International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(3): 444-448

Received: 03-03-2017
Accepted: 04-04-2017

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Effect and economic feasibility of preharvest spray of Calcium nitrate, Boric acid and Zinc sulphate on yield attributing characters of Nagpur mandarin (*Citrus reticulata* Blanco.)

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Abstract
An investigation was carried out during 2014-15 to study the effect of preharvest spray of Calcium nitrate, Boric acid and Zinc sulphate on yield attributing characters of Nagpur mandarin. Various doses of Calcium nitrate (1.0%, 2.0% and 3.0%), Boric acid (0.2%, 0.4% and 0.6%) and Zinc sulphate (0.2%, 0.4% and 0.6%) were sprayed before harvesting. The maximum increase in yield attributing characters like diameter of fruit, fruit weight, fruit volume, fruit yield/plant, estimated (yield/hec), maximum gross return, highest net profit and reduced peel thickness was recorded with T27 treatment combination (calcium nitrate 3.0% + boric acid 0.6% + Zinc sulphate 0.6%) over control. Further, T24 treatment combination (calcium nitrate 3.0% + boric acid 0.4% + Zinc sulphate 0.6%) has also significantly increased number of segments per fruit, and reduced number of seeds per fruit over control.

Keywords: Pre-harvest spray, calcium nitrate, zinc sulphate, boric acid, yield and economic feasibility

1. Introduction
Nagpur Mandarin (Citrus reticulata Blanco) which occupies the first position among the citrus in India with respect to area and production is considered one of the most important cultivated varieties among loose skinned oranges and is being commercially grown in Nagpur region of Maharashtra and Jhalawar District of Rajasthan. In India citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits after mango and banana. The Fruit of Nagpur Santra are subglobose, with average weight 110-125g, rind medium thick, fairly loosely adherent, surface is relatively smooth, segment 10-15 number and seeds 1-2 per segment, peel colour pale orange fruits quality good. The total production of mandarin in India is 34.31 lakh tonnes from an area of 330.0 thousand hectares with the productivity of 10.4 MT/ha]. In Rajasthan mandarin covers 11.20 thousand hectares area producing 229.90 thousand MT with the productivity of 20.5 MT/ha (Anonymous, 2015) [1].
The nutrient plays an important role in the development and growth of new cells in plant meristem. The Calcium salts are known to be involved in a number of physiological processes concerning membrane structure, function and enzymatic activity. The exact role of calcium, like that of all minerals, is still obscure, but it is important for cell wall development (Babu and Yadav (2005) [2]. Zinc (Zn) is an essential micro element for plants, being involved in many enzymatic reactions and is necessary for their good growth and development. Zinc improves the auxins content and it also acts as catalyst in oxidation-reduction processes (Khan *et al*. (2015) [6]. Boron is also a heavy metal micronutrient. It is absorbed by plant in the form of boric acid (H_3BO_3). It is essential for translocation of sugar; involved in reproduction of plants and germination of pollen grains (Haque *et al.* (2000) [5].
Since the demand of fruit is increasing in the market, thereby to achieve higher yield of good quality fruit become the priority. The application of mineral nutrients like calcium nitrate, boric acid and zinc sulphate are known to play a crucial role in growth, development of fruits. The present study will contribute in understanding the physical and biochemical status of Nagpur mandarin fruits at harvest as influenced by pre-harvest spray of mineral nutrients, which may help in increasing the yield Nagpur mandarin. Hence the present studies were undertaken under Rajasthan conditions especially in Jhalawar with the followings objectives:

To study the effect of preharvest spray of calcium nitrate, boric acid and zinc sulphate on yield attributing characters and economic feasibility of Nagpur mandarin.

2. Materials and Methods

The present investigation was carried out on eight years old Nagpur mandarin (*Citrus reticulata* Blanco.) of uniform size and growth at the Fruit research farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar during the year 2014-15. The selected plants were sprayed with Calcium nitrate (1.0, 2.0 and 3.0 per cent), Boric acid (0.2, 0.4 and 0.6 per cent) and Zinc sulphate (0.2, 0.4 and 0.6 per cent).This experiment was laid out in Factorial Randomized Block Design (RBD) with three replications. The factors of experimentation comprising of 28 treatment combinations to study the effect of pre-harvest spray of Calcium nitrate, Zinc sulphate and Boric acid on yield and economic feasibility of Nagpur mandarin (*Citrus reticulata* Blanco). The treatments were applied during second week of September, 2014 after selection of good uniform size and bearer plant. The observations were recorded on different aspects viz. physical characteristics of fruits (diameter of fruit, peel thickness, fruit weight, fruit volume, number of fruits per plant, number of sacs per fruit, number of seeds per fruit. 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. The critical difference was calculated to assess the significance of difference among the different treatments as described by Fisher (1950) [4].

3. Result and Discussion

(1) Yield attributing characters

A. Diameter of fruit (cm)

The data in (table 4.1) reveal that interaction effect of calcium nitrate, boric acid and zinc sulphate was significant on diameter of fruits. The maximum increase in horizontal diameter (7.89 cm) and vertical diameter (7.58 cm) was observed with treatment T27 (Calcium nitrate @ 3.0% + boric acid @ 0.6% + zinc sulphate @ 0.6%), which was closely followed by T23, T26, T24, T22 and T21 treatments. The higher fruit diameter due to combined application of calcium, boron and zinc may be attributed to their stimulatory effect of plant metabolism and better increase in cell division and cell elongation of cells. The results are in conformity with the observations recorded by Trivedi *et al.* (2012) [12] in Guava, Razzaq *et al.* (2013) [9] in Kinnow and Meena *et al*. (2014) in Guava [7].

B. Peel thickness (mm)

The data in (table-1) reveal that interaction effect of calcium nitrate, boric acid and zinc sulphate was significantly observed on peel thickness. The minimum peel thickness (3.21 mm) of fruit was recorded with the treatment T_{27} (Calcium nitrate @ 3.0% + boric acid @ 0.6% + zinc sulphate @ 0.6%) and which was closely followed by T_{24}, T_{26}, T_{22} and T_{25} treatments. However, the maximum peel thickness of fruit (4.86 mm) was recorded under control. The reduction in peel thickness might be attributes to the effect of zinc sulphate and prevailing climate condition during harvesting of fruit. The present results are in close conformity with the finding of Haque *et al*. (2000) [5] in Mandarin, Razzaq *et al*. (2013) in kinnow [9].

(C) Fruit weight (gm) and Volume (cc)

The data in (Table-1) narrate that fruit weight and fruit volume of Nagpur mandarin increased significantly by the application of calcium nitrate, boric acid and zinc sulphate. The maximum fruit weight (160.72 g) and volume (190.14 cc) were recorded with treatment T_{27} (Calcium nitrate @ 3.0% + boric acid @ 0.6% + zinc sulphate @ 0.6%). The minimum fruit weight and volume (113.61 g) and 138.03 cc) were measured under control. The increase in fruit weight and volume might be due to increased rate of cell division and cell enlargement leading to more accumulation of metabolites in the fruit and better translocation of photosynthates as a result of boron application (Abd-Allah (2006). The findings are similar to those reported by Babu and Yadav (2007) [3] in Kinnow and Meena *et al.* (2008) in Ber [7].

(D) Number of seeds per fruit

The data in (table-2) reveal that interaction effect of calcium nitrate, boric acid and zinc sulphate was significant on number of seeds per fruit. The minimum number of seeds per fruit (6.33) was recorded with treatment T_{24} (calcium nitrate @ 3 per cent + boric acid @ 0.4 per cent + zinc sulphate @ 0.6 per cent) which was closely followed by T_{27}, T_{26}, T_{21}, T_{22} and T_{23} treatments. However, the maximum number of number of seed per fruit (9.89) was recorded in control. The present results are in consonance with the findings of Haque *et al.* (2000) [5] in Mandarin and Sharma *et al.* (2002) [10] in Kagzi lime.

(E) Number of segments per fruit

The data in (table-2) reveal that interaction effect of calcium nitrate, boric acid and zinc sulphate was significant on number of segments per fruit. The maximum number of segments per fruit (12.56) was recorded with treatment T_{24} (calcium nitrate @ 3.0 per cent + boric acid @ 0.4 per cent + zinc sulphate @ 0.6 per cent) which was closely followed by T_{23}, T_{27}, T_{21} and T_{26} treatments. However, the minimum number of number of segments per fruit (9.00) was recorded in control. The variation in the number of segments per fruit due to combination of different micronutrients might be attributed to difference in enzyme ion alluding during cell division and cell differentiation phases of fruit developments. The present results are in conformity with the findings of Razzaq *et al*. (2013) [9] in kinnow, and Khan *et al.* 2015 in Kinnow [6].

(F) Number of fruits per plant

The maximum number of fruits per plant (134.43) was recorded with treatment T_{27} (calcium nitrate @ 3.0% + boric acid @ 0.6% + zinc sulphate @ 0.6%) treatments. (Table-4.2) It was closely followed by T_{24}, T_{26} and T_{23} treatments. However, the minimum number of fruits per plant (97.67) was recorded in control. The increase in number of fruits by application of micronutrient treatments may be due to reduction in fruit drop as a result of zinc, boron and calcium application which resulted in higher number of fruits and consequently the yield. The present results are in conformity with the findings of Haque *et al*. (2000) [5] in mandarin and Razzaq *et al*. (2013) in kinnow [9].

(G) Fruit yield in kg/tree

The data in (table-2) indicated that the interaction effect of calcium nitrate, zinc sulphate and boric acid was significantly observed on fruit yield in kg/tree and tonnes/ha.The fruit yield of Nagpur mandarin (21.67 kg/tree and 6.32 tonnes/ha)

recorded maximum with treatment T_{27} (calcium nitrate @ 3.0% + boric acid @ 0.6% + zinc sulphate @ 0.6%) which was at par with T_{24}, T_{26}, T_{23} and T_{25} treatments. However, the minimum fruit yield (11.27) kg/tree and 3.55 tonnes/ha) was recorded in control. The increase in yield of Nagpur mandarin fruits by application of micronutrient treatments may be due to the direct or indirect involvement of nutrients which provide better mobilization of nutrients and metabolites for the growth and development of fruits by increase in metabolic activities and better cellular pathways. These activities improve their size, weight and volume and thereby synergistically increased the total yield of Nagpur mandarin. The present results are in conformity with the findings of Abd-Allah (2006) [2] in Orange and Patil *et al*. (2014) in Kinnow [8].

(2) Economics Feasibility

The economics of different micronutrient treatments used at various concentrations in the present investigation was calculated and presented in Table-3. The economic feasibility calculated for various treatments showed that the application of T_{27} (calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.6%) treatment has resulted the maximum gross return of Rs. 1,26,400/ha which was Rs. 55,400/ha excess over control and with highest net profit (Rs. 48,560 /ha) which was 78.03 per cent higher than control,. which was followed by T_{24} (calcium nitrate @ 3.0% + boric acid @ 0.4% + Zinc sulphate @ 0.6%) and T_{26} (calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.4%) having net profit values of Rs. 48, 272 and Rs. 47,208 which was 76.90 per cent and 75.49 per cent higher than control, respectively.

The highest percent increase in net profit due to calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.6%) (T_{27}) treatment may be because of highest yield under this treatment as evident from the present results discussed earlier in the text. Therefore, among the various micronutrient treatments attempted under present investigation, the application of calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.6%) (T_{27}) was found to be most economic and desirable treatment.

The relative economics of the various micronutrient treatments was also worked out. On the basis of relative economics it can again be suggested that calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.6% treatment was found to be most effective and desirable on the basis of highest yield of Nagpur mandarin fruit.

Table 1: Effect of pre-harvest spray of calcium nitrate, boric acid and zinc sulphate on physical characteristics of Nagpur mandarin (*Citrus reticulata* Blanco)

Treatments		Diameter of fruits (cm)		Peel Thickness (mm)	Fruit weight (g)	Fruit volume (cc)
		Horizontal	Vertical			
T_0	$Ca_0 B_0 Zn_0$	6.11	5.18	4.86	113.61	138.03
T_1	$Ca_1 B_1 Zn_1$	6.22	5.56	4.78	122.67	148.79
T_2	$Ca_1 B_1 Zn_2$	6.48	5.65	4.52	125.83	149.45
T_3	$Ca_1 B_1 Zn_3$	6.58	5.78	4.39	130.53	152.82
T_4	$Ca_1 B_2 Zn_1$	6.80	5.82	3.97	132.34	160.00
T_5	$Ca_1 B_2 Zn_2$	6.79	5.98	4.29	129.28	156.29
T_6	$Ca_1 B_2 Zn_3$	6.85	5.60	3.82	138.30	156.24
T_7	$Ca_1 B_3 Zn_1$	6.92	5.98	3.83	140.11	170.16
T_8	$Ca_1 B_3 Zn_2$	6.66	6.02	3.79	130.22	157.82
T_9	$Ca_1 B_3 Zn_3$	7.12	6.44	3.53	140.08	168.55
T_{10}	$Ca_2 B_1 Zn_1$	6.88	6.34	3.72	147.98	173.22
T_{11}	$Ca_2 B_1 Zn_2$	6.94	5.95	3.69	140.12	167.45
T_{12}	$Ca_2 B_1 Zn_3$	7.38	6.42	3.77	141.36	171.32
T_{13}	$Ca_2 B_2 Zn_1$	7.41	6.54	3.78	148.97	175.22
T_{14}	$Ca_2 B_2 Zn_2$	7.43	6.76	3.74	139.32	171.11
T_{15}	$Ca_2 B_2 Zn_3$	7.39	6.38	3.66	150.19	178.82
T_{16}	$Ca_2 B_3 Zn_1$	7.48	6.85	3.67	142.78	167.17
T_{17}	$Ca_2 B_3 Zn_2$	7.52	7.05	3.65	151.07	178.33
T_{18}	$Ca_2 B_3 Zn_3$	7.11	6.92	3.50	144.83	176.12
T_{19}	$Ca_3 B_1 Zn_1$	7.53	6.22	3.57	153.42	183.11
T_{20}	$Ca_3 B_1 Zn_2$	7.42	7.08	3.67	150.99	178.31
T_{21}	$Ca_3 B_1 Zn_3$	7.70	7.23	3.67	145.54	176.23
T_{22}	$Ca_3 B_2 Zn_1$	7.77	7.27	3.38	147.44	176.57
T_{23}	$Ca_3 B_2 Zn_2$	7.83	7.47	3.57	157.33	187.34
T_{24}	$Ca_3 B_2 Zn_3$	7.78	7.31	3.27	158.89	189.37
T_{25}	$Ca_3 B_3 Zn_1$	7.31	6.93	3.48	153.78	183.87
T_{26}	$Ca_3 B_3 Zn_2$	7.82	7.44	3.33	157.33	187.86
T_{27}	$Ca_3 B_3 Zn_3$	7.89	7.58	3.21	160.72	190.14
CD at 5%		0.14	0.16	0.07	2.73	3.75
SEm±		0.41	0.46	0.21	7.77	10.63

Here,

Ca1 – Calcium nitrate– 1% B1 – Boric acid – 0.2%, Zn1 – Zinc sulphate – 0.2%

Ca2 – Calcium nitrate –2% B2 – Boric acid – 0.4%, Zn2 – Zinc sulphate – 0.4%

Ca3 – Calcium nitrate – 3% B3 – Boric acid – 0.6%, Zn3 – Zinc sulphate – 0.6%

Table 2: Effect of pre-harvest spray of calcium nitrate, boric acid and zinc sulphate on yield attributes characters of Nagpur mandarin

Treatments		No. of seeds / fruit	No. of sacs / fruit	No. of fruits per plant	Yield per plant (kg)	Estimated yield (tones / ha.)
T_0	$Ca_0 B_0 Zn_0$	9.89	9.00	97.67	11.27	3.55
T_1	$Ca_1 B_1 Zn_1$	9.78	9.89	100.33	12.06	3.69
T_2	$Ca_1 B_1 Zn_2$	9.78	9.67	107.00	12.11	3.77
T_3	$Ca_1 B_1 Zn_3$	9.42	9.89	109.00	12.33	3.94
T_4	$Ca_1 B_2 Zn_1$	9.67	10.33	108.00	13.77	4.02
T_5	$Ca_1 B_2 Zn_2$	9.67	10.11	110.67	15.22	4.14
T_6	$Ca_1 B_2 Zn_3$	9.23	10.78	118.00	14.33	4.24
T_7	$Ca_1 B_3 Zn_1$	8.94	10.44	117.67	15.78	3.92
T_8	$Ca_1 B_3 Zn_2$	9.12	10.78	110.67	16.39	4.14
T_9	$Ca_1 B_3 Zn_3$	8.89	10.00	118.54	16.22	4.62
T_{10}	$Ca_2 B_1 Zn_1$	9.12	10.33	120.00	15.78	4.27
T_{11}	$Ca_2 B_1 Zn_2$	8.89	10.78	121.33	17.34	4.42
T_{12}	$Ca_2 B_1 Zn_3$	9.00	11.11	118.33	17.77	4.77
T_{13}	$Ca_2 B_2 Zn_1$	8.78	10.67	125.33	17.92	4.64
T_{14}	$Ca_2 B_2 Zn_2$	8.50	11.44	119.00	17.11	4.96
T_{15}	$Ca_2 B_2 Zn_3$	8.24	10.89	119.00	18.37	5.27
T_{16}	$Ca_2 B_3 Zn_1$	8.37	11.78	120.00	18.44	5.12
T_{17}	$Ca_2 B_3 Zn_2$	8.10	11.00	118.34	19.55	5.42
T_{18}	$Ca_2 B_3 Zn_3$	7.96	11.78	125.67	19.78	5.74
T_{19}	$Ca_3 B_1 Zn_1$	8.10	10.89	121.34	19.04	5.82
T_{20}	$Ca_3 B_1 Zn_2$	7.78	11.67	121.67	18.99	5.94
T_{21}	$Ca_3 B_1 Zn_3$	7.44	12.00	125.00	20.33	6.04
T_{22}	$Ca_3 B_2 Zn_1$	7.67	11.78	128.23	20.11	5.85
T_{23}	$Ca_3 B_2 Zn_2$	7.67	12.33	130.78	21.10	6.18
T_{24}	$Ca_3 B_2 Zn_3$	6.33	12.56	132.33	21.48	6.28
T_{25}	$Ca_3 B_3 Zn_1$	7.78	11.44	128.67	20.77	6.11
T_{26}	$Ca_3 B_3 Zn_2$	7.14	11.89	131.11	21.37	6.23
T_{27}	$Ca_3 B_3 Zn_3$	6.82	12.22	134.43	21.67	6.32
CD at 5%		0.23	0.27	2.77	0.39	0.10
SEm±		0.65	0.76	7.87	1.11	0.31

Here,
Ca1 – Calcium nitrate– 1% B1 – Boric acid – 0.2%, Zn1 – Zinc sulphate – 0.2%
Ca2 – Calcium nitrate –2% B2 – Boric acid – 0.4%, Zn2 – Zinc sulphate – 0.4%
Ca3 – Calcium nitrate – 3% B3 – Boric acid – 0.6%, Zn3 – Zinc sulphate – 0.6%

Table 3: Economic feasibility of Pre harvest spray of micronutrient treatments in Nagpur mandarin

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
T_0	$Ca_0 B_0 Zn_0$	0	3.55	71000	0	0	0	0
T_1	$Ca_1 B_1 Zn_1$	2280	3.69	73800	2800	520	3.94	0.73
T_2	$Ca_1 B_1 Zn_2$	2728	3.77	75400	4400	1672	6.20	2.35
T_3	$Ca_1 B_1 Zn_3$	3176	3.94	78800	7800	4624	10.99	6.51
T_4	$Ca_1 B_2 Zn_1$	2792	4.02	80400	9400	6608	13.24	9.31
T_5	$Ca_1 B_2 Zn_2$	3240	4.14	82800	11800	8560	16.62	12.06
T_6	$Ca_1 B_2 Zn_3$	3688	4.24	84800	13800	10112	19.44	14.24
T_7	$Ca_1 B_3 Zn_1$	3304	3.92	78400	7400	4096	10.42	5.77
T_8	$Ca_1 B_3 Zn_2$	2752	4.14	82800	11800	9048	16.62	12.74
T_9	$Ca_1 B_3 Zn_3$	4200	4.62	92400	21400	17200	30.14	24.23
T_{10}	$Ca_2 B_1 Zn_1$	3600	4.27	85400	14400	10800	20.28	15.21
T_{11}	$Ca_2 B_1 Zn_2$	4048	4.42	88400	17400	13352	24.51	18.81
T_{12}	$Ca_2 B_1 Zn_3$	4496	4.77	95400	24400	19904	34.37	28.03
T_{13}	$Ca_2 B_2 Zn_1$	4112	4.64	92800	21800	17688	30.70	24.91
T_{14}	$Ca_2 B_2 Zn_2$	4560	4.96	99200	28200	23640	39.72	33.30
T_{15}	$Ca_2 B_2 Zn_3$	5008	5.27	105400	34400	29392	48.45	41.40
T_{16}	$Ca_2 B_3 Zn_1$	4624	5.12	102400	31400	26776	44.23	37.71
T_{17}	$Ca_2 B_3 Zn_2$	5072	5.42	108400	37400	32328	52.68	45.53
T_{18}	$Ca_2 B_3 Zn_3$	5520	5.74	114800	43800	38280	61.69	53.92
T_{19}	$Ca_3 B_1 Zn_1$	4920	5.82	116400	45400	40480	63.94	57.01
T_{20}	$Ca_3 B_1 Zn_2$	5368	5.94	118800	47800	42432	67.32	59.76
T_{21}	$Ca_3 B_1 Zn_3$	5816	6.04	120800	49800	43984	70.14	61.95
T_{22}	$Ca_3 B_2 Zn_1$	5432	5.85	117000	46000	40568	64.79	57.14
T_{23}	$Ca_3 B_2 Zn_2$	5880	6.18	123600	52600	46720	74.08	65.80
T_{24}	$Ca_3 B_2 Zn_3$	6328	6.28	125600	54600	48272	76.90	67.99
T_{25}	$Ca_3 B_3 Zn_1$	5944	6.11	122200	51200	45256	72.11	63.74
T_{26}	$Ca_3 B_3 Zn_2$	6392	6.23	124600	53600	47208	75.49	66.49
T_{27}	$Ca_3 B_3 Zn_3$	6840	6.32	126400	55400	48560	78.03	68.39

Here,
Ca1 – Calcium nitrate– 1% B1 – Boric acid – 0.2%, Zn1 – Zinc sulphate – 0.2%
Ca2 – Calcium nitrate –2% B2 – Boric acid – 0.4%, Zn2 – Zinc sulphate – 0.4%
Ca3 – Calcium nitrate – 3% B3 – Boric acid – 0.6%, Zn3 – Zinc sulphate – 0.6%

5. Conclusion

On the basis of results obtained from the field experiment, it may be concluded that the pre-harvest spray of different micronutrients was found beneficial for yield attributes and economic feasibility of Nagpur mandarin. Among different doses the application of T_{27} treatment was found best with regards to maximum increase in fruit weight, fruit volume, diameter of fruit (horizontal and vertical), reduced peel thickness, number of fruit per plant, fruit yield per plant, estimated yield tonnes/ha, gross return, highest net profit. Further T_{24} treatment combination (calcium nitrate @ 3.0% + boric acid @ 0.4% + Zinc sulphate @ 0.6%) has also given maximum increased number of segments per fruit and reduced number of seeds per fruit.

Therefore, based on the present research it may be concluded that, in Nagpur mandarin the pre harvest spray of calcium nitrate @ 3.0% + boric acid @ 0.6% + Zinc sulphate @ 0.6% before harvesting may improve the yield characteristics of Mandarin.

5. Acknowledgement

The authors of the manuscript are highly thankful to College of Horticulture and forestry Jhalawar and Agriculture University, Kota, Rajasthan for providing facility to carry out the research on this aspect.

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