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Effect of Foliar Applied Nitrogen with Growth Regulators (2,4 D, GA_3, *Amrut-pani*) and Soil Applied Potassium on the Management of the Rough-skin Disorder of Nagpur Mandarin (*Citrus reticulata* Blanco)

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ABSTRACT

Background: Rough-skin disorder mainly occurs in 6-12 years old young and senile orchards of Nagpur mandarin due to excess application or availability of potassium. The characteristics of rough-skinned fruits are large fruit size with rough textured peel, segments are loose intact with rind, improper fruit shape (fruit length to breadth ratio is equal to one or more than one), reduced juice per cent and TSS.

Methods: Based on the incidence of rough-skin disorder, an orchard of Nagpur mandarin was earmarked at Hetikundi village of Wardha district, Maharashtra for *Mrig bahar* during 2020. The selected orchards are 10 years old, spaced at 6 m × 6 m and grafted on Rangpur lime rootstock. At harvest, yield and yield attributes, fruit physical characteristics and critical quality characteristics *viz.* TSS, acidity, TSS/ acidity ratio and vitamin C content of disordered and normal fruits were recorded according to treatments.

Result: Foliar application of plant growth regulators like 2,4-D 15 ppm and GA_3 15 ppm and reducing soil application of potassium in high potassium available soils reduced the rough skin and improved the rind texture and physicochemical characteristics at harvesting in *mrig bahar*.

Key words: 2,4-D, GA_3, Nagpur mandarin, Recommended dose of fertilizer, Rough-skin disorder.

INTRODUCTION

Nagpur mandarin is the important mandarin cultivar grown in central India. Fruits have special importance due to their distinct flavours and therapeutic values. These are rich in vitamin C and minerals like calcium, phosphorus and iron (Ladaniya, 2008). Rough-skin disorder is one of the serious yield-reducing disorders in young (6-12 years old) and senile Nagpur mandarin orchards due to excess application or availability of potassium. The disordered fruits are large in size with improper shape and with more thickened rind compared to normal fruits (Erner *et al.,* 2002 and Srivastava, 2013). The core diameter was more and reduced juice per cent and TSS are the characteristics of rough skin fruits. The fruits remain green with patches of yellow colouration at the time of harvest with improper maturity. Thus, these fruits won't fetch the market values and cause the economic losses to Nagpur mandarin growers.

MATERIALS AND METHODS

Based on the incidence of rough-skin disorder, an orchard of Nagpur mandarin was earmarked at Hetikundi village of Wardha district, Maharashtra for *Mrig bahar* during 2020. The selected orchard was 10 years old, spaced at 6 m × 6 m and grafted on Rangpur lime rootstock. Different cultural treatments like foliar application of plant growth regulators *viz.* 2,4-Diclorophenoxy acetic acid sodium salt (2,4-D) 15 ppm and gibberellic acid (GA_3) 15 ppm along with urea 1.5% and amrut pani at monthly intervals from October to December in *mrig bahar* was done. Recommended dose of fertilizer (600:300:300g of NPK/plant) with and without potassium applied in June (50% of nitrogen, potassium and a full dose of phosphorus applied before flowering) and October (remaining 50% of nitrogen and potassium applied

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during the period of fruit growth) in *Mrig bahar* (Table 1). The experiment was replicated four times and laid out in a randomised block design (RBD). Before application of treatments soil and leaf nutrient analysis was done for nitrogen, phosphrus and potassium availability in the selected orchard.

At harvest, yield and yield attributes, fruit physical characteristics and critical quality characteristics *viz.* TSS, acidity, TSS/ acidity ratio and vitamin C content of disordered and normal fruits (Plate 1) were recorded according to treatments. Average fruit weight was calculated by weighing ten selected fruits per replication using an electronic balance. Fruit dimensions such as length and breadth, rind thickness and core diameter of selected fruits were measured with a digital vernier calliper. The juice was extracted by an electronic citrus juicer and juice content was calculated on a volume by weight basis and expressed in per cent. Total Soluble Solids (TSS) were determined by using a hand refractometer while titrable acidity was estimated by titration with standard alkali and calculated in terms of per cent citric acid. The ascorbic acid content was determined by the method prescribed by Ranganna (2001). The data was statistically analysed by using the OPSTAT software.

Table 1: Schedule of application of cultural treatments to control rough skin disorder and to improve quality characteristics of Nagpur mandarin fruits in *Mrig bahar*.

Treatments		Time of application in *Mrig bahar*
T_1	2,4-D 15 ppm + Urea 1.5%	October, November and December
T_2	GA_3 15 ppm + Urea 1.5%	
T_3	Amrut pani spray	
T_4	RDF without potassium (600:300 g of NP/plant)	June and October
T_5	RDF (600:300:300 g of NPK/ plant)	
T_6	Control	-

RESULTS AND DISCUSSION

Soil and leaf nutrient status before application of treatments

The soil and leaf nutrient status of the experimental plot was presented in Table 2. The soil available nutrients were analysed as nitrogen (274.08 kg/ha), phosphorus (22.96 kg/ha) and potassium (387.20 kg/ha) in the selected experimental

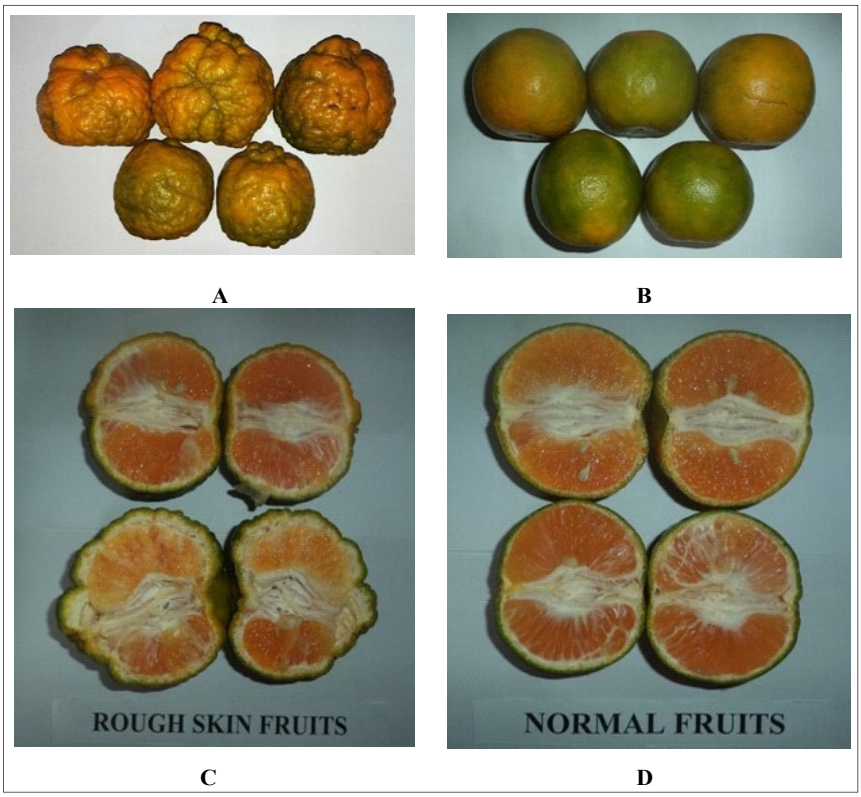

Plate 1: Rough-skinned (A and C) and normal (B and D) grown Nagpur mandarin fruits at the harvesting stage.

Table 2: Soil and leaf nutrient status before application of treatments in an experimental orchard located at Hetikundi village.

	Soil nutrient status			Leaf nutrient status		
	N (kg/ha)	P (kg/ha)	K (kg/ha)	N (%)	P (%)	K (%)
Hetikundi	274.08	22.96	387.20	2.07	0.08	2.27

orchard. Similarly, leaf available nutrients were analysed as nitrogen (2.07 %), phosphorus (0.08%) and potassium (2.27%) in the experimental orchard. The range of potassium availability both in the soil and leaf was quite high due to excess application of potash fertilizers causing the incidence of rough-skin disorder in selected Nagpur mandarin orchard. Similar results were also noted by Erner *et al.* (2002); Ashok *et al*. (2006) and Srivastava (2013). When the number of fruits on a plant are less (100-200) which normally occurs in the initial years of plant bearing, the potash appears to be absorbed rapidly causing rough skin. In the senile orchards as well, sometimes fruits borne on solitary shoots old scaffold branches assume this disorder.

Physicochemical characteristics of rough-skinned fruits in *Mrig bahar*

Rough-skinned fruits are large in size (156.00-171.50 g) with improper shape (length/breadth ratio 0.89-0.98 mm) and with more thickened rind (2.95-3.27 mm) compared to normal fruits. The core diameter was more (20.18-22.16 mm) and reduced juice percent (37.49-41.69%) and TSS (6.90-7.25%) were recorded in rough-skinned fruits. The fruits remain green with patches of yellow colouration at the time of harvest with improper maturity, so TSS/acid ratio was noted in the range of 9.50-11.14 (Table 3).

Effect of different cultural treatments in *Mrig bahar* of Nagpur mandarin

Effect on yield characteristics

The results observed on yield and yield attributes, number of rough-skinned fruits and per cent of disorder in *Mrigbahar* of rough-skinned experiment on Nagpur mandarin were presented in Table 4. The maximum number of fruits per plant (519), yield per plant (81.99 kg/plant) and total estimated yield per hectare (22.71 t/ha) were recorded in the treatment GA_3 15 ppm + Urea 1.5% whereas minimum number of fruits per plant (377), yield per plant (51.15 kg/plant) and total estimated yield per hectare (14.16 t/ha) were recorded in control.

The cultural treatments viz. GA_3 15 ppm + Urea 1.5%, 2, 4-D 15 ppm + urea 1% and RDF-600:300:300 g of NPK/ plant applied to control the rough-skin disorder have improved the yield and yield attributes by reducing the disorder. The applied treatments improved the growth and development of developing fruits and reduced the incidence of rough-skin disorder compared to control, thus, improving the yield and yield attributes *viz*. number of fruits per plant, yield per plant and total estimated yield per hectare compared to control. Similar results are also reported by Quaggio *et al*. (2006); Yasin *et al*. (2010) and Ashkevari *et al*. (2013) concerning the application of nitrogen, phosphorus and potassium and Ingle *et al*. (2001); Chao and Lovatt (2006); Rattanpal *et al*. (2008); Debaje *et al*. (2011); Patil *et al*. (2011); Choudhary *et al*. (2013); Jain *et al*. (2014); Jain *et al*. (2015); Rokaya *et al*. (2016); Ennab (2017); Prabhu *et al*. (2017); Pongnart (2018) and Sweety *et al*. (2018) concerning the application of growth regulators viz. GA_3 and 2,4-D.

Effect on number of rough-skinned fruits per plant and per cent of disorder

The minimum number of rough-skinned fruits (40) and per cent of disorder (9.22%) was recorded in the treatment RDF without potassium whereas the maximum number of rough- skinned fruits (70) and per cent of disorder (18.66%) was recorded in control (Table 4). The treatments RDF without potassium and GA_3 15 ppm + Urea 1.5% noted the minimum number of rough-skinned fruits and per cent of disorder incidence due to no application of potassium because there is higher soil availability of potassium as discussed above and foliar application of GA_3 enhanced the growth and development of fruits with improved peel texture compared to control. Similar information on the optimum application of potassium will improve the yield and quality characteristics of citrus fruits or excess application of potassium will results in large fruits with poor colour, coarse-textured and thick peel in citrus by Erner *et al*. (2002); Ashok *et al*. (2006) and Srivastava (2013).

Effect on physico-biochemical characteristics of fruits at harvest

The physicochemical characteristics of fruits at harvest were presented in Table 4. The maximum fruit weight (185.50 g) and fruit volume (182.00 cm^3) were recorded in the treatment control due to the large fruit size of rough-skinned fruit

Table 3: Physicochemical characteristics of rough-skinned fruits of Nagpur mandarin in *Mrig bahar* at Hetikundi village.

Treatment	Fruit weight (g)	Length/ breadth ratio	Rind thickness (mm)	Core diameter (mm)	Juice (%)	TSS (%)	Acidity (%)	TSS/ acid ratio	Vitamin C (mg/ 100 ml)
T_1	171.50	0.93	3.08	20.18	41.69	7.22	0.76	9.50	42.18
T_2	171.25	0.94	3.09	20.26	41.17	7.25	0.73	9.93	43.01
T_3	165.00	0.90	3.13	20.26	39.40	7.15	0.75	9.55	41.07
T_4	156.00	0.89	2.95	21.02	37.49	7.10	0.72	9.94	43.01
T_5	169.25	0.89	3.15	21.84	41.50	7.22	0.70	10.30	42.73
T_6	170.50	0.98	3.27	22.16	37.85	6.90	0.62	11.14	41.90
CD at 5%	4.78	0.04	NS	NS	1.73	NS	NS	NS	NS
SE (m)	1.57	0.01	0.11	0.58	0.57	0.08	0.03	0.53	0.84

Table 4: Effect of different cultural treatments on yield and yield attributes, per cent of disorder and physicochemical characteristics of Nagpur mandarin fruits in *Mrig bahar* at Hetikundi village.

Treatment	No. of fruits/ plant	Yield (Kg/ plant)	Yield (t/ha)	No. of rough-skinned fruits	Percent of disorder	Fruit weight (g)	Fruit dimensions			Fruit volume (ml)	Rind thickness (mm)	No. of seeds	Core diameter (mm)	No. of segments	Juice (%)	TSS (%)	Acidity (%)	TSS/ acid ratio	Vit C (mg/ 100 ml)
							Length (mm)	Breadth (mm)	Length/ breadth ratio										
T_1	487	73.21	20.28	51	10.47	150.50	60.16	68.51	0.87	148.50	2.61	8	16.23	11	47.01	10.50	0.74	14.10	43.01
T_2	519	81.99	22.71	53	10.21	157.75	56.80	70.30	0.80	155.00	2.59	9	15.80	10	46.10	10.62	0.78	13.66	45.23
T_3	429	60.88	16.86	55	12.86	141.75	53.13	63.44	0.83	139.00	2.69	7	16.30	10	43.24	10.37	0.73	14.11	43.56
T_4	435	61.00	16.89	40	9.22	140.25	54.90	65.01	0.84	137.75	2.47	8	17.06	10	43.37	10.32	0.72	14.35	42.18
T_5	498	76.52	21.19	58	11.71	153.50	56.49	68.79	0.82	150.75	2.51	8	17.88	10	47.09	10.50	0.76	13.67	44.67
T_6	377	51.15	14.16	70	18.66	185.50	67.56	72.24	0.93	182.00	3.12	8	21.44	10	39.66	6.30	0.64	9.88	39.96
CD at 5%	42.00	7.55	2.09	2.38	0.93	9.43	2.83	2.17	0.05	9.59	0.29	NS	1.42	NS	2.28	0.19	0.06	1.18	2.07
SE(m)	13.81	2.48	0.68	0.78	0.30	3.10	0.93	0.71	0.01	3.15	0.09	0.56	0.46	0.26	0.75	0.06	0.02	0.39	0.68

followed by treatment GA_3 15 ppm + Urea 1.5% (157.75 g and 155.00 cm^3 respectively) whereas minimum fruit weight (140.25 g) and fruit volume (137.75 cm^3) were recorded in RDF without potassium. The control noted the maximum fruit length (67.56 mm) and fruit breadth (72.24 mm) followed by treatment 2,4-D 15 ppm + Urea 1.5% (60.16 mm) for fruit length and GA_3 25 ppm + Urea 1.5% (70.30 mm) for fruit breadth whereas minimum fruit length (53.13 mm) and fruit breadth (63.44 mm) was recorded in amrut pani spray. Treatment control noted the maximum length/breadth ratio (0.93) followed by 2,4-D 15 ppm + Urea 1.5% (0.87) whereas minimum length/breadth ratio (0.80) was noted in GA_3 25 ppm + Urea 1.5%. No treatment effect was observed on the characteristics *viz*. number of seeds and number of segments.

Maximum rind thickness (3.12 mm) and core diameter (21.44 mm) were recorded in the control followed by amrutpani spray (2.69 mm) for rind thickness and RDF–600:300:300 g of NPK/ plant (17.88 mm) for core diameter whereas minimum rind thickness (2.47 mm) noted in RDF without potassium and minimum core diameter (15.80 mm) was recorded in treatment GA_3 15 ppm + Urea 1.5%. Maximum juice per cent (47.09%) was recorded in the treatment RDF-600:300:30 g of NPK/ plant followed by treatment 2, 4-D 15 ppm + Urea 1.5% (47.01%) whereas minimum juice per cent (39.66%) was recorded in the control. GA_3 15 ppm + Urea 1.5% has noted the maximum TSS (10.62%), acidity (0.78%) and vitamin C (45.23 mg/100 ml) whereas minimum TSS (6.30%), acidity (0.64%) and vitamin C (39.96 mg/100 ml) were noted in the control. Maximum TSS/acid ratio (14.35) was recorded in RDF without potassium followed by amrut pani spray (14.11) whereas minimum TSS/acid ratio (9.88) was recorded in the control.

The cultural treatments *viz*. GA_3 15 ppm + Urea 1.5%, 2, 4-D 15 ppm + urea 1%, RDF-600:300:300 g of NPK/ plant and amrutpani applied to control the rough skin disorder have improved the quality characteristics of fruits at harvest by reducing the disorder. The applied treatments enhanced the growth and development of fruits, further synthesis and accumulation of photosynthates improved the TSS and TSS/acid ratio compared to control. Similar results are also reported by Quaggio *et al*. (2006); Yasin *et al*. (2010) and Ashkevari *et al*. (2013) concerning the application of nitrogen, phosphorus and potassium and Ingle *et al*. (2001); Chao and Lovatt (2006); Rattanpal *et al*. (2008); Debaje *et al*. (2011); Patil *et al*. (2011); Choudhary *et al*. (2013); Jain *et al*. (2014); Rokaya *et al*. (2016); Ennab (2017); Prabhu *et al*. (2017); Pongnart (2018) and Sweety *et al*. (2018) concerning the application of growth regulators *viz*. GA_3 and 2,4-D.

Conclusion

The different cultural treatments *viz*. foliar spray of growth regulators 2,4-D 15 ppm and GA_3 15 ppm reduced the rough-skin, improved the rind texture, yield and physicochemical characteristics of fruits at harvesting and also reducing soil

application of potassium in high potassium available soils reduced the rough-skin and improved the yield at harvesting. Thus, it is recommended that apply the potash fertilisers based on the soil and leaf analysis especially in the young Nagpur mandarin orchards during initial years of plant bearing.

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Conflict of interest

All authors declare that they have no conflict of interest.

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