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Effect of foliar application potassium forms, micronutrients and its combination on quality attributes of sweet orange (*Citrus sinensis* L Osbeck)

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Abstract
As investigation on Effect of foliar potassium forms, micronutrients and its combination on quality attributes of sweet orange (C*itrus sinensis* L Osbeck) was undertaken to study the effect of nutrients chemical properties on quality parameters of sweet orange at Horticulture Research Scheme (Pomology), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the year 2016-17 to 2017-18. The experiment was laid out on well-established orchard at spacing of 6 x 6 m on Rangpur lime root stock in factorial randomised block design. The potassium form applied in the form of potassium nitrate @ 1%, mono potassium phosphate @ 1.5% and potassium sulphate @ 1% and micronutrient like chelated zinc @ 0.5% and ferrous @ 0.4%.
With respect of micronutrients foliar application of chelated zinc 0.5% recorded significantly maximum highest reducing sugar, total sugars percentage, ascorbic acid (mg/100ml) and minimum acidity during the two years and pooled analysis. With respect to potassium forms, foliar application of potassium sulphate 1% recorded significantly highest total soluble solids, reducing sugar, total sugar percentage, ascorbic acid (mg/100ml), firmness (kg/cm^2) and minimum acidity. Foliar application of chealted zinc 0.5% + mono potatssium phosphate 1.5% (N_1K_2) recorded significantly highest values in chemicals parameters and lowest values observed in N_2K_3.

Keywords: Foliar application, potassium forms, micronutrients, quality attributes, sweet orange (*Citrus sinensis* L Osbeck)

Introduction

Sweet orange (*Citrus sinensis*, Osobeck) is a small tree in the Rutaceae family and native in southern China, where it has been cultivated for long periods. Nutrition has become a key management practice for growers to achieve maximum fruit size in their orchards. In relation to fruit size there are major and minor nutrients which all play important roles and interact with each other. Earlier studies on K nutrient management in citrus warrants the need of potassium is important in sweet orange crops. Sweet orange fruits remove more amounts of potassium compared with other nutrients. Increasing potassium in the tree from deficient to optimum concentration increases juice content, total soluble solids (TSS), reducing sugar, total sugar, acidity, ascorbic acid Sufficient potassium reduces incidence of fruit splitting, creasing, fruit plugging and stem-end rot of fruit in storage (Dalal *et al*.,2017) [4].

Foliar spray application of K has been demonstrated to influence physical and chemical characteristics of sweet orange fruits. Application of potassium nitrate or mono-potassium phosphate can be very effective and rapid to correct K deficiency in sweet orange on calcareous soil. Foliar application of potassium nitrate (KNO_3) increased leaf K more rapidly compared with soil-applied fertilizers because plant uptake was much faster, but the positive effect was shorter-lasting.

Micronutrient play significant role in fruit developments. Small amount of micronutrient is required as compared to those of primary nutrients, but these are equally important for plant metabolism. Growth of citrus also influenced by micronutrient such as Zinc (Zn), Iron (Fe), Boron (B), Manganese (Mn) and Copper (Cu) application. These elements affect metabolic functions such as starch metabolism, affects photosynthesis reaction, nucleic acid metabolism, chlorophyll synthesis and protein biosynthesis etc in plant system. (Swietlik, 1999) [8].

Materials and Methods

The present experiments was conducted at Horticulture Research Scheme (Pomology) VNMVK, Parbhani during years 2016-17 and 2017-18. The experimental trees used 12 years budded grafts of sweet orange cv. Nucellar in factorial randomized block design. There are two factors. Factor A – potassium form K_1 - potassium nitrate @ 1%, K_2- mono potassium phosphate @ 1.5% and K_3 - potassium sulphate @ 1% and second factor B - micronutrient N_1- chelated zinc @ 0.5% and N_2 - chelated ferrous @ 0.4%.

The required solution of micronutrients and potassium form was prepared by dissolving required amounts of nutrients as per treatments.

The nutrients were sprayed on fruits at pea stage and marble size. It was ensured that tree sprayed in all directions. Observation recorded and analysed statistically as per methods suggested by Panse and Sukhatame (1985) [7].

Result and Discussion

The foliar application of micronutrient, potassium forms and their interaction on quality of fruits was presented in Table.

TSS

Significantly the maximum TSS was observed in treatment K_3 *i.e.* K_2SO_4 1% and minimum TSS in treatment K_2 (KH_2PO_4 1.5%) in the year 2016-17 and pooled analysed respectively. Significantly highest TSS (12.03%) was observed in treatment K_3 whereas lowest TSS (11.81%) in treatment K_1 during 2017-18 was observed and in pooled analysed shown highest in K_3 treatments.

With respect to treatments combination maximum TSS was observed N_1K_2 minimum TSS was found in treatment combination of N_2K_3 during the year 2016-17. In pooled significantly highest TSS was observed in treatment combination of N_2K_2 which was statically at par with N_1K_2 and lowest TSS was observed in treatment combination N_2K_3.

The increase in TSS content with foliar application of potassium is related with role of potassium in translocation of sugars from leaves to fruits. Similarly, soluble solid contents significantly increased with number of potassium sprays K_2SO_4-positive relationship was noted between concentration of K applications and TSS contents of fruits. Potassium and micronutrients play important role in sugar metabolism it which increased TSS in fruts juice. Similar result obtained by Vijaya *et al* (2016b) [11] in sweet orange and Chaudhary *et al.* (2016) [3] in sweet orange. Kaur and Dhillon (2012) [6] noticed that the TSS was more with K_2SO_4 in guava crops.

Acidity

Data showed acidity was influence of micronutrient. Significantly minimum acidity (0.40%, 0.40% and 0.40%) was found in treatment K_3 *i.e.* (K_2SO_4 1%) and maximum (0.46%, 0.46% and 0.46%) was observed in treatment K_1 during the year 2016-17, 2017-18 and pooled mean respectively. The treatment combination of N_1K_2 recorded minimum acidity (0.41%) in N_1K_2 whereas and maximum acidity (0.46%) was found in treatment combination of N_1K_3 during experiments and pooled mean also.

Increased sugar which minimize the acidity in fruit or other hands the reduction of acidity might be to increase TSS in fruits. These results confirmed by Vijay *et al.* (2016b) [11], Dalal *et al.* (2017) [4] in sweet orange and Yadav *et al.* (2014) [12] in ber and Baiea *et al.* (2015) [1] in mango.

Reducing sugars and total sugars

Significantly highest reducing sugars (7.43%, 7.45% and 7.44%) and total sugars (10.72%, 10.71% and 10.71%) was observed in treatment N_1 *i.e.* Zn 0.5% and lowest reducing sugars (7.35%, 7.38%and 7.37%) and total sugars (10.27, 10.28 and 10.27%) was observed in treatment N_2 *i.e.* Fe 0.4% in the year 2016-17, 2017-18 and pooled mean respectively. Among the potassium forms application K_3 (K_2SO_4 1%) recorded highest reducing sugars (7.84%, 7.87% and 7.86%) and total sugars (11.39%, 11.34% and 11.37%) whereas lowest reducing sugars (7.13%, 7.17%and 7.15%) in treatment K_2 (KH_2PO_4 1.5%) and however lowest total sugars (10.02, 10.04 and 10.03%) was observed in K_1 (KNO_3 1%) the year 2016-17, 2017-18 and pooled mean respectively. With respect to interaction of micronutrients and potassium forms on reducing sugars and total sugars was found to be increased in all combination. Significantly maximum reducing sugars (7.70, 7.79 and 7.74%) and total sugar (11.75, 11.65 and 11.70%) was observed in treatment N_1K_2 (Zn 0.5% + KH_2PO_4 1.5%) which was closely followed by treatment combination of N_2K_2 and minimum reducing sugars (7.07, 7.17 and 7.12%) and total sugars (9.71, 9.73 and 9.72%) was observed in N_2K_3 during the experiments and pooled analysis.

Combine effect of zinc and potassium play important role in carbohydrates which cause increase in reducing sugars and total sugars in fruits. Potassium is known for helping in sugar translocation in plants, thus its application increases reducing sugar and total sugar. Simillarly concluded by Chaudhary *et al.* (2016) [3] conducted a experiments to study effect of foliar application of potassium and zinc at different concentrations on quality parameters of Kinnow and Zagade *et al.* (2017) [13] in guava.

Ascorbic acid

Foliar spraying of Zn 0.5% was recorded significantly maximum ascorbic acid (55.93 mg/100 ml, 56.06 mg/100 ml and 56.00 mg/100 ml) and it was minimum (54.87 mg/ 100ml, 54.97 mg/ 100ml and 54.92 mg/100 ml) in treatment N_2 (Fe 0.4%) for the year 2016-17, 2017-18 and pooled mean respectively. Potassium forms also influenced on ascorbic acid mg per 100 ml juice. Significantly maximum ascorbic acid was observed (56.90 mg/ 100 ml, 57.01 mg/100 ml and 56.96 mg/100 ml) in treatment K_3 (K_2SO_4 1%) whereas it was observed minimum in treatment (53.59 mg/100 ml, 53.88 mg/100 ml and 53.74 mg/100 ml) K_2 (KH_2PO_4 1.5%) during the year 2016-17, 2017-18 and pooled mean respectively. Effect of N x K combination was on ascorbic acid non-significant for the year 2016-17, 2017-18 and pooled mean.

It might be related with improved sugar metabolism increase the ascorbic acid due to chelated zinc. The increased ascorbic acid content with foliar application of potassium might be related with improved sugar metabolism or potassium might activate the synthesis of ascorbic acid somewhere between D-glucose to L-ascorbate. These results corroborate the earlier findings of Chaudhary *et al.* (2016) [3] ascorbic acid content (24.12 mg/100 ml) in Kinnow and Kaur and Dhillon (2012) [6] in guava crop.

It's concluded that chelate zinc and potassium sulphate and their interaction significant in quality parameters like TSS, reducing sugar, total sugar, acidity and ascorbic acid in sweet orange Cv Nucellar.

Table 1: Effect of micronutrients, potassium forms and their interactions on quality attributes in sweet orange cv. Nucellar

Treatments	TSS (%)			Acidity (%)			Reducing Sugars			Total Sugars			Ascorbic Acid		
	2016-17	2017-18	Pooled data	2016-17	2017-18	Pooled data	2016-17	2017-18	Pooled Mean	2016-17	2017-18	Pooled data	2016-17	2017-18	Pooled data
Micronutrients (N)															
N_1	11.87	11.86	11.87	0.43	0.43	0.43	7.43	7.45	7.44	10.72	10.71	10.71	55.93	56.08	56.00
N_2	11.86	11.89	11.88	0.44	0.44	0.44	7.35	7.38	7.37	10.27	10.28	10.27	54.87	54.97	54.92
S.E N±	0.003	0.004	0.002	0.001	0.001	0.001	0.009	0.013	0.009	0.08	0.014	0.009	0.13	0.15	0.09
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.025	0.037	0.02	0.021	0.038	0.02	0.36	0.40	0.25
Potassium forms (K)															
K_1	11.80	11.81	11.81	0.46	0.46	0.46	7.20	7.22	7.21	10.02	10.04	10.03	55.70	55.69	55.70
K_2	11.79	11.82	11.81	0.45	0.45	0.45	7.13	7.17	7.15	10.06	10.09	10.08	53.59	53.88	53.74
K_3	12.00	12.03	12.02	0.40	0.40	0.40	7.84	7.87	7.86	11.39	11.34	11.37	56.90	57.01	56.96
S.E K±	0.005	0.004	0.003	0.001	0.002	0.001	0.01	0.017	0.001	0.009	0.017	0.019	0.16	0.18	0.11
C.D. at 5%	0.01	0.013	0.009	0.005	0.006	0.004	0.03	0.04	0.03	0.002	0.047	0.032	0.44	0.49	0.32
Interaction (N x K)															
N_1K_1	11.87	11.88	11.87	0.44	0.43	0.43	7.43	7.43	7.43	10.54	10.55	10.54	55.77	55.77	55.77
N_1K_2	11.94	11.94	11.94	0.41	0.41	0.41	7.70	7.79	7.74	11.75	11.65	11.70	57.97	58.26	58.12
N_1K_3	11.81	11.83	11.82	0.46	0.46	0.46	7.16	7.15	7.16	9.87	9.92	9.90	54.03	54.21	54.13
N_2K_1	11.88	11.90	11.89	0.45	0.44	0.45	7.31	7.36	7.35	10.31	10.33	10.32	54.48	54.20	54.29
N_2K_2	11.93	11.93	11.95	0.42	0.42	0.42	7.64	7.62	7.63	10.79	10.78	10.79	57.28	57.49	57.39
N_2K_3	11.77	11.81	11.79	0.45	0.45	0.45	7.07	7.17	7.12	9.71	9.73	9.72	52.94	53.23	53.09
S.E N±	0.006	0.023	0.004	0.002	0.003	0.002	0.01	0.02	0.01	0.013	0.024	0.016	0.23	0.25	0.16
C.D. at 5%	0.019	NS	0.013	NS	0.009	NS	0.04	NS	0.04	0.03	0.067	0.046	NS	NS	NS
Factor – A	K_1- KNO_3 1%			K_2- KH_2PO_4 1.5%			K_3- K_2SO_4 1%			Factor - B			N_1- Zn 0.5%,	N_2 - Fe 0.4%	

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