Quality Improvement of Mandarin Through Use of GA_3 and Micronutrients

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Abstract

Mandarin (Citrus reticulata Blanco) reserves a prominent position in the total fruit industry of Nepal. However, quality performance of mandarin has been declined over the last ten years, mainly due to improper improved management practices and has remained as low as 9 tonnes per hectare as compared to other developed countries. Foliar application of GA_3 and nutrient application has been found effective and efficient for quality improvement of mandarin across the citrus growing areas of the world. Hence, this experiment was carried out to assess the responses of GA_3 and micronutrients in the quality improvement of mandarin production. The experiments on GA_3, urea and micronutrient were conducted in private orchard of Lamjung district. GA_3 10, 20 and 30 ppm along with urea (2%), agromin (0.4%) and combined of them was experimented. Results revealed that the fruits treated with GA_3 at 20 ppm retained higher fruit weight (128.6 g) and more firmness (3.54 kg/cm2). Combined application of urea at 2% and micronutrients (agromin) at 0.4% resulted in the highest number of fruit (489.55), greater yield (51.82 kg/tree), and maximum weight per fruit (105.5 g).

Keywords: Fruit quality, Gibberellic acid, Peel puncture resistance, Foliar application, Micronutrient

Introduction

Mandarin (*Citrus reticulata Blanco*) stands a prominent position in the total fruit industry as this alone contributes about 15 percent in the total fruit production in Nepal which is expanding rapidly due to its superb eating quality (MOAD, 2021). However, quality performance of mandarin has been declined over the last ten years, mainly due to improper improved management practices and has remained as low as 9 tonnes per hectare as compared to other developed countries. Inadequate nutrition level and lack of advance orchard management practices limit the production and productivity of mandarin across the country. Majority of the orchards in Nepal are deficient in nitrogen and micronutrients (Dhakal & Khanal, 2003; Tripathi & Harding, 2004; Karki et al., 2005; Baral, 2008; Dawadi & Thapa, 2015).

Exogenous application of growth regulators significantly decreased fruit drop leading to increase in total number of fruits per plants, fruit weight, juice percentage, total soluble solids, acidity, and vitamin C (Nawaz et al., 2008). Pre-harvest application of GA3 has been reported to delay softening, delay rind colour, and minimize the fruits drops and puffiness (Ladaniya, 1997; 2001, Kawase et al. 1981; Coggins, 1969; & Blondel, 1972). Kher et. al., 2005 found that GA3 was the most effective chemical in increasing the weight, specific gravity and decreasing the total acid content in guava fruits. Nutrition management is one of the most important factor in improving the plant growth and yield through increasing photosynthetic efficiency (Ilyas et al., 2015). Foliar application of some nutrients can be 10-20 times more effective than their soil application (Alva et al., 2006).

Materials and Methods

This investigation was undertaken on 15 years old uniform and healthy tree with spacing of 5m x 5m in Lamjung district of Nepal in the year 2013 and 2014. GA3 was applied at 2 and 5 weeks before the normal harvesting at foliar mode. The experiment was laid out in randomized complete block (RCBD) design including four (Control, GA3 10, 20 and 30 ppm) treatments with four replications and observation on physicochemical characteristics was taken on 15 days interval from 20 Nov to 20 Dec. Likewise, another experiment on micronutrient was carried out in using a Randomized Complete Block design, comprised of four treatments (T1-water spray; T2- urea 2%, T3- micronutrient (Agromin) 0.4%; and T4- urea 2%+micronutrient (Agromin) 0.4% replicated four times. Two times spray as per the treatments was done on 1st May and 1st September of each year. All the data collected during field and laboratory investigation were pooled, tabulated and statistically analysed according to the procedure of Gomez and Gomez (1984).

Result and Discussion

Fruit weight Data presented in the table 1 show that fruit weight was increased significantly in all the treatments of GA3 with the advancement of the maturity as compared to control. Perusal on observations of fruit weight indicates that fruits treated with GA3 were able to increase in weight. Maximum fruit weight was recorded (128.6 g) with GA3 at 20 ppm against control (95.51 g) at the end of experiment (20 December). It was noted that GA3 treated fruit had maximum increase on 5 December, and beyond this date it was observed slow, stagnant and declined where as sharp decline in control fruits. Based on the findings, GA3 with the concentration at10-20 ppm was the most effective effect treatment for fruit growth in mandarin. The higher fruit growth with GA treated fruits might be due to mediating process for faster translocation and mobilization of photosynthates from source. These findings are in agreement with the reports of Pal et.al. (1997) in kinnow mandarin who had observed GA3 (10 ppm) has resulted in an increase in fruit diameter who recorded three times increment on fruit weight in mandarin. The increment in fruit weight might be due to hormone directed to transportation and accumulation of phytosynthates which resulted in better fruit development and also acceleration of cell division, elongation, and enlargement. Similar observation was recorded by Daulta and Veniwal (1983) in sweet orange who claimed maximum weight with GA3 sprayed tree fruits.

Table 1. Periodical changes on fruit weight, rind colour, and peel puncture resistance mandarin fruit during on-tree storage in 2012 and 2013

Treatments (ppm)	Fruit Weight (gram)				Rind Colour Index (1-5 scale)				Peel Puncture Resistance (kg/cm^2)		
	A	B	C		A	B	C		A	B	C
GA_3 10	110.58	125.04	125.01		2.05	2.93	3.42		4.36	4.21	3.24
GA_3 20	113.50	127.46	128.60		1.92	2.84	3.16		4.19	3.80	3.54
GA_3 30	113.16	123.80	124.66		1.83	2.69	2.97		4.19	3.71	3.45
Control	98.75	98.26	95.51		3.37	4.63	5.00		3.75	2.80	2.73
LSD (0.05)	6.07	9.36	7.88		0.26	0.39	0.40		NS	0.27	NS
A= 20.11, B= 05.12, and C= 20.12											

Rind colour

Rind colour is perhaps the most important and reliable index of mandarin fruit GA3 treated fruits resulted in delaying the rind colour development as well as delay in the maturity of the mandarin fruits. Perusal from the observations in the table 1 shows that GA3 treated fruits resulted in significant delay in the rind colour development. On 20 November, the index value of 3.37 indicated orange colour in control as against index of less than 2.0 indicating greener fruits with GA3 treatments. Likewise at the end of the study (20 December), the colour index of GA3 treated fruits was 2-3.5 indicating orange colour as against of 5.0 indicating orange yellow with over ripe fruits in control. These findings are in consonance with the findings of the Ladaniya (1997) in mandarin who stated that GA3 treatments significantly delayed the rind colour development in Nagpur mandarin. Kaur et. al. (2008) also observed that colour development of the fruits was delayed by gibberellin treatments in plum. Gibberellin has been reported to delay chlorophyll degradation and the senescence in the fruits (El-Otmani, 1991). Colour development is associated with a loss of texture, increasing sugar content and decreasing acidity (Rana, 2006).

Peel puncture resistance

Peel puncture resistance serves as fruit quality determinant. Peel puncture resistance was significantly higher in the GA3 treated fruits as compared to control. Table 1 shows that on 20 November harvesting, the firmness of the fruits was non-significant although GA3 treated fruits had appeared higher index value (> 4.0 kg/cm2) than control (3.75 kg/cm2). On 5 December, this value decreased in all treatments, however, GA3 treated fruits had significantly much higher (3.71-4.21 kg/cm2) than control (2.8 kg/cm2). On 20 December, the resistance sharply declined and observed as non-significant among the treatments. However, fruits treated with GA3 at 20 ppm had higher firmness (3.54 kg/cm2) than the untreated fruits (2.73 kg/cm2). These results are in conformity with the findings of the Ladaniya (1997) in Nagpur mandarin who stated that GA3 treated fruits had higher peel puncture resistance and Kaur et. al. (2008) observed the similar trends in the plum. In all the treatments the firmness was found decreasing with ripening advancement. This might be due to cell wall loosening of the fruit. The pro-pectin, which acts as a cementing material for binding the cellulose and hemicelluloses is converted to soluble pectin. As a result, it loosens the cell wall's binding force during ripening (Rana, 2006).

Number of fruit per plantThe number of the fruit per tree was ranged from 302.69-489.55. Spray of urea @ 2% and Agromin @ 0.4% singly, or in combination resulted a higher productivity over the control (Table 1). The treatments were significantly different ($p<0.05$) to the parameter-number of fruit per plant. The highest fruit per plant was obtained for the treatment-urea 2% plus Agromin 0.4% whereas the lowest number was for control. This increment in number of fruit was might be due to nitrogen which is major constituent of protoplasm and is helpful in chlorophyll synthesis by increasing in photosynthetic activity of trees. The combined positive effect of urea and micronutrients on number of fruit might be due to increase in the rate of biosynthesis of various metabolites and physiological process in the plant system leading to increase rate of fruit growth and efficient uptake of nitrogen and micronutrients through foliage.

Monga et al. (2004) reported that the supplementation of the urea increased the number of fruits significantly in Kinnow mandarin. Similar observation was found by Roussos and Tassis (2011) as well as Malik et al. (2000) who reported foliar application of urea and zinc increased the number of fruits. These findings are in corroboration with the finding of

Babu et al. (2007) in Kinnow mandarin, Gill et al. (2005) in Kinnow mandarin, and Ram and Bose (2000) in mandarin who reported that mandarin tree with foliar spray of urea and micronutrients increased the number of fruits. Likewise, Mattos et al. (2012) suggested that high doses of N increase the number of fruits and improve fruit size.

Fruit weight The average fruit weight per plant was varied with the treatments and ranged from 98.28-106.56 g. The treatments with urea at 2% and Agromin at 0.4% were found to be beneficial in improving fruit weight and retained the maximum weight (105.56 g) followed by Agromin at 0.4% (104.79 g) over the control (98.28 g). These findings are in corroboration with the findings of Monga et al. (2004) in case of Kinnow mandarin, and also to the report of Tariq et al. (2007) in sweet orange as the authors reported that urea and micronutrients sprayed tree had produced significantly heavier fruit. The increase in fruit weight with application of urea plus commercial micronutrients might be due to increase in the rate of biosynthesis of various metabolites and physiological process in the plant system through the efficient uptake of nitrogen and micronutrients.

Table 1. Effect of foliar spray of urea and micronutrients on yield and yield attributing characteristics of mandarin

Treatments	Number of fruit/plant	Fruit yield (kg/plant)	Fruit weight (g)	Fruit diameter (cm)
Control	302.69[b]	29.70[b]	98.28	5.72
Urea 2%	409.09[a]	42.63[a]	104.61	6.01
Agromin 0.4%	417.46[a]	43.72[a]	104.79	6.05
Urea 2% + Agromin 0.4%	489.55[a]	51.82[a]	105.56	6.17
Mean	404.70	41.97	103.31	5.99
$LSD_{0.05}$	122.91	12.80	NS	NS

Fruit yield

Fruit yield was increased with the application of treatments and found in the range of 29.7 kg per tree to 51.82 kg per tree. The treatments were significantly different ($p<0.05$) to the parameter-fruit yield. The highest fruit yield was obtained for the treatment-urea 2% plus Agromin 0.4% (51.82 kg/plant) whereas the lowest yield was for control (29.7 kg/tree). These findings are in line with the reports of Babu et al. (2007) in Kinnow mandarin, Ram and Bose (2000) in mandarin as in both cases the fruit yield are reported to be increased by the use of foliar application of urea (2%) along with micronutrients (0.4%). The highest yield in our case might be due to increase in biosynthesis through urea and micronutrient application thereby increase in weight and number of the fruit by reducing the fruit drops, disease and insect pests incidence and physiological disorders (Tariq et.al., 2007).

Fruit diameter

The response of treatments to the fruit diameter was statistically similar (Table 1). However, comparatively the diameter of each fruit was higher for the treatment with urea and Agromin mixture whereas control had the lower diameter of each fruit (Table 1). The increment in diameter of the fruits treated with urea and micronutrients might be due to faster cell division and elongation of the fruits during the growth and development process. This finding related to diameter is in agreement with the findings of Gill et al. (2005) as the authors reported about increase in fruit size and diameter with increased level of nutrients.

Conclusion

Foliar application of GA3 at 20 ppm was more effective to increase fruit weight and overall fruit quality of mandarin. GA3 at 20 ppm retained higher fruit weight (128.6 g), higher peel puncture resistance (3.54 kg/cm2). Combined application of urea at 2% and micronutrients (Agromin) at 0.4% resulted in the highest number of fruit (489.55), greater yield (51.82 kg/tree), and maximum weight per fruit (105.5 g). Fruit yield and quality of mandarin was improved by the application of GA3 and combined application of urea plus micronutrient.

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