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Effect of potassium and its time of application on yield and quality of tomato

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Abstract- A field experiment was conducted to investigate the effect of potassium and its time of application on yield and quality of tomato variety, Nagina. Treatments included three potassium levels i.e. 60, 90 and 120 kg ha^{-1} and two application timings: at transplanting as single dose, and half at transplanting + half at 40 days after transplanting in two splits, were applied along with a control (0 kg ha^{-1} K). Potassium application @ 60 kg ha^{-1} either applied in single or in two splits, significantly increased the yield and improved the quality parameters of tomato over control while higher levels of K (90 and 120 kg ha^{-1}) did not show further significant increase in the yield and quality subsequently. Ascorbic acid remained unaffected. Results revealed that time of application/splitting of K did not affect the yield and quality. The highest yield (23.3 t ha^{-1}), firmness (8.32 kg), fruit weight (83.24 g fruit^{-1}), total invert sugars (4.11 %), dry matter (6.33 %) and mineral matter (1.95 %) were recorded with the application of 120 kg ha^{-1} potassium at transplanting while the highest values of acidity (0.81%) , TSS (7.03 %) and ascorbic acid (30.33 mg 100 g^{-1}) were observed in treatment where potassium was applied @ 60 kg ha^{-1} in two splits. Minimum yield (17.2 t ha^{-1}), firmness (6.35 kg), fruit weight (68.11 g/fruit), mineral matter (1.80 %), dry matter (5.26 %), acidity (0.61 %), ascorbic acid (21.79 mg 100g^{-1}), TSS (6.60 %) and total invert sugars (3.85 %) were found in control.

Index Terms- Potassium, Tomato, Quality, Ascorbic acid, Acidity

I. INTRODUCTION

Tomato (*Lycopersicon esculentum)* is a nutritious and popular product all over the world. Tomatoes are grown over about 53.1 thousand hectares in Pakistan with an average yield of about 10.1 t ha^{-1} (Anonymous, 2008). Potassium is one of the essential mineral nutrients in the plant food and taken up by roots from the soil solution in its ionic form. It is involved in numerous physiological processes that control plant growth, yield and quality parameters such as sugars, titratable acidity, total soluble solids, taste, color and firmness (Lester *et al*., 2005). High levels of available K improve the physical quality, disease resistance, and shelf life of fruits and vegetables (Better Crops, 1999). It is not a part of plant or plant product; however it is very important for the life process of plant (Haji *et al*., 2011) and it is often referred as the quality element for crop production (Usherwood, 1985). Production of quality fruits is controlled by the interaction of genetic, environmental and cultural factors including plant nutrients (Dorais *et al.*, 2001). Among essential plant nutrients, potassiumis the one that is absorbed by the tomato plant in the largest amounts and it is considered to be the key to production of quality fruits (Mengel and Kirkby, 1987). According to several authors, it plays a key role in the improvement of several post harvest quality traits in tomato fruits and in almost all vegetables (Cakmak, 2005), Chapagain and Wiesman, 2004). Keeping in view the importance of potassium for tomato this study was carried out to see the effect of potassium on the yield and quality of tomato.

2. MATERIALS AND METHODS

This research was conducted in a field at Biochemistry Section, Post Harvest Research Centre, Faisalabad, Pakistan during 2012, 2013 and 2014 on tomato variety, Nagina. Randomized Complete Block Design was used as the experiment layout with three replications. Thirty days old seedlings were transplanted in the field during the last week of November of each year. The treatments detail of the experiment is shown below

Treatments	K-applied (kgha^{-1})	Time of K-application
T_1	00 (Control)	No K- applied
T_2	60 (Single dose)	At transplanting
T_3	60 (Two splits)	½ at transplanting + ½ at 40 days after transplanting
T_4	90 (Single dose)	At transplanting
T_5	90 (Two splits)	½ at transplanting + ½ at 40 days after transplanting
T_6	120 (Single dose)	At transplanting
T_7	120 (Two splits)	½ at transplanting + ½ at 40 days after transplanting

Recommended doses of N and P (100 and 90 kg ha^{-1}) in the form of urea and single super phosphate were applied to all the treatments. Phosphorus was applied at transplanting while nitrogen in three splits: at transplanting, 40 days after transplanting and 60 days after transplanting. Potassium sulphate fertilizer was used for K and applied according to the treatment plan. Harvesting of mature fruits started during March and continued till June of every year. Yield was recorded and representative fresh fruit samples were collected for assessing the firmness, fruit weight, acidity, total soluble solid (TSS), ascorbic acid , total invert sugars, dry matter and mineral matter. Sugars, acidity and ascorbic acid were determined by methods given in AOAC, (2000). Dry matter was determined by drying the samples at 64^{o}C till constant weight. TSS was measured with a digital refractometer. The data collected were subjected to analysis of variance to test the significance at $P \leq 0.05$ with Statistix 8.0 software and presented as means of 3 years and treatment means were compared using least significant difference (Steel *et al.*, 1997).

3. RESULTS AND DISCUSSIONS

Yield

Potassium application increased the yield significantly over control but increasing levels of potassium did not increase the yield subsequently (table 1).The highest yield (23.3 t ha^{-1}) was found with the application of 120 kg ha^{-1} potassium at transplanting in single dose. The lowest yield (17.2 t ha^{-1}) was found in control. The yield produced with the application of K @ 60 kg ha^{-1} was 20.0 t ha^{-1} which was statistically at par with the yield 20.6 and 23.3 t ha^{-1} recorded in the treatments receiving 90 and 120 kg ha^{-1} potassium applied at transplanting. Results also revealed that time of application/splitting of K did not affect the yield significantly. Results were in agreement to the findings of Afzal *et.al*., (2015) who reported that foliar application of 0.6 % K improved the fruit yield of tomato, however, higher doses of K (0.7, 0.8, 0.9, and 1.0 %) did not improve fruit yield subsequently. Similar results quoted by Kazemi (2014). Results are in contrary to Akhter *et al*., (2010), Khan *et al*., (2005), Gupta and Senger (2000) who found increased tomato yield by increasing levels of potassium. Javaria *et al*., (2012) found an incremental increase in yield from 12.34 to 30.56 t ha^{-1} by increasing levels of K from 0 to 450 kg ha^{-1} while Iqbal *et al*., (2011) found maximum yield (19 t ha^{-1}) with the application of 130 kg ha^{-1} potassium as compared to control (0 kg ha^{-1}). El-Nemr *et al*., (2012) reported that by increasing potassium levels in the nutrient solution, total yields were increased significantly.

Firmness

Potassium application increased the firmness of fruit from 6.35 kg in control to 8.32 kg with the application of K @ 120 kg ha^{-1} in single dose (table-1). The results revealed that firmness of fruits increased significantly with the application of potassium @ 60 and 90 kg ha^{-1} at the time of transplanting as compared to control. After that, the effect of the application of increased levels of potassium leveled off and no significant difference was observed between the K- levels 90 and 120 kg ha^{-1}. The effect of potassium application in two splits was also found non-significant. The best dose of K for the good firmness was found as 120 kg ha^{-1} either applied at transplanting or in two splits. Asri and Sonmez (2010) found maximum firmness with increasing dose of potassium. The significant effects of enhanced potassium fertilization were observed on firmness, sweetness, crispness and flavor ($P \leq 0.001$) by Javaria *et al.*, (2012).

Fruit weight

Average fruit weight was calculated by selecting ten fruits randomly and then weighing. Average fruit weight indicated that potassium application increased the fruit weight from 68.11 to 83.24 g $fruit^{-1}$, minimum in control and maximum in treatment where 120 kg ha^{-1} potassium was applied at transplanting as single dose. Results also revealed that time of application/splitting of K did not affect the fruit weight significantly (table 1). Iqbal, *et al*., (2011) found that maximum fruit diameter (5.08 cm) was noted when plants received 120 kg N and 90 kg ha^{-1} K. Similar results were reported by Padem and Ocal (1999) who found that average fruit weight of tomato was increased significantly in all the potassium treated pots in comparison to K untreated pots. It was 52.62 g in the control while maximum fruit weight (106.4 g) was recorded in the treatment receiving 450 Kg K_2O ha^{-1}. Results was also in line with the results of Afzal *et al.*, (2015) who found that the fruit weight of variety Roma increased from 57.30 g (control) to 72.0 g with the foliar application of 0.6 % potassium solution.

Table 1 Effect of potassium application on Yield, Firmness and Fruit weight of tomato

K-applied	Time of K-application	Yield	Firmness	Fruit weight
kgha^{-1}		t ha^{-1}	kg	g $fruit^{-1}$
0	Control	17.2 c	6.35 b	68. 11 e
60	at transplanting	20.0 b	7.01 b	69.49 e
60	½ at transplanting + ½ at 40 days after transplanting	21.2 ab	7.33 b	75.26 bc
90	at transplanting	20.6 b	7.40 ab	78.80 b
90	½ at transplanting + ½ at 40 days after transplanting	21.2 ab	7.57 ab	73.11 cd
120	at transplanting	23.3 a	8.32 a	83.24 a
120	½ at transplanting + ½ at 40 days after transplanting	20.8 b	8.03 a	79.40 ab
LSD		2.3	0.93	4.32

Acidity

Acidity increased with the application of potassium @ 60 kg ha^{-1} applied in two splits but the increasing levels of potassium caused no effect on the acidity of tomato (table 2). Results also revealed that the time of application/splitting of K dose did not affect the acidity significantly. Acidity ranged from 0.61 to 0.81 %, minimum in control and maximum in treatment where potassium was applied in two splits @ 60 kg ha^{-1}. At higher levels of potassium (90 and 120 kg ha^{-1}), acidity did not increase further. The results of this study showed correspondence with the results of Kazemi (2014), Asri and sonmez, (2010), EL Nemr *et al*., (2012) and Wuzhong (2002). Present results are in contrast to the results of Akhter *et al*., (2010) who found no significant effect of potassium application and its increasing levels on the acidity of the tomato.

Table 2 Effect of potassium application on Acidity, TSS and Ascorbic acid of tomato

K-applied	Time of K-application	Acidity	TSS	Ascorbic acid
kgha^{-1}		%	%	mg $100g^{-1}$
0	Control	0.61 c	6.60 c	21.79 b
60	at transplanting	0.70 bc	6.88 abc	26.06 ab

60	½ at transplanting + ½ at 40 days after transplanting	0.81 a	7.03 a	30.33 a
90	at transplanting	0.71 b	6.98 a	25.64 ab
90	½ at transplanting + ½ at 40 days after transplanting	0.71 b	7.00 a	22.65 b
120	at transplanting	0.67 bc	6.96 a	21.83 b
120	½ at transplanting + ½ at 40 days after transplanting	0.73 ab	6.95 ab	25.63 ab
LSD		0.10	0.31	6.57

Total soluble solids

Potassium application had a significant effect on the total soluble solids (TSS) of tomato. However, splitting of K into two doses had no effect on TSS. The highest TSS content (7.03%) was observed in treatment where K was applied @ 60 kg ha^{-1} in two splits while the lowest TSS (6.60 %) was found in control (table 2). However, increasing levels of K did not make a further increase in TSS. Potassium application rates above 60 kg ha^{-1} i.e. 90 and 120 Kg ha^{-1} were found statistically at par. Contrary results obtained by Cakmak (2005) and Asri and Sonmez (2010) who found the highest TSS with ascending doses of potassium. El-Nemr *et al.*, (2012) reported that by increasing the potassium levels in the nutrient solution, TSS were increased significantly.

Ascorbic acid:-

Potassium either applied in one or in two splits had no significant effect on the ascorbic acid contents of tomato (table 2). Ascorbic acid content in tomato varied from 21.79 to 30.33 mg $100g^{-1}$. It is indicated that potassium application @ 60 kg ha^{-1} in two splits yielded the highest ascorbic acid content (30.33 mg$100g^{-1}$) while minimum ascorbic acid (21.79 mg $100g^{-1}$) was recorded in control as well as in the treatment (21.83 mg $100g^{-1}$) where 120 kg ha^{-1} potassium was applied at transplanting in single dose. The study of Asri and Sonmez (2010) supported the results of present study who found no significant difference in ascorbic acid concentration of fruit for K and Fe application. Results obtained are contradictory to the findings of Wuzhong (2002) and Bose *et al*., (2006) who reported a positive correlation between enhanced potassium doses and ascorbic acid contents. Afzal *et al*., (2015) found that among foliar treatments (0.5, 0.6 and 0.7 %), 0.7 % K spray improved ascorbic acid contents in tomato.

Total invert sugars

Total invert sugars were significantly increased in tomato fruit by the application of potassium over control, but splitting of K had no significant effect on total invert sugars. Potassium application increased the total invert sugars from 3.85 % in control to 4.11 % in treatment where 120 kg ha^{-1} potassium was applied at transplanting in single dose (table-3). Increasing levels of potassium i.e. 90 and 120 kg ha^{-1} were found at par. The reason of enhanced sugar content could be the role of potassium in biosynthesis and transfer of sugars (Karam *et al*., 2009). Present results were in agreement with results reported by Javaria *et al*., (2012). These results are in contrast with the result quoted by Akhter *et al*., (2010) who found no significant effect of potassium on total sugars in tomato.

Dry matter

Dry matter increased significantly with the application of potassium. But the increasing levels of potassium and time of application did not affect the dry matter significantly (table 3). Dry matter increased from 5.26 % in control to a maximum of 6.33 % at 120 kg ha^{-1} potassium application in single dose at transplanting.. Splitting of K did not differ statistically from the application of K in a single dose. These results were in agreement with those of Wuzhong, (2002) who found that increasing potassium levels from 0 to 112.5 kg ha^{-1} resulted in a higher level of dry matter in tomato fruit i.e. 5.82 to 7.15 %. Amjad *et al*., (2014) reported that application of potassium both in soil (3.3 and 6.6 mmol kg^{-1}) and foliar form (4.5 and 9 mM), significantly increased the TSS and fruit dry matter in all genotypes of tomato compared to the control (0 mM K). Similar results were quoted by Payvast, *et al*., (2009).

Table 3 Effect of potassium application on Total invert sugars, dry matter and mineral matter of tomato

K-applied	Time of K-application	Total invert sugars	Dry matter	Mineral matter
$Kgha^{-1}$		%	%	%
0	Control	3.85 c	5.26 c	1.80 c
60	at transplanting	3.94 b	5.78 b	1.86 bc
60	½ at transplanting + ½ at 40 days after transplanting	3.95 b	6.02 ab	1.81 c
90	at transplanting	4.00 ab	5.83 b	1.82 c
90	½ at transplanting + ½ at 40 days after transplanting	4.05 ab	5.63 bc	1.91 ab
120	at transplanting	4.11 a	6.33 a	1.95 a
120	½ at transplanting + ½ at 40 days after transplanting	3.98 ab	6.00 ab	1.83 c
LSD		0.091	0.428	1.069

Mineral matter

Result showed that the potassium application significantly increased the mineral matter in tomato (table 3). The highest mineral matter 1.91 and 1.95% were noted in treatments where potassium was applied at the rate of 90 and 120 kg ha^{-1} respectively applied in one or two splits. The lowest mineral matter (1.80 and 1.81%) was observed in control and in treatment where potassium was applied at the rate of 60 kg ha^{-1} in two splits respectively. The results also showed that time of application /splitting of potassium had no significant effect on mineral matter. Khan *et al*., (2006) reported a synergistic effect of foliar application of potassium on ash content.

4. CONCLUSIONS

It is concluded that potassium application @ 60 kg ha^{-1} significantly increased the yield, fruit weight, firmness, acidity,

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dry matter, mineral matter, TSS and total invert sugars of tomato fruit over control while statistically, higher levels of K (90 and 120 kg ha^{-1}) did not further increase the yield and quality parameters subsequently. Ascorbic acid remained unaffected. Results also revealed that time of application/splitting of K did not affect the yield and quality parameters.

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