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Effect of potassium and zinc on growth, physiological and yield attributes in sweet orange (*Citrus sinensis* Osbeck) cv. "mosambi" under high density planting

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Abstract
The present investigation was carried out to study the effect of potassium and zinc on Sweet orange (*Citrus sinensis* Osbeck) cv. "Mosambi" during the year 2018. Eight years old uniformly grown Mosambi Sweet orange plants, grafted on Karna Khatta rootstock and planted at a distance of 3.0 x 2.5m were used in this investigation. The investigation was carried out in high density planting area of Bihar Agricultural College, Sabour, Bhagalpur, under the Department of Fruit & Fruit Technology. Twelve different treatments of K and Zn in a simple randomized block design were used. Various treatments showed significant effect on physiological, vegetative and yield parameters. The maximum leaf area (23.53cm^2), total chlorophyll content (3.04mg/g), leaf relative water content (75.82%), specific leaf weight (0.0164g/cm^2) were observed in T_{12} (K_2O @500g +Zinc sulphate @200 g) whereas minimum in T_1(control). The maximum increase in current season shoot length (13.22cm), canopy spread (64.17cm), trunk girth (1.93cm) and plant height (36.67cm) were also recorded in T_{12} (500g K_2O and 200g $ZnSO_4$) whereas minimum in control. The maximum number of fruits per tree was counted (92.67) in T_8.

Keywords: Potassium, *Citrus sinensis*, mosambi

Introduction
Citrus is the third most important fruit crop of India after banana and mango. It occupies an area of 0.973 million hectares and share 12.66% of total fruit production. Among Citrus, Sweet orange occupies 2.74% of area and share 2.97% of total fruit production (Anon, 2018-19) [2]. Citrus stands first among fruit crops in the world with respect to production leaving behind banana, apples and grapes. Mosambi cultivar is one of the most important cultivar of sweet orange which is commercially grown in Western and Central India. It is one of the promising cultivar of Sweet orange but due to nutritional deficiency especially potassium and zinc, the quality and yield are decreasing. Among the important elements, potassium (K) plays a major role, second only to nitrogen, and is considered as a key element in fruit production and quality worldwide. Potassium plays a very important role in citrus crop production and it affects many phenomenon's, both visible and invisible. Adequate yield, for the fresh fruit market can be achieved only when the level of K is in the optimum range. Potassium has dominant effects on external and internal fruit qualities, including yield, color, size, acidity and roughness. It is an essential nutrient for several basic physiological functions such as formation of sugar and starch, synthesis of protein, normal cell division and growth, neutralization of organic acid, fruit formation and enhances fruit size, flavor and color. Most of the fruit characteristics including vitamin C contents are correlated with sugar metabolism that can be improved by proper K nutrition management (Mengel, 1997) [12]. Zinc plays an important role in sweet orange fruit production. It involves in several physiological functions, and in plant carbon metabolism. Zn is essential for formation of chlorophyll and functions of normal photosynthesis and needed to form auxins, which are growth promoting substances in plants. It is considered a necessary component of several enzyme systems that regulate various metabolic activities within plants. It is also a part of two enzymes that play a role in protein metabolism. Zinc is associated with water relations in plants; improves water uptake.

Indian soils are generally deficient in zinc and its deficiency has traditionally been the most widespread nutrient deficiency in citrus. Thus potassium and zinc both are essential in respect to taking good crop of sweet orange cultivar Mosambi and soil application of both the nutrients is found beneficial for the farmers those have established their sweet orange orchard under high density planting.

Method & materials

The field experiment was conducted during 2018 in high density orchard of the permanent experimental area of Bihar Agricultural University, Sabour, and Bhagalpur. The eight years old uniform plants of *Citrus sinensis* cv. "Mosambi" plants were selected for experiment. The experiment was layed out in RBD with three replications and twelve treatments. Therefore total (12×3×1) 36 plants of Sweet orange (Mosambi) were used for the experiment. Fertilizers were applied as basal dose ing per plant. The dose of N and P was constant for each treatment and applied through the source of Urea and SSP. Source of K_2O and Zn were MOP and Zinc sulphate respectively. The dose of K_2O was applied in three equal split doses during first fortnight of May, June and July whereas dose of Zn was applied in two equal split doses during first fortnight of May and July. The twelve different treatments were T_1 (control), T_2 (300g K_2O), T_3 (400g K_2O), T_4 (500g K_2O), T_5 (100g $ZnSO_4$), T_6 (300g K_2O +100g $ZnSO_4$), T_7 (400g K_2O +100g $ZnSO_4$), T_8 (500g K_2O +100g $ZnSO_4$), T_9 (200g $ZnSO_4$), T_{10} (300g K_2O +200g $ZnSO_4$), T_{11} (400g K_2O +200g $ZnSO_4$), T_{12} (500g K_2O +200g $ZnSO_4$).

Physiological parameters e.g. leaf area of each treatment was measured by using graph paper. To measure the leaf area five leaves on each tree were collected during August-September and used freshly for measurement. The chlorophyll content of the leaves was analyzed by following the method of Barnes *et al*. (1992) [3]. The RWC in the recently mature leaves (August-September) were determined by using the method suggested by Weatherley (1950) [18]. Specific leaf weight (SLW) was measured by dividing the dry weight of leaf to the leaf area of the same leaf before drying it. Vegetative parameters in plant such as height (cm) trunk girth (cm), canopy spread (cm) and length of current season shoot (cm) were measured by measuring tape and measuring pipe having meter marking. The net increase was calculated by subtracting the initial data to the final data after fertilizer application during August-September. The number of fruits per plant was calculated after harvesting under different treatments.

Bihar Agricultural University; Sabour, Bhagalpur is situated at longitude 87º2'42" East and latitude 25º15'40" North at an altitude of 46 m above mean sea level in the heart of vast Indo-Gangatic plains of North India. The climate of this place is sub-tropical of slightly semi-arid in nature. It is characterized by dry summer, moderate rainfall and cold winter. January and February are usually the coldest month when the mean temperature normally falls as low as 8.4ºC whereas April & May are generally the hottest months having the maximum average temperature of 37 ºC.

Meteorological observation of 2018

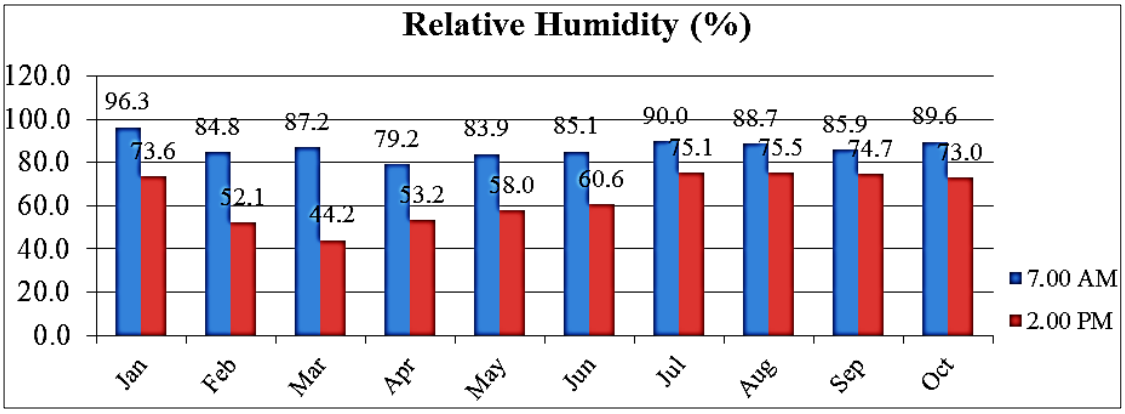


Fig 1.

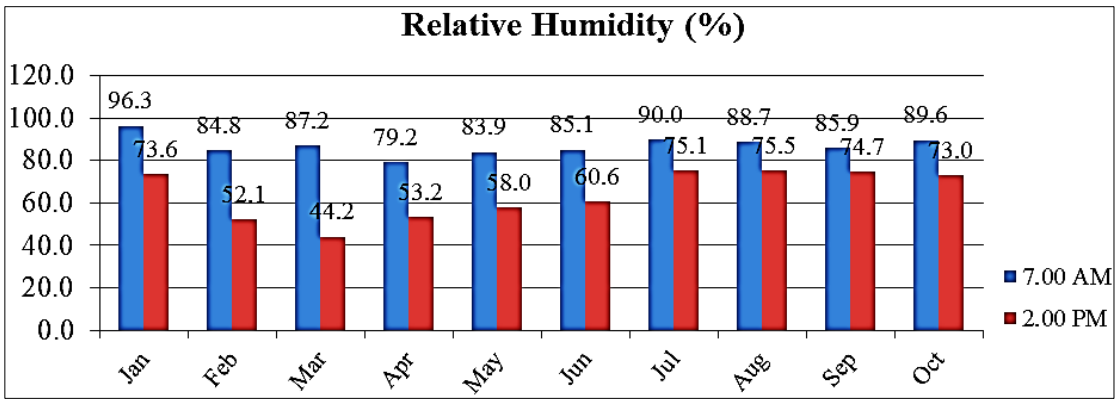
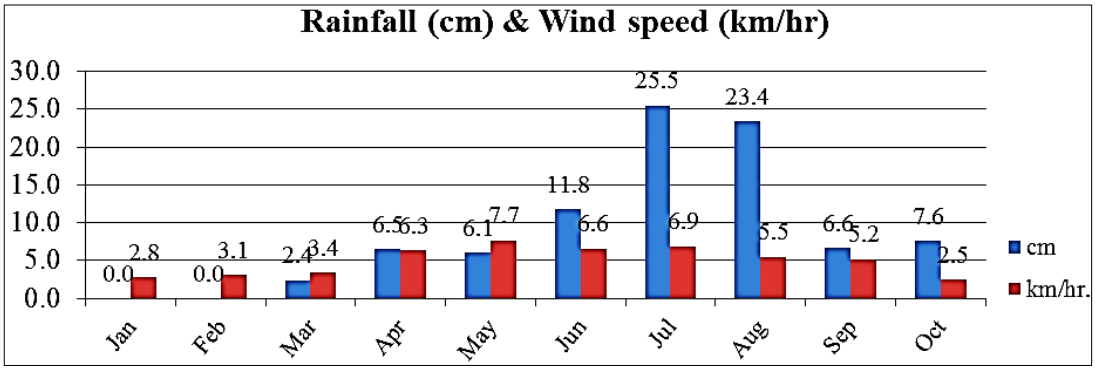


Fig 2.



Source: Agro-meteorology department, Bihar agricultural university, sabour

Fig 3.

Result and discussion

The critical observation of the data reflected significant influence of the treatments on all vegetative, physiological parameters and yield of Sweet orange. Significant differences have been observed in physiological parameters such as leaf area, total chlorophyll content, leaf relative water content and specific leaf weight in trees among the treatments. The maximum leaf area (23.53cm^2), total chlorophyll content (3.04 mg/g), leaf relative water content (75.82%), specific leaf weight (0.0164g/cm^2) were observed in T_{12} (K_2O @500g +Zinc sulphate @200g) whereas minimum in control. The maximum length of current season shoot was found in T_{12} (13.22cm) which was at par with T_8 (12.42cm) and T_{11} (12.41cm) whereas minimum in T_1 (5.46cm). Lengths of current season shoot in rest of the treatments were in between 7.38cm to 10.86cm. The maximum increase in canopy spread was recorded in T_{12} (64.17cm) which was

Table 1: Effect of potassium and zinc sulphate on physiological parameters and vegetative growth in Sweet orange cv. "Mosambi".

Treatments	Leaf area (cm^2)	Total chlorophyll content (mg/g)	Leaf relative water content (%)	Specific leaf weight (g/cm^2)	Length of current season shoot (cm)	Increase in Canopy spread (cm)	Increase in Trunk girth (cm)	Increase in Plant height (cm)
T_1	17.35	2.38	63.52	0.0113	5.46	35.75	0.8	14.33
T_2	19.29	2.45	64.16	0.0117	8.18	41.08	1.17	17.33
T_3	20.84	2.51	64.53	0.0129	8.3	44.83	1.27	21
T_4	21.24	2.75	67.77	0.013	8.98	49.75	1.4	24.33
T_5	20.78	2.68	62.64	0.0114	7.38	37.83	1.07	18
T_6	21.71	2.88	66.64	0.0128	10.32	51.17	1.4	22
T_7	20.98	2.87	69.88	0.013	10.31	54.67	1.57	25
T_8	20.82	2.85	70.65	0.0136	12.42	59.33	1.73	30.17
T_9	21	2.62	63.73	0.0124	7.81	45.17	1.27	20
T_{10}	22.18	2.91	69.06	0.0143	10.86	55.17	1.6	28.33
T_{11}	21.22	2.96	71.92	0.0151	12.41	57.5	1.77	31.67
T_{12}	23.53	3.04	75.86	0.0164	13.22	64.17	1.93	36.67
C.D. at 5%	1.81	0.3	6.53	0.0015	1.14	7.17	0.19	3.46
C.V. (%)	5.1	6.36	5.71	6.63	6.98	8.52	7.95	8.48
SEm(±)	0.616	0.101	2.22	0.0005	0.389	2.44	0.065	1.18

statistically similar with T_8 (59.33cm) and T_{11} (57.5cm) and was followed by T_{10} (55.17cm), T_7 (54.67cm) and T_6 (51.17cm). Similar trends were observed in case of trunk girth and plant height increase. Treatment T_{12} (1.93cm) showed maximum increase in trunk girth which was statistically at par with T_{11} (1.77cm) followed by T_8 (1.73cm), T_{10} (1.60cm) and T_7 (1.57cm). Maximum increase in plant height among all the treatments was recorded in treatment T_{12} (36.67cm) and followed by T_{11} (31.67cm) which was statistically at par with T_8 (30.17cm) and T_{10} (28.33cm).However the lowest increase in plant height (14.33cm), canopy spread (35.75cm), trunk girth (0.8cm) and plant height (14.33cm) were recorded in treatment T_1 (control). The significant effect of the treatments was recorded for fruit yield (Kg per plant) in Sweet orange cv. Mosambi. The maximum fruit yield in Kg per plant was recorded in treatment T_8 (17.95Kg) followed by T_7 (15.20Kg), T_{12} (14.54Kg) and T_{11} (14.50Kg) whereas minimum in T_1 (7.75Kg).

In the present investigation the results obtained on physiological and vegetative parameters such as leaf area, total chlorophyll content, leaf relative water content and specific leaf weight, length of current season shoot, canopy spread, trunk girth and plant height were significantly influenced by various treatments**.** The data also showed significant differences in number of fruits per plant among different treatments after harvest. Potassium plays an important role in several enzymes activation like synthase, oxidoreductase, dehydrogenase, kinases and transferase. These enzymes are necessary for essential plant processes such as energy utilization starch synthesis N metabolism and respiration. In addition, potassium affects the photosynthesis process in many levels. Synthesis of ATP is needed for increasing energy uptake by leaves. Hence, it increases the leaf area, total chlorophyll content, relative water content of leaf as well as specific weight of leaf. Zinc is an essential micronutrient for plant growth and plays an important role in the catalytic part of several enzymes, absorption of water and nutrient responsible for growth of plant. However, there is an inhibitory effect in combination of zinc and potassium and the zinc uptake is inhibited. However, as the experimental plot

was rich in calcium, the inhibitory effects weakened suggesting that the combination of both at higher concentration might have promoted increase in physiological characters of tree.

It has been observed that increased level of potassium and zinc fertilizer with balance dose of nitrogen and phosphorus caused plant to attain more vegetative growth. Different doses of K and Zn have significant effect on vegetative growth as compare to control and it showed positive correlation with increasing the level of K and Zn fertilizers. K fertilization plays a major role in, protein synthesis, photosynthesis, and vegetative growth Alva *et al*. (2006) [1] which might be cause of significant increase in vegetative growth. David *et al.* (1998) [4] reported that K is essential for normal cell division and growth. Erner *et al.* (2002) reviewed the significant role of K on Citrus production and found that K plays a critical role in vegetative and reproductive growth of plant. Kumar *et al.* (2017) [11] reported similar scenario on papaya and found significant growth in stem girth (40.2cm) and plant height (165.1cm) with soil application of 500g K_2O per plant and constant dose of N fertilizer. Randhawa *et al.* (2017) [15] also observed similar trend on Ber (*Zizyphus mauritiana* Lamk.) cv. Umran and found the maximum tree height (4.56m), trunk girth (7.47cm) and current season shoot growth with soil application of 1.5Kg MOP per plant. Guneri *et al.* (2016) [7] found that potassium and phosphorus application increased seedling rootstock diameter and length of stem. Soil application of zinc play a vital role in indole-acetic acid (IAA) oxidase system, Zn fertilizer application improved the root growth enabling better extraction of nutrients and water available within the rhizosphere to impart favorable response on growth and yield (Shrivastava and Singh, 2009) [16]. Hippler *et al.* (2015) [8] found that plant growth was 68% higher for plants that treated with zinc sulphate. Yadav *et al.* (2007) [19] observed that plant height and plant spread was maximum in Sweet orange cv. Jaffa with soil application of 250g zinc sulphate per plant. Throat *et al.* (2018) [17] found highest tree height and canopy volume in Sweet orange cv. Nucellar with soil application of zinc sulphate @150g per tree with combination of foliar spray of zinc sulphate. Davinder *et al.* (2018) recorded maximum plant height increase of 29.46cm in Kinnow with soil application of 250g chelated zinc and foliar 3g zinc sulphate.

The highest fruit yield might be due to the direct and indirect involvement of potassium in increasing fruit weight and size. Guneri *et al*., (2016) [7] found that with increased level of K and P increased fruit weight and the number of fruits per plant in Kumquat. Amina *et al*., (2018) obtained maximum fruit yield (474.33 fruits/tree) in *Citrus reticulata* (Blanco) when applied 150g K_2O +200g P_2O_5 along with constant dose of N and followed by (466.33 fruits/tree) with 250g K_2O+ 200g P_2O_5. Zinc is necessary for synthesis of auxins in plant which play major role in maximum fruit weight and good size. This may be reason of more yield and number of fruit per plant in zinc treated plants along with potassium fertilizer. Shrivastava *et al.* (2009) [16] observed that yield response were superior for all treatments involving soil application of Zn as compare to foliar application. Javaid *et al.*, (2004) [9] reported that the effect of micronutrient application on yield and size of fruit statistically significant. They obtained highest yield (1406 fruits/plant), weight (233.75g/fruit) with soil application of $ZnSO_4$ @100g in Kinnow mandarin along with each of $CuSO_4$, $MnSO_4$, and FeSO4 @60g.

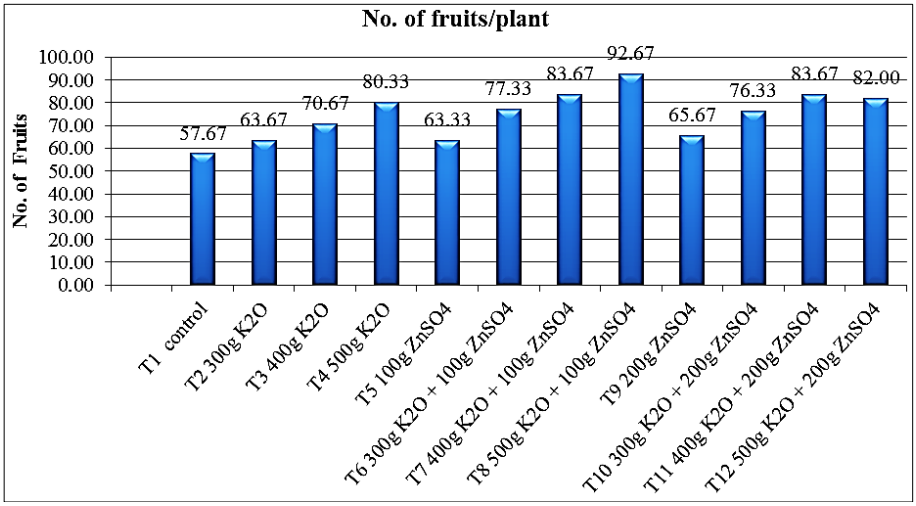


Fig 4.

Conclusion

K and Zn have significant effect on vegetative and physiological growth of tree as compare to control and it showed positive correlation with increasing the level of K and Zn fertilizers. The tree physiological characters like leaf area (23.53cm^2), total chlorophyll (3.04 mg/g), leaf relative water content (75.86%) and specific leaf weight (0.0164g/cm^2) were higher under treatment receiving higher dose of potassium and zinc sulphate e.g. (500g K_2O and 200g $ZnSO_4$). The maximum current season shoot length (13.22cm) was obtained with soil application of 500g K_2O and 200g $ZnSO_4$ along with balance dose of N and P_2O_5, whereas minimum current season shoot length was recorded in control. Similar trends were observed in other vegetative parameters such as canopy spread, trunk girth and plant height. The maximum fruits yield (kg per plant) was recorded in T_8 (500g K_2O and 100g $ZnSO_4$).

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