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Effect of foliar application of plant growth regulators and micronutrients on vegetative and reproductive growth of Nagpur mandarin *(Citrus reticulata Blanco)*

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Abstract

We report an experimentation on effect of different plant growth regulators and effect of micronutrient on growth and yield of Nagpur mandarin. The study was conducted at the Instructional cum Research Fruit Orchard, Department of Fruit Science, College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RVSKVV), Gwalior, Madhya Pradesh, India. We undertook 13 treatments and 3 replications in randomized block design. The results revealed that, foliar spray of T12 [Gibberellic acid (GA_3) @ 60 ppm + Naphthalene acetic acid (NAA) @ 100 ppm + Ferrous sulphate ($FeSO_4$) @ 0.6 %) was found to be the best for maximum increase in plant height (3.15 m), canopy volume (1.77 m^3) canopy spread (8.03 E-W) (cm), canopy spread (7.80 N-S) (cm), and number of flowers/ plant (551), fruit set (55.05%), fruit retention (67.30 %), fruit weight (137.00 g) and number of fruits/plant (192.50), fruit yield /plant (26.38 kg)and yield per hectare (7.25 tons). Hence the foliar application of GA3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6% significantly increased the growth and yield of Nagpur mandarin.

Key words: *PGR's; Micronutrients; Growth, Yield, Nagpur mandarin ; Gibberellic acid (GA3); Naphthalene acetic acid (NAA); Ferrous sulphate($FeSO_4$).*

Introduction

Citrus (*Citrus reticulate* Blanco.) is one of the most important fruit crops of the globe, extensively cultivated in tropical and sub-tropical climate. Mandarin orange (*Citrus reticulate* Blanco.) is most common among citrus fruits grown in India. It occupies nearly 40 per cent of the total area under citrus cultivation India. The total area and production under mandarin in India is estimated 428.3 thousand hectares and 5101.10 million tonnes. The total area and production of mandarin in Madhya Pradesh are 121.11 thousand hectares and 2103.64 million tonnes, respectively (Anonymous, 2018). In Madhya Pradesh, it is cultivated in Chhindwara, Dhar, Badawani, Khargon, Khandwa, Ujjain, Ratlam, Mandsaur, Neemach, Shajapur, Gwalior, Burhanpur, Hoshangabad, Murena, and Guna Districts. Malwa is an important region in Madhya Pradesh, where acid mandarin is grown, respectively (Anonymous, 2018). The fruits are well known for their dietary, nutritional, medicinal and cosmetic properties and are also good source of citric acid, flavonoids, phenolics, pectin, limonoids, ascorbic acid etc. (Saini *et al.,* 2022). Pre-harvest fruit drop is major reason of low yield in malwa regions, this drop of fruit at various stages of fruit development is due to malnutrition, water stress, and excessive insect pest attack and most important is the hormonal imbalance. Tree drops its fruit when the concentration of auxins decreases and the concentration of abscisic acid (ABA) increases (Marinho *et al.*, 2005) as the endogenous hormones and their balance play a modulating role in the mobilization of nutrients to the developing organs. The use of growth regulators has become an important component of agrotechnical procedures for most of the cultivated plants and especially for fruit plants (Monselise, 1979). So in citrus fruits, excessive fruit drop can be controlled by the exogenous application of plant growth regulators. The auxins and gibberillins are used to control the fruit drop in citrus and to improve the quality of fruit (Almeida *et al.*, 2004). The micronutrients on the other hand though are required in small amount but play a great role in plant metabolism (Kazi *et al.,* 2012). These are involved in the synthesis of many compounds essential for plant growth and productivity and are the activators for various enzymes. Iron plays a key role in several enzyme-systems (Khurshid *et al.,* 2008). Although some references are available in the literature and efforts have been made to control the fruit drop by exogenous application of growth regulators and iron but there is no precise recommendation for the control of fruit drop in Nagpur Santra in Malwa plateau conditions. So there is a need to test the efficacy of plant growth regulators and micronutrient to reduce fruit drop and improve the quality and yield under agro-environmental conditions of Malwa region. Soil application of micronutrients is not effective as citrus is deep rooted crop. Since, Micronutrient applied to soil may be of little value, the alternative way is to supply micronutrient fertilizer through foliar spray.

Material and Methods

The research was conducted during 2018-2019 at the *Instructional cum Research Fruit Orchard*, Department of Fruit Science, KNK College of Horticulture, Mandsaur (MP), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (MP). Mandsaur is situated at 23.45^0 to 24.13^0 N latitude and 74.44^0 to 75.18^0 E longitudes at an altitude of 435 m mean sea level (MSL).

Soil analysis

The soil of the orchard is rich in organic matter, black in colour, little heavier and possesses good water holding capacity. The representative samples each of 5 g for analysis were taken and the samples were analyzed in the laboratory of Soil Science, KNK College of Horticulture, in order to determine the texture and fertility status of the soil. The soil of the experimental site has been classified as light black in colour, little heavier and possesses good water holding capacity. The result of soil analysis presented in the Table 1.

Table 1: Chemical analysis of soil

S. N.	Soil Components	contents	Remarks
1	Available nitrogen (kg/ha) (Subbiah and Asija, 1956)	533	High
2	Available P_2O_5 (kg/ha) (Olsen *et al.*,1954)	14.9	Low
3	Available K_2O (kg/ha) (Jackson,1967)	533	Very high
4	pH (Piper ,1966)	7.5	Normal
5	Electrical conductivity (mm mho/cm) (Piper,1966)	0.49	Normal
6	Organic carbon (Chopra and Kanwar,1980)	0.94	High

Selection of tree

Five years old uniform trees of mandarin (*Citrus reticulate* Blanco) were selected for the study at *Instructional cum Research Fruit Orchard*, Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.).

Experimental details

The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments and three replications consisting of thirtynine trees altogether. Each tree is considered as one replication.

Treatment details

GA_3@ 20ppm (T_1), GA_3 @ 40 ppm (T_2), GA_3 @ 60 ppm (T_3), NAA @ 50 ppm (T_5), NAA @ 75 ppm (T_6), NAA @ 100 ppm (T_7), FeSO4 @ 0.2 % (T_8), $FeSO_4$ @ 0.4% (T_1), $FeSO_4$@ 0.6% (T_9), GA_3 @ 20 ppm + NAA @ 50 ppm + $FeSO_4$ @ 0.2 % (T_{10}), GA_3 @ 40 ppm + NAA @ 75 ppm + $FeSO_4$ @ 0.4 % (T_{11}), GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 % (T_{12}) and water spray (T_{13}).

Preparation of solution

NAA and Ferrous Sulphate ($FeSO_4$)

The required amount (1g) of NAA was weighed with the help of electronic balance for the preparation of solution. After dissolving them in 10ml of 99% absolute ethyl alcohol, the solution was replaced in 1000 cc volumetric flask, when distilled water (990 ml) was added to it for make up the volume up to the 1000 cc. It was used as stock solution. Ferrous sulphate were dissolved in 1 liter of distilled water.

Gibberellic acid (GA_3)

The required amount (1g) of GA_3 was weighed with the help of electronic balance for the preparation of solution. After dissolving them in 10ml of 99% absolute ethyl alcohol, the solution was replaced in 1000 cc volumetric flask, when distilled water (990 ml) was added to it for make up the volume up to the 1000 cc. It was used as stock solution.

Stage and method of application

Foliar sprays of prepared solutions *i.e.* Naphthalene acetic acid (NAA), Gibberellic acid (GA_3) and Ferrous sulphate ($FeSO_4$) as per treatment were done when the full blooming stage. The spray solutions of the required concentrations of different level of plant growth regulator and nutrient were prepared from the stock solutions and sprayed on the trees on the scheduled day in the morning hours (before 9 a.m.) with the help of foot sprayer equipped with a long handle and micro-fine nozzle to ensure a fine mist sufficiently for wetting the foliage without causing run-off.

Observational parameters

The observations were recorded on different aspects to vegetative, reproductive and yield characteristics like plant height (m), canopy spread (cm), canopy volume (m_3), leaf area (cm_2), number of flower per plant, fruit set (%), fruit retention (%), fruit drop (%) and yield parameters such as number of fruit per plant, fruit weight (gm), fruit yield per plant (kg) and estimated fruit yield per hectare (ton) were recorded at horticultural maturity of Nagpur mandarin fruits.

Result and Discussion

Vegetative parameters

Mean value of different vegetative parameters obtained from statistical analysis under different treatments are presented in Table 2.

The data on plant height, canopy volume, canopy spread and leaf area significantly influenced due to the effect of foliar application of GA_3, NAA and $FeSO_4$ over the control. When applied singly without combination (T_1 to T_9), the maximum plant height (2.74 m) was observed with application of GA_3 @ 60 ppm over all the single treatments. Different level of GA_3, NAA and $FeSO_4$ when spray in combinations (T_1 to T_{13}), higher combination (T_{12}) given significantly maximum plant height (3.15 m) which is followed by the treatment T_{11} (3.10 m) and T_{10} (2.93 m). The minimum value of plant height found with control T_{13} (2.35 m). The increase in plant height by GA_3 might be due to the fact it stimulates rapid cell elongation in part to the activation of intercalary meristematic region of the growing shoots and also increases inter nodal length of the branches. GA_3 helps in cell elongation and enlargement thereby increase in uptake of water and nutrients due to persuasive swelling forces leading the softening of cell wall and thereby enhanced development of plants resulting in greater height. These results are in accordance with the findings of Dwivedi *et al.* (2018) and Singh *et al.* (2018) in Kinnow mandarin and (Knoche *et al*., 2000) in sweet cherry. NAA also involved to improves the effects of cell division and cell wall elongation and leads to the increase shoot length, whereas, tree canopy spread may be due to effective conversion of stored food material for initiation of more side branches in the trees (Crosier *et al.,* 2000).

Table 2: Effect of foliar application of GA_3, NAA and $FeSO_4$ on vegetative characteristics of Nagpur Mandarin

Treatments	Plant height (m)	Increase in canopy volume (m^3)	Increase in canopy spread (E-W) & (N-S) (cm)		Leaf area (cm^2)
			E-W	N-S	
GA_3 @ 20 ppm	2.64	1.34	6.47	6.17	26.59
GA_3 @ 40 ppm	2.70	1.53	7.57	7.50	26.08
GA_3 @ 60 ppm	2.74	1.62	7.67	7.63	27.00
NAA@ 50 ppm	2.52	1.37	5.90	6.10	25.29
NAA@ 75 ppm	2.58	1.42	6.60	6.43	25.57
NAA @ 100 ppm	2.62	1.45	6.80	6.60	25.78
$FeSO_4$ @ 0.2 %	2.40	1.24	6.43	6.03	25.21
$FeSO_4$ @ 0.4%	2.52	1.38	6.70	6.27	25.60
$FeSO_4$ @ 0.6 %	2.50	1.41	6.90	7.43	25.74
GA_3 @ 20 ppm + NAA @ 50 ppm + $FeSO_4$ @ 0.2 %	2.93	1.57	7.07	7.13	29.77
GA_3 @ 40 ppm + NAA @ 75 ppm + $FeSO_4$ @ 0.4 %	3.10	1.73	7.73	7.57	30.57
GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 %.	3.15	1.77	8.03	7.80	30.76
Control (Water Spray)	2.35	1.09	5.83	5.57	23.44
S.Em.±	**0.08**	**0.05**	**0.22**	**0.17**	**0.71**
C.D. at 5%	**0.23**	**0.15**	**0.63**	**0.49**	**2.07**

Irrespective of treatments there was a linear increasing trends of canopy volume with the foliar spray of GA_3, NAA and $FeSO_4$ over control. Higher combination (T_{12}) (GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 %) given significantly maximum increase canopy volume (1.77 m^3). Treatment T_{11} (1.73 m^3) and T_3 (1.62 m^3) were also reported statistically at par with T_{12}. The minimum canopy volume found with control T_{13} (1.09 m^3). While (T_{12}) had given significantly maximum increase in canopy spread (E-W) and (N-S) (8.03 cm and 7.80 cm), which is followed by the treatment T_{11} (7.73 cm and 7.57 cm), T_3 (7.67 and 7.63 cm) and T_2 (7.57cm and 7.50 cm). The minimum value of plant spread in (E-W) direction found with control T_{13} (5.83 cm and 5.57 cm). GA_3 helps in cell elongation and enlargement thereby increase in uptake of water and nutrients due to persuasive swelling forces leading the softening of cell wall and thereby enhanced development of plants resulting in greater height and number of branches per plant and ultimately the greater plant spread and canopy volume. Similarly, effect of GA_3 treatment on per cent increase in plant spread and crown volume was recorded significantly by Eelkim *et al.* (2003). Tree canopy spread may be due to effective conversion of stored food material for initiation of more side branches in the trees. The results are in accordance with the findings reported Jagtap *et al*. (2013), Shinde *et al*. (2008), Kachave and Bhosale (2007) in Acid Lime, Yadav and Chaturvedi (2004) in ber, Dixit *et al.* (2013) in Litchi and Gaur *et al.* (2014) in guava. Choudhary *et al.* (2013) revealed that application of GA_3@ 100 ppm showed superior results with respect per cent increase in plant spread (20.59%) over control on 150 days after treatment of Nagpur mandarin.

Higher level of combination (T_{12}) significantly enhanced leaf area (30.76 cm^2) over rest of the treatments. However, it was also found at par with treatment (T_{11}) (30.57cm^2) and T_{10} (29.77 cm^2). The minimum value among all the treatments was found with control T_{13} (23.44 cm^2), showed in Table 1. Similarly, Karole and Tiwari (2016) revealed that Maximum values for leaf length (1.70 cm), leaf width (1.49 cm) and leaves/shoot were recorded with foliar application of 60 ppm NAA + 30 ppm GA3 + 2.0% urea followed by 40 ppm NAA + 20 ppm GA_3 + 1.5% urea whereas minimum in control of ber. The favorable effect of GA_3 and NAA in promoting area of leaves might be due to abundant supply of GA_3 on plant growth moreover, the increase in vegetative growth may be attributed to an increase uptake of these elements which being a constituent of protein component of protoplasm, favorably influenced chlorophyll content in leaves. All these factors contributed to cell multiplication, which has resulted in to better photosynthetic activity and its translocation to promote better vegetative growth.

Reproductive parameters

Number of flowers per plant, Fruit set percentage, Fruit drops and fruit retention was significantly affected by the foliar spray of GA_3, NAA and $FeSO_4$ over control.

The maximum number of flower (531.00) was observed with application of NAA @ 100 ppm in comparison to the single treatments and control. Whereas significantly higher number of flowers (551.00) gained from the plant who sprayed with higher level of GA_3, NAA and $FeSO_4$ in combinations (T_{12}) as compared to other treatments. Although, treatment T_{11} (544.67) and T_6 (531.00) was found at par with T_{12}. The minimum value found with control T_{13} (320.67). The improvement in flowering parameters may be due to that combined effects of $GA_{3,}$ NAA and Fe, the role of GA_3 and NAA was to boost up of growth by providing stability to flowers by constant supply of nutrients leads to increase in earliness in flowering traits. Similar findings were also reported by Bhati *et al.* (2016) and Tagad *et al.* (2018) in Acid lime.

Table No. 3. Showed that the maximum fruit set (47.88%) was observed with application of NAA @ 100 ppm over all the remaining single treatments. When different levels of GA_3, NAA and $FeSO_4$ applied in singly and in combination (T_1 to T_{13}), higher combinations (T_{12}) significantly increased fruit set (55.85%) which is statistically at par with the treatment T_{11} (54.11%) and T_{10} (52.54%). The minimum fruit set was observed with control (T_{13}) (36.27 %). The application 2,4-D (100 mg/l) and GA3 (100 mg/l) to fruiting branches increased fruit set by 17.3 and 21.4%, respectively in ginkgo (Ginkgo biloba) trees (Zhao *et al*, 2005). The results of our study indicate that 5 mg/l GA3 can be used to enhance fruit set in 'Kinnow' mandarin.

The minimum fruit drop was observed with application of NAA @ 100 ppm (34.45%) over all the single treatments, showed in Table No. 2. Different level of GA_3, NAA and $FeSO_4$ when sprayed single as well as in combinations (T_1 to T_{13}), higher combination (T_{12}) significantly reduced fruit drop (27.17%) which is followed by the treatment T_{11} (28.78%). The maximum fruit drop found with control T_{13} (53.94%). Similarly, Kumar *et al.,* (2014) conformed in phalsa that the higher number of fruits might be due to fact that nitrogen is component of chlorophyll and gibberellic acid and auxin help in chlorophyll formation that regulate the buildup of proper C:N ratio, which controls the flowering and fruiting of plants.

NAA @ 100 ppm exhibited significantly higher fruit retention (66.51 %) when applied singly or without combination (T_1 to T_9). Different levels of combination as well as single spray of all components i.e. GA_3, NAA and $FeSO_4$ (T_1 to T_{13}), higher combination (T_{12}) had significant effect to increasing fruit retention (67.30 %) followed by the treatment T_{11} (66.68 %), T_6 (66.51%), and T_5 (66.43%). The minimum fruit retention among all the treatment was found with control.T_{13} (59.20 %). Foliar application of the growth regulators GA3 and NAA application significantly reduced the fruit drop and increased fruit retention therefore, number of fruits per tree was found highest in GA3 treated acid lime trees. These results are in accordance with the findings of Kachave and Bhosle (2007) in kagzi lime, Singh and Rethy (1995) in acid lime and Babu *et al.* (1984) in lime.

Table 3: Effect of foliar application of GA_3, NAA and $FeSO_4$ on reproductive characteristics of Nagpur Mandarin

Treatments	Number of flowers per plant	Fruit setting (%)	Fruit drop (%)	Fruit retention (%)
GA_3 @ 20 ppm	446.67	36.98	42.63	61.23
GA_3 @ 40 ppm	461.33	38.09	38.23	61.82
GA_3 @ 60 ppm	469.33	39.15	37.11	62.60
NAA@ 50 ppm	486.67	46.73	39.63	64.93
NAA@ 75 ppm	526.00	46.97	35.90	66.43
NAA @ 100 ppm	531.00	47.88	34.45	66.51
$FeSO_4$ @ 0.2 %	460.67	40.93	40.16	64.02
$FeSO_4$ @ 0.4%	474.33	42.52	37.53	64.43
$FeSO_4$ @ 0.6 %	487.33	44.53	36.79	64.64
GA_3 @ 20 ppm + NAA @ 50 ppm + $FeSO_4$ @ 0.2 %	522.00	52.54	33.40	65.36
GA_3 @ 40 ppm + NAA @ 75 ppm + $FeSO_4$ @ 0.4 %	544.67	54.11	28.78	66.68
GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 %.	551.00	55.85	27.17	67.30
Control (Water Spray)	320.67	36.27	53.94	59.20
S.E.	**6.96**	**1.18**	**1.72**	**0.64**
C.D. at 5%	**20.31**	**3.44**	**5.02**	**1.87**

Yield parameters

Number of fruits per plant, fruit weight and yield significantly increased due to foliar application of GA_3, NAA and $FeSO_4$ over control (Table 4).

The maximum fruit weight (134.40 g) was achieved with application of GA_3 @ 60 ppm when applied without combinations (T_1 to T_9). Among the Lower to higher combination of all components i.e., GA_3, NAA and $FeSO_4$ when sprayed alone and in combination (T_1 and T_{13}), higher combination (T_{12}) had significant effect on increasing the fruit weight (137.00 g) followed by T_{11} (136.33 g) and T_{10} (135.33 g). The minimum value among all the treatment of fruit weight (126.33 g) was found with control (T_{13}). Huang and Huang (2005) reported that spraying GA3 (50 mg/l) on citrus achieved good results by protecting fruitlets and increasing yield in 'Nanfengmiju' mandarin. Similarly, Saleem *et al.* (2008) observed that application of 45 mg/l GA3 to 15-years-old 'Blood Red' sweet orange plants at the full bloom stage increased yield (71 kg/tree) more than the control (48 kg/tree).

When GA_3, NAA and $FeSO_4$ applied singly without combination (T_1 to T_9), the maximum fruits per plant (156.00) was received with application of GA_3 @ 60 ppm. Different level of GA_3, NAA and $FeSO_4$ when sprayed alone and in combinations (T_1 to T_{13}), higher combination (T_{12}) significantly increased number of fruits per plant (192.50) which is followed by the treatment T_{11} (187.50) and T_{10} (181.00). The minimum number of fruits per plant (90.00) found with control (T_{13}). While, the maximum fruits yield per plant (20.96 kg) was obtained with application of GA_3 @ 60 ppm over all the single treatments. Different level of GA_3, NAA and $FeSO_4$ when sprayed in combinations (T_1 to T_{13}), higher combination (T_{12}) significantly maximum increased the fruits yield per plant (26.38 Kg) and it is also followed by the treatment T_{11} (25.55 Kg). The minimum number of fruit yield per plant (11.98) found with control (T_{13}). Similarly, the maximum fruits yield per hectare (5.80 ton) was obtained with application of GA_3 @ 60 ppm over all the single treatments. Different level of GA_3, NAA and $FeSO_4$ when sprayed in alone and in combinations (T_1 to T_{13}), higher combination (T_{12}) significantly increased fruits per yield per hectare (7.25 ton) which is followed by the treatment T_{11} (7.07 ton) and T_{10} (6.77 ton). The minimum fruits yield per hectare (3.28 ton) found with control (T_{13}).

Table 4: Effect of foliar application of GA_3, NAA and $FeSO_4$ on marketing characteristics of Nagpur Mandarin

Treatments	Number of fruits/plants	Fruit yield (kg) per plant	Fruit yield/ ha. (tone)	Fruit weight (g)
GA_3 @ 20 ppm	142.00	18.91	5.22	133.00
GA_3 @ 40 ppm	153.33	20.60	5.70	134.33
GA_3 @ 60 ppm	156.00	20.96	5.80	134.40
NAA@ 50 ppm	117.67	15.44	4.27	131.33
NAA@ 75 ppm	124.67	16.48	4.56	132.13
NAA @ 100 ppm	131.67	17.41	4.79	132.67
$FeSO_4$ @ 0.2 %	105.33	13.81	3.82	131.10
$FeSO_4$ @ 0.4%	116.67	15.35	4.25	131.67
$FeSO_4$ @ 0.6 %	121.33	16.34	4.52	131.83
GA_3 @ 20 ppm + NAA @ 50 ppm + $FeSO_4$ @ 0.2 %	181.00	24.47	6.77	135.33
GA_3 @ 40 ppm + NAA @ 75 ppm + $FeSO_4$ @ 0.4 %	187.50	25.55	7.07	136.33
GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 %.	192.50	26.38	7.25	137.00
Control (Water Spray)	90.00	11.98	3.28	126.33
S.E.	**4.63**	**0.64**	**0.17**	**0.89**
C.D. at 5%	**13.51**	**1.87**	**0.49**	**2.59**

The reason for increase in growth due to Iron increases the manufacture of more carbohydrate in the leaves which increase in flowering, fruit set, fruit size, control the fruit drop and ultimately it increases the yield of plants (Rana and Sharma, 1979). The results are also consonance with the similar finding of Jagtap *et al*. (2013). The significant increase in yield by NAA application may be accredited to the maximum number of fruits per plant with NAA might be attributed to less dropping of flowers and fruits, as the application of growth regulators made up the deficiency of endogenous auxin, which prevented formation of abscission layer possibly through the inhibition of enzymatic activity at higher temperature. The results of present investigation are in conformation with the findings of (Greenberg *et al.,* 2006 and Nawaz *et al.,* 2008). The higher yield may be probably due to consolidated effect of better cell division, cell differentiation thereby causing increased size and weight of fruits caused by foliar application of GA_3 and iron. The increment in fruit weight might be due to hormone directed to transportation and accumulation of photosynthetic which resulted in better fruit development and also acceleration of cell division, elongation, and enlargement. In addition, GA_3 may have affected the auxin metabolism, which may have indirectly aided in fruit enlargement and thus the production of fruits in higher number, which ultimately increases yield per plant and yield per hectare (Kappel and Mac Donald, 2007 and Singh and Singh, 2006).

Conclusion

On the basis of results obtained in present investigation it is concluded that foliar spray of T_{12} (GA_3 @ 60 ppm + NAA @ 100 ppm + $FeSO_4$ @ 0.6 %) was found to be the best for maximum increase in Plant height (m), canopy volume (m^3) canopy spread (E-W) (cm), canopy spread (N-S) (cm), and leaf area (cm^2) number of flowers/ plant, fruit set (%), fruit retention (%),fruit length (cm), fruit diameter (cm), fruit volume (ml), fruit weight (g), and number of fruit per plant, average fruit weight and reduced fruit drop (%) which ultimately increased the yield of fruit per plant.

In conclusion, thus the results of this study suggested that growth regulators and micronutrients have a great potential to affect yield of Nagpur mandarin. Therefore, these can be utilized for sustainable and higher fruit production and the fruit drop can be reduced to a great extent.

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