Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.3095

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (5):** 587-594 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Influence of Foliar Sprays of Different Potassium Fertilizers on Quality and Leaf Mineral Composition of Sweet Orange (*Citrus sinensis*) cv. Jaffa

R. P. S. Dalal, Vijay* and B. S. Beniwal

Department of Horticulture, CCS Haryana Agricultural University, Hisar- 125004 (Haryana), India

*Corresponding Author E-mail: shotreturns@gmail.com

Received: 6.06.2017 | Revised: 10.07.2017 | Accepted: 14.07.2017

ABSTRACT

A field study was undertaken to extrapolate the impact of foliar application of potash on physical and chemical parameters of sweet orange cv. Jaffa at experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar. The results revealed that foliar application of K_2SO_4 (2% and 3%) and Multi-K (3%) was found significantly or marginally better than other potash treatments in increasing physical parameters of sweet orange cv. Jaffa. Average fruit weight and fruit diameter were found to be significantly influenced by foliar application of K_2SO_4 (2% and 3%). Peel thickness and peel content was recorded maximum with foliar application of Multi-K (3%) which was found at par with K_2SO_4 (2% and 3%) treatment. Maximum juice (%) was recorded with KH_2PO_4 tretments which was at par with K_2SO_4 (2% and 3%) whereas minimum juice content was observed with KNO_3 (3%) foliar application. Chemical parameters were also significantly influenced with foliar K applications. Effect of K_2SO_4 and Multi-K was found somewhat more pronounced than other K treatments. Maximum T.S.S, acidity, ascorbic acid values were recorded with K_2SO_4 (3%) and Multi-K (2% and 3%) whereas minimum values were observed in control. Leaf nitrogen content was not significantly influenced by various K sprays whereas highest leaf P content was found with KH_2PO_4 at 3% and leaf K content was recorded maximum with K_2SO_4 (2% and 3%) and KNO_3 3%. The findings signify the importance of K sprays in enhancing physical and chemical parameters of sweet orange under semi-arid north-western conditions of India.

Key words: *Potash, Rates of spray, Quality parameters, Leaf nutrient content, Sweet orange.*

INTRODUCTION

Citrus fruits are grown under varying agro-climatic regions of India except hilly high regions. In India, citrus occupies second position in area next to mango and third in production next to banana and mango[1]. The cultivation of citrus is gaining momentum in north-western states of India like Punjab, Haryana and Rajasthan[2]. In Haryana, citrus ranks 1st in area with 19600 ha which is about 30% of total area under fruit crops. Given the global market requirement for quality citrus fresh fruit in context of globalization and emergence of new citrus producing countries, India is expected to review its citrus sector strategy to improve its competitiveness.

Cite this article: Dalal, R.P.S., Vijay and Beniwal, B.S., Influence of Foliar Sprays of Different Potassium Fertilizers on Quality and Leaf Mineral Composition of Sweet Orange (*Citrus sinensis*) cv. Jaffa, *Int. J. Pure App. Biosci.* **5(5):** 587-594 (2017). doi: http://dx.doi.org/10.18782/2320-7051.3095

So, to compete in the international market, more emphasis has to be given towards quality production in terms of size and chemical quality of fruit to get better price in the market. Citrus bear fruits of variable sizes and most of the fruits are undersized and are of poor quality and do not fetch better price in the market. However, there are various factors responsible for quality improvement in citrus. Out of these factors one of the most important factor is nutrition which play an important role in plant metabolism and moreover, citrus is highly responsive to nutrients. It is well known that nutrients sprayed on fruit trees for improvement of vegetative growth, flowering, correction of deficiency symptoms would invariably affect the fruit quality[3]. Potassium is one of the most important nutrients which play a key nutritional role in determining physical and chemical characteristics of citrus fruits[2]. Foliar application of potassium has been reported to influence juice content of Clementine citrus fruits[4], peel and peel thickness in Kinnow[5,6]. Foliar K sprays have been found to influence acidity[7] and ascorbic acid[6]. However, very less information is available on the response of different potassium source/form on the quality of sweet orange cv. Jaffa in present agro-climatic conditions of Haryana. So, present studies were undertaken with the objective to find the effect of potassium sources on the quality of sweet orange cv. Jaffa.

MATERIALS AND METHODS

The present investigation was carried out at experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar on 16-year-old fruit trees of sweet orange cv. Jaffa. Four sources of K (i.e. KNO_3, K_2SO_4, KH_2PO_4 and Multi-K) were used as foliar spray each at three application rate of 1,2 and 3% each. The experiment comprised of 13 treatments viz. potassium nitrate at 1% (T_1), 2% (T_2) and 3% (T_3); potassium sulphate at 1% (T_4), 2% (T_5) and 3% (T_6); monopotassium phosphate at 1%(T_7), 2% (T_8) and 3% (T_9); Multi-K at 1%(T_{10}), 2% (T_{11}) and 3% (T_{12}) applied as foliar spray on 25th May which were compared with T_{13} i.e. control (water spray). All the thirteen treatments were replicated thrice taking one plant as single unit in randomized block design. Uniform cultural practices and plant protection measures were followed for these trees throughout the study period as per package of practices[8].

Five randomly selected fruits from different positions of the tree per replication were picked and weighed on top pan electronic balance. The average fruit weight was calculated by dividing the total fruit weight by total number of fruits taken and expressed in gram (g). Diameter of five randomly selected fruits from each plant was recorded with Digital Vernier's Calipers and average value was expressed in centimeters (cm). Five randomly selected fruits were peeled manually. The peel thickness was measured with the help of Digital Vernier's Calipers at the equator of fruit and the average value was calculated and expressed in millimeter (mm). Five randomly selected fruits were peeled manually. Peel was weighed with electronic balance and percentage of peel was worked out on the basis of total weight of the fruit and weight of the peel. The percent peel content was calculated by using the formula:

$$\text{Peel content (\%)} = \frac{\text{Peel weight} \times 100}{\text{Fruit weight}}$$

The fruits were cut into equal halves and juice was extracted with simple juice extractor. The juice was weighed with electronic balance and percentage of juice was worked out on the basis of total weight of fruit and the weight of juice.

The percent juice content was calculated by using the formula:

$$\text{Juice content (\%)} = \frac{\text{Juice weight} \times 100}{\text{Fruit weight}}$$

The total soluble solids (TSS) of five randomly selected fruits was determined at room temperature by using Hand

Refractometer having a range of 0 to 32 ^{0}Brix, by placing a drop of juice and taking the readings. The Refractrometer was calibrated with distilled water with every use and the values were expressed in degree brix. The acidity and ascorbic acid was determined by the method described by AOAC [9]. Well grind sample of known weight was digested for nutrient estimation of N, P and K in leaves using diacid mixture of concentrated sulphuric acid and perchloric acid in the ratio of 4:1 as per procedure described by Jackson[10]. Nitrogen and phosphorus content of leaf was estimated by nessler's reagent method and vandomolybdo yellow colour method respectively as described by Jackson[10] and potassium by flamephotometer as described by Piper[11]. The data was analyzed in factorial RBD for evaluating the different parameters.

RESULTS AND DISCUSSION

Physical parameters: Maximum average fruit weight (187.22g) was recorded with foliar application of K_2SO_4 3% (T_6) which was found at par with T_5 (K_2SO_4 2%) whereas minimum value (164.44g) was recorded with Multi-K 1% (T_{10}) which was at par with all other potassium treatments as well as with control. Increase in fruit weight with potassium application might be due to the enhanced photosynthesis which leads to supply of more carbohydrates[12]. Another probable cause could be the greater mobility of assimilates by potassium to the developing fruits which acted as strong metabolic sink. The enhanced effect of K_2SO_4 might be because of the role of sulphur in increased carbohydrate metabolism. Josan *et al.*[3] reported similar results in lemon by foliar sprays of 10% K_2SO_4. Vijay *et al.*[2] also reported increased average fruit weight with application of K_2SO_4 3% in sweet orange cv. Jaffa. Fruit diameter was recorded highest (7.30cm) with K_2SO_4 3% i.e. T_6 which was found at par with T_5 (K_2SO_4 2%). Minimum fruit diameter (6.85cm) was observed with T_1 (KNO_3 1%) which was found at par with control and other potassium treatments. Wei *et al.*[13] and Obreza *et al.*[14] reported that foliar application of K is accompanied by an increase in citrus fruit size. The increased fruit size might be due to the role of potassium in cell wall construction[15]. Yadav *et al.*[16] also reported a significant increase in fruit diameter with three sprays of 2% K_2SO_4 in ber fruits. Best peel thickness value (0.42mm) was recorded with T_{12} (Multi-K 3%) and T_3 (KNO_3 3%) which were found at par with T_2, T_4, T_5, T_6, T_7 and T_{11}. Minimum peel thickness (0.32mm) was recorded in T_9 i.e. KH_2PO_4 3% which was at par with T_1, T_8 and control (water spray). Similar trend was observed in peel content and maximum peel content (27.99%) was observed in Multi-K 3% foliar application (T_{12}) found at par with T_3, T_5, T_6. Minimum peel content (22.57%) was recorded with T_9 i.e. KH_2PO_4 3% effect of which was at par with that of T_{10} (Multi-K 1%). The increased peel content might be due to the role of potassium in enhancing cell wall construction[15]. The increase in peel content is due to increased peel thickness as evident from present investigation. The increase in peel content and peel thickness was also recorded by Gill *et al.*[7] and reported maximum peel thickness with 2% Multi-K foliar application in Kinnow mandarin. Sangwan *et al.*[6] in Kinnow mandarin, reported increased peel thickness and peel content with foliar application of KNO_3 @ 2% sprayed thrice. Likewise, Rattanpal *et al.*[5] obtained maximum peel content in Kinnow fruits with KNO_3 @ 5% sprayed 60 days after full bloom. Kumar and Kumar[17] also observed similar results with foliar application of K_2SO_4@ 1.5% in banana. Maximum juice content (39.09 %) was recorded in T_9 i.e. KH_2PO_4 3% which was at par with T_1, T_5, T_6, T_7, T_8 and control (water spray) whereas minimum juice content (36.67%) was observed with KNO_3 3% (T_3) foliar application found at par with T_2, T_4, T_{10}, T_{11} and T_{12}. Higher juice content in control (water spray) against K treatments might be because of the role of potassium in increasing peel proportion of fruits. The decrease in juice content with foliar application of potash fertilizers was reported by Rattanpal *et al.*[5] in Kinnow. These observations are supported by earlier findings of Cicala and Catara[18] in 'Torocco' orange and by Sangwan *et al.*[6] in Kinnow mandarin.

Table 1: Effect of foliar application of potash fertilizers on physical quality of sweet orange cv. Jaffa

Treatments	Average Fruit wt. (g)	Fruit diameter (cm)	Peel thickness (mm)	Peel content (%)	Juice (%)
T_1: KNO_3 (1%)	168.22	6.85	0.36	25.21	38.52
T_2: KNO_3 (2%)	171.67	6.86	0.39	26.11	37.75
T_3: KNO_3 (3%)	173.69	6.97	0.42	27.73	36.67
T_4: K_2SO_4 (1%)	173.33	6.95	0.38	25.32	37.57
T_5: K_2SO_4 (2%)	186.11	7.25	0.41	26.95	38.44
T_6: K_2SO_4 (3%)	187.22	7.30	0.41	26.35	38.19
T_7: KH_2PO_4 (1%)	170.56	6.94	0.39	25.95	38.00
T_8: KH_2PO_4 (2%)	170.00	7.05	0.34	24.73	38.73
T_9: KH_2PO_4 (3%)	176.67	7.00	0.32	22.57	39.09
T_{10}: Multi-K (1%)	164.44	6.91	0.37	23.28	37.74
T_{11}: Multi-K (2%)	174.44	6.98	0.38	25.35	37.39
T_{12}: Multi-K (3%)	176.11	7.03	0.42	27.99	36.74
T_{13}: Control	168.22	6.88	0.36	24.86	38.34
CD at 5%	8.86	0.22	0.04	1.87	1.27

Chemical parameters: chemical parameters i.e. TSS, acidity and ascorbic acid were significantly influenced by various potash treatments. Maximum TSS (8.90 ˚Brix) was recorded with foliar treatment of K_2SO_4 (3%) i.e. T_6 which was found at par with T_3, T_5, T_{11} and T_{12}. Minimum TSS (8.40 ˚Brix) was observed with KH_2PO_4 (1%) treatment (T_7) effect of which was at par with that of T_1, T_2, T_4, T_8, T_9, T_{10} and T_{13} (control). The increase in TSS content with foliar application of K is related with role of potassium in the synthesis of more carbohydrates and its translocation from leaves to fruits[19]. Similar results have also been observed by Josan *et al.*[3] in lemon with foliar spray of 10% K_2SO_4, Bar-Akiva[20] in Valencia orange and Ahmed *et al.*[21] in Balady lime also reported similar results. Boman[22] reported that trees receiving KNO_3 application, sprayed thrice in February, April and in summer (July/August) had 25% higher TSS than the control treatment in Valencia orange fruits. Likewise, Hamza *et al.* ([4]) observed that TSS increased as the K concentration (5 and 8% KNO_3 and 2.5 and 4% K_2SO_4) or number of sprays increased and best results were obtained with three potassium sprays as compared to two potassium sprays. Similarly, Gill *et al.*[23] showed highest TSS with three foliar application of K_2SO_4 @ 2% in Patharnakh pear. Maximum acidity (0.74%) was recorded with K_2SO_4 3% and KH_2PO_4 3% (T_6 and T_9 respectively) which was found at par with T_2, T_7 and T_{12} whereas minimum acidity was observed with KNO_3 1% foliar application (T_1) which was found at par with T_{11} and control (water spray). The increased acidity by K application may be due to synthesis of more organic acids. Abd-Allah[24] reported that acidity percentage in the fruit juice was significantly increased by K_2HPO_4 treatment in Washington Navel orange. Josan *et al.*[3] recorded maximum acid content with 6 and 8% K_2SO_4 foliar application in lemon. Similar findings were reported earlier in different fruits by various workers viz, Koo and Mcornack[25] in Dancy tangerine; Dube and Ram[26] in pear; Bar-Akiva[20] in Valencia orange and Ahmed *et al.*[21] in Balady lime. Maximum ascorbic acid (59.72 mg/100 ml of juice) was recorded with KNO_3 1% (T_1) and K_2SO_4 3% (T_6) which was at par with T_2, T_3, T_4, T_7, T_8, T_{11} and T_{12}. Minimum ascorbic acid (56.02 mg/100 ml of juice) was observed in control (water spray). Increased ascorbic acid with foliar application of potassium might be related with improved sugar metabolism[27]. Another probable reason might be the role of potassium in activating the synthesis of ascorbic acid somewhere between D-Glucose to L-Ascorbate[12]. Similar findings have also been observed by Sangwan *et al.*[6]. They found maximum ascorbic acid with KNO_3 @ 2% in Kinnow mandarin. Similar results have been earlier reported by Josan *et al.*[3] in lemon and Sarrwy *et al.*[28] in Balady mandarin.

Table 2: Effect of foliar application of potash fertilizers on chemical quality of sweet orange cv. Jaffa

Treatments	TSS (%)	Acidity (%)	Ascorbic acid (mg/100ml of juice)
T_1: KNO_3 (1%)	8.47	0.61	59.72
T_2: KNO_3 (2%)	8.60	0.69	58.78
T_3: KNO_3 (3%)	8.80	0.68	58.56
T_4: K_2SO_4 (1%)	8.53	0.67	58.56
T_5: K_2SO_4 (2%)	8.70	0.67	56.33
T_6: K_2SO_4 (3%)	8.90	0.74	59.72
T_7: KH_2PO_4 (1%)	8.40	0.69	58.69
T_8: KH_2PO_4 (2%)	8.60	0.70	57.57
T_9: KH_2PO_4 (3%)	8.52	0.74	56.87
T_{10}: Multi-K (1%)	8.50	0.67	56.66
T_{11}: Multi-K (2%)	8.70	0.65	58.25
T_{12}: Multi-K (3%)	8.80	0.70	58.57
T_{13}: Control	8.50	0.65	56.02
CD at 5%	0.22	0.05	2.69

Effect on leaf nutrient content: leaf nitrogen content was not affected significantly by various potash foliar treatments however mathematically maximum leaf nitrogen (2.51%) was found with KNO_3 3% treatment. Phosphorus content of leaf was influenced significantly by various potassium sprays and maximum P content (0.14%) was recorded in T_9 i.e. KH_2PO_4 (3%) which was found at par with T_3 (KNO_3 3%) and T_5 (K_2SO_4 2%). Minimum P content (0.09%) was observed with foliar application of Multi-K 1% (T_{10}). Sarrwy *et al.*[28] reported KH_2PO_4 and KNO_3 foliar sprays increased leaf P content in 'Balady' mandarin fruits. The obtained results are in agreement with those reported by Mostafa and Saleh[29] and Mostafa *et al.*[30]. Maximum leaf K (1.37%) was recorded in T_3 (KNO_3 3%), T_5 (K_2SO_4 2%) and T_6 (K_2SO_4 3%) whereas minimum K content (1.17%) was observed in control i.e. water spray. Leaf potassium content increased significantly with all potassium treatments and there was an increase in leaf potassium content with an increase in K doses. These results are in accordance with the findings of Mostafa *et al.*[30] and Mostafa and Saleh[29]. They concluded that spraying KNO_3 raised K level in leaves of Balady mandarin. Also, Calvert [31], El-Darier[32] and Boman[33] suggested that spraying either KNO_3 or K_2SO_4 is more effective in raising K content of leaves in Balady mandarin. In Balady mandarin, Sarrwy *et al.*[28] reported highest value (1.73%) of leaf K content with KNO_3 @ 1.5% spray.

Table 3: Effect of foliar application of potash fertilizers on leaf nutrient content in sweet orange cv. Jaffa

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1: KNO_3 (1%)	2.45	0.11	1.29
T_2: KNO_3 (2%)	2.48	0.11	1.36
T_3: KNO_3 (3%)	2.51	0.12	1.37
T_4: K_2SO_4 (1%)	2.42	0.11	1.28
T_5: K_2SO_4 (2%)	2.39	0.12	1.37
T_6: K_2SO_4 (3%)	2.42	0.11	1.37
T_7: KH_2PO_4 (1%)	2.39	0.11	1.22
T_8: KH_2PO_4 (2%)	2.37	0.13	1.29
T_9: KH_2PO_4 (3%)	2.45	0.14	1.32
T_{10}: Multi-K (1%)	2.42	0.09	1.29
T_{11}: Multi-K (2%)	2.48	0.11	1.32
T_{12}: Multi-K (3%)	2.45	0.11	1.36
T_{13}: Control	2.42	0.11	1.17
CD at 5%	NS	0.02	0.09

CONCLUSION

Enrichment in quality parameters of citrus fruits is of prime importance for nutritional security, longevity of the fruit and premium marketing. The present study indicates that foliar application of K_2SO_4 @ 2% and 3% in last week of May enhanced the physical and chemical quality of sweet orange. These treatments increased the average fruit weight, peel thickness, peel content, juice (%), TSS, acidity and ascorbic acid. The study also reflects the significant effect of foliar application of potash on leaf nutrient content. Highest leaf P content was found with KH_2PO_4 3% and leaf K content was recorded maximum with K_2SO_4 (2% and 3%) and KNO_3 3%.

REFERENCES

1. NHB database. http//www.nhb.gov.in (2016).
2. Vijay, Dalal R.P.S., Beniwal B.S. and Hemant Saini, Impact of foliar application of potassium and its spray schedules on yield and quality of sweet orange (*Citrus sinensis*) cv. Jaffa. *Journal of Applied and Natural Science*, **8(4):** 1893-1898 (2016).
3. Josan, J.S., Sandhu, A.S., Singh, R. and Monga, P.K., Effect of various nutrient sprays on fruit quality of lemon. *Indian Journal of Horticulture*, **52:** 288-290 (1995).
4. Hamza, A., Bamouh, A., Guilli, M.El. and Bouabid, R., Response of Clementine citrus var. *Cadoux* to foliar potassium fertilization; Effects on fruit production and quality. *e-ifc* No. 31, pp:8-15 (2012).
5. Rattanpal, H.S., Rani, Shobha, Kumar, A. and Dhaliwal, H.S., Effect of potassium and 2,4-D sprays on physical parameters of Kinnow fruits. *Haryana J. Hortic. Sci.*, **34(3-4):** 222-223 (2005).
6. Sangwan, A.K., Rattanpal, H.S., Arora, N.K. and Dalal, R.S., Effect of foliar application of potassium on fruit yield and quality of Kinnow mandarin. *Environment and Ecology*, **26(4C):** 2315-2318 (2008).
7. Gill, P.S., Singh, S.N. and Dhatt, A.S., Effect of foliar application of K and N fertilizers on fruit quality of kinnow mandarin. *Indian Journal of Horticulture.* **62:** 282-284 (2005).
8. Anonymous, Package of Practices for Horticultural Crops and Products. Directorate of Publications, Haryana Agric. Univ., Hisar, India (2013).

9. AOAC. *Official methods of analysis.* Association of Analytical Chemists, 15th Ed., Washington, D.C. (2000).
10. Jackson, M.L., Soil chemical analysis. Prentice Hall of India, New Delhi. (1967).
11. Piper, C.S., Soil and Plant Analysis. Hans Publications, Bombay. pp:368 (1966).
12. Harold, J.E. and George, J.S., Role of mineral elements with emphasis on the univalent cations. *Ann. Pl. Physiol.*, **11:** 47-76 (1966).
13. Wei, L.J., Fang, C., Dongbi, L., Yun Fan, W., Chang Bing, Y. and Hua, W.Y., Effect of application of potassium sulphate and potassium chloride on growth of citrus tree, yield and quality of fruits. *Soil and Fertilizers Beijing*, **4:** 34 (2002).
14. Obreza, T.A., Morgan, K.T., Albrigo, L.G. and Boman, B.J., Recommended fertilizer rates and timing. In: nutrition of Florida citrus trees. Second edition edited by Thomas A. Obreza and Kelly T. Morgan (2008).
15. Boman, B.J. and Hebb, J.W., Post bloom and summer foliar K effects on grapefruit size. *Proc. Fla. State Hort. Soc.*, **111:** 128-135 (1998).
16. Yadav, D., Singh, S.P. and Singh, S., Effect of foliar application of potassium compounds on yield and quality of ber (*Zizyphus mauritiana)* cv. Banarasi Karaka. *International Journal of Research in Applied, natural and social sciences,* **2:** 89-92 (2014).
17. Kumar, A.R. and Kumar, N., Sulphate of potash spray effects on yield, quality and post harvest life of banana. *Better crops*, **91:** 22-24 (2007).
18. Cicata, A. and Catara, V., Potassium fertilization effects on yield, fruit quality and mineral composition of 'Torocco' orange trees. *Proc. Int. Soc. Citric.*, **2:** 618-620 (1994).
19. Havlin, J.L., Tisdale, S.L., Beaton, J.D. and Nelson, W.L., Soil Fertility and Fertilizers. An Introduction to Nutrient Management (7th Edn.), Dorling Kindersley Pvt. Ltd., India, pp. 196-216 (2007).
20. Bar-Akiva, A., Effect of potassium nutrition on fruit splitting in Valencia orange. *J. Hort. Sci.*, **50:** 85-89 (1975).
21. Ahmed, F.F., El-Sayed, M.A. and Matouta, M.A., Effect of N, K and P fertilization on yield and quality of Egyptian Balady lime trees. *Ann. Agric. Sci.*, **33:** 1249-1268 (1988).
22. Boman, B.J., Foliar nutrient sprays influence yield and size of 'Valencia' orange. *Proc. Fla. State Hort. Soc.*, **114:** 83-88 (2001).
23. Gill, P.P.S., Ganaie, M.Y., Dhillon, W.S. and Singh, N.P., Effect of foliar sprays of potassium on fruit size and quality of 'Patharnakh' pear. *Indian Journal of Horticulture,* **69(4):** 512-516 (2012).
24. Abd-Allah, A.S.E., Effect of spraying some macro and micro nutrients on fruit set, yield and fruit quality of Washington Navel orange trees. *Journal of Applied Sciences Research*, **2(11):** 1059-1063 (2006).
25. Koo, R.C.J. and Mcornack, A.A., Effect of irrigation and fertilization on production and quality of Dancy tangerine. *Proc. Fla. St. Hort. Soc.*, **78:** 10-15 (1965).
26. Dube, S.B. and Ram, C.B., Control of fruit cracking in pear. *Curr. Sci.*, **39(9):** 446-447 (1970).
27. Mengal, K., Impact of potassium on crop yield and quality with regard to economical and ecological aspect. Proc. Reg. Workshop, Int. Potash. Inst., Izmir, Turkey. (1997).
28. Sarrwy, S.M.A., El-Sheikh, M.H., Sanna Kabeil, S. and Shamseldin, A., Effect of foliar application of different potassium forms supported by zinc on leaf mineral contents, yield and fruit quality of "Balady" mandarin trees. *Middle-East Journal of Scientific Research,* **12(4):** 490-498 (2012).
29. Mostafa, E.A.M. and Saleh, M.M.S., Response of Balady mandarin trees to girdling and potassium sprays under sandy soil conditions. *Res. J. Agric. and Biol. Sci.*, **2(3):** 137-141 (2006).

30. Mostafa, E.A.M., Hassan, H.S.A. and Sabag, A.S., Influence of spraying GA_3 and KNO_3 on yield, fruit quality and leaf mineral contents of Balady mandarin trees. *Minufiya J. Agric. Res.*, **30(1):** 283-295 (2005).
31. Calvert, D.V., Spray applications of potassium nitrate for citrus on calcareous soils. Proc. 1st Int'l Citrus Symposium, **3:** 1587-1597 (1969).
32. El-Darier, S.M., Mineral composition in the ecosystem of fruit trees in Egypt, *Citrus reticulata*, Blanco and *Citrus aurantium* L. *J. Islamic Academy of Sci.*, **4(3):** 211-220 (1991).
33. Boman, B.J., Effectiveness of fall potassium sprays on enhancing grapefruit size. *Proc. Fla. State Hort. Soc.*, **110:** 1-7 (1997).