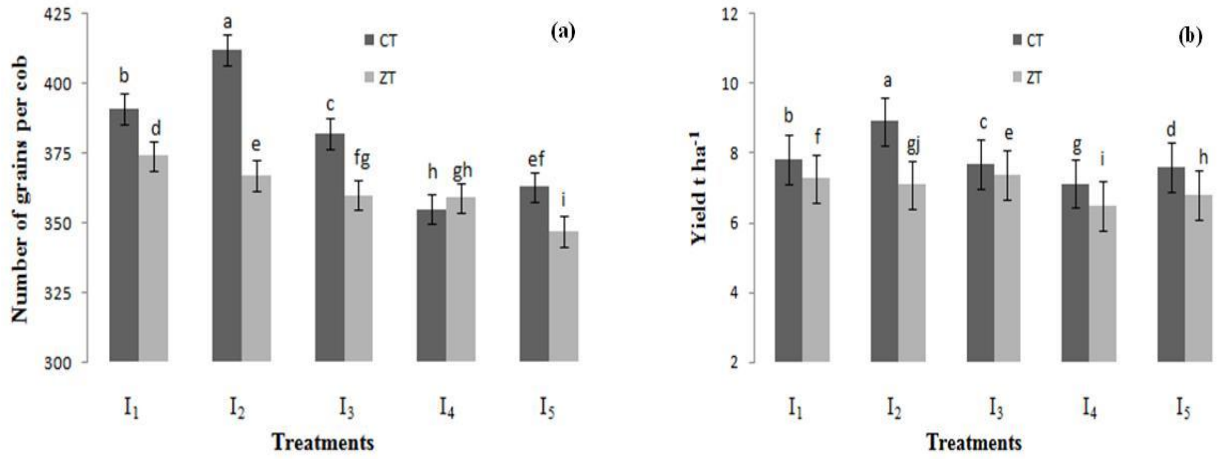

Fig.1: Interactive effect of foliar applied potassium at different soil moisture deficits and tillage practices on number of grains per cob and grain yield of hybrid maize.

DISCUSSION

The results of this study revealed that different tillage systems and skip irrigation along with foliar application of 1% SOP significantly affected the phonological and agronomic attributes of maize. Minimum days to 50% silking and tasseling were observed in the conventional tillage as compared to zero tillage with full irrigation + foliar application of 1% SOP. These results were in accordance with the findings of Ali *et al.,* (2004) and Ali *et al.,* (2012) who reported that conventional tillage shorted the days to tasseling and silking. Similarly, Reynaldo, (2002) also documented that application of full irrigation and optimum use of nutrients hastened the tasseling of maize. However,the fewer days to silking and tasseling might be due to the integrated use of macro nutrients along with full irrigation. Similarly, in this study foliar application of K with supplemental irrigation increased days to silking and yield of maize crop. Reductionin plant population was also noticed in zero tillage as compared to the conventional tillage which might be due to the more competition for basic needs of plants with increasing competition periods.Moreover, with every increase in competition period, there was more competition for space, light and nutrients which ultimately decreased the number of plants. Substantial decrease in plant height was observed under skipping irrigation and zero tillage that might be due to the water stress and compaction of soil under zero tillage systems. With maximumincrease in skip irrigation there was more decrease in the height of maize plants. However, foliar supplementation of potassium improved the stomatal conductance which maintains the water balance that might be the possible reason for increase in the plant height of maize.

All the yield related attributes were reduced under water stress and zero tillage system. However, foliar applied SOP reduced the water stress upto certain extent and improved the yield attributes of maize (Table 1, 2). These results are in line with the findings of Basamba *et al*., (2006) and Memon *et al.,* (2013) who concluded that conventional tillage operations preserved more soil nutrients, resources, and soil water as compared to zero tillage which resulted in better growth of plants. Deep tillage enhanced the root promulgation, root extension and nitrogen recovery efficiency (NER) i.e. the deep tillage treatments provided higher nitrogen recovery efficiency than no tilled or compacted soil reported by (Motavalliv *et al*., 2003 and Habib *et al.,* 2016). Appropriate tillage was vital for good crop stand establishment, plant growth and eventually increased the yield (Atkinson *et al*., 2007). In zero tillage production, soil organic matter also endorsed in upper soil layer due to its stratification (Garcia *et al.,* 2007) which caused the reduction in the soil fertility. Garcia *et al*., (2007) concluded that soil nutrients such as N, P and C were more equally distributed in ploughed soil within plough layers during maize production. So, in the present study higher yield and yield related attributes in the conventional tillage might be due to the better root growth, optimum water, nutrients availability and proper weeds control as compared to zero tillage. As in another study Raper; (2005) observed that the extent of soil water content was closely linked with the number of turns of conventional tillage. Tillage improved soil water storage as it increased soil surface roughness and controlled weeds during fallow (Lipiec *et al*., 2005 and Karuma *et al.,* 2014). Similarly, maximum plant height, grains per ear, leaf area index (LAI), 1000-grain weight, seed and stover yield was observed in soils where tillage was applied as compared to no tilled soil (Khan *et al*., 2009). However, Rashidi and Kashavarzpour., (2007) observed significant increase in maize yield and its components due to tillage, as tillage reduced soil compaction,

enhanced availability of moisture storage in soil, suppresses weed establishment and their growth and it also increased the seed and soil interaction.

As the water resources are diminishing around the globe, water saving through skip irrigation and identification of most sensitive stage to water stress, and foliar feeding of potash are the prime ways to get maximum productivity with less water use reported by (Jalota *et al.,* 2006). Foliar application of SOP at 1% with full irrigation significantly increased the yield and yield attributes of maize.

Potassium is an important crop nutrient after nitrogen and phosphorus. It has a role in the leaf expansion and stem length by maintaining turgor pressure. It increases sun light absorption rate to maximize growth which accelerates canopy formation (Alias *etal*., 2009; Ebrahim*et al.,* 2011). So, the increase in the yield and yield attributes of maize might be due to better leaf size, increased photosynthetic activity and better water in the plant. These results are in line with the work reported by Hussain *et al*., (2007) and Amanullah *et al.,* (2016) who stated that application of potassium under skip irrigation conditions significantly increased the number of grains or grain weight per cob and 1000-grain weight. Similarly, Rotundo *et al*., (2006) found that water stress decreases the leaf area index, photosynthetic rates and chlorophyll contents that results in the reductionin grain size and grain yield. However, foliar application of potassium reduced the water stress by improving the water relation, stomatal conductance and improving the defensive mechanism of the maize plant under drought conditions (Cox, 2001 and Aown *et al.,* 2012). Skipping irrigation at tasseling and silking stage reduced the number of grains, grains weight that ultimately resulted in the reduction of grain yield. Costa and Shanmugathasan., (2002) found that it was difficult to identify the critical growth stages, and water stress at any stage which significantly decreased the crop growth and productivity.

Conclusion: The findings of this study showed that skipping irrigation at any crop growth stage of the maize crop led to decrease in crop growth and yield. Skipping irrigation at any stage seems to affect the grain production more than the biomass production. However, foliar application of SOP at 1% under conventional tillage system significantly improved the growth and yield attributes of autumn planted maize by better root growth, optimum water, nutrients availability and proper weeds control as compared to zero tillage.

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