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Original Research Paper

Effect of GA_3 and fungicide at colour-break stage for extension of bearing period and shelf-life in *Khasi* mandarin (*Citrus reticulata* Blanco.)

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ABSTRACT

The effect of GA_3 of different concentrations along with fungicide was investigated on ten year old trees of *Khasi* mandarin to study the extension of bearing period and its post harvest shelf life the year, 2014-2015. Fruits on the tree at colour break stage were sprayed with seven concentrations of 10, 15, 25, 30, 35, 40 and 45 ppm of GA_3 each along with the fungicide (Carbendazim 1g/L of water) and the control (no GA_3 and fungicide). Among the different treatments, optimum fruit retention (237 fruits/tree) was observed in T_5 (GA_3@30ppm + fungicide i.e Carbendazim 1g/L of water) as compared to control (162 fruits/tree) and also extended the harvesting period for about 18.3 days in T_7 (GA_3@45ppm + fungicide i.e Carbendazim 1g/L of water) which is at par with T_5 and T_6 (18 days). Besides, imposition of GA_3 and fungicide at colour break stage also minimized the physiological loss in weight, spoilage loss, shriveling and thus, extended the post harvest shelf life of the fruits of about one week as compared to control under the room temperature.

Key words : *Khasi* mandarin, GA_3, fungicide, fruit retention

INTRODUCTION

Citrus is an important fruit crop which ranks third in production and occupies 12.5% of the total fruit crops production in India. Among the citrus group, mandarin orange (*Citrus reticulata* Blanco.) is one among the most common among citrus fruits grown in India. It occupies nearly 50% of the total citrus area in India (Anon, 2014). In the North East region of India (Assam, Arunachal Pradesh, Manipur, Tripura and Meghalaya), an ecotype of mandarin called *Khasi* mandarin occupied an important place among the other varieties of mandarin orange. In Arunachal Pradesh, which is known for its organic *Khasi* mandarin production it is facing problems. Further, fruits mature and ripe during the period of Nov-Dec months (peak period for *Khasi* mandarin under Pasighat condition). Due to the harvesting of all the fruits at one peak period and relatively short harvest period, there is low price of the crop value resulting low income to the *Khasi* mandarin growers. Besides, improper storage facilities, after the harvesting of it result in a glut in the market.

However, such post harvest loss can be minimized through storing for a longer period at temperature of 5-7^{0}C with relative humidity 85-90% for about 4-8 weeks in the cold storage or with the application of growth regulator (GA_3), its bearing period can be extended so that there will be minimization of glut in the market. Therefore, the present research was initiated to explore the potential of growth regulators in extension of its bearing period and improving the harvesting management in *Khasi* mandarin under the Pasighat condition. Information regarding application of plant growth regulators like GA_3 are still lacking in East Siang district of Arunachal Pradesh. Keeping the view and considering the need of fruit retention during the bearing period and to increase the profit among the mandarin growers, the present research was initiated to explore the potential of growth regulators for extension of bearing period and better shelf life of *Khasi* mandarin under the Pasighat condition of Arunachal Pradesh, India.

MATERIAL AND METHODS

The present investigations were carried out at the at Bodak village under East Siang district of Arunachal Pradesh (Fig.1.a) during the year 2014-

Fig.1. (a) Experiment site, Bodak village, A.P.

2015 to evaluate the different concentration of GA_3 for the extension of bearing period in the tree. The average altitude of the sites of the experiment are about 155 m MSL and represent a subtropical, hot and humid climate; in the lower valleys, summer temperatures in June, July, and August typically rise to about 30°C, while winter temperatures in December, January, and February usually drops to 13°C. Annual rainfall in the state averages about 130 inches (3,300 mm), mostly between April and September. The details of the eight treatments are T_1: GA_3@10ppm + Carbendazim 1g/L, T_2: GA_3@ 15ppm + Carbendazim 1g/L, T_3:GA_3@25ppm + Carbendazim 1g/L, T_4:GA_3@30ppm + Carbendazim 1g/L, T_5: GA_3 @35ppm + Carbendazim 1g/L, T_6:GA_3@ 40ppm + Carbendazim 1g/L, T_7:GA_3@45ppm + Carbendazim 1g/L and T_8: Control. The PGR GA_3 sprayed at colour break stage during September months and the extension of bearing period was evaluated by counting the average fruit retention / branche before spraying at September month as initial reading (equal average fruit number/tree) and counted average fruits/branche at November to observ the fruit retention and its extension of bearing period. Finally, the number of fruits/tree at harvesting stage (last week of Nov) was counted for each treatment for the evaluation for better fruit retention/tree and also evaluated for its fruit quality parameters. Every treated plant was supplemented with 450:450:900g N: P: K/plant/year in two split doses. First split dose of the recommended dose of fertilizer of total P and K fertilizers along with half of nitrogen fertilizer was applied in one time at March-April along with a light irrigation after fruit setting and the remaining half of the recommended dose of nitrogen was applied during June-July. Before the fruit drop was anticipated to begin, all the fruits on the ground under the trees were removed. At the time of counting, dropped fruits were classified as sound or unsound. Sound fruit had no visible signs of injury or infection and unsound fruit had visible injury or pathological infection which we assumed induced by abscission. The statistical analysis of the data on the mean values of individual characters was analyzed using M Stat software.

RESULTS AND DISCUSSION

The effect of different concentrations of GA_3 along with fungicide showed significant influence in the extension of bearing period and better shelf life as compared to control without effecting its fruit quality (Tables 1, 2 and 3). It was observed that the maximum extension of bearing period (18 days) was observed in T_5 and T_6 (18 days) and T_7 (18.3 days) whereas the earliest fruit ripening was recorded in control (T_9) (50.6 days) after the initiation of colour break stage. Stewart and Hield (1950) reported that the fall of mature fruit was characterized mainly by alterations in the cellular walls in the zone abscission, localized at the peduncle and that the main action of plant growth regulators in the fall of ripe fruit was that of reducing the weakening of the cellular wall material in this region, reducing the fall of fruit (Fig.1.b). Besides, Monselise and Goren

Fig.1. (b) Fruits drop in control plant

Table 1: Fruit retention of *Khasi* mandarin for different GA_3 combination treatments

Treatment	Initial average fruit no./branch, Sept., 2014	Average fruit no./branch, Nov. 2014	Final fruit retention % Nov. 2014	Total no. of fruits / tree	Days taken for harvest period after GA_3 spray	Days taken for extension after GA_3 spray
T_1	10.00	5.40	54.00	194.30	61.60	11.00
T_2	10.00	5.40	54.00	186.30	63.00	12.40
T_3	10.00	5.70	57.00	194.00	64.00	13.40
T_4	10.00	5.80	58.00	192.30	64.60	14.00
T_5	10.00	6.30	63.00	237.00	68.00	17.40
T_6	10.00	6.10	61.00	215.00	68.00	17.40
T_7	10.00	6.10	61.00	209.60	68.30	17.70
T_8	10.00	4.00	40.00	162.00	50.60	-----
SEM	.....	1.07	4.50	23.75	6.49	2.30
CD *(P=0.05)*	.....	12.00	12.10	62.80	22.76	8.06

Table 2: Physical parameters of *Khasi* mandarin for different GA_3 combination treatments

Treatment	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Peel weight (g)	Pulp weight (g)	Juice (ml)	No. of seeds/fruit	Peel thickness (cm)
T_1	6.20	4.70	115.31	25.32	89.99	35.60	7.30	0.28
T_2	6.41	4.70	115.71	25.62	90.09	36.30	8.31	0.29
T_3	6.51	4.71	116.72	24.33	92.23	37.30	7.32	0.29
T_4	6.22	4.72	115.74	24.32	91.42	37.00	8.31	0.29
T_5	6.41	4.81	118.74	25.64	93.10	36.00	8.01	0.28
T_6	6.33	4.71	118.03	24.33	93.70	36.6	7.62	0.30
T_7	6.41	4.84	120.73	24.05	96.68	37.61	8.61	0.30
T_8	6.14	4.51	113.30	23.61	89.69	34.31	8.01	0.27
SEM	0.02	0.03	0.50	0.70	0.74	0.16	0.16	.....
CD *(P=0.05)*	0.20	0.13	2.93	0.28	3.19	1.04	0.45	.....

Table 3. Quality parameters of *Khasi* mandarin for different GA_3 combination treatment

Treatment	TSS (° B)	Reducing sugars (%)	Acidity (%)	Vitamin C (mg/100g)	Total sugars (%)	Chlorophyll content (mg/100g)	Shelf life*
T_1	11.06	4.10	0.91	35.33	7.66	0.46	9.00
T_2	11.33	4.03	0.92	35.33	7.63	0.48	9.00
T_3	11.33	4.03	0.92	35.66	7.30	0.49	9.33
T_4	11.50	4.0	0.92	36.33	7.23	0.49	9.33
T_5	11.53	4.03	0.92	35.66	7.43	0.50	9.66
T_6	11.33	3.90	0.93	34.66	7.20	0.50	10.00
T_7	11.43	3.73	0.92	34.66	7.40	0.50	10.00
T_8	11.56	4.16	0.91	35.33	7.73	0.37	5.33
SEM	0.14	0.01	....	0.19	....	0.04	0.48
CD (P=0.05)	0.26	0.16	....	1.3	....	0.22	1.66

*Room temperature: 20.5°C and relative humidity : 72.0%

(1978) also reported that the spraying of auxins and GA_3 prevented the dropping of fruit by maintaining the cells at the zone of abscission, preventing the synthesis of hydrolitic enzymes, such as cellulose, which decomposed the cell walls. The trees which are treated with GA_3 and fungicide were better in the retention of the green chlorophyll pigment of the fruit and extended the bearing period on the tree. Besides, fungicide spray during the colour break stage helped in reducing the fungal infection of the mature fruits, resulting in more fruits retention as compared to control. Babu *et al.* (1984) in acid lime and Greenburg *et al.*, (1986) in Clementine mandarin also reported that application of GA_3 at colour break stage increase fruit yield as well as delay in harvest. This might be due to the enhancement of vegetative growth and preventing the degreening process of the fruit by the GA_3 spray which in turn direct improvement in carbohydrate metabolism resulting in better size of the fruit. The application of GA_3 and fungicide at the colour break stage also increased the fruit retention and minimized the fruit drop resulting in more number of fruits/tree of 63% at T_5 (237 fruits/tree) which are at par with 61% of fruit retention in $T_{6,}$ T_7 & T_8 showing 215 fruits/tree in T_8, 209 fruits/tree in T_7 and 202 fruits/tree in T_8 respectively. Moreover, a study conducted by Lakshmi *et al.*, 2014 revealed that increase in yield and yield components of acid lime by GA_3 spray was attributed to synthesis of chlorophyll from source to sink.

The physical parameters like fruit length, fruit breadth, fruit weight, peel weight, pulp weight juice content, number of seeds/fruit were significantly improved by the application of $GA_{3,}$ however non-significant improvement was found in peel thickness (Table 2). This can be attributed to nature of gibberellins in cell elongation which makes better size of fruits, correspondingly it increases fruit weight which certainly affect the fruit juice content. The results are in line with the findings of many workers Ratnababu *et al.*, (1984) in Pant lemon-1, Lakshmi *et al.*, (2014) in acid lime as well as Reddy and Prasad (2012) in pomegranate with the application of GA_3.

Analytical investigation with different treatments of GA_3 along with fungicide at colour break stage (Fig. 1.c) revealed that the parameters like TSS, reducing sugar, vitamin C, chlorophyll content were significantly but improved there was non-significant improvement

Fig.1. (c) Application of GA_3 and fungicide

Fig.1. (e) Extension of bearing in the tree

Fig.1. (d) Colour break stage

Fig.1. (f) Better shelf life after treatment

in acidity and total sugar content of the fruit after the imposition of GA_3 and fungicide application at colour break stage (Fig. 1.d). Besides, shelf-life was also found to improve significantly under the average room temperature of 20.5^{0}C and average relative humidity of 72 % after the imposition of treatment without affecting the fruit quality (Table 3). The results are in line with the findings of Parthiban *et al*., (2010); Debaje *et al*., (2011) and (Lakshmi *et al*., 2014) who reported GA_3 increased quality of acid lime fruits by stimulating the functioning of enzymes involved in physiological processes moreover it might be due to more chlorophyll content resulting extension of bearing period of the tree with GA_3 (Fig.1.e) resulting in higher accumulation of metabolites synthesis which makes improvement of the fruit quality parameters after the imposition of the treatment. Besides, the normal harvesting period of the *Khasi* mandarin was winter period hence, they could kept under the room temperature for a long period (Fig.1.f) however, there was fungal infection after 5th day onwards (Table 3). It was also reported that fungicide spray of carbendazim one month before harvest prolong the storage period under the room condition by minimizing the fungal infection of the fruits resulting in the prolonged in shelf-life of the fruit (Ladaniya, 1997).

From the investigation, it is concluded that the combination GA_3 and fungicide i.e. carbendazim@ 1g/ L of water helped in the extension of the bearing period in the tree and also extended the post harvest shelf - life of the fruits under the room condition for a week more than the control which will help in the controlling of glut in the market during the peak harvest season of *Khasi* mandarin. Therefore, application of GA_3 @ 30 ppm along with fungicide (Carbendazim 1g/L of water) can be recommended to the citrus grower which will help in minimizing the spoilage of the fruit in the peak harvest season and increases the profit to the citrus growing farmers.

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REFERENCES

Anonymous 2014. All India area and production of fruits and vegetables. Indian Horticulture Database, National Horticulture Board, Ministry of Agriculture, Govt. of India. pp. 50. (http.//www.nhb.gov.in).

Babu, R.S.H., Rajput, C.B.S. and Rath, S. 1984. Effect of Zinc, 2,4-D and GA_3 on fruiting of Kagzi lime (*Citrus aurantifolia* Swingle). *Indian Journal of Horticulture*, **41**(3/4): 216-220.

Debaje, P., Ekta, P., Shine, D. and Ingle, H.V. 2011. Effect of plant growth regulators and nutrients on quality of acid lime (*Citrus aurantifolia* Swingle). *The Asian Journal of Horticultur*e. **6**(1): 253-255.

Greenburg, J., Monselise, S.P. and Goldschmidt, E.E. 1986. Effect of ingestion of GA_3 and CCC into citrus trees. *Acta Horticulture*, **179** (I): 283-286.

Ladaniya, M.S. 1999. Response of Nagpur mandarin fruit to pre-harvest spray of gibberellic acid and carbendazim. *Indian Journal of Horticulture*, **54** (3): 205-212.

Lakshmi, L.M., Ramana, K.T.V., Krishna, V.N.P.S., Yuvaraj, K.M., Lakshmi, T.N., Sarada, G.T., Sankar, T.G., Gopi, V. and Gopal, K. 2014. Effect of growth regulators and chemicals on fruit yield and quality of hasta bahar flowering in acid lime (*Citrus aurantifolia* Swingle) cv. Balaji. *Journal of Agriculture and Allied Sciences*, **3**(3): 11-13.

Monselise SP and Goren R 1978. The role of internal factors and exogenous control in flowering, peel growth, and abscission in citrus. *Hortscience*, **13**, 134-139.

Parthiban, S., Saraswathy, S., Indra, N., Samundeeswari, A.V., Rani, B.U. and Selvarajan, M. 2010. Problems and prospectus of citrus production in India with special reference to acid lime (*Citrus aurantifolia* Swingle) cultivation in Karnataka. Proceeding of National Seminar on "Citrus Biodiversity for livelihood and Nutritional Security" October 4-5, 2010, NRC, Citrus, Nagpur, Maharastra. pp. 344-349

Ratnababu, G.H.V. Lavaniya, M.L. and Misra, K.K. 1984. Effect of plant growth regulator on yield and physiochemical composition of Pant lemon-1 (*Citrus limon* Burm.) fruits in the off season flush. *Progressive Horticulture*, **16**(3-4): 191-198.

Reddy, P.A. and Prasad, D.M. 2012. Effect of plant growth regulators on fruit characters and yield of pomegranate (*Punica granatum* L.) cv. Ganesh. *International Journal of Plant, Animal and Environmental Science,* **2**(2): 91-93.

Stewart, W.S. and Hield, H.Z. 1950. Effects of 2,4-Dichlorophenoxyacetic acid and 2,4,5-Trichlorophenoxyacetic acid on fruit drop, fruit production, and leaf drop of lemon trees. *Proceeding American Society Horticulture Science*, **55**, 163-171.

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