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Effect of fertigation on growth, yield and quality of Nagpur mandarin

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ABSTRACT

A field experiment was conducted during 2015-16 to find out the Effect of fertigation on growth, yield and quality of Nagpur mandarin (Citrus reticulata Blanco). The experiment was laid out in randomized block design with six treatments with six fertigation levels including, 55, 70, 85, 100 and 115 per cent water soluble fertilizers (NPK) were applied through fertigation as well as soil application with RDF to test various attributes of 10-years old Nagpur mandarin orcharding and replicated four times. The investigation indicated that treatment T_2 with 115% NPK fertigation resulted in maximum incremental plant height (0.63 m), stem girth (5.83 cm), plant spread (0.68 m) and canopy volume (13.88 m^3). However, highest number of fruits plant^{-1} (649.86), fruit yield (107.98 kg plant^{-1}) and (29.9 t ha^{-1}) were recorded in 100% fertigation with RDF which was at par with fertigation with 115% and 85 % of recommended dose of fertilizers. superior fruit quality parameters i.e. juice content (52.32%), TSS (11.06^{0}Brix), acidity (0.81%) and TSS : acidity ratio (13.66) were observed in 85% fertigation with RDF. Lower growth, yields and quality attributes were obtained in soil application of fertilizers and fertigation with 70% and 55% of recommended dose of NPK fertilizers. This showed that optimum dose of fertigation (85%) is necessary for higher yields, improving fruit quality with saving of fertilizers in Nagpur Mandarin crop.

Keywords: *fertigation, Nagpur Mandarin crop*

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INTRODUCTION

Citrus is often regarded as a queen of all fruits, it is one of the importance subtropical fruit crop and which is largest grown fruit in the world originates from the wet tropics in Southeast Asia. It is the third largest fruit crop grown next banana and mango in India. In India it is cultivated on 329900 ha i.e. 3.9 % of the total area under fruit crops with annual production of 3431400 MT. In India the average productivity of Mandarin is 10.4 t ha^{-1} (National Horticulture Database 2015). Citrus is cultivated between 40ºN and 40ºS, up to 1800 m altitude in the tropics and up to 750 m altitude in the subtropics.

In Maharashtra it is mainly grown in Vidarbha and known as Nagpur Mandarin having average productivity of only 5.5 t/ha. Improper water and fertilizer management is one of the reasons of low productivity and decline of citrus orchards. The soil close to the active root zones, when the roots are more active increase fertilizer use efficiency, resulting in higher productivity (Lyenger *et al*, 1996). Traditionally this crop is grown with 6 x 6 m spacing on level field and irrigated with basin method. Because of scarcity of water many orchard growers are adopting drip irrigation. But fertilizers are still applied with band placement or soil application method which requires more labours and also results in low fertilizer use efficiency. This practice does not match with the drip irrigation. Therefore application of fertilizers along with drip irrigation i.e. fertigation is necessary.

Fertigation which combines irrigation with fertilizers is well recognized as the most effective, economical and convenient means of maintaining optimum fertility level and water supply according to the specific requirement of each crop and resulting in higher yields and better quality fruits (Smith, 1979; Syvertsen, 1996). Fertigation offers the best and sometimes the only way of ensuring that nutrients enter the rootzone in areas with inadequate rainfall. Keeping these points in view, an experiment was conducted at farmer field to find out optimum dose of fertigation during 2015-16 to study the effect of fertigation on growth, yield and quality of Nagpur mandarin

MATERIAL AND METHODS

A field experiment was conducted to study the effect of effect of fertigation on growth, yield and quality of 10 years old Nagpur Mandarin crop for *ambia bahar* during the year 2015-16 at farmers field (Shri. Anantraoji Gharad) at village Nimaji Ta: Kalmeshwar, Dist. Nagpur, Maharashtra. The soil with pH 7.25 and EC 0.35 dSm^{-1}, Mechanical analysis of soil showed that the soil contains 20.00% sand, 38.80% silt and 41.20% clay portion. Organic carbon, available nitrogen, phosphorus and potassium of soil were 0.60%, 193.70, 12.7 and 402.5 kg ha^{-1}, respectively. The treatment details and split schedule of fertigation are given in below.

Details of treatments:

	Specifications
T_1	Soil application with RDF - 1200 - 400 - 600 NPK (g $plant^{-1}$) [332 - 110 - 166 (kg ha^{-1})]
T_2	Fertigation with 115% of RDF - 1380 - 460 - 690 NPK (g $plant^{-1}$) [382 - 127 - 191(kg ha^{-1})]
T_3	Fertigation with 100% of RDF - 1200 - 400 - 600 NPK (g $plant^{-1}$) [332 - 110- 166 (kg ha^{-1})]
T_4	Fertigation with 85% of RDF - 1020 - 340 - 510 NPK (g $plant^{-1}$) [283 - 94 - 141 (kg ha^{-1})]
T_5	Fertigation with 70% of RDF - 840 - 280 - 420 NPK (g $plant^{-1}$) [233 – 76 - 116 (kg ha^{-1})]
T_6	Fertigation with 55% of RDF - 660 - 220 - 330 NPK (g $plant^{-1}$) [183 - 61 - 91 (kg ha^{-1})]

The water soluble fertilizers 19:19:19, urea and muriate of potash (water soluble) were used for fertigation treatments (T_2 to T_6). Firstly the P dose was fulfilled .by using 19:19:19 fertilizer and thereafter additional N and K were supplied through urea and muriate of potash (water soluble) fertilizers. The soil was found deficient in zinc. Therefore zinc sulphate was applied uniformly initially @ 40 g $tree^{-1}$ by soil application.

Split schedule for fertigation

For treatment T_1, as per Dr. PDKV Akola recommendation, the circular soil application of granular fertilizers (urea, single super phosphate and muriate of potash) at 1 m radius from plant stem under basin irrigation was performed three times a year. Fertilizers were applied through in line drip irrigation system as per the schedule given below. After the withdrawn of water stress fertilizers were started in April 2015. Subsequently the fertilizers were applied as per schedule during 2nd month (May), 3rd and 4th month (June, July), 5th and 6th (August, September), 7th month (October) and 8th month (November 2015).

	Percentage Quantity of fertilizers through drip at each stage		
Stage	N	P	K
At withdrawn of water stress	20	25	20
2nd Month	20	25	20
3rd and 4th Month	20	25	15
5th and 6th month	20	10	15
7th month	10	10	15
8th month	10	5	15

The biometric growth parameters of Nagpur mandarin plants (plant height, stem girth, tree spread and canopy volume) were recorded initially and after harvesting of the crop during experimentation. The plant stem girth was taken 15 cm above the soil surface. The canopy volume of the mandarin tree was calculated according to formula suggested by Castle (1983). The number of fruits per tree was counted and fruit diameter, length was taken with the help of Vernier caliper. Average fruit weight was recorded with the help of an electronic balance. Mature fruits were harvested periodically from each treatment separately and the weight was recorded with the help of single pan balance and expressed in kilogram. Further, fruits ha^{-1} was calculated by multiplying the fruit yield $plant^{-1}$ to the number of plants ha^{-1}.

The samples of ten fruits per tree were randomly taken to determine fruit quality parameters (juice per cent, acidity and total soluble solids). Juice was manually extracted by juice extractor and its percent was

estimated on weight basis with respect to the fruit weight as per Garwell *et al.* (2000). The total soluble solid (TSS) was determined by digital refractometer by Lacey (2009) and acidity was measured by volumetric titration with standardized sodium hydroxide, using phenolphthalein as an internal indicator (Ranganna, 2001). All the data generated were subject to analysis of variance (ANOVA) and the critical difference (CD) at 5% probability according to the method described by Gomez and Gomez (1984).

Results and Discussion

Effect of fertigation on growth of Nagpur mandarin

The growth parameters showed significant difference in response to different levels of fertigation and soil application of fertilizers.

Table. 1 Effect of fertigation on growth of Nagpur mandarin

Treatments	Plant height (m)	Stem girth (cm)	Plant spread (m)	Canopy volume (m^3)
T_1 -Soil application with RDF	0.48	4.46	0.45	8.20
T_2- Fertigation with 115% of RDF	0.63	5.83	0.68	13.88
T_3- Fertigation with 100% of RDF	0.61	5.51	0.63	12.59
T_4- Fertigation with 85% of RDF	0.59	5.40	0.61	12.01
T_5- Fertigation with 70% of RDF	0.55	5.15	0.53	10.38
T_6- Fertigation with 55% of RDF	0.46	4.35	0.46	8.78
F Test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.01	0.20	0.04	0.81
CD at 5%	0.05	0.61	0.12	2.44

From the observations in Table.1 it is revealed that the highest incremental plant height (0.63 m), stem girth (5.83 cm), plant spread (0.68 m) and canopy volume (13.88 m^3) was recorded under treatment T_2- Fertigation with 115% of RDF which was statistically at par with treatment T_3- Fertigation with 100% of RDF (plant height 0.61 m, stem girth 5.51 cm, plant spread 0.63 m and canopy volume 12.59 m^3) and T_4- Fertigation with 85% of RDF (plant height 0.59 m, stem girth 5.40 cm, plant spread 0.61 m and canopy volume 12.01 m^3).

The lowest incremental plant height (0.46 m), stem girth (4.35 cm), plant spread (0.46 m) and canopy volume (8.78 m^3) among the fertigation levels was observed in treatment T_6- Fertigation with 55% of RDF. However, the incremental plant height (0.48 m), stem girth (4.46 cm), plant spread (0.45 m) and canopy volume (8.20 m^3) was also lower under T_1 - Soil application with RDF.

Among various fertigation levels, higher doses showed better growth of the plant. It might be due to application of higher dose of fertilizers attributed to better nutritional environment in the root zone as well as in plant system. Nitrogen, phosphorus and potassium are most indispensable of all mineral nutrients for growth and development of the plant as these are the basis of fundamental constituents of all living matter (Throughton *et al.,* 1974). Klein *et al*. (1989) found that vegetative growth was correlated positively with the amount of nitrogen applied. Results are in accordance with the findings of Shirgure *et al.* (2001b) in Nagpur mandarin.

Effect of fertigation on yield of Nagpur mandarin

The fruit yield contributing characters and fruit yield showed significant difference in response of different levels of fertigation and soil application of fertilizers.

Table.2: Effect of fertigation on yield of Nagpur mandarin

Treatments	Fruits Plant^{-1}	Avg.wt of fruit (g)	Fruit yield (kg plant^{-1})	Fruit Yield (t ha^{-1})
T_1 -Soil application with RDF	534.99	168.15	89.98	24.92
T_2- Fertigation with 115% of RDF	649.55	166.16	107.93	29.89
T_3- Fertigation with 100% of RDF	649.86	166.15	107.98	29.91
T_4- Fertigation with 85% of RDF	643.72	163.42	105.19	29.13
T_5- Fertigation with 70% of RDF	628.76	156.32	98.28	27.22
T_6- Fertigation with 55% of RDF	598.81	150.33	90.04	24.94
F Test	Sig.	Sig.	Sig.	Sig
SE (m) ±	9.55	0.68	1.64	0.45
CD at 5%	28.80	2.05	4.95	1.37

The fertigation with five different level of NPK had a positive effect on the yield as well as fruit quality of the Nagpur mandarin during 2015-16. The Nagpur mandarin fruits were harvested during first fortnight of January month in the year 2016. The average number of fruits per plant, yield, TSS, Juice content, and acidity was analysed for the study period and mean values were presented. The Nagpur mandarin yield (number of fruits per plant, fruit yield and average fruit weight) significantly influenced by the different NPK fertilizers fertigated in Nagpur mandarin.

The average number of fruits per plant was ranged from 534.99 to 649.86. The highest number of fruits per plants (649.86 fruits plant^{-1}) was recorded under fertigation with 100% of RDF which is at par with T_2 Fertigation with 115% of RDF (649.55 fruits plant^{-1}), T_4 Fertigation with 85% of RDF (643.72 fruits plant^{-1}) and T_5 Fertigation with 70% of RDF (628.76 fruits plant^{-1}). The lowest number of fruits per plant was observed under T_1 -Soil application with RDF (534.99 fruits plant^{-1}). The fruit yield was ranged from 24.92 to 29.91 tonnes ha^{-1}. The highest fruit yield was recorded under T_3- Fertigation with 100% of RDF (107.98 kg plant^{-1} and 29.91 tonnes ha^{-1}) which is at par with T_2 Fertigation with 115% of RDF (107.93 kg plant^{-1} and 29.89 tonnes ha^{-1}), Fertigation with 85% of RDF (105.19 kg plant^{-1} and 29.13 tonnes ha^{-1}). The lowest fruit yield was observed under T_1 -Soil application with RDF (89.98 kg plant^{-1} and 24.92 tonnes ha^{-1}).

Although the fruit yield of Nagpur mandarin obtained at fertigation with 85% RDF is at par with 70% fertigation of RDF in respect of number of fruits per tree but most of the parameters like average weight of fruit, fruit yield (kg plant^{-1}) and fruit yield (t ha^{-1}), the yield at fertigation with 70% of RDF is significantly lower indicating that fertigation with 85% of RDF is essential. Thus due to fertigation there is saving in fertilizers by almost 15 per cent.

The higher fruit yield under optimal drip-fertigation over surface irrigation with conventional fertilization was also observed earlier in various citrus cultivars (Duenhas *et al*., 2005; Morgan *et al*., 2009; Ramniwas *et al.,* 2012b). Fertigation reduces the use of fertilizers and at the same time increases the yield in most of the vegetables (Tiwari *et al*., 2003; Vijayakumar *et al*., 2010)

Effect of fertigation on quality of Nagpur mandarin

The effect of different levels of NPK fertigation was studied on fruit quality parameters. The recorded observations are shown significant differences among various treatments.

Table.3: Fruit quality parameters as influenced by different levels of fertigation

Treatments	Fruit length (cm)	Fruit dia. (cm)	TSS (^{0}Brix)	Acidity (%)	TSS:Acidity Ratio	Juice content (%)
T_1 -Soil application with RDF	6.70	6.83	9.31	0.84	11.03	43.89
T_2- Fertigation with 115% of RDF	6.35	6.47	10.65	0.82	12.95	49.65
T_3- Fertigation with 100% of RDF	6.33	6.43	10.76	0.82	13.05	49.555
T_4- Fertigation with 85% of RDF	6.26	6.23	11.06	0.81	13.66	52.32
T_5- Fertigation with 70% of RDF	5.84	6.07	10.22	0.84	12.29	48.61
T_6- Fertigation with 55% of RDF	5.68	5.96	10.08	0.83	12.06	47.12
F Test	Sig.	Sig	Sig.	NS	Sig.	Sig.
SE (m) ±	0.05	0.03	0.07	0.01	0.22	0.49
CD at 5%	0.16	0.09	0.24	0.04	0.68	1.49

The highest TSS (11.06^{o}Brix), juice per cent (52.32 %), lowest acidity (0.81%) and TSS-Acidity ratio (13.66) was observed under T_4- Fertigation with 85% of RDF which is at par with T_2- Fertigation with 115% of RDF and T_2- Fertigation with 100% of RDF. The highest average fruit length (6.70 cm), fruit diameter (6.83 cm) was observed under T_1 -Soil application with RDF, The lowest TSS (9.31^{o}Brix), juice per cent (43.89%) and highest acidity (0.84%) was observed under T_1 -Soil application with RDF.

The lowest average fruit length (5.68 cm), fruit diameter (5.96 cm) was observed under T_6- Fertigation with 55% of RDF. The higher TSS to acidity ratio is the indicator of sweetness of the fruit. If the TSS to acidity ratio is high means that the fruits have more TSS (total soluble solids) and less acidity. This ratio was analysed and the highest TSS to acidity ratio (13.66) was found under T_4- Fertigation with 85% of RDF which is at par with T_3- Fertigation with 100% of RDF (13.05) and T_3- Fertigation with 115% of RDF (12.90). The lowest TSS to acidity (11.03) was observed under T_1 -Soil application with RDF (Table.3).

The similar fruit yield and quality experimental results were observed in Nagpur mandarin (Shirgure *et al.,* 2001a), in Valencia orange (Koo and Smajstrla, 1984).

CONCLUSIONS

The application of fertilizers through drip system was found to be a potential fertilizer saving method in Nagpur mandarin. Fruit yield was significantly higher under all treatments of fertigation over soil application of RDF. The fruit yield and quality at 85% of RDF through fertigation was at par with 100% and 115% of RDF through fertigation. However, yield of fertigation with 70% RDF and 55% RDF were found statistically inferior to higher doses of fertigation. Drip-fertigation not only enhanced the fruit yield but also improved the fruit qualities (Juice percent, TSS, acidity) over soil application. Overall it can be concluded that application of 85% RDF through fertigation (1020-340-510 NPK g plant^{-1}) in six splits is beneficial for improving growth, yield and quality of Nagpur mandarin.

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