Improving the Efficacy of GA_3 to Increase Fruit Set and Yield of Clementine Mandarins in California

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The overall goals of this research are to identify the proper rate, proper timing, and best frequency of GA_3 and/or 1% urea applications to increase fruit set and yield of Nules Clementine mandarin (Citrus reticulata Blanco). We also will determine if there is any negative effect on the current and following year's yield due too high a concentration or too frequent applications of moderate rates of GA_3. We will provide growers with updated recommendations and the necessary data to amend the label for use of GA_3 on Clementine mandarins in California.

GA_3 is routinely used in the production of seedless mandarins to increase both fruit set and fruit size. GA_3 concentrations and application times effective for achieving these production goals in Spain, Morocco and South Africa have not proven reliable in California. A comprehensive experiment testing the efficacy of eight combinations of GA_3 concentrations and application times and urea, the effect of which was unknown, was undertaken to maximize the yield of commercially valuable large size fruit of Nules Clementine mandarin in a commercial orchard in California's San Joaquin Valley in 2004-2005.

The results from the 2004 December harvest are shown in Tables 1 and 2. The fruit quality data are shown in Table 3. The correlations between total rate of GA_3 applied per season and fruit weight in different size classes are shown in Table 4.

Application of GA_3 (25 mg/L) at 60% and 90% full bloom, 75% petal fall and 10 days after 75% petal fall resulted in retention of significantly more small fruit (kilograms and number) per tree of packing carton sizes tiny and small (fruit 51-<44 mm in diameter) compared to untreated control trees. Trees receiving GA_3 at 15 mg/L at the same application times produced significantly more tiny and small fruit (kilograms and number) per tree than control trees, whereas trees treated with GA_3 at 10mg/L at these same times produced significantly small size fruit (kilograms and number) per tree but not more tiny fruit.

GA_3 strategies that increased retention of small fruit resulted in significantly lower yields (kilograms and number) of commercially valuable large fruit of packing carton sizes large, jumbo and mammoth (57-76 mm in diameter) per tree compared to the control. Trees receiving GA_3 (10 mg/L) at 90% full bloom, 10 days after 75% petal fall and in early July, a winter prebloom foliar application of low-biuret urea (1% or 3%) and the untreated control produced more commercially valuable large size fruit (kilograms and number) with no reduction in total kilograms or number of fruit per tree. GA_3 (25 mg/L) at 60% and 90% full bloom, 75% petal fall and 10 days after 75% petal or GA_3 (10 mg/L) at 60% full bloom, at 75% petal fall and in early July fall produced significantly less total kg/tree with no increase in yield of large size fruit.

Our data showed that most GA_3 treatments produced more tiny and small size fruit, less large, jumbo, mammoth, and colossal size fruit than the untreated control. There was a negative correlation between higher concentration of GA_3 treatments and large fruit size (Table 4). These data suggest that higher concentrations and/or higher frequency of GA_3 application might have a negative effect on fruit set and yield of Nules Clementine mandarins in the San Joaquin Valley of California. More experiments over multiple seasons are needed to confirm these findings. Better concentration, better frequency of application, and/or better timing of GA_3 applications are needed to set more fruit of Nules Clementine mandarins. Combination of GA_3 and other plant growth regulators might be needed to set better crops of Nules Clementine mandarins in California.

From Winter 2004, a new experiment was established at an isolated Nules Clementine mandarin location near Grapevine, CA. Treatments were applied in Winter 2004 and Spring 2005. Fruit drop data has been collected at this new location since the bloom. Fruit of all treated trees will be harvested in December 2005. Treatment for the following season will begin in winter 2005.

		Fruit size distributionz							
Treatments	Total	Tiny	Small	Medium	Large	Jumbo	Mammoth	Colossal	La-Jb-Ma
(1) 5 ppm GA3 x4	94.0 abc	1.3 be	10.1 bed	21.3	37.3 c	12.2 be	10.7 bed	1.1	60.2 bed
(2) 10 ppm GA3 x4	91.9 be	1.3 be	11.3 abc	20.6	37.5 c	12.0 be	8.3 def	0.8	57.9 d
(3) 10 ppm GA3 x3 60%	88.9 c	1.3 be	9.3 bed·	17.5	36.8 c	13.5 ab	9.5 cde	1.1	59.7 cd
(4) 10 ppm GA3 x3 90%	99.1 abc	0.9 c	9.2 cd	19.1	39.4 abc	15.6 a	13.6 ab	1.3	68.6 ab
(5) 15 ppm GA3 x4	94.6 abc	2.9 a	13.9 a	23.1	36.9 c	10.2 c	7.0 ef	0.7	54.1 d
(6) 25 ppm GA3 x4	90.2 c	2.1 ab	12.8 ab	22.2	36.5 c	10.4 c	5.7 f	0.5	52.7 d
(7) 1% Urea	104.9 a	0.8 c	9.3 bed	20.2	43.9 a	15.3 a	13.8 ab	1.5	73.1 a
(8) 3% Urea	98.7 abc	1.1 c	10.5 abed	18.8	38.5 be	15.3 a	13.0 abc	1.6	66.8 abc
(9) Control	103.8 ab	0.8 c	7.8 d	21.8	43.0 ab	16.2 a	15.1 a	1.8	74.2 a
P-value	0.0849	0.0001	0.0238	0.2066	0.0211	<0.0001	<0.0001	0.1127	<0.0001

zFruit sizes categories based on fruit diameters (mm): Tiny (<44), Small (44-51), Medium (51-57), Large (57-64), Jumbo (64-70}, Marrunoth (70-76), Colossal (76-83), and Large+Jumbo+Mammoth (57-76).

Table 1. Total yield {average kg fruit per tree} and average fruit weight {kg} distribution in different fruit size classes of Nules Clementine mandarin of 2003-2004 treatments from Selma, Calif Average weight followed by different letters are significant different at P = 0.05 based on Fisher's Protected LSD Test. (1 kg= 2.21bs)

		Fruit size distributionz							
Treatments	Total	TiD}'	Small	Medium	Large	Jumbo	Mammoth	Colossal	La-Jb-Ma
(1) 5 ppm GA3 x4	1101	34 be	174 bed	304	396 c	107 be	81 bed	6	584 bed
(2) 10 ppm GA3 x4	1094	34 be	196 abc	294	398 c	106 be	63 def	4	567 cd
(3) 10 ppm GA3 x3 60%	1028	32 be	161 bed	249	390 c	119 ab	72 cde	6	581 bed
(4) 10 ppm GA3 x3 90%	1121	24 c	159 cd	273	418 abc	137 a	103 ab	7	658 ab
(5) 15 ppm GA3 x4	1180	73 a	240 a	329	392 c	90 c	53 ef	3	534 d
(6) 25 ppm GA3 x4	1116	53 ab	222 ab	316	388 c	92 c	43 f	3	523 d
(7) 1% Urea	1184	21 c	161 bed	288	466 a	135 a	105 ab	8	706 a
(8) 3% Urea	1126	27 c	182 abed	268	408 be	134a	99 abc	8	641 abc
(9) Control	1189	21 c	134 d	311	457 ab	142 a	114a	9	713 a
P-value	0.4591	0.0001	0.0238	0.2066	0.0211	<0.0001	<0.0001	0.1127	<0.0001

zFruit sizes categories based on fruit diameters (mm): Tiny (<44), Small (44-51}, Medium (51-57), Large (57-64}, Jumbo (64-70), Mammoth (70-76}, Colossal (76-83}, and Large+Jumbo+Marrunoth (57-76).

Table 2. Total y1eld {average number fru1t per tree} and average fru1t number distribution in different fruit size classes of Nules Clementine mandarin of 2003-2004 treatments from Selma, Calif. Average weight followed by different letters are significant different at P = 0.05 based on Fisher's Protected LSD Test.

	Fruit weight (g)	Juice weight (g)	Percent acid	ºBrix	Brix:acid
(1) 5 ppm GA_3 x4	105.94	31.97	0.65	10.81	16.67
(2) 10 ppm GA_3 x4	97.47	30.63	0.65	10.73	16.59
(3) 10 ppm GA_3 x3 60%	103.50	33.50	0.68	10.69	15.90
(4) 10 ppm GA_3 x3 90%	97.69	31.47	0.70	10.92	15.59
(5) 15 ppm GA_3 x4	100.79	36.47	0.70	10.62	15.16
(6) 25 ppm GA_3 x4	92.54	29.74	0.68	10.66	15.83
(7) 1% Urea	104.40	35.77	0.70	10.89	15.56
(8) 3% Urea	111.50	37.72	0.68	10.79	16.05
(9) Control	108.10	36.63	0.68	10.66	15.87
P-value	0.1456	0.1541	0.5726	0.9891	0.7194

Table 3. Juice quality parameters of Nules Clementine mandarin of 2003-2004 treatments from Selma, Calif.

	Total wt	Tiny wt	Small wt	Medium wt	Large wt	Jumbo wt	Mammoth wt	Colossal wt	L-J-M wt
Rate of GA_3	–0.15	0.31	0.31	0.07	–0.17	–0.36	–0.44	–0.29	–0.41
P-value	0.1137	0.0010	0.0009	0.4862	0.0765	0.0001	<0.0001	0.0018	<0.0001

Table 4. Pearson correlation coefficients (r) between total rate of GA_3 applied per season and fruit weight (kg) in different fruit size classes of Nules Clementine mandarin in 2004. (1 kg = 2.2 lbs)