RESPONSE OF TOMATO YIELD AND POST HARVEST LIFE TO POTASH LEVELS

SADAF JAVARIA, M. QASIM KHAN, HABIB UR RAHMAN and IMAM BAKHSH

Faculty of Agriculture, Gomal University, Dera Ismail Khan – Pakistan.
E-mail: sadafjavaria@yahoo.com

ABSTRACT

The present study was undertaken to develop potassium management recommendations that maximize yield and post harvest quality of tomato. Studies were conducted at Faculty of Agriculture, Gomal University, Dera Ismail Khan, KPK, Pakistan during 2008-2009. A pot experiment was designed, which included six potassium fertilizer treatments (75, 150, 225, 300, 375, 450 Kg K_2O ha^{-1}) with basal doses of N and P (100 Kg and 80 Kg ha^{-1}, respectively). Pots treated with N and P alone were kept as control treatment. Each treatment was replicated 4 times and treatments were arranged in Complete Randomized Design. All potassium treatments significantly increased yield characteristics as well as post harvest quality of tomato fruit compared with untreated one (control). However, Treatment (NP+450 K_2O Kg ha^{-1}) surpassed all the other treatments in term of yield parameters. Potassium application significantly increased number of flowers $plant^{-1}$, fruit setting rate, number of truss $plant^{-1}$, fruits $plant^{-1}$ and yield ha^{-1}. Moreover, increased potassium levels also had positive effect on post harvest life attributes of tomato fruit. In addition, the Shelf life, quality of general appearance and taste were significantly influenced as potassium levels increased to 375 kg K_2O ha^{-1} but decreased at 450 Kg K_2O ha^{-1}. On the other hand, while increased potassium levels decreased all the undesired parameters, wilting and drying of calyx, physiological weight loss %, and % non marketable yield .Therefore, when potassium was applied @ 450 Kg K_2O ha^{-1} it increased the yield had decreased the adverse effect on marketable yield, wilting and drying of calyx and weight retention of tomato fruit. In conclusion 375-400 Kg K_2O ha^{-1} is recommended as it produced better quality tomatoes with longer postharvest life.

Key Words: **Tomato, potassium levels, yield attributes, post harvest life.**

Citation: Javaria, S., M.Q. Khan, H.U. Rahman and I. Bakhsh. 2012. Response of tomato (*Lycopersicon Esculentum L.*) yield and post harvest life to potash levels. Sarhad J. Agric. 28(2):227-235

INTRODUCTION

Tomato (*Lycopersicon esculentum L.*) is a nutritious and popular product all over the poses relatively high fertilizer requirements in traditional production. At present tomato ranks third in terms of global vegetable production. The continued importance of tomato as a vegetable and salad commodity is reflected by the large volume of research on virtually all aspects of the crop. However, average tomato yield in Pakistan is quite low (9.6 t/ ha^{-1}) as compared to other countries of south and southeast Asia; such as India (17.00 t ha^{-1}), Thailand (23.79 t ha^{-1}) as well as Asia is (24.30 t ha^{-1}) and world (26.74 t ha^{-1}). Moreover, the post-harvest loss of tomato fruit in Pakistan accounts for 35-40 percent of horticulture produce. The softening that accompanies ripening of fruits makes worse damage during shipping and handling processes (FAO, 2002).

It has utmost importance as it synergistic effect with nitrogen and phosphorus (Das, 1999). It is not a constituent of organic structures, but regulates enzymatic activities (over 60 enzymes require K for activation), translocation of photosynthates and considerably improves yield and post harvest quality of fruits and vegetables (Mengel and Kirkby, 1987). Generally the crop response to K application is expected, where the soils are low in available potassium. But, there are numerous reports, where crop response to K fertilization is positive even in soils high in K status (Bidari and Hebsur, 2011). Trudel and Ozbun (1971) found tha most of the carotenoids especially lycopene increased with increase in K supply and hence, positively effect the fruit color and general appearance. Potassium is the most efficient cation for tomato plants and 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; Dorais *et al.*, 2001, Oded and Uzi, 2003). Plants receiving higher K applications matured earlier had significantly higher total soluble solids concentration and less post harvest physiological weight loss, therefore retain texture and structure of fruits (Lester, 2005). Enhanced potassium levels also affect the sensory attributes and shelf life of tomato (Etminan *et al*., 2004).

Keeping in view the importance of potash for plants this study was carried out to investigate the yield and post harvest life response of tomato to different levels of potash.

MATERIALS AND METHODS

A pot experiment on effects of different levels of K fertilizer on yield parameters and postharvest life of tomatoes was conducted at the Gomal University, D.I.Khan, Pakistan during 2008-2009. Dera Ismail Khan is the southern most district of KPK lying between 31°15' to 32°32' N and 70°11' to 71°20' E, with an elevation of 600 meter from sea level. The average rainfall of the area is 259.2 mm per annum (Umar *et al.,* 2007).

Initial analysis of the soil showed that it had textural class "Sandy loam", having alkaline pH of 7.8, low organic matter content (0.92%), deficient in some major and minor nutrient elements (total N 0.04%, available P 12 µg/g soil, Zn 4.012 µg/g soil and Cu 5.012 µg/g soil) with minimal content of available K (102.15 µg/g soil). CEC was 9.25 meq/100 g of soil, EC 1.4 dSm^{-1} while $CaCO_3$ was found to be 10.05 % (Table I).

Table I ***Physico-chemical characteristics of soil***

Characteristics	Values	Units
Textural class	Sandy loam	-
pH	7.8	-
Organic matter	0.92	%
ECe	1.4	dSm^{-1}
$CaCO_3$	10.05	%
CEC	9.25	meq/100 g
Total Nitrogen	0.04	%
Available phosphorous	12	µ g/g soil
Available potassium	102.15	µ g/g soil
Zn	4.012	µ g/g soil
Cu	5.012	µ g/g soil

Soil texture was measured by the hydrometer method as described by Jaiswal (2003). Organic matter, $CaCO_3$, total N by Kjeldahl method, available P, available K , available Zn, Cu, Mn, and Fe were estimated by the method of MAFF (1986), Galia variety of tomato was used as a test crop. One month old seedlings raised in seed bed were transplanted to the pots Table II. Each pot was filled with 22 Kg of soil. The pots were treated with K_2O @ 75, 150, 225, 300, 375, 450 Kg ha^{-1} along with recommended doses of N and P (100 and 80 Kg ha^{-1}, respectively). Full doses of K and P were applied to the pots before transplantation of seedlings while N was applied in 2 splits, half at the time of transplantation and half with 2nd irrigation. Each treatment was replicated 4 times and the experiment was arranged in a complete randomized block design.

Table II ***Production and phonological dates***

Sown	Transplanted	First flowering	First fruit setting	First ripe fruit
24th October	26th November	20th January	1st February	21 March

Pre harvest sampling and counting of number of flower\plant^{-1}, number of truss\plant^{-1}, number of fruit\ plant^{-1}, were conducted twice a week till final harvesting of fruits. Fruit setting rate (FSR %) was calculated by the method described by Solaiman and Rabbani (2006). Average weight of fruits (g) was recorded by harvesting tomato fruits twice weekely and then the total yield was calculated.

Assessment of Post harvest Life of Tomato Fruits

In the end of March, when the tomatoes reached the Table ripe stage of maturity, determined visually by the USDA (1975), they were and subjected to analyse the post harvest life of tomato fruits.

The post harvest life of tomato fruits was evaluated on the basis of shelf life (days), General appearance, taste, wilting and drying of calyx, physiological weight loss%, and non marketable yield (%).

Shelf life and non marketable yield of tomato fruits are very important parameters. These parameters were evaluated on the basis of general appearance (for rotting, microbial infection, color, gloss, tightness), wilting and drying of calyx, and taste. Method of Mondal, (2000) was used to evaluate shelf life and non marketable yield on the basis of different scales of judgment. The scales for judgments are given below

i. General Appearance of tomato fruit was scored by overall rating that included rotting, microbial infection, color, gloss and tightness on a scale of 1-9 (≤ 1-4) poor ,(≥ 5) marketable, (7-8) good and (9) excellent .

ii. Wilting and drying of calyxes were evaluated using a scale of 0-4 where (0) was healthy calyxes , (1-1.4) slight , (1.5-2.4) mild, (2.5-3.4) severe, and (3.5-4) very severe .

iii. Taste of tomato fruits was evaluated using a scale of (0-5) where (0) was very poor, (1-2) poor, (3) mild, (4) good and (5) excellent .

Samples of half of a tomato from each treatment were served on white plates coded with a 3-digit number in arbitrary order to each assessor. Two evaluations of the samples were carried out per day. Between sample's sensory analysis panel was guided to clean their mouths with a piece of bread and mineral water to vanish the effect of taste of previous sample. Post harvest physiological weight loss (%) was determined by periodical weighing of fruits by using electrical balance and expressed as percentage of original weight.

Statistical Analysis

The data related to yield parameters, were analyzed with Analysis of variance (ANOVA) according to Russell (1991) at p =0.05. LSD was used to assess the location of the significant differences. Post harvest life attributes were statistically analyzed by broken stick model (Hunt, 1982).

RESULTS AND DISCUSSION

Number of Flowers Plant^{-1}

Data in Table III showed that all potassium treatments significantly increased number of flowers plant^{-1} compared with control treatment. However, K_7 treatment recorded the maximum number of flowers plant^{-1} (176.2). These results are in agreement with those obtained by Picha and Hall (1982), Gupta and Sengar (2000),who stated that these results may be due to major role of potassium element in many physiological and biochemical processes such as cell division, metabolism of carbohydrates and increased photosynthesis.

Fruit Setting Rate (FSR %)

Fruit setting rate is an important yield parameter. Amplified potassium levels affected the FSR% significantly (Table III). FSR% increased gradually with potassium fertilizer doses which ranged from 44.19 to 77.80 . All the potassium treated pots had significantly higher fruit setting rate in comparison to control treatment. These results are in line with those reported by Bernard *et al*. (2006), who found that increased application of K resulted in enhanced fruit setting rate of tomato. They suggested that there may be a marked increase in the absorption of potassium by roots, which accelerated metabolism in younger tissues of the plant, resulting in enhanced fruit setting rate.

Number of Truss Plant^{-1}

Number of truss plant^{-1} ranged from 5.25 in control treatment to 23.25 recorded in treatment which received 450 kg ha^{-1} potassium fertilizer (Table III). All the treatments had a significantly higher number of trusses per plant than the control. Which is attributable to positive action of potassium fertilizer application on water and plant relationship as well as physiological and metabolic activities. Carter (1986) stated that, addition of potassium increases the water retaining capacity of cells, decreasing the transpiration rate of leaves through improving stomata opening and closure, and increasing photosynthesis rate and translocation of assimilates which, in turn, enhances yield of produce. A complementary explanation of the increased number of truss by K fertilizer applications might be related to the cation saturation ratio of soils. Likewise results were also reported by Wijewardena and Amarasiri (1997).

Fruits Plant^{-1}

Number of fruits plant^{-1} increased significantly with the increase in potassium levels. It was 40 where no potassium was added but progressively increased with augment doses of potassium fertilizer and reached to 130 fruits per plant at the highest dose of potash (Table III). The results are in conformity to those as reported by Samiullah and Khan (2003), who noticed that addition of potassium doubled the number of fruits plant^{-1} as compared to K untreated plot. The reason of this increase might be increased enzyme actions, aids in photosynthesis and food formation, helps translocation of sugars and starches, maintains turgor and reduces water loss which in turn, enhanced number of fruits plant^{-1} of tomato (Tsialtas and Maslaris., 2009).

Average Fruit Weight

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 treatment receiving 450 Kg K_2O ha^{-1}. The results are in harmony with the results of Padem and Ocal (1999), who

demonstrated that increased potassium levels led to a significant increase in fruit weight. Potash has major role in translocation of photosynthates and develop healthy fruits with improved weight.

Yield Ton ha^{-1}

Yield ha^{-1} was increased significantly with the increase in potassium fertilizer rates (Table III). Plants in control treatment gave the yield of 12.34 t ha^{-1} yield which was increased to 15.12 t ha^{-1} when potassium fertilizer was applied at the rate of 75 Kg ha^{-1} ,while (30.56 t ha^{-1}) were obtained at the highest level of potassium fertilizer i.e. 450 Kg ha^{-1} the highest (Table III) The reason of tremendous increase that tomato is a high potassium requiring crop and K application increased the yield through the soil had relatively high initial plant available K (Bidari and Hebsur., 2011). Thisalso indicates that even though being adequate K levels in soil were high, the crop potassium requirements for attaining higher yield could not be met from native source, thus addition of potassium through fertilizers was required (Ehsan *et al*., 2010). Significant effect of potassium on yield of tomato is in conformity with the findings of Khan *et al*. (2005), Yurtseven (2005), Al-Karaki (2000) and Gupta and Sengar (2000). They also concluded that increasing potassium fertilization levels could be used to improve or enhance fruit yield in tomato.

Table III ***Yield attributes of tomato fruit as affected by potassium fertilizer levels***

Treatments	Flowers/plant	FSR (%)	Truss/plant	Fruits/ plant	Av. Fruit weight (g)	Yield(t/ha)
T_1 = NP+ 0 K_2O Kg ha $^{-1}$	88.99 d	44.19 f	5.25 g	40.00 g	52.62 g	12.34g
T_2 = NP+ 75 K_2O Kg ha $^{-1}$	156.9 c	48.00 f	8.00 f	75.21 f	64.19 f	15.12f
T_3 = NP+ 150 K_2O Kg ha $^{-1}$	162.9 bc	55.99 e	12.50 de	98.37 e	71.50 e	19.5e
T_4 = N P+ 225 K_2O Kg ha $^{-1}$	167.0 b	62.64 d	14.00 d	105.1 d	79.88 d	25.87cd
T_5 = NP +300 K_2O Kg ha $^{-1}$	168.0 ab	68.69 c	18.00 bc	111.6 c	85.50 c	27.0c
T_6 = NP +375 K_2O Kg ha $^{-1}$	170.8 ab	72.73 b	20.00 b	123.9 b	93.52 b	29.31ab
T_7 = NP+450 K_2O Kg ha $^{-1}$	176.2 a	77.80 a	23.25 a	130.0 a	106.4 a	30.56a
LSD ($p \leq 0.05$)	**8.442**	**3.836**	**6.897**	**3.930**	**3.484**	**1.073**
	4.42%	**4.21%**	**32.17%**	**2.71%**	**2.97%**	**8.62%**

Post harvest Life

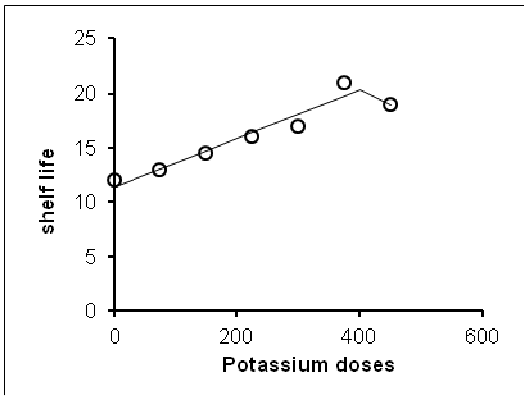
Among the factors that influence the post harvest life of tomato fruit, potassium plays a major role (Dorais *et al*., 2001). Data on shelf life, general appearance, Taste, Wilting and drying of calyx, Physiological Weight loss (%), and Non marketable fruit (%) of tomato were analyzed at 12th and 24th day of storage period.

Shelf Life

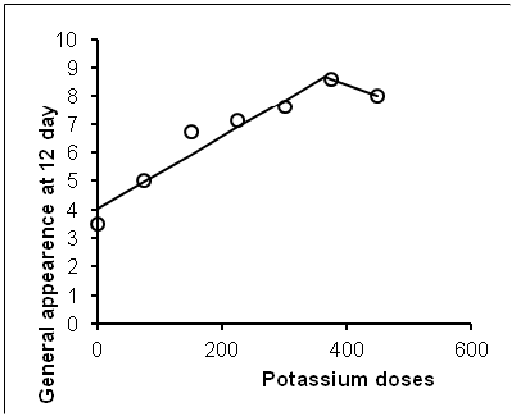
The study has revealed significant increase (p<0.01) in shelf life with the increased potassium levels but decreased when potassium levels were increased to 400 kg K_2O ha^{-1} (Table IV, Fig. 1a) . The results are in line with the results of Munson (1985) who found that with proper potassium nutrition fruit is generally higher in total soluble solids, carotenoids, sugars and acids and has a longer shelf life. Tucker *et al.* (1994) stated that under supply of potassium nutrition resulted in thin skinned fruit promoting fruit spoilage, even though extra potassium not always correlated to thick skinned fruit with increased shelf life, there should be apt dose of potassium. According to Martin (1989) the effects of appropriate dose of potassium on shelf life are predominantly favorable, both through slowing senescence and through a decrease of physiological disease but extra doses favor early senescence due to thin skin of fruit and textural disorders.

General Appearance

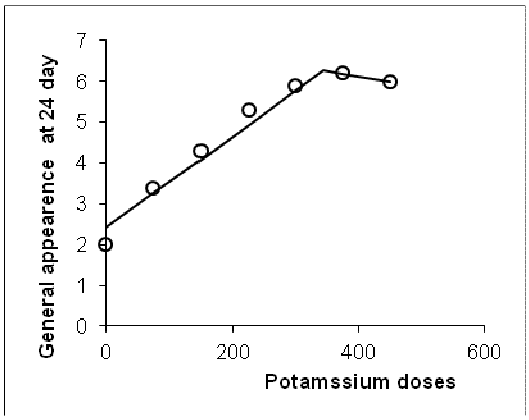
General appearance of tomato fruit was evaluated on the basis of rotting, microbial infection, color, gloss and tightness. The results showed that general appearance of tomato fruits was improved significantly (p<0.01) with enhanced potassium levels. Thereafter, data taken at 12th day and 24th day of storage reveled that when potassium dose was increased to 365 Kg K_2O ha^{-1} it had adverse effect on appearance of tomato fruit (Table IV, Fig. 1 b,c). The results are in line with the results of Gormely and Mayer (1990) ; Dorais *et al*., (2001) ; Trudel and Ozbun (1971) who stated that exact potassium dose reduces catalase and peroxidase enzyme and improves post harvest quality of tomato fruit but extra dose could accelerate their activity and may affect adversely.



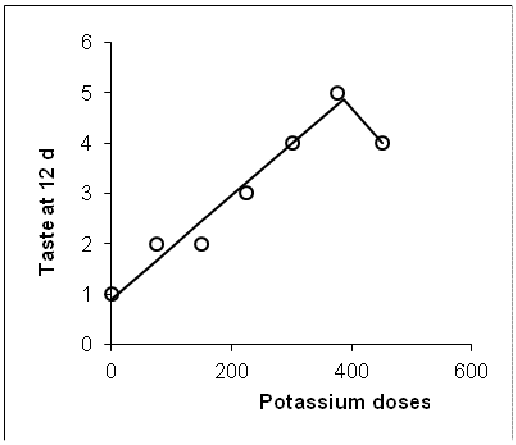
(a)



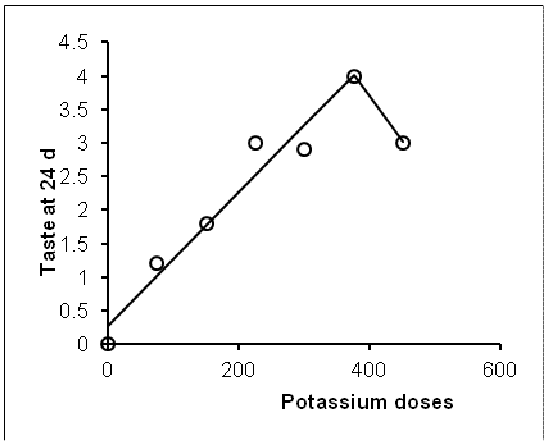
(b)



(c)



(d)



(e)

Fig. 1. Effect of Potassium fertilizer levels on (a) Shelf life (b) General appearance at 12th day of storage (c) General appearance at 24th day of storage (d) Taste at 12th day of storage (e) Taste at 24th day of storage .

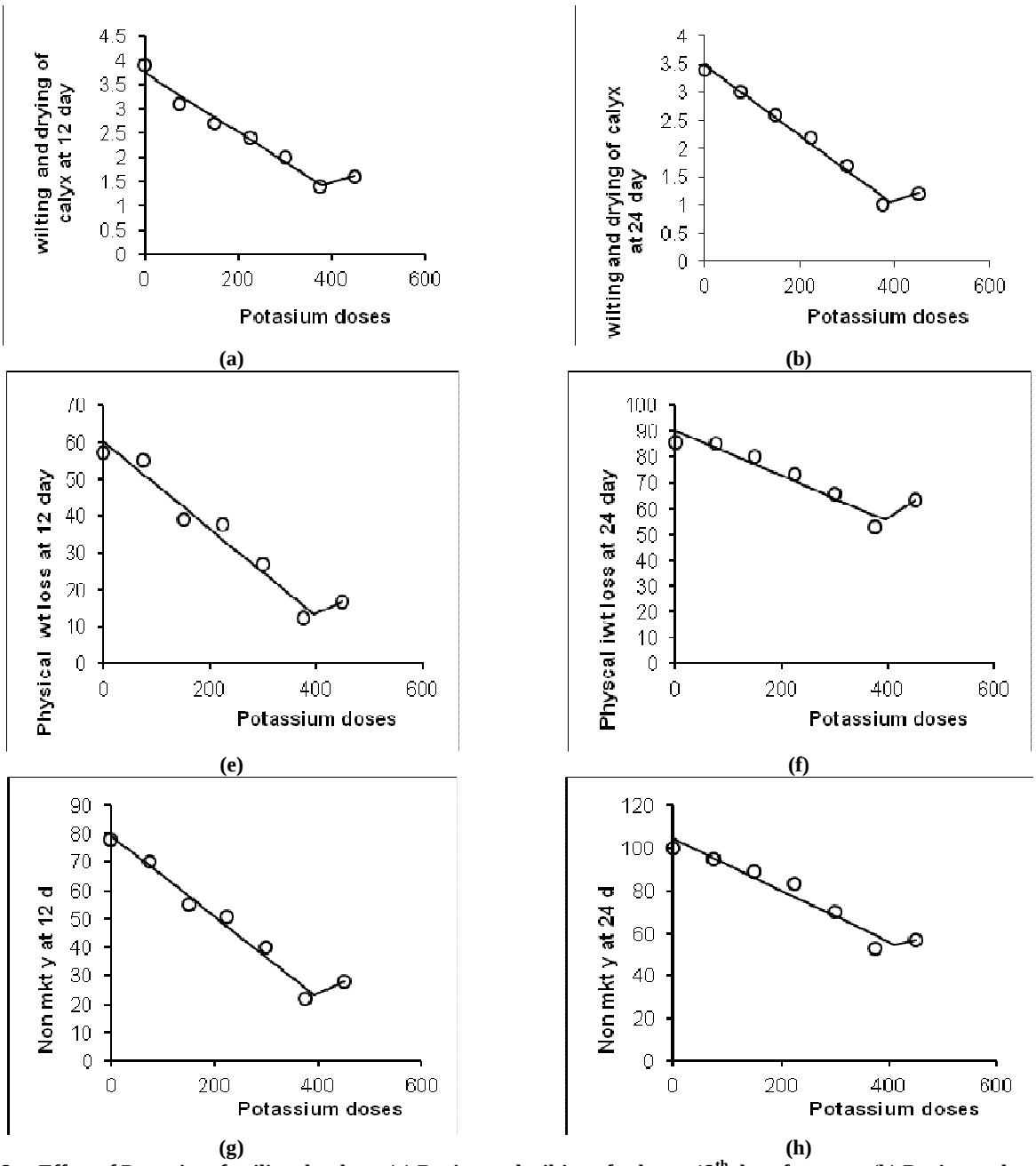


Fig. 2. Effect of Potassium fertilizer levels on (a) Drying and wilting of calyx at 12th day of storage (b) Drying and wilting of calyx at 24th day of storage (c) Physical wt loss at 12 day (d) Physical wt loss at 24 day (e) Nonmarketable yield % at 12th day (f) Non marketable yield % at 24th day

Taste

The results showed that increased pre harvest application of potassium fertilizer had significant effect (P<0.01) on taste of tomato fruit during the storage period of 24 days (Fig. 1 d,e). The taste improved subsequently, when potassium dose was increased to 375 kg K_2O ha^{-1} it had adverse effect on tomato taste (Table IV). The results are in line with the results of Davies and Winsor (1967) who observed a positive response of tomato to augment potassium levels in terms of fruit acidity, sugars, and total solids which in turn enhanced taste. They added that extra potassium fertilizer (beyond optimum level), it produced fruits with sugar acid ratio imbalance, increased total solids and dry textured fruit with poor taste.

Wilting and Drying of Calyx

It is an important parameter to access the post harvest life of tomato fruit. Data taken at 12^{th} and 24^{th} day of storage indicated that potassium levels significantly (P<0.01) affected the wilting and drying of calyx of tomato fruit (Table 4 , Figure 2 a, b) . The results revealed that wilting and drying of calyx was declined linearly during storage with increased pre harvest potassium doses. However, when potassium dose was exceeded to 380 kg K_2O ha^{-1} it had adverse effect on wilting and drying of fruit. The results are in harmony with the results of Voogt and Sonneveld (1997) and Williumsen *et al*., (1996) who stated that high levels of potassium fertilizer stimulated the formation of organic acids in tomato that reduced fruit Ca availability and permeability of cell membrane, that reduced the post harvest weight loss and wilting and drying of calyx. However, extra potassium doses may have opposite effect.

Physiological Weight Loss %

Data taken at 12^{th} day and 24^{th} day of storage period revealed that augment potassium levels significantly affected (P<0.01) physiological weight loss (%) of tomato fruit. Physiological weight loss of tomato fruit was declined with increased potassium levels, thereafter, when potassium levels increased to 395 kg K_2O it had negative effect on weight loss and post harvest life (Table IV, Fig. 2 c, d)**.** The results are in harmony with the results of Cakmak (2005) and Wuzhong (2002) who found that increased levels of potassium increased total solids, total soluble solids, better firmness and hence less physiological weight loss % during storage but excessive potassium had negative effect.

Non marketable Fruit (%)

Results indicated that potassium levels effected significantly (p<0.01) on non marketable yield (%) of tomato fruit. Increased potassium levels (upto 375 kg $K_2O\backslash ha^{-1}$) improved quality of tomato fruit and decreased non marketable fruits. However, data taken at 12^{th} and 24^{th} day of storage depicted that when potassium was applied above 400 kg K_2O ha^{-1} it had negative effect on fruit quality and non marketable fruit (%) was increased (Table IV, Fig. 2 e, f) .The results are in line with the results of Bar and Pressman (1996) and Bryson and Barker (2002).

Table IV ***Regression coefficients for different parameters studied, where a, b and r^2 are the intercept, the linear coefficient and coefficient of determination respectively. The values in parenthesis are the slandered error***

Parameters	Storage period	a	b	r2
Shelf life(days)	0-24 day	11.71± 0.79	0.19± 0.0029	0.89
General appearance	*12^{th} day*	4.14±0.39	0.01±0.0014	0.91
	24^{th} day	91.87±13.26	-221.2±67.62	0.90
Taste	*12^{th} day*	1.125±0.17	0.009 ±0.00065	0.97
	24^{th} day	0.007±0.0016	0.58±0.44	0.80
Wilting and drying of calyx	*12^{th} day*	3.58± 0.15	-0.007±0.0005	0.96
	24^{th} day	3.62± 0.165	0.0052±0.00061	0.93
Physiological Weight loss %	*12^{th} day*	58.43± 3.34	-0.10 ± 0.01	0.93
	24^{th} day	89.26± 4.64	-0.06 ± 0.01	0.73
Non marketable fruit (%)	*12^{th} day*	79.96 ± 3.64	-0.135± 0.01	0.97
	24^{th} day	106.85±6.69	-0.12± 0.024	0.82

CONCLUSION AND RECOMMENDATIONS

The findings of this research indicate that 350-400 kg K_2O ha^{-1} could be recommended to the growers of Dera Ismail Khan or of similar agro-climatic regions for minimizing tomato productivity and quality.

ACKNOWLEDGMENT

The author is heartily thankful to the Higher Education Commission, Pakistan for financial assistance to conduct the research.

REFERENCES

Al-Karaki, G.N. 2000. Growth, sodium, and potassium uptake and translocation in salt stressed tomato. J. Plant Nut. 23(3): 369-379.

Bidari, B.I., M.D. Martur and K.K. Math. 2004. Influence of soil properties on yield and quality of chillies (*Capsicum annuum* L.) and partitioning of nutrients in fruit components. Paper presented in "National Symp. on Input Use Efficiency in Agric. – Issues and Strategies", 25-27th Nov. 2004, Kerala Agric. Univ., Thrissur, Kerala.

Bernard, J.Z., W. Kocialkowski and W. Grzebisz. 2006. Evaluation of potassium quantity intensity parameter of selected polish agriculture soils. J. Polish Agric. Univ. Agron. 9 (40) :67-72.

Bryson, G.M and A.V. Barker. 2002. Determination of optimal fertilizer concentration range for tomatoes. Soil Sci. Plant Anal. 33: 759-777

Cakmak, I. 2002. Plant nutrition research: Priorities to meet human needs for food in sustainable ways. Plant & Soil. 247: 3–24

Carter, J.N. 1986. Potassium and sodium uptake effects on sucrose concentration and quality of sugar beet roots. J. Amer. Soc. Sugar Beet Technol. 23 (3-4): 183-202.

Chapagain, B.P. and Z. Wiesman. 2004. Effect of potassium magnesium chloride in the fertigation solution as partial source of potassium on growth, yield and quality of greenhouse tomato. Sci. Hort. 99:279–288.

Das, P.C. 1999. Plant Nutrients. In: *Manures and Fertilizers*. 2nd Ed. Kalyani Publishers, New Dehli, India. 13: 5-10.

Davies, M. and G.W. Winsor. 1967. Effect of nitrogen, phosphorous, potassium, liming and magnesium on the composition of tomato fruit. J. Sci. Food Agric. 18: 459-466

Dorais, M., A.P. Papadopoulos, A. Gosselin .2001. Greenhouse tomato fruit quality. Hort. Rev. (Amer. Soc. Hort. Sci.) 26:239–319.

Ehsan, M.I., M. Zameer, R.Tahir, A. Zaheer and A. Sagheer. 2010. Effect of potash application on yield and quality of tomato. Pak. J. Bot. 42(3): 1695-1702

Etminan, M., B. Takkouche and F. Caamano. 2004. The role of tomato products and lycopene in the prevention of prostate cancer: a meta-analysis of observational studies. Cancer Epidemiol Biomarkers Prev. 13(3): 340-345.

Jaiswal, 2003. Soil water, and water analysis. 1st ed. Published by Kalyani Publishers, New Delhi.

Khan, A., A.S. Khatri, M.A. Nizamani, S.R. Siddiqui and N. Dabar. 2005. Effect of NPK fertilizer on the growth of sugar cane Clone AEC. 86-347. Developed by NIA Tandojam, Pakistan. Pak. J. Bot. 37(2): 355-360.

FAO STATE. 2002. Research.cip.cgiar.org/confluence/display/wpa/Pakistan.

FAO. 2003. FAO Bulletin of Statistics. 3(2). FAO, Rome.

Gormely, T.R. and M.J. Mayer. 1990. Tomato fruit quality: an inter disciplinary approach. Prof. Hort. 4:107-112

Gupta, C.R. and S.S. Sengar. 2000. Response of tomato (*Lycopersicon esculentum* Mill.) to nitrogen and potassium fertilization in acidic soil of Bastar. Veg. Sci. 27(1): 94-95.

Hunt, R. 1982. Plant growth curves. The functional approach to plant growth analysis. Edward- Arnold, London.

Lester, G.E., J.L. Jifon and D.J. Makus. 2006. Supplemental foliar potassium applications with or without a surfactant can enhance netted muskmelon quality. HortSci. 41(3): 741-744.

MAFF. 1986. The analysis of agricultural materials. Ref. Book 427, 3rd ed Ministry of Agric. Fisheries & Food. HMSO, London.

Martin, P.J. 1989. Physiological processes related to handling and storage quality of crops. *In:* "Methods of K-Research in Plants". pp. 219-248. Int'l Potash Instt. Basel, Switzerland.

Mengel, K. and E.A. Kirkby. 1987. Principles of plant nutrition. West Publishing Co. Int'l. Potash Instt. Bern, Switzerland. pp.100-115.

Mondal, M.F. 2000. Production and storage of fruits (in Bangla). Published by Mrs. Afia, BAU Campus, Mymensingh-2202. 312p.

Oded, A. and K. Uzi. 2003. Enhanced performance of processing tomatoes by potassium nitrate-based nutrition. Acta Hort. (ISHS), 613: 81-87.

Picha, D.H. and C.B. Hall. 1982. Influence of K, cultivar and season on tomato gray wall and blotchy ripening. J. Amer. Soc. Hort. Sci. 106:704-708

Padem, H. and A. Ocal. 1999. Effects of humic acid applications on yield and some characteristics of processing tomato. Acta Hort. 487: 159-164.

Russel, D.F. 1991. M. States C. Mischell Stat. Univ. Ver. 1.3.

Samiullah, K. and N. Khan. 2003. Physiological investigation on interactive effect of P and K on growth and yield of chickpea. Indian J. Plant Physiol. 8(2): 165-170.

Solaiman, A.M. and M.G. Rabbani. 2006. Effects of NPK and cow dung on growth and yield of tomato. Bullet. Instt. of Trop. Agric. Kyushu Univ. 29 (1) 31-37.

Trudel, M.J. and J.L. Ozbun. 1971. Influence of potassium on carotenoid content of tomato fruits. J. American Soc. Hort. Sci., 96 (6) : 763-765.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1985. Soil and fertilizer potassium. In: Soil Fertility and Fertilizers. 4th ed., S.L. Tisdale, W.L. Nelson and J.D. Beaton (eds.), 249-291, MacMillan Publ. Co., New York.

Tsialtas, J.T. and N. Maslaris. 2009. Selective absorption of K over Na in Sugar Beet cultivars and its relationship with yield and quality in two contrasting environments of Central Greece. J. Agron. & Crop Sci. ISSN 0931-2250 : 384–392.

Tucker, D.P.H., L.G. Abrigo, T.A. Wheaton and J.R. Parsons .1994. Tree and fruit disorders. Fact Sheet HS-140. Instt. of Food & Agric. Sci. Univ. of Florida.

Umar, M.K., M. Qasim and I. Khan. 2007. Effect of Zn fertilizer on rice growth in different soils of Dera Ismail Khan. Sarhad J. Agric. 23(4): 1034-1040.

USDA. 1975. Visual Aid TM-L-1. The John Henry Co., Lansing, MI.

Voogt,W. and C. Sonneveld. 1997. Nutrient management in closed growing systems for green house production. In: Goto, E.(Ed) Plant Production in closed Ecosystem. pp.83-102.

Williumsen, J., K.K. Petersen and K. Kaack. 1996. Yield and blossom end rot of tomato as affected by salinity and cation activity ratios in the root zone. J. Hort. Sci. 71: 81-98

Wuzhong, N. 2002. Yield and quality of fruits as of solanaceous crops as affected potassium fertilization. Better Crops Int'l. 16(1): 6-9.

Wijewardena, J.D.H. and S.L. Amarasiri. 1997. Long-term use of potassium fertilizer for vegetable crops in the country intermediate zone. J. National Sci. Council of Sri Lanka. 25: 59-68

Yurtseven, E., G.D. Kesmez and A. Unlukara. 2005. The effects of water salinity and K levels on yield, fruit quality and water consumption of native central Anatolian tomato species available online at http://www.sciencedirect.com.