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Significance of different Sources of Fertilizers Application on Yield and Physiochemical properties of Kinnow Mandarin

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ABSTRACT: The field experiment conducted during 2017-2018 to evaluate the significance of different sources of fertilizers application on yield and physiochemical properties of Kinnow mandarin at experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar. The highest number of flowers per twig, initial fruit set, final fruit retention, number of fruits per plant, average weight, yield and minimum fruit drop observed in treatment Ammonium sulphate (2838gm) + DAP (695gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm). However, fruit quality parameters *i.e.*, TSS, acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugar were enhanced with Ammonium sulphate (2975gm) +SSP (2000gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm).

Keywords: Kinnow, fertilizers, yield, quality, Physiochemical properties, flowers per twig

INTRODUCTION

Citrus species are widely cultivated throughout the worldwide tropics and subtropics. The original native range of the genus citrus can be followed to South-east Asia and India. Kinnow (*Citrus reticulata* Blanco) mandarin hybrid, a cross between 'King' and 'Willow Leaf' (*C. nobilis Lour* × *C. deliciosa Tenora*) is one of the most important and finest varieties of mandarin grown especially in North India. It has gained a lot of popularity among North Indian farmers, and a huge area is being covered in it, especially in Punjab, Haryana, Rajasthan, and Himachal Pradesh. Citrus fruits are grown in four different zones in India: central India (Madhya Pradesh, Maharashtra, and Gujarat), southern India (Andhra Pradesh and Karnataka), north-western India (Punjab, Rajasthan, Haryana, and western Uttar Pradesh), and north-eastern India (Punjab, Rajasthan, Haryana, and western Uttar Pradesh) (Meghalaya, Assam and Sikkim). Kinnow mandarin is gaining commercial importance due to high production, high processing quality, fresh consumption fragrant flavour, and superior adaptation to agro-environmental circumstances. Nutrition is a crucial component for successful and healthy citrus cultivation. An inadequate supply of nutrition causes the improper growth and reduced productivity of the citrus trees. In the adequate fertilization, regular application of nutrients or alternatively use of nutrient enriched organic manures and biofertilizers in integrated nutrient management results in quality citrus production (Srivastava, 2012).

The effects of nutrition on fruit quality are important to understand and taken into consideration by citrus growers to increase profitability and enhance sustainability and worldwide competitiveness (Zekri and Obreza 2009). Micronutrients are needed in minute amounts, yet they play an important role in plant metabolism. (Katyal, 2004; Kazi *et al*., 2012). Integrated nutrient supply management (INM) aims to maintain or alter soil fertility and plant nutrient supply to an optimal level for sustaining desired crop yield by effective and efficient utilization from all available plant nutrients in an integrated approach. Therefore, keeping in view the nutritional requirements, the present study was undertaken to find out the most suitable fertilizer combination and their effect on yield and quality of Kinnow mandarin.

MATERIALS AND METHODS

This experiment was done on eight years of age Kinnow mandarin trees in Experimental Orchard and Post-harvest Technology Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the year 2017-18. The treatments containing 8 combinations *viz*., T_1: Urea (1520gm) + SSP (2000gm) + MOP (175gm), T_2: Urea (1358gm) + DAP (695gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_3: Ammonium sulphate (3570gm) + SSP (2000gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_4: Ammonium sulphate (2975gm) + DAP (695gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_5: Urea (1520gm) + SSP (2000gm) + SOP (220gm) + $ZnSO_4$ (200gm), T_6: Urea (1358gm) + DAP (695gm) + SOP (220gm) + Zn SO_4 (200gm), T_7: Ammonium sulphate (2975gm) + SSP (2000gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm) and T_8: Ammonium sulphate (2838gm) +DAP (695gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm) **(**In T_1 to T_8, recommended dose of nitrogen (N) (750gm), phosphorus (P_2O_5) (320gm) and potassium (K_2O) (105gm) per replication was applied by different sources of fertilizers. $ZnSO_4$ (200gm) per replication was applied from T_2 to T_8 were spread out in randomized block design (RBD) with three replications in three different time of soil application *i.e*., end of December, last week of February and last week of April.

During the experiment different observations were recorded *i.e.,* Number of flowers per twig was taken in every direction, four twigs were chosen on the tree and therefore the number of flowers was counted per twig. Initial fruit set (%) was calculated by subtracting the number of fruits set at initial stage from the total number of flowers on labelled twigs. Fruit drop (%) was calculated by subtracting the number of fruits retained in the month of July from the number of fruits set at initial stage of four labelled branches. Final fruit retention (%) was measured by subtracting the total number of mature fruits from the quantity of initial fruit set. Number of fruits per plant on entire tree was enumerated at harvesting. Average fruit weight (g) was calculated through five arbitrarily chosen fruits from different position of the tree were picked and weighed on electric balance. The average weight was determined by dividing the absolute fruit weight by complete number of fruits taken and communicated in gram. Fruit yield (kg/plant) was determined by multiplying the number of fruits per tree with average fruit weight and communicated in (kg/plant). Total soluble solids (%) was estimated with the assistance of automated hand refractometer (%) and communicated as percent total soluble solids. Titratable acidity (%) estimated by the strategy proposed by AOAC (2000) was pursued for the estimation of titratable acidity. TSS to acid ratio was calculated by dividing TSS with the acidity. Ascorbic acid (mg/100 ml of juice) was detected by the standard method (AOAC, 2000). Total sugars and reducing sugars were estimated by using the method of Hulme and Narain (1993). The non-reducing sugar was detected by subtracting the value of reducing sugar from the estimated total sugar for each sample.

RESULTS AND DISCUSSION

The data proposed in Table 1 describe the number of flowers per twig tagged in each direction of Kinnow mandarin plant before the application of different combinations of Urea, K_2SO_4, $ZnSO_4$, SSP, MOP, DAP, KNO_3 and ammonium sulphate. The number of flowers tagged per twig was not significantly affected by the treatments. The maximum number of flowers tagged per twig was observed in treatment T_8 and the minimum number of flowers tagged per twig was in treatment T_1. Whereas, the maximum initial fruit set (%) was recorded in treatment T_8 and the minimum initial fruit set (%) was obtained from the treatment T_2. Different chemical treatments significantly affected percent fruit drop in Kinnow mandarin as shown in Table 1. Minimum number of percent fruit drop (59.20%) was recorded with T_8 and it was found superior. Maximum number of fruit drop (67.43%) was observed in T_1. The perusal data given in Table 1 revealed that the different treatments considerably affected final fruit retention. The maximum retention (22.11%) was observed in $T_8$and the minimum (17.05%) was observed in T_1. The influence of different sources of fertilizers was significantly seen in case of number of fruits per tree, fruit weight and yield as given in Table 1. The observations pertaining in Table 1 was evaluated and it is evident from data that the different sources of fertilizers affected significantly. The maximum number of fruits (550.67) was recorded in T_8 which was at par with T_7 (548.33). The minimum (503.33) was observed in T_1. Average fruit weight was significantly affected by the treatments applied. The maximum fruit weight (152.8 gm) was observed in T_8 which was statistically at par with T_2 (152.3gm), T_3 (152.7gm), T_4 (152.3gm) and T_7 (152.7gm). Yield was significantly influenced by different sources of fertilizer according to data pertained in Table 1. The maximum yield of 84.14 kg/tree was observed in $T_8$with the effect of which was closely followed by T_7. Minimum yield (76.15 kg/tree) was recorded in T_1.

According to the literature, the appliance of Zn augmented the fruit production and quality (Rodríguez *et al*., 2005), so the best combination of macro-, micronutrients and plant growth regulators could manage the extreme fruit drop and recover the citrus fruit yield and its quality (Doberman and Fairhurst, 2000; Saleem *et al*., 2008). The reduction in fruit drop is due to completion of the deficiency in plants which leads to synthesis of carbohydrates. According to Awasthy *et al.* (1975) zinc sulphate spray positively significantly abridged fruit drop in litchi. The decline was due to augmented biosynthesis of IAA in zinc treated plants and concluded that foliar appliance of $ZnSO_4$ at 0.5, 1.0 and 1.5 per cent concentrations, significantly amplified number of fruits, pulp weight and volume. Fruit drop and final fruit retention are generally varietal traits, even though water and nutritional stress increases fruit drop in liable trees (Rameshwar and Rao 1980). The different treatments considerably improved number of fruits per tree, average fruit weight and yield. Due to accretion of more food material in the trees leads to an efficient exploitation of the same for development of fruit which leads to better fruit diameter and yield. As evidenced by the current study, increased number of flowers, fruit set, and reduced fruit drop and concluded obtained a higher number of fruits per tree and yield. Nutrient management can augment the fruit yield by increasing fruit number, retention and reducing fruit drop (Saleem *et al*., 2005; Ashraf *et al*., 2010). Application of NPK fertilizers proves promising for increasing fruit size and yield (He *et al*., 2003; Abd-allah, 2006). In addition to increasing the size of Kinnow's fruit by modification of soil through application of potassium fertilizer. According to current and previous findings the application of potassium (K) has a positive link with fruit size (Obreza, 2003; Quaggio *et al*., 2002). Daulta *et al*. (1983) stated that all the concentrations (0.2, 0.4 and 0.6%) of $ZnSo_4$ significantly enhanced the berry weight above the control in Beauty Seedless grape. $ZnSO_4$ with 0.4 and 0.6 per cent significantly augmented the berry length and breadth over control, while the utmost berry weight was obtained with $ZnSO_4$ (0.6%), while boron could not influence berry weight.

Table 1: Effect of soil application of different sources of fertilizers on different yield parameters in Kinnow mandarin.

Treatments	*Number of flowers per twig	*Initial fruit set (%)	Fruit drop (%)	Final fruit retention (%)	Number of fruits per plant	Average weight (gm)	Yield (kg/ha)
T_1	12.3	52.34	67.43	17.05	503.33	151.3	76.15
T_2	12.6	50.45	64.85	17.74	511.67	152.3	77.90
T_3	13.1	52.90	63.64	19.24	547.33	152.7	83.50
T_4	12.8	51.10	61.13	19.87	543.33	152.3	82.74
T_5	14.2	53.92	61.34	20.08	539.67	152.0	82.02
T_6	13.0	51.38	66.06	17.44	534.33	151.6	81.00
T_7	15.1	53.12	60.18	21.16	548.33	152.7	83.72
T_8	15.4	54.18	59.20	22.11	550.67	152.8	84.14
C.D. at 5% level of significance	**NS**	**NS**	**0.56**	**0.30**	**5.56**	**0.87**	**1.08**

*Before application of treatments

T_1: Urea (1520gm) + SSP (2000gm) + MOP (175gm), T_2: Urea (1358gm) + DAP (695gm) +MOP (175gm) + $ZnSO_4$ (200gm), T_3: Ammonium sulphate (3570gm) + SSP (2000gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_4: Ammonium sulphate (2975gm) + DAP (695gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_5: Urea (1520gm) + SSP (2000gm) + SOP (220gm) + $ZnSO_4$ (200gm), T_6: Urea (1358gm) + DAP (695gm) + SOP (220gm) + $ZnSO_4$ (200gm), T_7: Ammonium sulphate (2975gm) + SSP (2000gm) + KNO_3 (230gm) + $ZnSO_4$(200gm), T_8: Ammonium sulphate (2838gm) + DAP (695gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm)

*In T_1 to T_8, recommended dose of N (750gm), P_2O_5 (320gm) and K_2O (175gm) per replication was applied by different sources of fertilizers. $ZnSO_4$ (200gm) per replication was applied from T_2 to T_8.

The data tabulated in Table 2 revealed that different sources of fertilizers significantly affected the quality parameters *i.e*., total soluble solids, acidity, TSS/acidity ratio, ascorbic acid, reducing sugars, non-reducing sugars and total sugars. The highest TSS (11.50 ºBrix) was observed with T_7 which was statistically superior to all the treatments. Minimum TSS (10.01 ºBrix) was recorded in T_1 and was statistically at par with T_2 (10.05 ºBrix). Various chemical treatments significantly affected acidity of Kinnow mandarin fruits. Minimum acidity (0.82%) was observed with T_7. Maximum acidity (1.01%) was observed in T_1. TSS/acidity ratio was significantly affected by different fertilizer treatments. Maximum TSS/acidity ratio (14.02) was recorded with soil application of T_7 which was statistically at par with T_8 (13.95). Lowest TSS/acidity ratio (9.91) was recorded in T_1.The ascorbic acid of kinnow mandarin was significantly affected by different sources of fertilizers. The maximum ascorbic acid content (31.01mg/100ml juice) was found in T_7 which was statistically at par with T_5 (30.38 mg/100ml juice) and T_8 (30.42mg/100ml fruit juice). The minimum value (28.36 mg/100ml juice) was seen in T_1. T_2 (28.45mg/100ml juice), T_3 (29.06 mg/100ml juice) and T_4 (28.85 mg/100ml juice) were found at par with T_1. The data pertaining to sugar content (%) is tabulated in Table 2 which was found significant towards the different sources of fertilizers applied. It is observed in treatment T_7 found maximum reducing sugar content (3.31 %) which was statistically at par with T_5 (3.28%), T_6 (3.29%) and T_8 (3.29%). The minimum reducing sugar content (3.19%) was observed in T_2 which was statistically similar to T_2 (3.23%). Whereas, the minimum non reducing sugar (4.15%) was observed in T_2 which was statistically at par with T_1 (4.16%). The maximum value (4.99%) was seen in T_7 and statistically similar effect was seen in T_3 (4.96%), T_4 (4.94%), T_5 (4.98%), T_6 (4.95%) and T_8 (4.98%). The total sugar content was affected significantly and the maximum total sugar content (8.30%) was observed in T_7 which was statistically at par with T_3 (8.24%), T_5 (8.26%), T_6 (8.24%) and T_8 (8.27%). The minimum total sugar content (7.35%) was reported in T_1 and it was statistically similar to T_2 (7.38%).

The different fertilizers significantly affected the quality parameters during the investigation. Maximum total soluble solids, TSS/acidity ratio, ascorbic acid and lowest acidity was recorded with Ammonium sulphate + SSP + KNO_3 + $ZnSO_4$. The foliar spray of micronutrients (0.5%) + B (0.3%) + Cu (0.7%) leads to upgrading of quality of fruit in requisites of TSS content and it might be contributed to the fact that micronutrients directly play a vital function in plant metabolism as zinc is required in enzymatic reaction like hexokinase, development of carbohydrate and protein synthesis (Pamila *et al*., 1992). The elevated total soluble solids could also be accredited to the efficient translocation of photosynthesis to the fruit by regulation of copper, boron and zinc as investigated by Ullah *et al*. (2012). Shukla *et al*. (2011) reported that amongst borax concentrations (0.4%) proved mainly helpful in increasing the TSS, total sugar and abridged titratable acidity in aonla fruits. Ullah *et al*. (2012) revealed that acidity percentage of mandarin fruit might have been abridged due to elevated synthesis of nucleic acids, on account of greatest accessibility of plant metabolism. The decline in acidity content as a result of micronutrient application in fruit juice samples might be due to their utilization in respiration and rapid metabolic transformation of organic acids in to sugars (Brahmachari *et al*, 1997). Enhancement in TSS, TSS/acid ratio, ascorbic acid content, and reduction in acidity may be due to the fact that phosphorus enters into the composition of phospholipids and nucleic acids. Nucleic acids combine with proteins and leads to formation of nucleoproteins which are important constituents of the nuclei of the cells. Potassium as a catalyst acts in the creation of more complex substances and in the hastening in the enzymatic activity. The complex carbohydrate substances and co-enzymes resulted into an enhancement in fruit quality. Nitrogen enhances the uptake of phosphorus and potassium. The appliance of FYM in soil is helpful for the growth of soil microorganisms, which also excrete the plant promoting substances, vitamins and amino acid content. These might have enhanced the fruit quality. The conversion of mannose or galactose molecules, which are monosaccharide carbohydrates, lead to the formation of ascorbic acid (Wheeler *et al.,* 1998).

Table 2: Effect of different sources of fertilizers on biochemical parameters ofKinnow mandarin.

Treatments	TSS (ºBrix)	Acidity (%)	TSS/Acidity Ratio	Ascorbic acid content (mg/100ml juice)	Reducing sugar (%)	Non Reducing sugar (%)	Total sugar (%)
T_1	10.01	1.01	9.91	28.36	3.19	4.16	7.35
T_2	10.05	0.97	10.36	28.45	3.23	4.15	7.38
T_3	10.50	0.95	10.78	29.06	3.28	4.96	8.24
T_4	10.25	0.93	11.29	28.85	3.26	4.94	8.20
T_5	11.12	0.91	11.87	30.38	3.28	4.98	8.26
T_6	10.81	0.90	12.35	29.35	3.29	4.95	8.24
T_7	11.50	0.82	14.02	31.01	3.31	4.99	8.30
T_8	11.30	0.88	13.95	30.42	3.29	4.98	8.27
C.D. at 5% level of significance	**0.14**	**0.016**	**0.08**	**0.90**	**0.044**	**0.071**	**0.060**

*T_1: Urea (1520gm) + SSP (2000gm) + MOP (175gm), T_2: Urea (1358gm) +DAP (695gm) +MOP (175gm) + $ZnSO_4$ (200gm), T_3: Ammonium sulphate (3570gm) + SSP (2000gm) + MOP (175gm) + $ZnSO_4$ (20gm), T_4: Ammonium sulphate (2975gm) + DAP (695gm) + MOP (175gm) + $ZnSO_4$ (200gm), T_5: Urea (1520gm) + SSP (2000gm) + SOP (220gm) + $ZnSO_4$ (200gm), T_6: Urea (1358gm) + DAP (695gm) + SOP (220gm) + $ZnSO_4$ (200gm), T_7: Ammonium sulphate (2975gm) + SSP (2000gm) + KNO_3 (230gm) + $ZnSO_4$(200gm), T_8: Ammonium sulphate (2838gm) +DAP (695gm) + KNO_3 (230gm) + $ZnSO_4$ (200gm)

*In T_1 to T_8, recommended dose of N (750gm), P_2O_5 (320gm) and K_2O (175gm) per replication was applied by different sources of fertilizers. $ZnSO_4$ (200gm) per replication was applied from T_2 to T_8.

CONCLUSION

From the current analysis, it is inferred that soil application of different sources fertilizers had significant effect on growth, yield and quality of kinnow mandarin. T_8 (Ammonium sulphate + DAP + KNO_3 + $ZnSO_4$) as soil application proved most effective in enhancing growth parameters *i.e.,* number of flowers per twig, initial fruit set and fruit drop. Fertilizers as soil application efficiently enhanced number of fruits per tree, fruit weight and yield of kinnow mandarin. Kinnow fruit quality in terms of TSS, acidity, TSS/acidity ratio, ascorbic acid content and sugar content was significantly affected by soil application of Ammonium sulphate + SSP + KNO_3 + $ZnSO_4$ *i.e*. treatment T_7.

FUTURE SCOPE

Due to nutritional deficiencies in Kinnow, the loss of yield as well as quality is a problem. In terms of yield, there is less fruit set, fruit retention as well as fruit drop is more. The quality deterioration comprises of less TSS, ascorbic acid, acidity etc. So, to overcome the losses in Kinnow, the usage of different fertilisers in combination can make a change and good yield as well as quality can be obtained.

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