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Dose Optimization of Potassium (K) for Yield and Quality Increment of Strawberry (*Fragaria ×ananassa* Duch) Chandler

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Authors' contributions

This work was carried out in collaboration between all authors. Author MS designed and supervised the research conduct. Authors RU and MS managed the data analysis and write up of the article. Author SH revised and edited the manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: Strawberry, being introduced recently to the fruit industry of Pakistan, is a new commodity therefore the growers are still unaware of the optimum fertilizer dose needed to obtain better yield. To achieve this goal the present research study was designed to optimize the proper dose of Potassium (K) for strawberry under the agro-climatic conditions of Peshawar-Pakistan.
Place and Duration of Study: The Research was conducted in open field conditions at newly Developed Farm (NDF) at Horticulture section, The University of Agriculture Peshawar, Pakistan during 2011-12.
Methodology: Phenotypic parameters such as days to flowering, fruit set, fruit maturity, number of fruit, number of runners, fruit size, fruit yield and physiological aspects such as fruit acidity, ascorbic acid, TSS and pH were evaluated to test potassium dose optimization for better yield of strawberries.
Results: The results obtained (for various yield and quality related attributes) were then compared with that of untreated control plants. The evaluation depicted some significantly

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influenced parameters attributed to different levels of Potassium. Days to flowering, fruit set, fruit maturity, number of fruit, runners, fruit size, total yield, fruit acidity, ascorbic acid, TSS and pH were efficiently influenced by Potassium applied at 70 kg ha^{-1}.
Conclusion: Results findings lead to conclusion that Potassium should be applied at 70 kg ha^{-1} in order to get good yield and to improve the quality of strawberry fruits under the agro-climatic conditions of Peshawar.

Keywords: Ascorbic acid; cultivar chandler; strawberry fruit; potassium; TSS.

1. INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch) did not get much popularity among growers due to several reasons, despite the fact it has been introduced since 1960s [1,2], however in recent years it is been a well-known fruit crop for its redolent and savour characteristics [1]. Strawberry cultivation prefers open field conditions [3]. Cultivar Chandler [4] and Elsanta [3] is the most commonly cultivated variety in India and Europe respectively due to their high potential yield and good fruit quality. In Pakistan, its production is confined to some specific areas of Khyber Pakhtunkhwa and Punjab, however its cultivation for commercial purpose is gaining importance among the growers as a cash crop. It is grown at lower altitudes in Khyber Pakhtunkhwa, from November to June in areas of Swat, Abbottabad, Mansehra, Haripur, Mardan, Peshawar, Charsada, while in some areas of Punjab like Gujrat, Sialkot, Jhelum and Chakwal [5]. The agro-climatic conditions of Peshawar region are subtropical and often receive less rainfall therefore most of the crops cultivated here remain under water stress which adversely affect its potential yield and quality [6]. Strawberry being a high value cash crop and highly perishable [7], much attention should be paid to standard cultivation practices along with proper and on time nutrition of the plants. Potassium has a well-known functional importance in water regulation and uptake in crops under water stress as it facilitates the turgor pressure of guard cell during stomata movements [8,9], the yield and quality of fruit crops is greatly dependent on the proper supply of essential plant nutrients and may deteriorates in case of nutritional imbalance [10]. Plants depend upon the regulation of potassium on opening and closing of stomata. It is also related to the transport of sugars and other nutrients in xylem [11]. Potassium helps in activation of several bio chemical processes like photosynthesis, formation of starch, protein synthesis, sugar and regulation of water balance. Potassium also activates enzymes which act as catalyst in several metabolic reactions. There are more than 60 enzymes discovered which needs potassium for activation [12]. Sulfate of potash (SOP) as a source of Potassium at 60kg K_2O ha^{-1} increases, fruit weight, fruit size, number of fruits $plant^{-1}$and fruit yield of different fruit plants. It was also observed that SOP significantly influenced the quality characteristic of chili. Plants treated with Potassium at 60 kg ha^{-1} also noted to have minimum disease occurrence in contrast to other treatment combinations therefore the proper application dose is very critical [13]. Strawberry is newly introduced crop and its average yield per hectare is very low in agro-climatic conditions of Peshawar. There are various limiting factors which are responsible for low yield i.e. lack of modern technology, less research work and technical guidance as well as lack of economic value among the growers for its better yield.

2. MATERIALS AND METHODS

2.1 Experimental Site and Plant Material

The research was conducted in open field conditions at Newly Developed Farm (NDF) at Horticulture section, The University of Agriculture Peshawar, Pakistan during 2011-12. The runners of Strawberry were provided by Agricultural Research Institute Mingora, Swat. These Strawberry runners were planted in the month of November 2011. Sawdust was used as mulch for mulching to avoid chilling temperature and to obtain clean fruits at the time of harvest.

2.2 Soil Analysis

The soil samples collected from the experimental site from various depths were analyzed for Nutrients, AB-DTPA extractable K, soil organic matter, Electro conductivity and pH under the standard methods [14,15 respectively]. The obtained values against different soil properties are presented in Table 1.

Table 1. Soil analysis for pH, EC, soil organic matter, lime and AB-DTPA extractable K determined for various soil depths

Property	Unit	0-15 cm	15-30 cm	30-45 cm	45-60 cm
pH (1:5)	-	7.71	7.92	7.94	7.87
EC (1:5)	dsm^{-1}	0.21	0.20	0.15	0.14
Soil organic matter	%	2.04	1.92	1.90	1.78
Lime	%	20.65	19.23	17.61	16.99
AB-DTPA Extractable K	$mg\ kg^{-1}$	6.41	6.18	5.47	5.46

2.3 Fertilizer Application and Experimental Design

Sulfate of potash (SOP) was used as a source of Potassium (K), Single Super Phosphate (SSP) as Phosphorus (P) and Urea as Nitrogen (N). Potassium was not applied in control treatment while P and N were applied at the rate of 90 and $100kgha^{-1}$ respectively in all treatments including control. Four different doses (50, 60, 70 and $80kgha^{-1}$) of Potassium (K) were tested. The experiment was laid out in Randomized Complete Block Design (RCBD) for the above mentioned levels of potassium with three replications. The experimental field was divided in 15 plots having a size of 6 square meters (m^2) with 5 rows each. Number of plants per row was kept 5 and thus each plot has total 25 plants. Plant to plant and row to row distance were kept 30cm and 60cm in each experiment, respectively. Sawdust was used as mulch for mulching to avoid chilling temperature and to obtain clean fruits at the time of harvest.

2.4 Parameters Studied

2.4.1 Yield related parameters

Days to flowering (DF), days to fruit set (DFS), days to fruit maturity (DFM),number of fruits $plant^{-1}$(NF), fruit size (FS (cm^3)), number of runners $plant^{-1}$(NR) and total fruit yield (TY (tonnes ha^{-1})), were studied and the results were statistically analyzed.

2.4.2 Quality related attributes

Total soluble solids (Brix^0), Percent acidity (%), Ascorbic acid (mg ml^{-1}) and pH of the fruit juice were studied through the standard methods developed by [16,17].

2.5 Statistical Analysis

The collected data for different parameters was subjected to analysis of variance (ANOVA) to find the difference between different treatments. In case where the differences were significant the mean was further assist for differentiation through least significant difference (LSD) test. Statistical software (Statistix8.1) was applied for computing both ANOVA and LSD.

3. RESULTS AND DISCUSSION

3.1 Yield Related Attributes

3.1.1 Days to flowering

The days to flowering in strawberry is shown in Table 2. The analysis of data recorded determines that different levels of Potassium had a significant effect (P=.05) on the days to flowering, the mean values revealed that potash levels were significantly different from untreated plants but non-significant with each other. The highest number of days (109.14) to flowering was noted in control plants, while the lowest number of days (102.39) to flowering recorded in plants treated with Potassium at 80 kg ha^{-1}.

Flowering is a vital role in plants for the processes of pollination which is essential for fruit growth and development. Early flowering induced in strawberries plants might be due to the applied potash because K induces early growth, activate enzymes and the efficiency of other applied nutrients [18]. Current results are in line with previous works evidencing potassium application significantly influenced days to flowering [19].

3.1.2 Days to fruit set

Days to fruit set in strawberry plants, is mentioned in Table 2. Data analysis shows that the days to fruit set in strawberries were significantly affected (P=.05) by different levels of Potassium.

The highest days for fruit set (6.84) were observed in control plot, while the lowest days to fruit set (6.53) were observed in plants treated with 80 kg Potassium ha^{-1}. Potassium applications gave reasonable good response for increasing number of fruits plant^{-1}. There is an indirectly proportional trend in days to fruit set and dose of potassium applied to the strawberries. This phenomenon can be justified with the early flower set induction in the strawberries with the potassium application thus making the plants able to bear fruits early than control or untreated plants. Potassium uptake helps the plant's nutrient uptake ability and increase the chlorophyll content in foliage resulting in improved synthesis of carbohydrates and producing new cells [20]. Potassium optimum dose is documented to be enhancing vigorous tomato growth, early flowering and setting of fruits, however its deficiency will causes slow stunted growth, number of fruits and reduction in yield [21]. The fruit set behavior associated with the increase in potassium application thus helps in understanding a significant role of potassium in the growth and development of strawberries fruits.

Table 2. Yield and yield related attributes as affected by different levels of potassium (K)

Treatments	DF	DFS	DFM	NF	FS (cm^3)	NR	TY (Tonnes ha^{-1})
Control	109.14^a	6.84^a	28.28^a	4.55^d	4.21^c	11.06	2.18^c
50 kg K ha^{-1}	105.95^b	6.65^b	23.83^b	6.49^c	5.09^{bc}	11.67	3.25^b
60 kg K ha^{-1}	105.29^b	6.58^{bc}	23.76^b	7.37^b	5.29^{bc}	12.33	3.42^b
70 kg K ha^{-1}	105.11^b	6.54^{bc}	23.13^b	8.30^a	5.94^b	11.39	5.07^a
80 kg K ha^{-1}	104.78^b	6.53^c	23.16^b	7.85^{ab}	7.63^a	12.34	4.48^a
Significance	*	*	*	*	*	NS	*
LSD	1.80	0.11	0.56	2.53	1.60	3.34	0.71

**Significance at α0.05; Values sharing same letters are non-significant with each other while significantly different from those values which have different letters*

3.1.3 Days to fruit maturity

The days to fruit maturity of strawberry plants is mentioned in Table 2. Data analysis indicates that, the days to fruit maturity of strawberry plants were significantly effected (P=.05) by all Potassium levels.

The mean values of data show that potash levels have significant difference to control plants but were non-significant with each other. The highest number of days to fruit maturity of strawberry plants (28.28) was observed in control plants and the lowest number of days (23.13) was observed in plants treated with 70kg potassium ha^{-1}. These results could be supported as the percentage of unevenly ripened, irregularly shaped and hollow tomato fruits decreased with increased potassium dose [22]. While the effects of K on maturity in different vegetable and fruits are variable, but its application in Maize speeds up silking, increases yield and the lack of K in soybean delays its maturity [23].

3.1.4 Number of fruits plant^{-1}

The number of fruits in strawberry plant is mentioned in Table 2.Data analysis shows that the number of fruits were significantly effected (P=.05) by different levels of potash.

The mean values show that the highest numbers of fruits (8.30) were observed in the plants that were treated with 70kg Potassium ha^{-1}, while the lowest numbers of fruits (4.55) were observed in control plot.

Potassium applications gave reasonably good response by increasing number of fruits plant^{-1}. The number of fruits plant^{-1} can be related with the increase and decrease of number of flowers. A higher nutritional dose helps in vigorous and enhanced growth in strawberries helping the plants to bear a higher number of fruits per plants. This phenomenon is justified by increased carbohydrates synthesis due to increased chlorophyll content of the foliage thus resulting increase number of fruits per plant [20]. Current results authenticate the application of potassium as SOP at 60kg K_2O ha^{-1}resulted in a superior number of fruits per plant in chilies [13]. Same trend was noted in another work where application of potash maximized the number of fruits per plant in chili [24].

3.1.5 Fruit size (cm^3)

The fruit size of strawberry plants is shown in Table 2. The Analysis of Variance shows that the fruit size of strawberry plants were significantly effected (*P*=.05) by different potash levels. The mean values reveals that the highest fruit size (7.63 cm^3) was observed in the plants treated with potassium at 80kg ha^{-1}, while the smallest fruit size (4.21cm^3) was recorded in control plot.

Potassium application shows a direct proportion with the size of fruits in strawberries plants. An understanding could be developed by the phenomenon where during photosynthesis; carbon dioxide is converted into sugars which have to be transported to organs of the plant where it will store or used for growth and development. The plants transportation system requires energy in the form of (ATP) which needs potassium for its synthesis. The transportation of sugar from leaves to fruit is greatly reduced in potassium deficient plants [25]. Thus, ample supply of potassium helps the plant better synthesize and utilize the vital functional elements and thus improve the fruits size and yield of the plants. These results confirm the crucial role of potassium in the production of the large yields combined with fruit quality [26]. Potassium stimulates plant growth, fruit size, fruit aroma and taste by enhancing the production of sugars and acids in tomato.

3.1.6 Number of runners

Number of runners of strawberry plant is shown in Table 2. Data analysis shows that the number of runners per plant is non-significantly influenced by different levels of potassium.

However, the mean values of data shows that the highest number of runners (12.34) was observed in the plants treated with 80kg Potassium ha^{-1}, while the lowest number of runners (11.06) was noted in untreated plants. The non-significant effect on number of runners of strawberry plant might be due to the same genetic makeup of plants. However the number of tillers in black barley increased significantly due to potassium accumulative ability of this cultivar [27].

3.1.7 Total fruit yield ha^{-1}

Total fruit yield of strawberry is mentioned in Table 2. Data analysis shows that the total fruit yield of strawberry plants were significantly effected (*P*=.05) by different levels of potassium. The mean values reveals that, the highest total fruit yield (5.07 tons ha^{-1}) was observed in plants treated with potassium at 70kg ha^{-1}, while the lowest yield (2.18 tons ha^{-1}) was recorded in control treatment.

The increase or decrease in yield is entirely depends upon the increase or decrease on total number of fruits $plant^{-1}$and maximum size of fruits. A higher weight of fruits gained upon increased nutrient application resulted in improved yield [8]. Potassium is the most abundant of cations present in phloem sap (almost 80%) helping in the production of sugar and transporting it through the phloem into sink organs [28]. Potassium have crucial role in photosynthesis and metabolism of carbohydrates. An optimum potassium supply results in better sugar content of sink organs [8]. Current results are in line with previous observations where the increase of potassium caused a significant increase in tomato yield [12]. The highest potassium fertilizer rate gave tallest sweet pepper plants, branches $plant^{-1}$, the highest fresh and dry weight of leaves, highest number of leaves and highest total yield [29].

The optimum dose of potassium also resulted in higher yield of tomato [26]. A higher potassium in the nutrient solution resulted in increased yield of tomato fruits [18].

3.2 Influence of Potassium Ionson Quality Attributes

3.2.1 Ascorbic acid (mg ml^{-1})

The data recorded for ascorbic acid in strawberry fruit's juice is mentioned in Table 3. The Analysis of Variance indicates that, the ascorbic acid content was significantly affected by different potassium doses at (*P*=.05) level of significance. The highest value for ascorbic acid concentration (63.50) was determined in fruits which were treated with potassium at 70 kg ha^{-1}, while the lowest concentration (54.71) was recorded in fruits obtained from control.

The gradual increase in potassium dose resulted in higher yield but it decreases the concentration of vitamin C content in fruit and vice versa. This might be due to an increase in water absorption capacity by plants as well as in fruits [30]. These results are in correspondence with some research findings that the optimum dose of potassium 360 kg k_2O ha^{-1} significantly increased the total yield, average fruit weight and acidity but decreased the ascorbic acid, total soluble solids and color of fruit [26]. Current findings however, nullify the results that increasing potassium dose caused an increased vitamin C content of tomato fruits [18].

Table 3. Quality attributes as affected by different levels of potassium (K)

Treatments	Ascorbic acid (mg ml^{-1})	%Acidity	TSS (Brix^{0})	pH
Control	54.71^{c}	0.57^{c}	6.30^{b}	2.27^{b}
50 kg K ha^{-1}	58.35^{b}	0.61^{bc}	7.46^{a}	2.33^{b}
60 kg K ha^{-1}	58.69^{b}	0.64^{abc}	7.70^{a}	2.33^{b}
70 kg K ha^{-1}	63.50^{a}	0.73^{a}	7.73^{a}	2.36^{ab}
80 kg K ha^{-1}	61.80^{a}	0.71^{ab}	8.00^{a}	2.46^{a}
Significance	*	*	*	*
LSD	2.85	0.10	0.63	0.11

** Significance at α0.05; Values sharing same letters are non-significant with each other while significantly different from those values which have different letters*

3.2.2 Percent Acidity

The data noted for percent acidity is mentioned in Table 3. The values mentioned in mean Table, indicates that percent Acidity was significantly effected (*P*=.05) by different levels of potassium. With reference to Table 3, highest percent Acidity (0.73) was observed in fruits of that plants which were treated with potassium at 70 kg ha^{-1}, while the lowest percent Acidity (0.57) was recorded in control treatment.

Increase in percent acidity of fruits in treated plants indicates the correlation between potassium levels and percent acidity. These results can be supported as; when potassium is applied with higher dose it increases the titratable acidity (TA) and sugar content of tomato. The higher dose decreases the ratio between sugar content and TA. Hence a decrease in this ratio results better taste development in tomato fruit [23]. Increasing potassium rate increases TA of fruit juice [22]. Similar results were also obtained that with increasing potash doses TA also increases [26].

3.2.3 Total soluble solids (Brixº)

The data noted for total soluble solids of strawberry fruit juice is described in Table 3.The Analysis of Variance shows that the total soluble solids were significantly effected (*P*=.05) by different levels of potassium. According to the mean values, the highest total soluble solids (8.00) for strawberry fruit was noted in the fruits of those plants treated with potassium at 80 kg ha^{-1}, while the lowest total soluble solids (6.30) were recorded in fruits of control plants.

An increase in TSS of tomato fruits depends on a higher sugar import and accumulation in fruits [31]. Increase of TSS with the higher potassium in the nutrient solution results the importance of potassium in enhancing quality of tomato fruits [32]. Potassium has a major role in photosynthesis and metabolism of carbohydrates. An optimum potassium supply determines better sugar content of sink organs [8]. These results were also in correspondence with findings that at optimum dose of potassium 360 kg K_2O ha^{-1} significantly increased the total yield, average fruit weight and acidity but decreased ascorbic acid, total soluble solids and color of fruit [26].

3.2.4 pH

Data pertaining pH of strawberry fruit juice is mentioned in Table 3. The mean values of shows that the pH was significantly effected (*P*=.05) by different potash levels. According to Table 2, highest pH value (2.46) was observed in the fruits of those plants treated with potassium at 80kg ha^{-1}, while the lowest pH value (2.27) was noted in control plants.

The percent acidity and pH are correlated with each other. The lower percent acidity the lower will be the pH and vice versa, but in case of potassium, pH increases due to the fact that potassium is known as electro neutrality maintenance element of organic acids in tomato fruit and by increasing potassium dose, the plant water absorption capacity also increases so pH becomes higher [33]. Current findings confirm that the higher potassium in the nutrient solution resulted in increased contents of TSS, Vitamin C contents, TA and juice pH in tomato fruits [18].

4. CONCLUSION

On the basis of results obtained, it could be infer that all potassium (K) levels significantly influenced the yield and quality related parameters such as days to flowering, fruit set and fruit maturity, number of fruits and runners, fruit size and total yield, fruit acidity, ascorbic acid, TSS and pH especially the potassium applied at70 kg ha^{-1}. Therefore it could be thoughtfully concluded that potassium applied at the rate of 70kg $ha^{-1}$was most efficient to obtain good yield and to improve fruit quality of Strawberry under the agro-climatic conditions of Peshawar-Pakistan.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma RR, Sharma VP. The Strawberry. ICAR, New Delhi, India; 2004.

2. Sharma RR, Sharma VP, Pandey SN. Mulching influences plant growth and albinism disorder in strawberry under subtropical climate. Acta Hortic. 2004;(662):187–191.
3. Wojcik P, Lewandowski M. Effect of calcium and boron sprays on yield and quality of Elsanta strawberry. J Plant Nutrition. 2003;(26):671–682.
4. Kaur R, Gautam H, Sharma DR. A low cost strategy for micropropagation of strawberry (*Fragaria*× *ananassa* Duch.) cv. Chandler. In VII International Symposium on Temperate Zone Fruits in the Tropics and Subtropics-Part Two. 2003;(696):129-133.
5. Dad AK. Strawberry Cultivation in Charsadda-Pakistan. Hafat Roza Vet. News and Views, Faisalabad, Agric.Livestock Bearue Pakistan; 2011.
6. Bakht J, Ahmad S, Tariq M, Akber H, Shafi M. Performance of various hybrids of sunflower in Peshawar valley. J Agricbiol sci. 2006;(1):3.
7. Amin NU. Evaluation of different strawberry cultivars for off-season production under plastic tunnels. M. Sc (Hons) Thesis, Deptt. Hort. KPK, Agri Univ Peshawar; 1996.
8. Marschner H. Mineral nutrition of higher.2nd ed. Plants Academic Press, San Diego; 1995.
9. Shukla SK, Yadav RL, Singh PN, Singh I. Potassium nutrition for improving stubble bud sprouting, dry matter partitioning, nutrient uptake and winter initiated sugarcane (*Saccharum spp*. hybrid complex) ratoon yield. Eur. J. Agron. 2009;(30):27-33.
10. Kumar YS, Prasad R, Khokhar UU. Optimization of integrated nutrient supply system for strawberry (*Fragaria* × *Ananassa* Duch. ‘Chandler’) in Himachal Pradesh (India). Acta Hort. 2009;(842):125-128.
11. Szczerba MW, Britto DT, Kronzucker HJ. K^+ transport in plants: Physiology and molecular biology. J. Plant Physio. 2008;(66):447-466.
12. Akhtar ME, Saleem MT, Stauffer MD. Potassium in Pakistan Agriculture. PARC, Islamabad, Pakistan. 2003;80.
13. Ananthi S, veeragavathatham O, Srinivasan K. Comparative efficacy of mutriate of potash and sulphate of potash on yield attributes, yield and economics of Chili (*Capsicum annuum L*). South Indian Hort. 2004;(5291):158-163.
14. Mc Lean EO. Soil pH and lime requirement. In: Page AL, Miller RH, Kenny DR, editors. Methods of Soil Analysis (Part 2), American Society of Agronomy. 1982;(2):199-223.
15. Soltanpour PN, Schwab AP. A new oil test for simultaneously extraction of macro and micro nutrients in alkaline soils, community of Soil Science. Plant Anal. 1977;(8):195-207.
16. AOAC Association of official analytical chemists, Official method of analysis Washington, D. C. USA; 1984.
17. AOAC Association of official analytical chemists, Official method of analysis.15th Edi. Washington D. C, USA; 1990.
18. El-Nemr MA, Abd El-Baky MMH, Salman SR, El-Tohamy WA. Effect of Different Potassium Levels on the Growth, Yield and Quality of Tomato Grown in Sand-phonic Culture. Aus J. Basic Appl. Sci. 2012;(6):779-784.
19. Subhani PM, Ravishankar C, Narayana N. Effect of graded levels and times of application of N and K_2O on flowering, fruiting and yield of irrigated Chili. J. Indian Cocoa Arec Spi. 1992(14):70-73.
20. Maynard DN. Influence of nitrogen levels on flowering and fruit set of peppers. Proceedings of American Society for Horticulture Science. 1962;(11):385-389.
21. Varis S, George T. The influence of mineral nutrition on fruit yield, seed yield and quality in tomato. J. Hortic. Sci. 1985;(60):373-376.
22. Winsor GW. Nutrition. Tomato Manual, London, UK: Grower books; 1973.

23. Ni Wuzhong. Yield and quality of fruits of Solanaceous crops as affected by potassium Fertilization. Better crops, Int. Plant Nutr. Inst. 2002;(16):6-8.
24. Medhi RP, Singh B, Parthasarathy VS. Effect of N, P and K on chilies. Progressive Hortic. 1990;(22):173-175.
25. Malik M. Horticulture. 1st ed. Pakistan, National Book Foundation; 1994.
26. Yagmur B, Okur B, Ongun. Effects on enhanced potassium doses on yield quality and nutrient uptake of Tomato. IPI regional workshop on Potassium and Fertigation development in West Asia and North Africa; Rabat, Morocco. 2004;24-28.
27. Al-Basal MA, Yasseen BT. Changes in growth variables and potassium content in leaves of Black Barley in response to Nacl. Braz J Plant Physiol. 2009;(21):4.
28. Cakmak I. The role of potassium in alleviating detrimental effects of abiotic stresses in plants. J. Plant Nutr. Soil Sci. 2005;(168):521-530.
29. El-Bassiony AM, Fawzy ZF, Abd El-Sammad EH, Riad GS. Growth, yield and fruit quality of sweet pepper plants (*Capsicum annuum L*) as affected by potassium fertilization. J. Amer. Sci. 2010;(6):12.
30. Mengel K, Kirkby E.A. Principles of plant nutrition. Int. Potash Inst., Berne, Switzerland; 1987.
31. Balibrea MA, Martinez-Andujar C, Cuartero J, Bolarin MC, Perez-Alfocea F. The high fruit soluble sugar content in wild Lycopersicon species and their hybrids with cultivars depends on sucrose import during ripening rather than on sucrose metabolism. Funct Plant Biol. 2006;(33):279-288.
32. Sofia C. Influence of potassium and genotype on vitamin E content and reducing sugar of Tomato fruit Hort. sci. 2008;(43):2048-2051.
33. Fandi M, Jalal M, Munir H. Effect of NPK Concentrations on Yield and Fruit Quality of Tomato (*Solanum lycopersicum* L.) in tuff culture. J Central Euro Agr. 2010;(11):179-184.

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