J. Glob. Innov. Agric. Soc. Sci., 2019, 7(3):135-139.
ISSN (Online): 2311-3839; ISSN (Print): 2312-5225
http://www.jgiass.com

GROWTH AND YIELD RESPONSE OF SPRING MAIZE (*Zea mays* L.) UNDER DIFFERENT POTASSIUM DOSES AND IRRIGATION REGIMES

Inzamam-ul-haq[1,*], Muhammad Shahbaz Naeem[1], Rana Muhammad Amir[3], Muhammad Ilyas[1], Faisal Shabir[1], Ibrar Ahmad[2], Bahaar Ali[2], Zia Farid[1] and Hafiz Ali Raza[3]

[1]Department of Agronomy, University of Agriculture Faisalabad, Pakistan;[2]Department of Plant Breeding and Genetics, Islamia University Bahawalpur, Pakistan;[3]Institute of Agri. Extension & Rural Development, University of Agriculture Faisalabad, Pakistan
[*]Corresponding author's e-mail: razaa0617@gmail.com

A field experiment was carried out to evaluate the effect of different potassium doses and irrigation regimes on growth and yield responses of spring maizeat Faisalabad in spring, 2016. It was comprised of three replications with net plot size 3 × 6 m. The treatments were irrigation regimes (Full irrigation (Control), Skip irrigation at vegetative growth stage, Skip irrigation at vegetative growth stage and grain filling stage) and potassium levels (0, 130, 163, 195 kg ha^{-1}). Murate of Potash (M.O.P) was used as the source of potassium. All other agronomic practices were kept normal and constant for all treatments excluding the factors under study. Data on growth, yield and quality parameters were recorded by following standard procedures. The data was analyzed by using Fisher's analysis of variance technique and the difference between the treatment means was compared by least significant difference (LSD) test at 5% probability level. The results show that maximum plant height at maturity (209.44 cm), stem diameter (2.11 cm), cob length (20.75 cm), cob diameter (4.09 cm), number of grain rows per cob (15.70), number of grains per cob (471.42), grains weight per cob (140.80 g), 1000-grain weight (275.89 g), economic yield (8.23t ha^{-1}), Stover yield (8.23t ha^{-1}), biological yield (19.34t ha^{-1}), crop growth rate (23.71 g m^{-2} day^{-1}) and maximum seed oil and protein contents was 4.60% and 8.11%, respectively. It is concluded that potassium should be applied @195 kg ha^{-1} to get maximum yield of maize under drought stress.
Keywords: Drought stress, irrigation regimes, potassium doses, flowering stage, yield.

INTRODUCTION

Maize belongs to cereal crops that grow all around the world and is fit for human and animal consumption. Millions of people get energy from it and ranked second cereal crop after rice in the world (World Agriculture Production, 2016). In Pakistan maize enjoys third position next to wheat and rice. Starch, protein, oil, fiber, sugar and ash contribute to maize grain 71, 11, 4.9, 5.7, 3.1 and 1.6 percent, respectively (Chuudhary, 1993). Due to its photo-thermic property, maize is known as "Queen of cereal" and propagated throughout the year (Verma, 2011). Many important products are formed from maize like fiber, dextrin, malto glucose and gluten harvests which are being used commercially as oil, pharmaceutical, paper, textile, maquillages, alcohol and poultry feedstuff (Khan, 2007).

Water is being most important gift of the world serves to mankind and plants by providing them inhabitation like sea, river and pond. Crop plants absorb water almost ninety percent of its weight and then transport it to all over plant body helping the minerals uptake from soil to plant shoots including leaves and stems, providing turgor pressure and support to the plant (Capon, 2010). Water takes part in photosynthesis reaction and gives us glucose in combination of carbon dioxide. Now a days, Pakistan is facing water shortage issue because of violation of Indus water treaty and less dams. So, there is need to conserve water for future usage for human as well as for crop plants (Baranyiova *et al.,* 2010). Irrigation scheduling help us to conserve water and give us net returns by saving charges on fertilizers applied as well as on applied water and it increases the quality of crops. Several verified irrigation scheduling methods have been presented to save water and net return (Stone *et al.,* 2001).

Maize water requirement varies with different ecological conditions and soil type. Fortnight application of water to maize crop can enhance its water use efficiency leading to maximal yield obtained from drought during growing season. Normally, through fast growing period maize has higher water requirement. Depending upon the favourable climatic conditions maximum maize crop production can be achieved through normally 600 to 700 mm of water. When water availability is beaten by evapotranspiration at any stage then maize crop yield is decreased. Crop plant becomes more susceptible to diseases and insect pest attacks after getting nutrient deficiency resulted from moisture shortage (Reddy, 2006).

Normally, Pakistan's soils have great dimensions to deliver accessible K to crops beneath regular environment but upsurge in the strength of cropping, considerable elimination of straw from the farm area, maximal water use of tube well and introduction of hybrids have caused decline in soil's K assets, and shortage of K is being detected in crop plants. More than 80 diverse enzyme types are activated by K and most of them are protein and sugar synthesis driven enzymes (Boutraa *et al.,* 2001). Potassium exploits the growth of stem and leaf extent by preserving plant turgor pressure. Canopy formation is enhanced by the maximal growth succeeded by absorption of sunlight which is increased by maximum potassium absorbed; however, deficiency of potassium may lead toward lesser crop growth rate (El-Abadi *et al*., 2009). Opening and closing of stomata is regulated by k absorption and it enhances enzymatic activity because more than 80 diverse enzyme types are activated (El-Harfi *et al.,* 2013). Movement of potassium ions controls the plant turgidity and crop water relations are being controlled by potassium uptake. If there is defiance of K then yield will be declined along with influence on stomata switch. There is a close relation between the carbon dioxide accumulation and potassium concentrations in the leaves. Maximal photosynthetic rate will decrease if there is damaging effect on stomatal regulation by potassium absorption (Shahi *et al.,* 2015).

Now a days, Pakistan is facing water shortage issue because of violation of Indus water treaty and less dams. So, there is need to conserve water for future usage for human as well as crop plants. Water shortage issue can be handled by removing or lowering the leaching, infiltration, water logging, percolation and runoff loses, by applying scheduled exact amount of water maintaining sustainability. In case of 15% not as much of accessibility of irrigation water (one irrigation missed at vegetative growth stage), optimum yield can be attained by applying potassium @ 195 kg ha^{-1}. Likewise, in case of 30% not as much of accessibility of irrigation water (two irrigations missed at vegetative growth stage and grain filling stage), minimum but economical production can be attained by using potassium @ 195 kg ha^{-1}. Hence, we can conclude that 15% of the applied irrational water can be saved by enhancing K applied rate up to 195 kg ha^{-1}. This study was conducted to find out the optimum dose of potassium for increasing the spring maize yield and to evaluate the growth and yield response of spring Maize (*Zea mays* L.) under different potassium doses and irrigation regimes.

MATERIALS AND METHODS

The experiment was conducted at Faisalabad, Agronomic Farm area of University of Agriculture Faisalabad during spring season (2016). The Agronomic Farm area is situated at 31° North latitude, 73° East longitude and altitude of 135 m above sea level. On the 3rd week of February 2016, crop was sown by upholding 75 cm as row to row and 25 cm as plant to plant distance by using ridge sowing method along with rate of seed was 25 kg ha^{-1}. Experiment was carried out having 3 × 6 m in RCBD (Randomized Complete Block Design) with split-plot arrangement along with 3 replications. On well prepared bed a single cross hybrid was sown. Nitrogen was applied in three split doses while K and P at sowing time. Maize hybrid Monsanto-DK 6525's seed was obtained from Ayub Agricultural Research Institute (AARI), Faisalabad. Drought was attained by skipping one irrigation at Vegetative Growth Stage and skipping two irrigations at Vegetative Growth Stage and Grain Filling Stage while potassium doses were 0, 130,163 and195kg ha^{-1}.

Data was recorded for cob length (cm), cob diameter (cm), grain weight per cob (g), biological yield (t ha^{-1}), seed oil contents (%) and seed protein contents (%).

***Stem diameter (cm)*:** Stem diameter was measured by selecting 10 plants randomly from each treatment and average stem diameter was calculated for 3 points stem diameters of each plant.

***Cob length (cm*):** Cob length per plant was measured by selecting 10 cobs randomly from each treatment with measuring tape plant^{-1} and then per plant cob length was calculated.

***Grains weight per cob (g)*:** Grains weight of 10 cobs selected randomly from each treatment was weighed and then average weight per cob was calculated.

***Biological yield (t ha^{-1}*):** Biological yield includes Stover, grains and pith yield. Crop was harvested manually when it was fully matured, weighed after sun drying and biological yield in t ha^{-1} in each treatment was calculated.

***Seed oil contents (%)*:** Oil content of the typical seed sample was find out by Soxhelt method described by Low (1990).

***Seed protein contents (%*):** A sample of 10 g grains was grounded in a centrifuge grinder to find out crude protein components. The nitrogen contents of grains were analyzed by the Kjedahl method and multiplied it by 6.51 percent N resembles to 6.25 g protein), to compute grain protein components.

RESULT AND DISCUSSION

The most important parameters regarding the maize production are discussed here to understand the nature of the drought stress.

***Stem diameter (cm)*:** Plant health and decent vegetative growth are always due to better stem diameter. Data concerning stem diameter is shown in the Table 1. Table 1a displays that various doses of potassium and irrigational water applied had notable influence and their collaborative influence was also substantial on plant stem diameter. The treatment mean's contrast in Table 1b illustrates that maximum stem diameter 2.11 cm was recorded in I_1K_3 (7 irrigation applied @ 195 kg ha^{-1} of K) which is trailed by I_1K_2 (7 irrigation applied @ 163 kg ha^{-1} of K) and I_2K_3 (6 irrigation applied @ 195 kg ha^{-1} of K) in which 2.10 cm and 2.03 cm stem diameter correspondingly was noted; however, the smallest 1.90 cm stem diameter was noted in I_3K_0 (5 irrigation applied @ 0 kg ha^{-1} of K),which may be the result of maximal accessibility of water to the maize crop and applied K. The results are comparable to Syers (2001) who testified that diverse doses of potassium and irrigational water applied had a substantial influence on stem diameter.

Table 1. Effect of potassium levels and irrigation on stem diameter (cm) of spring maize.

(a) Analysis of Variance.

Source of variation	D.F	M.S	F .Ratio
Replication	2	0.00014	
Irrigation(I)	2	0.06454	264.05**
Main plot Error	4	0.00024	
Potassium(K)	3	0.00845	27.50**
I × K	6	0.00060	1.94*
Sub plot Error	18	0.00031	
Total	35		

*= Significant; **=Highly significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125 % K (163 kg ha^{-1})	K3=150 % K (195 kg ha^{-1})	
I_1=7 irrigations	2.06	2.08	2.10	2.11	2.09A
I_2=6 irrigations	1.95	2.01	2.03	2.05	2.01B
I_3=5 irrigations	1.90	1.96	1.94	1.96	1.94C
Mean	1.97C	2.02B	2.03AB	2.04A	

***Cob length (cm)*:** Grain yield and productivity of maize crop mainly depends upon cob length being an important factor. Data about cob length is shown in Table 2. ANOVA Table 2a demonstrates that cob length had highly significant influence on cob length but K and their collaborative effect I x K was non-significant. The treatment mean's contrast in Table 2b displayed maximal cob length 20.80 cm in I_1 (7 irrigation applied with 163 kg ha^{-1} of K) while it was reduced up to 20.50 cm in I_3 (5 irrigations applied with 0 kg ha^{-1} of K). The results are like Oktem (2008) who recorded notable influence of applied irrigation on cob length, but it did not show significant results for K.

***Grains weight per cob (g)*:** Maize yield depends upon grain weight cob^{-1} which is an imperative yield parameter. Data about grain weight cob^{-1} of maize influenced by various doses of potassium and irrigational water applied is shown in Table 3. ANOVA Table 3a indicates that various doses of potassium and irrigational water highly significantly influenced the grains weight cob^{-1}and their interaction (I x K) also showed significant influence on grain weight cob^{-1}.The treatment means in Table 3b depicts maximum grains weight cob^{-1}(140.86 g) in I_1K_3 (7 irrigation with @ 195 kg ha^{-1} of K) and minimum (94.45 g) in I_3K_0 (5 irrigation with no potassium). Results are similar of stated by Younas (2001) and Khan *et al.* (2014) who reported that grains weight cob^{-1} was significantly influenced by various doses of potassium and irrigation water application.

Table 2. Effect of potassium levels and irrigation on cob length (cm) of spring maize.

(a) Analysis of Variance.

Source of variation	D.F	M.S	F. Ratio
Replication	2	0.00406	
Irrigation(I)	2	0.22890	45.93**
Main plot Error	4	0.00498	
Potassium(K)	3	0.00114	0.31^{NS}
I × K	6	0.00142	0.39^{NS}
Sub plot Error	18	0.00367	
Total	35		

**=Highly significant; NS= Non-Significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125% K (163 kg ha^{-1})	K3=150% K (195 kg ha^{-1})	
I_1=7 irrigations	20.77	20.78	20.80	20.75	20.78A
I_2=6 irrigations	20.60	20.60	20.62	20.64	20.62B
I_3=5 irrigations	20.50	20.52	20.51	20.47	20.50C
Mean	20.62	20.63	20.64	20.62	

Table 3. Effect of potassium levels and irrigation on grains weight per cob (g) of spring maize.

(a) Analysis of Variance

Source of variation	D.F	M.S	F. Ratio
Replication	2	52.24	
Irrigation(I)	2	1677.49	245.05**
Main plot Error	4	6.85	
Potassium(K)	3	868.67	170.27**
I × K	6	8.99	1.76*
Sub plot Error	18	5.10	
Total	35		

*= Significant; **=Highly significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125 % K (163 kg ha^{-1})	K3=150 % K (195 kg ha^{-1})	
I_1=7 irrigations	115.30	128.03	133.00	140.86	129.30A
I_2=6 irrigations	103.83	116.73	121.32	129.40	117.82B
I_3=5 irrigations	94.45	106.73	107.53	113.90	105.66C
Mean	104.53B	117.16C	120.62B	128.06A	

***Biological yield (t ha^{-1})*:** The data about the biological yield t ha^{-1} as influenced by various doses of potassium and irrigation water applied is shown in Table 4. ANOVA Table 4a shows that various doses of potassium and irrigation water had an extremely significant influence on the biological yield and their interaction (I x K) also showed highly significant results for biological yield. The treatment mean's presented in Table4b demonstrates that maximum biological yield (19.34 t ha^{-1}) was produced from I_1K_3 (7 applied irrigation @ 195 kg ha^{-1} of K) while minimum biological yield (10.21 t ha^{-1}) was produced from I_3K_0 (5 applied irrigation @ 0 kg ha^{-1} of K). The results are alike Ali *et al.* (2013) who found that both irrigation and potassium showed significant influence on biological yield. Nasri *et al.* (2010) also recorded significant increase in biological yield under the influence of various doses of potassium and irrigation water.

Table 4. Effect of potassium levels and irrigation on biological yield (t ha^{-1}) of spring maize.

(a) Analysis of Variance.

Source of variation	D.F	M.S	F.Ratio
Replication	2	0.0763	
Irrigation(I)	2	87.0962	2171.37**
Main plot Error	4	0.0401	
Potassium(K)	3	31.3111	1169.09**
I × K	6	1.2712	47.47**
Sub plot Error	18	0.0268	
Total	35		

**=Highly significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125 % K (163 kg ha^{-1})	K3=150 % K (195 kg ha^{-1})	
I_1=7 irrigations	16.53	18.23	18.66	19.34	18.19A
I_2=6 irrigations	12.18	15.69	16.70	17.83	15.60B
I_3=5 irrigations	10.21	12.42	13.84	14.73	12.80C
Mean	12.97 D	15.45 C	16.40 B	17.30 A	

***Seed oil contents (%)*:** Quality of seed of any crop mainly depends upon seed oil content. The data about seed oil content as influenced by various doses of potassium and irrigation water applied is shown in Table 5. ANOVA Table 5a indicates that diverse levels of irrigation significantly influenced the seed oil content but potassium and collaborationist interaction (I x K) did not show significant influence on seed oil content. Maximum seed oil contents (4.49%) was yielded by I_1K_3 (7 applied irrigation @ 195 kg ha^{-1} of K) and minimum (4.25%) in I_3K_0 (5 applied irrigation @ 0 kg ha^{-1} of K) (Table 5b).This may be due to increase in protein percentage which leads to a gradual decline in seed oil content. These results are in accordance with Minjian *et al.* (2007) who stated that increase in seed protein contents leads to a gradual decline in seed oil content.

***Seed protein contents (%)*:** Nutritional value of crop and quality of seed is mainly dependent on seed protein content. The data about the seed protein content as influenced by various doses of potassium and irrigation water applied is shown in Table 6. Levels of irrigation significantly influenced the seed protein content; however, potassium and its interaction with irrigation (I x K) did not show significant results for seed protein content (Table 6a).The treatment mean's presented in Table 6b exhibited maximum protein contents (8.11%) in I_3K_0 (5 applied irrigation @ 195 kg ha^{-1} of K) which was trailed by I_3K_1 (5 applied irrigation @ 195 kg ha^{-1} of K) with 8.08% protein content. A minimum protein content of 6.21% was recorded in I_1K_3 (7 applied irrigation @ 195 kg ha^{-1} of K). Minjian *et al.* (2007) stated that protein parentage is increased in grains by increasing moisture deficit.

Table 5. Effect of potassium levels and irrigation on seed oil contents (%) of spring maize.

(a) Analysis of Variance.

Source of variation	D.F	M.S	F.Ratio
Replication	2	0.0763	
Irrigation(I)	2	87.0962	2171.37**
Main plot Error	4	0.0401	
Potassium(K)	3	31.3111	1169.09**
I × K	6	1.2712	47.47
Sub plot Error	18	0.0268	
Total	35		

**=Highly significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125 % K (163 kg ha^{-1})	K3=150 % K (195 kg ha^{-1})	
I_1=7 irrigations	16.53	18.23	18.66	19.34	18.19A
I_2=6 irrigations	12.18	15.69	16.70	17.83	15.60B
I_3=5 irrigations	10.21	12.42	13.84	14.73	12.80C
Mean	12.97 D	15.45 C	16.40 B	17.30 A	

Table 6. Effect of potassium levels and irrigation on seed protein contents (%) of spring maize.

(a) Analysis of Variance

Source of variation	D.F	M.S	F. Ratio
Replication	2	0.0021	
Irrigation(I)	2	10.0740	14306.3**
Main plot Error	4	0.0007	
Potassium(K)	3	0.0078	32.98^{NS}
I × K	6	0.0002	0.64^{NS}
Sub plot Error	18	0.0002	
Total	35		

**=Highly significant; NS= Non-Significant

(b) Comparison of individual treatment means

Irrigation applied	Potassium Levels				Mean
	K_0=0% K	K_1=100% K (130 kg ha^{-1})	K2=125% K (163 kg ha^{-1})	K3=150% K (195 kg ha^{-1})	
I_1=7 irrigations	8.03	8.06	8.08	8.11	8.07A
I_2=6 irrigations	7.17	7.19	7.21	7.24	7.20B
I_3=5 irrigations	6.21	6.23	6.25	6.26	6.24C
Mean	7.14	7.16	7.18	7.21	

***Conclusion*:** It was concluded from the results that there is no need of potassium application if we have optimum irrigational water. But if the sufficient amount of water is not available (one/two irrigations missed) then potassium should be applied @195 kg ha^{-1} to get maximum yield of maize.

REFERENCES

Ali, A., N. Ali, N. Ullah, F. Ullah, M. Adnan and Z.A. Swati. 2013. Effect of drought stress on the physiology and yield of the Pakistani wheat germplasms. Int. J. Adv. Res. Technol. 2:419-430.

Baranyiova, I. and K. Klem. 2016. Effect of application of growth regulators on the physiological and yield parameters of winter wheat under water deficit. Plant Soil Environ. 62:114-120.

Boutraa, T., A. Akhkha, A.A. Al- Shoaibi and A.M. Alhejeli. 2010. Effect of water stress on growth and water use efficiency (WUE) of some wheat cultivars (*Triticum durum*) grown in Saudi Arabia. J. T. Uni. Sci. 3:39-48.

Capon, B. 2010. Botany for Gardeners: An Introduction and Guide, 3rd edition. Portland, Oregon: Timber Press.

Chuudhary, A.R. 1993. Maize in Pakistan. Punjab Agric. Res. Coord. Board, Univ. Agric. Faisalabad, Pakistan.

El-Abady, M.I., S.E. Seadh, A. El-Ward, A. Ibrahim and A.A.M. El-Emam. 2009. Irrigation withholding and potassium foliar application effects on wheat yield and quality. Int. J. Sustain. Crop Prod. 4:33-39.

El-Harfi, M., H. Hanine, H. Rizki, H. Latrache and A. Nabloussi. 2010. Effect of drought and salt stresses on germination and early seedling growth of different color-seeds of sesame (*Sesamum indicum* L.). Int. J. Agric. Biol. 61:195-217.

Khan, G.D., M. Ali, F. Akbar and M. Hameed. 2014. Impact of different potassium (K) application on oil content of Brassica under field condition. J. Biol. Agric. Healthcare 4:54-57.

Khan, I. 2007. Response of maize (*Zea mays* L.) to nitrogen and irrigation application strategies. M.Sc. Thesis, Univ. Agric., Faisalabad, Pakistan.

Minjian, C., Y. Haiqui, Y. Hongkui and J. Chungi. 2007. Difference in tolerance to potassium deficiency between maize inbred lines. Plant Prod. Sci. 10:42-45.

Nasri, M., M. Khalatbari and H.A. Farahani. 2010. The effect of alternate furrow irrigation under different nutritional element supplies on some agronomic traits and seed qualitative parameters in com (*Zea mays* L.). J. Cereals Oilseeds 1:17-23.

Oktem, A. 2008. Effects of deficit irrigation on some yield characteristics of sweet corn. Bangladesh J. Bot. 37:127-131.

Reddy, S.R. 2006. Agronomy of Field Crops, 2ndEd. Kalyani Publishers New Delhi, India); pp.209-216.

Shahi, C., Vibhuti, K. Bargali and S.S Bargali. 2015. How seed size and water stress effect the seed germination and seedling growth in wheat varieties? Curr. Agric. Res. J. 3:60-68.

Stone, P.J., D.R. Wilson, P.D. Jamieson and R.N. Gillespie. 2001. Water deficit effects on sweet com canopy development. Aust. J. Agric. Res. 52:115-126.

Syers, J.K. 2001. Soil moisture and potassium in maize. Proceeding NO.411m The International Fertilizer Society, New York.

Verma, N.K. 2011. Integrated nutrient management in winter maize (*Zea mays* L.) sown at different dates. J. Plant Breed. Crop Sci. 3:161-167.

World Agriculture Production. 2016. Foreign Agricultural Service. United States Department of Agriculture 27:1-16.

Younas, M.H., Rehman and G. Hayder. 2002. Magnitude of variability for yield and associated traits in maize hybrids. Asian J. Plant Sci. 1:694-696.