Response of Tomato (*Lycopersicon esculentum* L.) at Varying Levels of Soil Applied Potassium

Zia-ul-Hassan[1], K.A. Kubar[2], M.A. Chhajro[2], M.N. Kandhro[3,*], G.M. Jamro[4], K.H. Talpur[1] and N. Talpur[1]

[1]*Department of Soil Science, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

[2]*College of Resources and Environment, Huazhong Agricultural University, Wuhan, Hubei, P.R., China*

[3]*Department of Agronomy, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

[4]*Department of Renewable Resources, University of Alberta, Edmonton, AB T6G 2E3, Canada*

Abstract: The pot study was conducted during autumn 2015 at Department of Soil Science, Sindh Agriculture University, Tandojam Pakistan to assess the effect of soil applied potassium sulphate (K_2SO_4) fertilizer on growth, biomass production and K accumulation of plants of tomato variety Roma. The study was executed in a net-house under natural conditions following completely randomized design. There were six treatments (0, 50, 100, 150, 200 and 250 kg K_2O ha^{-1}), each repeated thrice. A recommended blanket dose of 150 kg nitrogen and 75 kg phosphorus ha^{-1} was also given to the crop. Tomato plants were raised in five kg plastic pots filled with a K-deficient soil (119 mg kg^{-1}). Results of the study indicated that K nutrition significantly enhanced growth, biomass production and K accumulation of tomato plants. K nutrition augmented different plant height (49%), shoot diameter (103%), fresh biomass (134%), dry biomass (182%), number of leaves (75%) and K concentration (3.1 fold). It is concluded that a dose of 100 kg K_2O ha^{-1} was the most optimum for tomato plants at early growth stage. These results need to be verified under field conditions at maturity level of tomatoes.

Keywords: Potassium, tomato, biomass production, K-accumulation.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is globally considered as an important vegetable crop. In Pakistan during 2009-10 it was grown on an area of 50,000 ha with production of 476800 tonnes having average yield of 9.5 t ha^{-1} [1]. However, this is quite meager when compared with the average yield of tomato in USA (73.9 t ha^{-1}), Spain (63.5 t ha^{-1}), Netherlands (146 t ha^{-1}) [2]. The sustainable production of tomato requires the involvement of high-yielding tomato genotypes, efficient crop management strategies which include balanced use of fertilizers, timely irrigation, integrated disease and pest management. In contrast, all these factors are the major limiting factor for cost-effective tomato production, especially the imbalanced use of fertilizers. Pakistani tomato-growers use high amounts of nitrogenous and phosphatic fertilizers with negligible use of potassium (K) fertilizer [3]. Hence, it becomes very difficult to obtain good tomato yields in the absence of balanced tomato nutrition involving K fertilization since the rapid potassium mining from Pakistani soils has recently been reported [4]. Soil K plays a significant role in enhancing carotenoids syntheses in tomato. Plants should have adequate supply of K particularly at the time of fruit development and maturation. Potassium content in vegetables bears significant positive relationship with quality attributes [5]. The higher K uptake of potassium efficient genotypes determines their seed yield under K deficiency stress [6, 7]. K plays as the most versatile nutrient in plants with its multiple important roles such as pH maintenance, osmoregulation, activating a number of enzymes, membrane transport [8, 9], biomass production [4, 10, 11] leaf growth, CO_2-assimilation [12], photosynthesis, transpiration, efficient use of water [13], enhancing product quality and crop yields [14]. Keeping in view the facts stated above, the response of tomato plants at early growth stage to soil-applied K fertilizer (K_2SO_4) in terms of their growth, production of biomass and accumulation of K were studied.

MATERIALS AND METHODS

The pot experiment was conducted during autumn 2015 at Department of Soil Science, Sindh Agriculture University, Tandojam Pakistan in a net-house under natural conditions. The nursery of tomato variety Roma was raised for 20 days and after that the seedlings were transplanted in black plastic coated pots with a capacity to accommodate 5-kg well-processed soil. A completely randomized design was followed for this study involving six treatments (0, 50, 100, 150, 200 and

*Address correspondence to this author at the Department of Agronomy, Sindh Agriculture University, Tandojam, Sindh, Pakistan; Tel: +92-344-3537114; Fax: +92-22-2765300; E-mail: kandhromn@sau.edu.pk

ISSN: 1814-8085 / E-ISSN: 1927-5129/16

250 kg K_2O ha^{-1}) and three repeats. A blanket dose of nitrogen and phosphorus (150 and 75 kg NP ha^{-1}, respectively) was supplied to the crop. Nitrogen was applied in the form of Urea (46% N) while phosphorus in the form of DAP (18% N and 46% P_2O_5). K was given to the crop through K_2SO_4 fertilizer (50% K_2O) as per treatment plan. The soil (0-20 cm depth) used in this study was a poorly fertile (organic matter: 0.53%), non-saline (EC: 0.8 dS m^{-1}) and alkaline (pH: 8.4) heavy clay (38%) with inadequate ABDTPA-K (119 mg kg^{-1}). Six uniform sized seedlings were transplanted in all pots and raised for 42 days. The seedlings were then harvested and the data was recorded on plant height (cm), shoot diameter (mm), fresh and dry biomass (g $plant^{-1}$), number of leaves $plant^{-1}$ and K-concentration (%). For number of leaves all leaves (fully grown and young) were counted. The K-concentration (%) of tomato plants was determined by standard method [4]. The necessary statistical analysis was performed by Statistix ver. 8.1.

RESULTS AND DISCUSSIONS

The results of present study indicated that K nutrition significantly enhanced the growth, biomass production and K-accumulation of tomato plants (Table **1**). The doses of 100 and 150 kg K_2O ha^{-1} affected various plant traits of tomato more than any other treatment including control. However, both these treatments were statistically similar for most of the considered plant traits. The data of Table **2** further revealed that K nutrition improved different traits of tomato plant, viz. plant height (49%), shoot diameter (103%), fresh biomass (134%), dry biomass (182%), number of leaves (75%) and K concentration (3.1 fold) as compared to T_1 (00 kg K_2O ha^{-1}). Maximum plant height (33.29 cm) was obtained where 200 kg K_2O ha^{-1} was applied and minimum plant height (22. 25 cm) was recorded in $T_{1,}$ where no K fertilizer was applied (Table **2**). A dose of 100 and 150 kg K_2O ha^{-1} significantly produced similar shoot diameter superior over control. Maximum diameter (2.35 mm) was obtained where 150 kg K_2O ha^{-1} was applied and minimum diameter was obtained (1.16 mm) where no K fertilizer was applied. Non-significant increase in shoot diameter of tomato was recorded when the K dose was increased from 200 to 250 kg K_2O ha^{-1}. Our results advocate the importance of balanced K nutrition for tomato crop. A number of other studies have also documented the positive response of various crops to K nutrition in terms of growth, yield and potassium accumulation, e.g. maize [15], cotton [4, 11, 6] and sunflower [16, 17, 18]. It is also apparent from these results (Table **2**) that K nutrition at 150 and 200 kg K_2O ha^{-1} significantly produced similar fresh biomass as compared to control. Maximum fresh biomass (3.02) was obtained where 150 kg K_2O ha^{-1} was applied and minimum fresh biomass was obtained (1.28) where no K fertilizer was applied. Similar dry biomass of tomato was recorded where K was supplied at the rate of 100, 150 and 250 kg K_2O ha^{-1}. Maximum dry biomass (0.87) was recorded where 100 kg K_2O ha^{-1} was applied and minimum dry biomass was recorded (0.31) where no K fertilizer was applied. Our results confirm some of the previous studies which highlighted that K nutrition had significant effects on plants and the increased levels of K had significant influence on tomato plants up to 90 kg K_2O ha^{-1} [19] or 160 kg K_2O ha^{-1}[20]. The data in Table **2** further revealed that the maximum number of leaves (33.3) was noted where 200 kg K_2O ha^{-1} was applied followed by 150 kg K_2O ha^{-1} and minimum (19.0) was recorded where no K fertilizer was applied. Non-significant increase in leaf count of tomato was recorded when the dose was applied 100, 150 and 250 as compared to control. Maximum K concentration (4.2%) was noted where 100 kg K_2O ha^{-1} was applied and minimum K concentration (0.75%) was noted where no K fertilizer was applied. These results were again in line with the findings of early studies advocating the importance of balanced K nutrition of tomatoes for growth, biomass production, fruit yield, and potassium uptake and content [21, 22, 23, 24, 25, 26].

Table 1: Significance of Mean Squares from Analysis of Variance of Various Parameters of Tomato Plant in Relation to Varying Levels of Soil Applied Potassium

Parameter	Mean square for K_2O treatments
Plant height (cm)	49.28**
Shoot diameter (mm)	0.60***
Fresh biomass (g $plant^{-1}$)	1.40***
Dry biomass (g $plant^{-1}$)	0.13***
Number of leaves $plant^{-1}$	98.05***
K concentration (%)	2.44***

***Represent significance levels at alpha 0.001 obtained through honestly significant difference (HSD) test.

CONCLUSIONS

It is concluded that potassium nutrition of tomato plants at early growth stage enhanced the growth, biomass production and K accumulation of tomato plants. A dose 100 kg K_2O ha^{-1} was found most

Table 2: Response of Tomato under Graded Levels of Soil Applied Potassium

K_2O (kg ha^{-1})	Plant height (cm)	Shoot diameter (mm)	Fresh biomass (g plant^{-1})	Dry biomass (g plant^{-1})	Number of leaves (plant^{-1})	K concentration (%)
00	22.25 b	1.16 d	1.29 d	0.31 d	19.00 c	0.77 e
50	31.33 a	1.73 c	1.81 c	0.58 c	21.67 c	1.75 d
100	30.01 a	2.30 a	2.71 ab	0.88 a	29.00 b	3.17 a
150	30.91 a	2.36 a	3.03 a	0.81 a	31.33 ab	2.70 bc
200	33.29 a	2.00 b	2.91 a	0.68 b	33.33 a	2.97 b
250	32.95 a	2.19 ab	2.50 b	0.80 a	30.00 ab	2.36 c

optimum dose. Further studies are suggested to validate these results, especially under field condition and at maturity level.

REFERENCES

[1] GOP. Agricultural Statistics of Pakistan, Ministry of Food, Agriculture and Livestock, Government of Pakistan, Islamabad 2011.

[2] UN. Food and Agriculture Organization (FAO) FAOSTAT Statistical Database, at Aps. FAO. Org. updated 20th December 2004.

[3] NFDC. Annual Fertilizer Review Report. National Fertilizer Development Centre, Planning Commission, Government of Pakistan, Islamabad 2007-08.

[4] Zia-ul-Hassan, Arshad M, Khalid A. Evaluating potassium-use-efficient cotton genotypes using different ranking methods. J Plant Nutr 2011; 34: 1957-1972. http://dx.doi.org/10.1080/01904167.2011.610483

[5] Bidari BI, Hebsur NS. Potassium in relation to yield and quality of selected vegetable crops. Karnataka J Agric Sci 2011; 24(1): 55-59.

[6] Kubar KA, Zia-ul-Hassan, Rajpar I. Potassium requirement of Bt and non-Bt cotton genotypes. LAP Lambert Academic Publishing, Germany 2012; pp. 62 VI.

[7] Zia-ul-Hassan, Kubar KA, Rajpar I, Tunio SD, Shah AN, Shah JA, Maitlo AA. Evaluating potassium-use-efficiency of five cotton genotypes of Pakistan. Pak J Bot 2014; 46(4): 1237-1242.

[8] Bhandal IS, Malik CP. Potassium estimation, uptake, and its role in the physiology and metabolism of flowering plants. Int Rev Cytol 1998; 110: 250-254.

[9] Marschner H. Mineral nutrition of higher plants. Academic Press, San Diego, CA 1995.

[10] Zhao D, Oosterhuis DM, Bednarz CW. Influence of potassium deficiency on photosynthesis, chlorophyll content, and chloroplast ultrastructure of cotton plants. Photosynthetica 2001; 39(1): 103-109. http://dx.doi.org/10.1023/A:1012404204910

[11] Zia-ul-Hassan, Arshad M. Cotton growth under potassium deficiency stress is influenced by photosynthetic apparatus and root system. Pak J Bot 2010; 42(2): 917-925.

[12] Reddy KR, Koti S, Davidonis DH, Reddy VR. Interactive effects of carbon dioxide and nitrogen nutrition on cotton growth, development, yield and fiber quality. Agron J 2004; 96: 1148-1157. http://dx.doi.org/10.2134/agronj2004.1148

[13] Pervez H, Ashraf M, Makhdum MI. Influence of potassium nutrition on gas exchange characteristics and water relations in cotton. Photosynthetica 2004; 42(2): 251- 255. http://dx.doi.org/10.1023/B:PHOT.0000040597.62743.5b

[14] Akhtar ME, Sardar A, Ashraf M, Akhtar M, Khan MZ. Effect of potash application on seed cotton yield and yield components of selected cotton varieties. Asian J Plant Sci 2003; 2(8): 602-604. http://dx.doi.org/10.3923/ajps.2003.602.604

[15] Nawaz I, Zia-ul-Hassan, Ranjha AM, Arshad M. Exploiting genotypic variation among fifteen Maize Genotypes of Pakistan for potassium uptake and use efficiency in solution culture. Pak J Bot 2006; 38(5): 1689-1696.

[16] Chajjro MA, Zia-ul-Hassan, Shah AN, Kubar KA. Sunflower hybrids differentially accumulate potassium for growth and achene yield. Pak J Agri Agril Engg Vet Sci 2013; 29(1): 31-43.

[17] Chajjro MA, Zia-ul-Hassan, Shah AN, Talpur KH, Kubar KA. Response of two hybrid sunflower genotypes to applied different levels of soil potassium. Persian Gulf Crop Protec 2014; 3(2): 45-52.

[18] Nanadal JK, Ramesh V, Pandey UP. Effect of phosphorus and potassium on growth, yield and quality of tomato. J. Potas Res 1998; 15(1-4): 44-49.

[19] Majumdar SP, Meena RL, Baghel, GDS. Effect of levels of compaction and potassium on yield and quality of tomato and chilli crops grown on highly permeable soils. J Indian Soc Soil Sci 2000; 48(2): 215-220.

[20] Laura C. Effect of different fertilization levels on yield and lycopene content of field tomatoes. Department of Plant Science Macdonald Campus of McGill University Sainte-Anne-de-Bellevue, Québec, Canada 2012.

[21] Hariprakasha RM, Subramanian TR. Effect of potassium application on the yield and content of K, Ca and Mg in cabbage, okra, tomato and beetroot. J Potash Res 1991; 7(3): 190-197.

[22] Krauss A. Potassium, the forgotten nutrient in West Asia and North Africa. In: J. Ryan (Ed.) Accomplishments and future challenges in dry land soil fertility research in the Mediterranian Area 1997; pp. 9-21, Syria.

[23] Liu Z, Jiang L, Li Xi, Hardter R, Zhang W, Zhang Y, Zheng DF. Effect of N and K fertilizers on yield and quality of greenhouse vegetable crops. Pedosphere 2008; 18(4): 496-502. http://dx.doi.org/10.1016/S1002-0160(08)60040-5

[24] Almeselmani M, Pant RC, Singh B. Potassium level and physiological response and fruit quality in hydroponically grown tomato. Int J Veget Sci 2009; 16(1): 85-99. http://dx.doi.org/10.1080/19315260903271526

[25] Akhtar ME, Khan MZ, Rashid MT, Ahsan Z, Ahmad S. Effect of potash application on yield and quality of tomato (*Lycopersicon esculentum* L.). Pak J Bot 2010; 42(3): 1695-1702.

[26] Javaria S, Khan MQ, Rahman HU, Bakhsh I. Response of tomato (*Lycopersicon esculentum* L.) yield and post-harvest life to potash levels. Sarhad J Agric 2012: 28(2): 227-235.

Received on 24-02-2016 Accepted on 06-04-2016 Published on 29-04-2016

http://dx.doi.org/10.6000/1927-5129.2016.12.29