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Effect of plant growth regulators on yield and economic feasibility of 'Nagpur Mandarin' (*Citrus reticulata* Blanco.)

H.D. Choudhary* and M.C. Jain
Department of Fruit Science, College of Horticulture and Forestry, Jhalawar-326001 (Rajasthan).
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Abstract

An investigation was carried out at Fruit Research Farm, Department of Fruit Science at College of Horticulture and Forestry, Jhalawar during July, 2012 to April, 2013 to study the individual effect of plant growth regulators on yield and economic feasibility of Nagpur mandarin (*Citrus reticulata* Blanco.). The physical characters of fruit like maximum increase in diameter (horizontal and vertical), weight, volume and number of sacs per fruit was recorded with the spray of 100 ppm GA_3, which was closely followed by 30 ppm 2,4-D. The maximum number of fruit per tree, fruit retention per cent, yield per plant and per hectare and economic feasibility was recorded with the spray of 30 ppm 2,4-D which was significantly higher to control.

Key words: *NAA, GA_3, 2,4-D, Triacontanol, yield and economic feasibility.*

Introduction

In India, citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits after mango and banana. Mandarin (*Citrus reticulata* Blanco) is considered to be one of the most important cultivated species among citrus and is being commercially grown in certain specific region of the country like Nagpur mandarin in Central India; this crop occupies the first position among the citrus in India with respect to area and production. Nagpur Santra is finest variety and very popular in India as well as in world for its good quality fruits. Fruit size big, subglobose, average weight 110-125 gm, rind medium thick, fairly loosely adherent, surface is also relatively smooth but, segment found in 10-15 number and number of seeds 1-2 per segment, colour of peel pale orange yellow. Fruit have mild flavor, excellent quality, juicy, TSS 10-12^0 brix, and acidity 0.50-0.70%. The total production of oranges in India is 3255.0 thousand MT from an area of 324.0 thousand hectares with the productivity of 10 MT/ha. In Rajasthan, mandarin covers 15.2 thousand hectares area and the productivity of 17.9 MT/ha (NHB, Database, 2011). In the state, In Jhalawar district mandarin where it is grown over 22,500 ha area, 13,000 ha of which are in the fruit bearing stage and the production is 2 lac tonnes (Anonymous, 2012).

*Corresponding author's email:
haridayal.choudhary@gmail.com

A lot of research has been done on the use of PGR to improve fruit size, delay in fruit maturity and overcome rind staining in citrus. However, limited studies have been conducted to evaluate the complete profile of fruit quality in response to growth regulators application to citrus during fruit development. The auxins and gibberellins are widely used to control the fruit drop in citrus and to improve the quality of fruit (Almeida *et al.*, 2004). The application of plant growth regulators can provide significant economic advantages to citrus growers when used in properly as these have proven effective in stimulating a number of desired responses such as increase in fruit size and delay in fruit maturity (Coggins Jr and Hield, 1968). Nawaz *et al.* (2008) reported that 2,4-D, NAA and GA_3 treatments reduced pre harvest drop of Kinnow mandarin compare to control, significantly. Application of Gibberellic acid (GA_3) before or at full bloom increased fruit size and pedicel length.

Materials and Methods

The present investigation was carried out on six years old mandarin **(***Citrus reticulata* Blanco.) cv. 'Nagpur' of uniform size and growth at the Fruit research farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar during first week of July, 2012 to last week of April, 2013. The experiment was consisting of 17 treatments having four levels of each NAA (50, 100, 150 and 200 ppm), GA_3 (25, 50, 75 and 100 ppm), 2,4-D (10, 20, 30 and 40 ppm) and triacontanol (5, 10, 15 and 20 ppm) along with water

spray as control. The experiment was laid out in randomized block design with three replications. The growth regulators, after weighing was dissolved in small quantity of 95 per cent absolute alcohol and 2,4-D was directly diluted in distilled water . Stock solution was first prepared for each growth regulator by diluting with distilled water. The solution of required concentration was then prepared by further dilutions of the measured volume of stock solution with distilled water. Spray of growth regulators were done at first week of July, 2012 under all treatments as per treatment for each plant taking equal volume of the solution. Spraying was done in the evening with a compressed air hand sprayer. The control plant was sprayed with distilled water. The data generated during the experimentation were subjected to statistical analysis of variance. The significance of the treatments was tested through 'F' test at 5 per cent level of significance.

Results and Discussion

It is evident from the present results that application of various plant growth regulators at different concentrations significantly improved physical characteristics of fruits like horizontal diameter, vertical diameter, weight, volume of fruit, number of sacs per fruit, number of fruits per tree, fruit retention and yield of fruits as compared to control are presented. The data recorded on horizontal and vertical diameter of fruit clearly indicate that application of GA_3 at 100 ppm exhibited maximum horizontal and vertical diameter of fruit (8.03 cm) and (8.23 cm) which was found to be at par with 30 ppm 2,4-D (7.64 cm) and (7.83 cm) treatment. The minimum horizontal diameter of fruit (6.12 cm.) and vertical diameter of fruit (5.64 cm.) was recorded at control (Table-1). The results obtained in present investigation are supported by the findings of Chao *et al*. (2011) in mandarin.

Application of plant growth regulators had significantly increased the weight and volume of fruits over control. However, in the present study, the maximum fruit weight (191.22 g) was recorded by 100 ppm GA_3 treatment closely followed by 30 ppm 2,4-D (184.22 g) as compared to minimum at control (135.56 g) (Table-1). Similarly, the maximum volume of fruit (247.56 cc.) was recorded at 100 ppm GA_3 treatment that was followed by 30 ppm 2,4-D (211.89 cc) while the minimum volume (145.44 cc) was recorded in control (Table-1). The increase in weight and volume of fruit due to GA_3 treatment were also recorded by Reddy and Prasad (2012) in pomegranate and Chao *et al*. (2011) in mandarin.

The maximum number of sacs per fruit of 12.56 was recorded at 100 ppm GA_3 treatment closely followed by 30 ppm 2,4-D. However, the minimum number of sacs per fruit of 9.89 was recorded at control, respectively. The variation in the number of sacs per fruit due to different plant growth regulators might be attributed to difference in enzymetion alluding during cell division and cell differentiation phases of fruit developments.

The application of plant growth regulator treatments had significantly increased the number of fruits per tree and fruit retention per cent over control are presented in Table 1. The maximum number of fruits per tree (126.0) was recorded at 30 ppm 2,4-D treatment as compared to minimum (100.67) in control. Similarly the maximum fruit retention per cent (70.68%) was recorded at 30 ppm 2,4-D treatment closely followed by 10 ppm 2,4-D (69.21%) treatment. The minimum fruit retention of 56.42 per cent was recorded at control. The application of 2, 4-D at 40 ppm gave significantly maximum number of fruits (64.00) Reddy and Prasad (2012) in pomegranate. Similar beneficial effect of 2,4-D on number of fruit per tree and fruit retention was also recorded by Ashraf *et al*. (2013) in Kinnow mandarin.

The effect of plant growth regulators on yield of Nagpur mandarin fruits are presented in Table 1. The data showed that the application of different plant growth regulators at various concentrations had significantly increased the yield of Nagpur mandarin fruits over control in the present investigation. Amongst the various plant growth regulator treatments attempted the maximum yield of 21.80 kg/plant and (6.08 tonnes/ha.) was recorded at 30 ppm 2,4-D treatment followed by 10 ppm 2.4-D treatment. The minimum yield of (12.94 kg/plant and 3.60 tonnes/ha.) was observed at control. The increase in yield of Nagpur mandarin fruits by application of 2,4-D and GA_3 treatments may be attributed to the fact that partitioning of assimilates by 2,4-D and GA_3 more towards the fruit development and better translocation of assimilates further leads to improvement in yield contributing characters like size and weight of fruits as evident by the present study which finally increased the yield (Khalid *et al*., 2012) in 'Kinnow' mandarin. Similar results were also observed by application of 2,4-D treatment in 'Nova' mandarin as reported by (Greenberg *et al*., 2006) and in Nagpur mandarin as reported by (Ingle *et al*., 2001).

The economics of different plant growth regulator treatments used at various concentrations in the present investigation are calculated and presented in Table 2. The economic feasibility of various treatments clearly showed that the application of 30 ppm 2,4-D treatment has resulted the maximum gross return of Rs. 1,21,600/ha which was Rs. 49600/ha excess over control. Further, the highest net profit (Rs. 48,855/ha) was estimated at 30 ppm 2,4-D treatment which was 67.85 per cent higher than control, which was closely followed by 10 ppm 2,4-D and 100 ppm GA_3. Ingle *et al*.

(2001) revealed that foliar application of 2, 4-D at 10 ppm treatment increased the fruit weight, volume, TSS, ascorbic acid, peel and yield over control in Nagpur mandarin. Amiri *et al.* (2008) found that spray of 2, 4-D in Italian orange and is an effective and economical way to reduce citrus pre harvest fruit drop. The application of 20 ppm 2,4-D treatment was observed by Nawaz *et al.* (2008) whose findings revealed that the the lowest fruit drop of 12.95% and increased number of fruits/plant and fruit weight/plant in Kinnow mandarin. The highest percent increase in net profit due to 30 ppm 2,4-D treatment may be because of highest yield and qualitative fruits under this treatment as evident from the present results discussed earlier in the text. Therefore, among the various plant growth regulator treatments attempted under present investigation, the application of 30 ppm 2,4-D was found to be most economic and desirable treatment.

The relative economics of the various plant growth regulator treatments was also worked out. On

Table 1. Effect of plant growth regulators on per cent increase in Physical characteristics and yield of Nagpur mandarin

Treatments	Diameter of fruit (cm)		Weight of fruit (g)	Volume of fruit (cc)	No. of sacs/fruit	No. of fruits/tree	Fruit retention (%)	Yield (kg/plant)	Estimated yield (tonnes/ha)
	Horizontal	Vertical							
T_0	6.12	5.64	135.56	145.44	9.89	100.67	56.42 (69.43)	12.94	3.60
T_1	6.80	5.97	144.11	155.22	10.89	115.67	67.42 (85.27)	16.67	4.64
T_2	7.02	6.50	150.22	171.78	11.11	112.33	66.32 (83.89)	16.87	4.69
T_3	6.82	6.22	143.11	164.22	11.56	109.33	66.24 (83.78)	15.65	4.35
T_4	7.13	7.44	164.89	189.44	11.11	110.33	65.07 (82.17)	18.19	5.06
T_5	7.26	7.27	141.11	149.89	11.44	107.67	69.04 (87.08)	14.12	3.93
T_6	6.97	6.71	145.56	177.78	10.56	110.33	66.50 (84.11)	16.06	4.46
T_7	6.59	6.37	167.78	181.78	11.44	106.67	67.49 (85.36)	17.89	4.98
T_8	8.03	8.23	191.22	247.56	12.56	113.33	65.29 (82.53)	21.67	6.03
T_9	6.43	6.38	172.11	190.22	11.11	117.67	69.21 (87.34)	21.68	6.03
T_{10}	7.46	7.39	149.44	164.22	11.78	123.67	67.25 (85.06)	18.48	5.14
T_{11}	7.64	7.83	184.22	211.89	12.11	126.00	70.68 (89.05)	21.80	6.08
T_{12}	6.97	6.75	144.22	173.78	10.89	119.67	64.60 (81.61)	17.26	4.80
T_{13}	6.90	6.26	156.44	160.56	11.44	101.67	62.96 (79.32)	15.91	4.42
T_{14}	7.40	7.34	164.22	181.56	10.89	107.67	64.17 (81.03)	17.68	4.92
T_{15}	7.08	6.37	164.22	186.78	10.44	105.33	59.93 (74.88)	17.30	4.81
T_{16}	6.65	6.28	152.11	172.78	10.56	114.67	61.20 (76.79)	17.44	4.85
SEm	0.20	0.25	7.95	10.66	0.42	3.12	1.03	0.50	0.14
C.D. at 5%	0.59	0.72	22.89	30.69	1.21	8.98	2.99	1.44	0.40

(**T_0**- Control, **T_1**- NAA 50ppm, **T_2**- NAA 100ppm, **T_3**- NAA 150ppm, **T_4**- NAA 200ppm**,** **T_5**- GA_3 25ppm, **T_6**- GA_3 50ppm, **T_7**- GA_3 75ppm, **T_8**- GA_3 100ppm, **T_9**- 2,4-D 10ppm, **T_{10}**- 2,4-D 20ppm, **T_{11}**- 2,4-D 30ppm, **T_{12}**- 2,4-D 40ppm, **T_{13}**- Triacontanol 5ppm, **T_{14}**- Triacontanol 10ppm, **T_{15}**- Triacontanol 15ppm, **T_{16}**- Triacontanol 20ppm)

Table 2. Economic feasibility of plant growth regulator treatments in mandarin cv. Nagpur mandrin

Treatments	Additional treatment cost	Yield (tones/ha)	Gross return (@ Rs. 20/kg)	Excess income over control	Net profit due to treatment	% Increase in yield over control	% Increase in net profit over control
Control (T_0)	-	3.60	72,000	-	-	-	-
NAA 50 ppm (T_1)	914.50	4.64	92,800	20,800	19,885	28.89	27.62
NAA 100 ppm (T_2)	1129.00	4.69	93,800	21,800	20,671	30.28	28.71
NAA 150 ppm (T_3)	1343.50	4.35	87,000	15,000	13,656	20.83	18.97
NAA 200 ppm (T_4)	1558.00	5.06	1,01200	29,200	27,602	40.56	38.39
GA_3 25 ppm (T_5)	2515.00	3.93	78,600	6,600	4,085	9.17	5.67
GA_3 50 ppm (T_6)	4330.00	4.46	89,200	17,200	12,870	23.89	17.88
GA_3 75 ppm (T_7)	6345.00	4.98	99,600	27,600	21,255	38.33	29.52
GA_3 100 ppm (T_8)	7960.00	6.03	1,20,600	48,600	40,640	67.50	56.44
2,4-D 10 ppm (T_9)	714.85	6.03	1,20,600	48,600	47,885	67.50	66.51
2,4-D 20 ppm (T_{10})	729.70	5.14	1,02800	30,800	30,070	42.78	41.76
2,4-D 30 ppm (T_{11})	744.55	6.08	1,21,600	49,600	48,855	68.89	67.85
2,4-D 40 ppm (T_{12})	759.40	4.80	96,000	24,000	23,240	33.33	32.28
Triacontanol 5 ppm (T_{13})	2350.00	4.42	88,400	16,400	14,050	22.78	19.51
Triacontanol 10 ppm (T_{14})	4000.00	4.92	98,400	26,400	22,400	36.67	31.11
Triacontanol 15 ppm (T_{15})	5650.00	4.81	96,200	24,200	18,550	33.61	25.76
Triacontanol 20 ppm (T_{16})	7300.00	4.85	97,000	25,000	17,700	34.72	24.58

the basis of relative economics it can again be suggested that 30 ppm 2,4-D treatment was found to be most effective and desirable on the basis of early maturity and highest yield coupled with superior nutritional qualities of mandarin cv. 'Nagpur' fruit. Among the various plant growth regulators tried, 2,4-D and GA_3 were found to be most effective for increasing the yield of mandarin cv. 'Nagpur' fruit. Of the two most effective treatments i.e. 30 ppm 2,4-D and GA_3 100 ppm, the 2,4-D treatment is economically cheaper than GA_3. Therefore, based on the findings the Nagpur mandarin growers may be advised to preferably spray the Nagpur mandarin plant with 30 ppm 2,4-D in the month of July to get better yield of 'Nagpur' mandarin crop with superior quality.

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