Environment & Ecology 35 (1) : 134—138, January—March 2017
Website: environmentandecology.com ISSN 0970-0420

Differential Response of Potassium and its Spray Schedule on Quality Parameters of Sweet Orange (*Citrus sinensis*) cv Jaffa under Semi-Arid Conditions of North Western India

Vijay, R. P. S. Dalal, Hemant Saini

Received 22 March 2016; Accepted 25 April 2016; Published online 12 May 2016

Abstract A field study was undertaken to investigate the impact of foliar application of potash and its spray schedule on quality parameters of sweet orange cv Jaffa during the year 2014-15. The results revealed that foliar application of KNO_3 (at the rate of 2 and 4%) and K_2SO_4 (at 1.5 and 3.0%) exhibited differential response on the quality parameters of sweet orange cv Jaffa. All the treatments of potash increased total soluble solids (TSS), total sugar, non-reducing sugar and reducing sugar over control (water spray) irrespective of harvesting stage. Maximum value of the quality parameters was recorded with K_2SO_4 at the rate of 3% and minimum with control. The quality of all the parameters was found to be improved with the increase in duration after the last spray. Maximum TSS, total sugar, non-reducing sugar and reducing sugar was recorded in the fruit harvested at 45 days after the last spray and minimum when the fruit was harvested at 15 days after the last spray irrespective of treatments. Maximum value of these parameters was observed with the foliar application of K_2SO_4 at 3% recorded at the harvesting stage of 45 days after the last spray. Three sprays of K_2SO_4 at the concentration of 3% done in the last week of April, May and August resulted in maximum improvement in quality parameters.

Keywords Potash, Foliar application, Spray schedule, Quality parameters, Harvesting stage.

Vijay*, R. P. S. Dalal, H. Saini
Department of Horticulture,
CCS Haryana Agricultural University,
Hisar 125004, India
e-mail : shotreturns@gmail.com
*Correspondence

Introduction

Citrus is an important fruit crop grown in India.l The cultivation of citrus in North-Western states of India has consistently increased due to its high productivity under various agro-climatic conditions. Application of K particularly at anthesis and fruiting stage had been found to enhance the quality and yield of citrus [1].

Foliar application of K is related with increased

Table 1. Effect of foliar application of potassium, spray schedule and harvesting stages on TSS of sweet orange cv Jaffa.

1a. Harvesting stage × Treatment

Treatment	KNO_3 2%	KNO_3 4%	K_2SO_4 1.5%	K_2SO_4 3%	Control (water spray)	Mean
Harvesting stage						
D_1: 15	7.89	8.38	8.23	8.46	7.56	8.10
D_2: 30	8.26	8.71	8.27	8.66	7.86	8.35
D_3: 45	8.52	8.68	8.88	8.97	8.11	8.63
Mean	8.22	8.59	8.46	8.70	7.84	
CD (p=0.05)	Treatment (T)–0.09		Harvesting stage (H)–0.07		T×H–0.16	

1b: Harvesting stage × Spray schedule

Harvesting stage	Spray schedule S_1	S_2	S_3	Mean
D_1: 15	7.89	8.11	8.31	8.10
D_2: 30	8.16	8.39	8.49	8.35
D_3: 45	8.45	8.58	8.87	8.63
Mean	8.16	8.36	8.56	
CD (p=0.05)	Harvesting stage (H)–0.07	Spray schedule (S)–0.07	H × S–NS	

1c: Treatment × Spray schedule

Treatment	Spray schedule S_1	S_2	S_3	Mean
T_1: KNO_3 2%	7.85	8.31	8.51	8.22
T_2: KNO_3 4%	8.55	8.49	8.72	8.59
T_3: K_2SO_4 1.5%	8.15	8.45	8.77	8.46
T_4: K_2SO_4 3%	8.44	8.70	8.94	8.69
T_5: Control (water spray)	7.83	7.86	7.83	7.84
Mean	8.16	8.36	8.55	
CD (p=0.05)	Treatment (T)–0.09	Spray schedule (S)–0.07	T × S–0.16	

Table 2. Effect of foliar application of potassium, spray schedule and harvesting stages on total sugar of sweet orange cv Jaffa.

2a. Harvesting stage × Treatment

Treatment	KNO_3 2%	KNO_3 4%	K_2SO_4 1.5%	K_2SO_4 3%	Control (water spray)	Mean
Harvesting stage						
D_1: 15	6.42	6.77	6.52	6.71	6.05	6.50
D_2: 30	6.59	6.78	6.61	6.92	5.93	6.57
D_3: 45	6.84	6.94	7.09	7.17	6.50	6.91
Mean	6.62	6.83	6.74	6.93	6.16	
CD (p=0.05)	Treatment (T)–0.07		Harvesting stage (H)–0.05		T×H–0.12	

2b: Harvesting stage × Spray schedule

Harvesting stage	Spray schedule S_1	S_2	S_3	Mean
D_1: 15	6.37	6.44	6.68	6.50
D_2: 30	6.41	6.61	6.68	6.57
D_3: 45	6.76	6.87	7.09	6.91
Mean	6.51	6.64	6.81	
CD (p=0.05)	Harvesting stage (H)–0.05	Spray schedule (S)–0.05	H × S–NS	

2c: Treatment × Spray schedule

Treatment	Spray schedule S_1	S_2	S_3	Mean
T_1: KNO_3 2%	6.40	6.65	6.81	6.62
T_2: KNO_3 4%	6.72	6.78	6.99	6.83
T_3: K_2SO_4 1.5%	6.52	6.69	7.01	6.74
T_4: K_2SO_4 3%	6.74	6.93	7.12	6.93
T_5: Control (water spray)	6.19	6.16	6.13	6.16
Mean	6.51	6.64	6.81	
CD (p=0.05)	Treatment (T)–0.07	Spray schedule (S)–0.05	T × S–0.12	

translocation of sugars from leaves to fruits [2]. Its impact on yield and quality parameters has been studied by different workers in various crops such as guava [3], banana [4], mango [5], pear [6], kokum [7] and kinnow mandarin [8]. The studies on the influence of foliar application of different sources of K and its schedule on quality aspects in sweet orange are hardly traceable. The present investigation was, thus, undertaken to evaluate the impact of foliar application of potassium and timing of its application on quality parameters in sweet orange cv Jaffa under agro-climatic conditions of western Haryana.

Materials and Methods

The present investigation was conducted at experimental orchard of Department of Horticulture, CCS

Haryana Agricultural University, Hisar (Haryana) during the year 2014-15. Forty five sweet orange cv Jaffa trees having uniform size and plant vigor were selected for investigation. The experiment comprised of four treatments of K fertilizers and its rate of application viz. potassium nitrate at 2 (T_1) and 4% (T_2), potassium sulfate at 1.5% (T_3) and 3.0% (T_4) which were compared with T_5 i.e. control (water spray). There were three spray schedules i.e. S_1 (two sprays in the last week of April and August), S_2 (two sprays in the last week of May and August) and S_3 (three sprays in the last week of April, May and August). All the fifteen treatments were replicated three times taking one plant as a single unit in randomized block design (RBD). Uniform cultural practices and plant protection measures were followed for these trees throughout the study period as per package of practices [9].

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, 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. Sugars were analysed by using standard method of sugar estimation [10]. For analyzing the reducing sugars, 5 ml of diluted juice was taken in a test tube and 5 ml of potassium ferricyanide solution was added to it. The tubes were covered with aluminium foil and kept for 15 minutes in boiling water bath. After cooling under water tap, 5 ml of potassium iodide solution followed by 3 ml of acetic acid solution were added in each test tube. The liberated iodine was titrated with sodium thiosulfate solution (0.01N) using starch as an indicator. The end point was the disappearance of blue color and the appearance of milky white color. A blank was also run simultaneously. The results were calculated by using the following formula and expressed in per cent:

mg of sugars/5 ml of diluted juice (X) = [(ml of sodium thiosulfate used in blank–ml of sodium thiosulfate used for sample) + 0.05] × 0.338.

$$\text{Reducing sugars (\%)} = \frac{\text{'X'} \times \text{dilution factor}}{\text{ml of sample} \times 1000} \times 100$$

To determine total sugars, 10 ml of diluted juice was taken in test tube and 2 ml concentrated HCl was added and kept for 15 minutes in water bath at 68°C temperature. Acidity was neutralized by adding anhydrous sodium carbonate till the effervescence stopped. After this, the volume was made to 25 ml and total sugars were then determined as per procedure described in reducing sugars. The non-reducing sugar was determined by subtracting the value of

Table 3. Effect of foliar application of potassium, spray schedule and harvesting stages on non-reducing sugar of sweet orange cv Jaffa.

3a. Harvesting stage × Treatment

Treatment	KNO_3 2%	KNO_3 4%	K_2SO_4 1.5%	K_2SO_4 3%	Control (water spray)	Mean
Harvesting stage						
D_1: 15	3.80	4.04	3.91	4.02	3.62	3.88
D_2: 30	3.92	4.02	3.90	4.12	3.55	3.90
D_3: 45	4.03	4.11	4.15	4.25	3.87	4.08
Mean	3.92	4.06	3.99	4.13	3.68	
CD (p=0.05)	Treatment (T)–0.05		Harvesting stage (H)–0.04		T×H–0.08	

3b: Harvesting stage × Spray schedule

Harvesting stage	Spray schedule S_1	S_2	S_3	Mean
D_1: 15	3.79	3.86	3.99	3.88
D_2: 30	3.83	3.92	3.96	3.90
D_3: 45	3.96	4.06	4.22	4.08
Mean	3.86	3.95	4.06	
CD (p=0.05)	Harvesting stage (H)–0.04		Spray schedule (S)–0.04	H × S–0.06		

3c: Treatment × Spray schedule

Treatment	Spray schedule S_1	S_2	S_3	Mean
T_1: KNO_3 2%	3.81	3.93	4.01	3.92
T_2: KNO_3 4%	3.97	4.02	4.18	4.06
T_3: K_2SO_4 1.5%	3.84	3.97	4.16	3.99
T_4: K_2SO_4 3%	3.97	4.14	4.27	4.13
T_5: Control (water spray)	3.69	3.68	3.66	3.68
Mean	3.86	3.95	4.06	
CD (p=0.05)	Treatment (T)–0.05		Spray schedule (S)–0.04	T × S–0.08		

reducing sugar from the estimated total sugar for each sample.

Results and Discussion

Total soluble solids increased significantly with all potassium treatments over control which also differed significantly among each other and there was an increase in TSS with the increase in doses of KNO_3 and K_2SO_4, irrespective of spray schedule (Table 1a, 1b and 1c). The perusal of data reveal that maximum TSS (8.70°brix) was recorded with K_2SO_4 @ 3%, whereas, minimum value (7.84°brix) with control. All the spray schedules increased the TSS content and maximum TSS (8.56°brix) was recorded with three sprays of potassium in the last week of April, May and August, whereas, minimum TSS (8.16°brix) was found with two spray of potassium in the last week of April and August. TSS content was significantly influenced by harvesting stages. TSS content increased significantly with every increase in the harvesting interval. This shows that fruits are approaching towards maturity and ripening. Maximum TSS (8.63°brix) was recorded in fruits harvested at 45 days after last spray and minimum value (8.10°brix) at 15 days after last spray. The interactive effect of treatments and harvesting stages was also found significant and maximum TSS (8.97°brix) was recorded with K_2SO_4 @ 3% at 45 days after last spray. This further reveals that K foliar spray advances the maturity by increasing the quality parameter at early stage. 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 [2]. Increase in TSS with the increase in K concentration or number of K spray from two to three in fruit plants has also been reported by other workers [6], [8], [11].

All the potassium treatments increased significantly total sugar, reducing sugar and non-reducing sugar content over control (Table 2a, 2b and 2c) and which also differed significantly among each other and there was an increase in sugar content with an increase in K doses of KNO_3 and K_2SO_4, irrespective of spray schedule. Maximum total sugar (6.93%), non-reducing sugar (4.13%) and reducing sugar (2.80%) were recorded with K_2SO_4 @ 3% and minimum value

Table 4. Effect of foliar application of potassium, spray schedule and harvesting stages on reducing sugar of sweet orange cv Jaffa.

4a. Harvesting stage × Treatment

Treatment	KNO_3 2%	KNO_3 4%	K_2SO_4 1.5%	K_2SO_4 3%	Control (water spray)	Mean
Harvesting stage						
D_1: 15	2.62	2.73	2.61	2.69	2.44	2.62
D_2: 30	2.67	2.76	2.70	2.81	2.39	2.67
D_3: 45	2.81	2.83	2.94	2.92	2.70	2.84
Mean	2.70	2.77	2.75	2.80	2.48	
CD (p=0.05)	Treatment (T)–0.04		Harvesting stage (H)–0.03		T × H–0.07	

4b: Harvesting stage × Spray schedule

Harvesting stage	Spray schedule S_1	S_2	S_3	Mean
D_1: 15	2.58	2.58	2.69	2.62
D_2: 30	2.59	2.69	2.72	2.67
D_3: 45	2.82	2.81	2.88	2.84
Mean	2.66	2.69	2.76	
CD (p=0.05)	Harvesting stage (H)–0.03		Spray schedule (S)–0.03	H × S–0.05

4c: Treatment × Spray schedule

Treatment	Spray schedule S_1	S_2	S_3	Mean
T_1: KNO_3 2%	2.59	2.72	2.80	2.70
T_2: KNO_3 4%	2.75	2.76	2.81	2.77
T_3: K_2SO_4 1.5%	2.68	2.72	2.85	2.75
T_4: K_2SO_4 3%	2.77	2.79	2.85	2.80
T_5: Control (water spray)	2.50	2.48	2.47	2.48
Mean	2.66	2.69	2.76	
CD (p=0.05)	Treatment (T)–0.04		Spray schedule (S)–0.03	T × S–0.11

with control. Sugar content differed significantly among the spray schedule)Tables 3 and 4). However, there was an increase in sugar content with the increased frequency of potassium sprays and spray in the later stages (May and August, and April, May and August) as compared to earlier stages (April and August). This reflects that K foliar application during May and August; and April, May and August ad-

vances the maturity by increasing the quality parameters in fruit and the effect of K_2SO_4 was some what more pronounced. Maximum total sugar (6.81%), non-reducing sugar (4.06%) and reducing sugar (2.76%) were recorded with three sprays of potassium in the last week of April, May and August. Harvesting stages significantly influenced the sugar content and maximum sugar content was recorded at 45 days after last spray, whereas, minimum value was recorded at 15 days after last spray. Interactive effect of treatments and harvesting stages significantly influenced sugar content. Maximum total sugar (7.17%) and non-reducing sugar (4.25%) was with K_2SO_4 @ 3% recorded at 45 days after last spray, whereas, reducing sugar was found maximum (2.94%) with K_2SO_4 @ 1.5% recorded at 45 days after last spray which was at par with K_2SO_4 @ 3% recorded at 45 days after last spray. Higher sugar content can be explained by the role of K in translocation of sugars from leaves to fruits [2], [8]. These results are in accordance with the earlier findings in guava [3], in banana [4], in mango [5] and in pear [6]. In contrast, sugar content of juice did not vary significantly with K treatments. However, maximum total and reducing sugar increased with all the potassium treatments in Kinnow mandarin [12].

From the present study it can be inferred that foliar application of K_2SO_4 at the rate of 3% done in the last week of April, May and August was found superior to K_2SO_4 at lower dose (1.5%) and KNO_3 at both the doses (2 and 4%) in combination with two spray (either in the last week of April and August or May and August) or three sprays in improving total soluble solids, total sugar, non-reducing sugar and reducing sugar. All the quality parameters improved with the increase in duration of fruit harvesting after the last spray done in the last week of August which was the highest in the fruits harvested at 45 days than when harvested at 15 or 30 days after the last spray irrespective of K treatments or spray schedule. However, these value were the highest with the foliar application of K_2SO_4 at 3%.

References

1. Alva AK, Mattos DJ, Paramasivam S, Patil B, Dou H, Sajwan KS (2006) Potassium management for optimizing citrus production and quality. Int J Fruit Sci 6 : 3—43.
2. Havlin JL, Tisdale SL, Beaton JD, Nelson WL (2007) Soil fertility and fertilizers. An introduction to nutrient management. 7th edn. Dorling Kindersley Pvt Ltd, India, pp 196—216.
3. Dutta P (2004) A short note on foliar potassium spray in improving the quality of Sardar guava (*Psidium guajava* L.). Orissa J Hort 32 : 103—104.
4. Kumar AR, Kumar N (2007) Sulfate of potash spray effects on yield, quality and post harvest life of banana. Better crops 91 : 22—24.
5. Dutta P, Ahmed B, Kundu S (2011) Effect of different sources of potassium on yield, quality and leaf mineral content of mango in West Bengal. Better Crops-South Asia, pp 16—18.
6. Gill PPS, Ganaie MY, Dhillon WS, Singh NP (2012) Effect of foliar sprays of potassium on fruit size and quality of 'Patharnakh' pear. Ind J Hort 69 : 512—516.
7. Haldankar PM, Somavanshi AV, Rangwala AD, Khandekar RG, Burondkar MM (2012) Effect of post flowering foliar sprays of nutrients for accelerating harvesting of kokum (*Garcinia indica*). Ind J Hort 69 : 55—59.
8. Siddappa M, Patil DR, Madawal SL, Sridhar (2015) Effect of chemicals/growth regulators on kinnow mandarin. Environ Ecol 33 : 1693—1697.
9. Anonymous (2013) Package of practices for horticultural crops and products. Direct Publ, Haryana Agric Univ, Hisar, India.
10. Hulme AC, Narain R (1931) The ferricyanide method for the determination of reducing sugars. A modification of Hafedom-Jenson-Hanes technique. Biochem J 25 : 1051—1061.
11. Hamza A, Bamouh A, Guilli MEI, Bouabid R (2012) Response of Clementine citrus var *Cadoux* to foliar potassium fertilization; effects on fruit production and quality. e-ifc No. 31, pp 8—15.
12. Sangwan AK, Rattanpal HS, Arora NK, Dalal RS (2008) Effect of foliar application of potassium on fruit yield and quality of Kinnow mandarin. Environ Ecol 26 : 2315—2318.