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Growth and yield of Kinnow mandarin in response to fertigation

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Abstract
The present investigations entitled "Growth and yield of Kinnow mandarin in response to fertigation" was carried out in the Horticultural Garden, Bihar Agricultural University, Sabour, Bhagalpur during the year 2016-2018. The experiment was laid down in Randomized Block Design with 5 treatments and 4 replications. The study comprises of one experiment in which Kinnow trees under investigation were subjected to different level of fertigation, *viz*. T1- 120% of RDF as fertigation; T2- 100% of RDF as fertigation; T3- 80% of RDF as fertigation; T4- 60% of RDF as fertigation; T5- 100% of RDF as soil application. The results revealed that the application of fertigation with NPK at the dose of 120% RDF (600:288:288g/plant/year) gave the highest increase in plant height (87.69 cm), stem girth (6.23cm), canopy volume (70.22cm^3) and yield (12.64 Kg/tree) of Kinnow tree under high density planting condition. Hence, treatment 120% RDF as fertigation can be recommended under Sabour, Bihar, India agro-climatic conditions to get high economic returns.

Keywords: Kinnow, growth parameters, yield, fertigation

Introduction
Citrus is one of the most important fruit crops of world (Reitz, 1984) belonging to the family Rutaceae and subfamily Aurantoideae (Samson, 1986) [15]. It includes hesperidium group like fruit lemon, mandarin and sweet orange; characterized by a juicy vesicles within its segments. Citrus is the world's leading fruit crops and contributes its share in area is 1077.7 thousand hectares and total annual production of 11147.1 thousand tones with productivity 10.3 tone /ha of total fruit production in India. Citriculture is the third largest fruit industry in India next to mango and banana. Among citrus, Kinnow is the most popular cultivar of mandarin group has become the most favourable in northern India. Kinnow is the 1st generation inter-specific hybrid of King (*Citrus nobilis)* and Willow leaf (*Citrus deliciosa)* developed by H.B. Frost at California University in the year 1936 and introduced in 1956 in Punjab region of India and attained a prominent place in citrus industry by replacing earlier traditionally grown citrus fruit due to its attractive colour, refreshing juice, nutritive value and overall productivity. Feasibility of Kinnow cultivation in Bihar was also tested at Sabour on large scale due to its high wider adaptability and high economic return. However, the productivity of citrus orchards in India is 7-8 tons per hectare compared to 20-25 tons per hectare in leading citrus producing countries in the world indicating the tremendous scope for flourishing the citrus industry in the country. Productivity of citrus orchard in India is less as compared to other leading citrus producing countries in the world. However, the gap in productivity level is a major cause of concern and is often ascribed to poor physical condition of the soil and unbalanced nutrition (Sinha *et al.*, 2017) [18]. Sufficient nutrition management is one of the most important factor in improving the plant growth and yield. Therefore, adequate nutrition of the plant for increasing the production through maximizing its growth (Srivastava and Singh, 2002) [19].Among irrigation methods, drip irrigation proved to efficiently provide water to the plant roots, while maintaining high yield (Mmolawa *et al*., 2000) [8]. High water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface run-off, as well as minimal deep percolation. Moreover, a drip irrigation system can easily be used for fertigation, through which crop nutrient requirements can be met accurately (Or *et al.*, 1996) [11]. Though, citrus is a nutrient demanding crop and highly responsive to applied nutrients in the form of fertilizers.Among the essential nutrients, Nitrogen (N),Phosphorus (P) and Potassium (K) plays a vital role in improving the tree vegetative growth, yield and quality in

citrus (Koo, 1985). Moreover, fertigation enables adequate supplies of water and nutrient with precise timing and uniform distribution to meet the crop nutrient demand (Narda and Chawla, 2002) [9]. Keeping the importance of nutrition, an experiment was conducted to visualize their effect on tree growth parameter and their yield performance.

Materials and Methodology

The field experiment was conducted on six year old Kinnow mandarin plant at high density orchard of the permanent experimental area of Bihar Agricultural University, Sabour, Bhagalpur. The climate of the experimental orchard is situated in the subtropical zone at latitude of 25.15° 48ˈ north and east longitude 87.2° 42ˈ and at an altitude of 45.72m above the mean sea level with desiccating hot summer, cold but frostless winter with mean annual rainfall of about 1380mm, out of which most of the rains are received during mid June to mid October. 40 plants of Kinnow plants of healthy and uniform size planted under the concept of high density were undertaken as experimental materials. The experiment was laid out in randomized block design with five fertigation level based on recommended dose of fertilizer (RDF) *i.e.* 500:240:240gram/ plant/ year, the treatments were T_1- 120% of RDF (600:288:288g); T_2- 100% of RDF (500:240:240g); T_3- 80% of RDF (400:192:192g); T_4- 60% of RDF (300:144:144g); T_5- 100% of RDF (500:240:240g) as basal without drip irrigation and each treatment were replicated four times with two plant in each replication. The treatment T_1, T_2, T_3, T_4 were applied in split doses whereas, treatment T_5 supplied directly in plant basin. Fertigation scheduling was administrated at monthly interval (Table 1). The fertilizer source used for fertigation was urea for nitrogen and mono potassium phosphate for phosphorus and sulfate of potash for potash. The growth parameters *viz.* plant height, trunk girth, canopy volume, was measured with the help of measuring tape before and after fertigation. Tree height was measured with the help of pre-marked bamboo pole of 15m length from the base of the trunk at the collar region to the tip of the terminal extension growth. Increase in height was calculated by subtracting initial values from the final values. Stem girth was measured in centimetres, at 15 cm above the ground level with the help of measuring tape where the trunk divides in primary scaffolds and expressed as increase in stem girth. The canopy volume was calculated by the formula given by Westwood *et al.* (1963).

Canopy volume= $4/3\ \pi\ a^2b$

Where a = half of the spread; b = half of the height

The fruit yield was estimated by multiplying average number of fruits with average weight of fruits and expressed as kg/tree.

Table 1: Monthly Fertigation Scheduling in Kinnow orchard

Month	Date	N	P	K
January	15	-	-	-
February	15	✓	✓	-
March	15	✓	✓	✓
April	15	✓	✓	✓
May	15	✓	-	✓
June	15	✓	-	✓
July	15	-	-	✓
August	15	-	-	✓
September	15	-	-	✓
October	15	-	-	✓
November	15	-	✓	✓
December	15	-	-	-

Result and Discussion

Tree Growth parameters

The data on different growth parameters have been presented in Table 2. The data presented clearly indicates significant differences in different growth parameters due to fertigation treatments. It is evident that the fertigation had improved the per cent increase in height of Kinnow plants compared to conventional irrigation combined with soil application of fertilizers. The perusal of pooled analysis data from the Table showed that the highest value of plant height was observed in the treatment T_1 (87.69 cm) and the minimum increase in plant height was found in the treatment T_4 (69.20 cm) which was at par with the treatment T_3 and T_5.

There is significant increase in stem girth due to fertigation over the soil application of fertilizers. The data presented in Table 2 indicates that the maximum increase in stem girth was in T_1 (6.23 cm) in the pooled analysis of data of two years 2016 and 2017 which was followed by the treatment T_2 (5.79 cm).The minimum increase in stem girth was recorded in T_5 (4.55 cm) that was at par by the treatment T_4.

Significant differences in increase in canopy volume were recorded due to different treatments (Table 2). Pooled mean analysis of the two years data signified that the maximum increase in canopy volume was in treatment T_1 (70.22 cm3) which was at par by T_2 and least increase in T_5 (39.03 cm3). The per cent increase in plant height, stem girth and canopy spread was found maximum in treatment receiving 120% NPK as fertigation (T_1) which was at par by the treatment with 100% NPK as fertigation (T_2). The lowest was recorded in treatment with ring irrigation and broadcast methods of fertilizer application. The increase in plant growth parameters may be due to increased availability of nutrients in root zone in balanced manner. Furthermore, there was a continuous supply of nutrients in fertigation as the fertilizers were applied in split doses during the entire growth period of the plants, which might have encouraged the plant in meeting the requirements of nutrients during the critical period of growth. These above findings are in accordance with Ramana *et al.* (2014) [13] who recorded highest plant growth parameters *i.e.* plant height, stem girth and canopy volume under higher dose

of NPK were supplied in sweet orange. Our finding is in conformity with the previous research conducted by Nirgude *et al*. (2016) [10] in Mosambi and Shrigure *et al*. (2001) [17] in mandarin reported higher vegetative growth when fertigation dose was kept 100% RDF NPK. Our result is in conformity with the findings of Bussi *et al.,* (1991) [2], they recorded that N fertigation enhanced trunk diameter as compared with single soil application of same quantity of fertilizer in peach trees. Trunk diameter growth is related to tree canopy growth, which was positively affected in response to N fertigation. In contrast, Carlos *et al.,* (2010) [3] reported that fertigation frequency had little impact on plant growth for all treatments received adequate and equal amount of water and fertilizer. There were no differences in trunk growth when receiving half and full nitrogen treatments throughout the experiment period (Ferguson *et al.,* 1990) [4]. Koo *et al*., 1969 [6] found no differences in the size of tree canopy growth between both forms of fertilizer application.

Table 2: Effect of Fertigation on increase in tree height, trunk girth and canopy volume in Kinnow mandarin

Treatments	Tree height (cm)	Trunk girth (cm)	Canopy volume (cm^3)	Yield/tree (Kg/tree)
T1	87.69	6.23	70.22	12.64
T2	82.95	5.79	61.31	11.62
T3	74.84	5.22	56.64	10.77
T4	69.30	4.83	47.78	9.77
T5	69.38	4.55	39.03	7.51
Sem (±)	3.5317	0.2896	4.7386	0.8538
CD at 5%	10.22	0.8387	13.72	2.4731

Yield per tree

The analysis of variance with respect to number of fruits at harvest presented in Table 2 showed that treatments were found to differ significantly. The maximum yield was calculated from treatment T_1 (12.64 kg/tree) whereas the lowest yield /tree (7.51 kg/tree) was noticed in treatment T_5. This result is in line with the study conducted by Coelho *et al*.,(1996) [11] who carried and compared the experiment including different treatment that have 4 levels of fertigation of NPK and soil application used as control, who found that there was significant improvement in yield, quality. Moreover, they found that the combination effect of drip irrigation and fertigation was found superior than their individual effects. It only be due to efficient use of nutrient and water. So, nutrient use efficiency (NUE) and water use efficiency (WUE) may be enhanced (Kaushal *et al*., 2012) [5]. Moreover, our finding is also supported by the findings of (Narda *et al.,* 2002) [9] who reported that, the increase in yield can be because of better root proliferation, increased nutrient elements in the soil, enhanced uptake of nutrients and water and higher photosynthesis leading to an increase in the assimilation rates. The low fruit set in control treatment could be the result of less nutrient availability and poor vegetative growth on account of scarce nutrient availability in turn, reducing the number, size and weight of the fruits (Kaushal *et al.,* 2012) [5] who found that amplification in these parameters due to increase in the number of leaves which worked as an efficient photosynthesis structure and produce high amount of carbohydrates in the plant system. More number of flowers, which resulted higher fruits per plant fruit yield and their attributes and the increase in marketable yield. Similar view is supported by previous research by Srivastava and Singh (2002) [19] and Shirgure *et al.* (2016) [16] in Nagpur mandarin. The fruit yield decreased with decreasing irrigation level and nutrient level resulting into lesser number of fruit with lower fruit weight This could be caused by lower photosynthesis rate of leaves under continuous soil water deficit prevailed under control condition or probably due to reduction in availability of assimilate and lower stomatal conductance. Moreover, yield results agree with those obtained by Boman (1983) [1] using Valencia orange trees and Maksoud *et al*., (2003) [7] using Balady mandarin trees and, who studied that potassium foliar application increased citrus yield.

Conclusion

The study has revealed that the application of fertigation with NPK at the dose of 100% RDF of NPK (600:288:288g/plant/year) gave the highest plant height, stem girth, canopy volume, number of fruits per plant of Kinnow tree under high density planting condition. Hence, on the basis of above results treatment T2 was found the best in respect of growth parameters and yield because almost all parameters showed parity results with T1 i.e. 120% RDF of NPK. Furthers research are required for validation of above results also.

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