Tree Condition in Relation to Fruit Thinning Effect of NAA Spray in Satsuma Mandarin

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溫州蜜柑에 있어서 NAA 摘果效果에 關與하는 樹體條件

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要 約

탱자대목 10年生 杉山系 溫州蜜柑 (*Citrus unshiu* Mar.) 나무에 開花 1個月後인 1976年 6月 24日 α—Naphthalene acetic acid (NAA)의 水溶液을 撒布하여 NAA의 摘果效果를 調査하고, NAA 撒布時 測定한 나무의 生長 및 結實狀態에 對한 撒布後의 殘果率 및 葉果比의 相關을 求해 본 結果를 要約하면 다음과 같다.

1) NAA 0, 100, 300*mg/l* 區에서 各各 殘果率은 61.80, 52.80, 43.16% 였고 葉果比는 19.18, 25.25, 32.44로서 NAA 300*mg/l* 區는 高度의 有意性 있는 摘果效果를 보였다.

2) NAA 撒布에 依해서 1果平均重이 增加되었다. 그러나 收穫果의 果肉率, 果汁의 Brix 및 遊離酸含量 等에는 影響이 없었다.

3) NAA 의 摘果效果는 같은 圃場 條件下에서도 나무에 따라 變動이 심했다.

4) NAA 撒布時 調査한 葉果比, 新葉과 舊葉의 比, 新梢發生數, 新梢길이 等의 變數中 撒布後의 殘果率 및 葉果比와 高度의 相關關係가 있는 것은 撒布時 葉果比 뿐이었다.

5) NAA의 摘果效果에 影響을 미치는 樹體內條件은 撒布時 葉果比로 推定할 수 있다고 思料되었다.

Abstract.

Small branches of ten year old 'Sugiyama' Satsuma mandarin (*Citrus unshiu* Mar.) trees were sprayed with α-naphthalene acetic acid (NAA) solutions on 30 days after full bloom. 100—300 *mg/l* NAA sprays showed thinning effect, especially 300 *mg/l* at 1% level probability. Fruit weight was increased by NAA spray, but flesh ratio, juice Brix and free acid contents of mature fruits were not influenced. Variations in NAA effect were significant among trees even under the same field conditions. The degree of fruit abscission after spray was highly correlated only with the number of leaves per fruit before spray among various apparent variables of tree.

Introduction

Many of citrus trees growing in Jeju island began to exhibit the undesirable biennial production pattern. The trees set so much fruit one year

that they are unable to produce a return crop the next.

It is often observed that some trees decline due to heavy crop in 'on' year. Heavy load with fruit results in decreased carbohydrate contents in the underground parts, and lack of sufficient carbohydrate energy to nurture a large crop of fruit and sustain the tree itself causes tree decline with starvation of roots (13, 14).

Among various practices which have been recognized to be efficacious on the control of alternate bearing of citrus, thinning has been recommended as the most reliable (8). Even though the advantages of fruit thinning is highly appreciated, it is too laborious to carry out by hand. Many attempts have been made to use chemicals in fruit thinning. Naphthalene acetic acid (NAA) sprays to several citrus varieties during bloom showed no influence on fruit set (1, 9), but applications to Wilking mandarin at about the normal period of 'June drop' produced a thinning effect and improved fruit size (2).

In Satsuma mandarin, most widely growing in Jeju island, NAA has been examined by several Japanese workers (3—7, 10—12, 15), and employed as an useful fruit thinning agent. 200 to 300 ppm NAA spray during the period of 'June drop' (on about 30 days after full bloom) was recommended (3, 7). But the degree of fruit thinning by NAA spray showed considerable variations among the reported experiments; application of the same concentration during the same period resulted in over-thinning in one case, and showed little effect in another. It was summarized that the effect of NAA was liable to be affected by various environmental and internal factors (3).

This study was initiated to examine the fruit thinning effect of NAA under Jeju's environmental conditions, and to find any apparent indicators to predict the degree of fruit abscission.

Materials and Methods

Ten year old 'Sugiyama' Satsuma mandarin (*Citrus unshiu* Mar.) trees on trifoliate orange stock, growing on the No. 3 farm attached to Jeju National University which is located to Seogwipo, were used for the experiment. Ten trees of different vigor were selected, and each tree was used for a block in Randomized Block Design. Three small branches of similar condition from each tree were sprayed with, respectively, 0, 100, and 300 *mg/l* α-naphthalene acetic acid (NAA) solution on June 24, 1976 (on 30 days after full bloom). So each level of concentration was applied in 10 replications to 1-branch plot.

Meteorological conditions during the experiment are shown in Table 1.

Table 1. Meteorological data during the experiment. (from Seogwipo Met. Obs. Stn.)

Month	June		July			Aug.
Date or Period	24[a)]	Late	Early	Middle	Late	Early
Weather condition	clear					
Mean temp. (°C)	21.1	21.3	20.6	23.4	25.4	27.3
Max. temp. (°C)	23.2	23.9	23.0	26.1	28.1	30.0
Min. temp. (°C)	18.9	18.8	18.4	21.0	22.7	25.4
Humidity (%)	86	81	86	85	84	88
Wind velocity (*m/sec.*)	1.8	3.5	4.2	3.3	1.8	2.7
Precipitation (*mm*)	—	97.2	70.4	77.9	60.0	55.5

a) Date on which NAA was sprayed.

Fruit thinning effect of NAA was estimated with fruit set ratio during the period from spray to Aug. 13, and the number of leaves at spray per fruit remained on Aug. 13 when 'June drop' ceased. Fruits and leaves were counted on the whole branch treated.

On Nov. 25, fruit quality was examined only in eight blocks, because two blocks were missed. Juice was extracted from 10 fruits each plot with gauze. Brix of juice was measured with Abbe-type refractometer, and free acid was titrated with 0.1N NaOH and calculated as citric acid.

Various apparent variables of tree, which might be related to fruit abscission, were measured before NAA spray. And correlation coefficients between those and fruit set ratio or number of leaves per fruit, were calculated.

Results

Application of 300 *mg/l* NAA solution decreased fruit set ratio and increased the number of leaves per fruit (Table 2). Though statistically insignificant, 100 *mg/l* NAA spray also tended to cause fruit abscission. The degrees to which fruit abscission occurred, however, varied not only with the concentrations of NAA, but also with blocks or trees significantly.

Table 2. Effect of NAA spray on fruit thinning of Satsuma mandarin.

Treatment	Per cent of fruit set[x)]	Number of leaves per fruit		Remarks
		Before spray	After spray[y)]	
Control	61.80	13.37	19.18	F-values for blocks both of per cent fruit set (7.88**) and No. of leaves after spray (3.86**) were also highly significant.
100	52.80	14.61	25.25	
300*mg/l*	43.16	14.82	32.44	
LSD 5%	11.01		6.57	
1%	15.08		8.99	

x) (No. of fruits on 50 days after spray)/(No. of fruits before spray) X 100.
y) Observed on 50 days after spray.

Table 3. Effect of NAA spray on fruit quality of Satsuma mandarin.

Treatment	Fruit weight	Flesh ratio[x)]	Juice contents		
			Brix	Free acid[y)]	Bx'-acid ratio
Control	68.9*g*	76.4	10.96	1.75	6.35
100	76.1	75.0	11.23	1.60	7.04
300*mg/l*	83.0	75.4	11.34	1.71	6.73
LSD 5%	8.36	NS	NS	NS	NS
1%	11.60				

x) (Flesh weight)/(Fruit weight)×100.
y) Calculated as citric acid, and unit in *g*/100 *ml* juice.

The effect of NAA on fruit quality is shown in Table 3. NAA spray increased average fruit weight, while it had no influence on flesh ratio, juice Brix and free acid contents of mature fruits.

Table 4 shows the correlation coefficients between fruit set ratio and tree conditions. Fruit set ratio was significantly correlated only to the number of leaves per fruit before spray among several apparent variables which might explain the physiological conditions.

Table 4. Correlation coefficients between fruit set ratio and tree conditions observed in NAA sprayed Satsuma mandarin.

Variable	Per cent of fruit set		
	Control	100	300 *mg/l*
No. of leaves per fruit before spray	0.8457**	0.9017**	0.9597**
New leaf to old leaf ratio	0.4098	0.7558*	0.1010
No. of flushes per twig	0.4453	0.3893	0.1449
No. of flushes per node of twig	0.0048	0.5301	−0.0082
Length of flush	0.6678*	0.6052	0.4961
Length of flush node	0.6306	0.5015	0.5236
No. of nodes per flush	0.5278	0.5420	0.5410

* Significant at 5% level (>0.632).
**Significant at 1% level (>0.765).

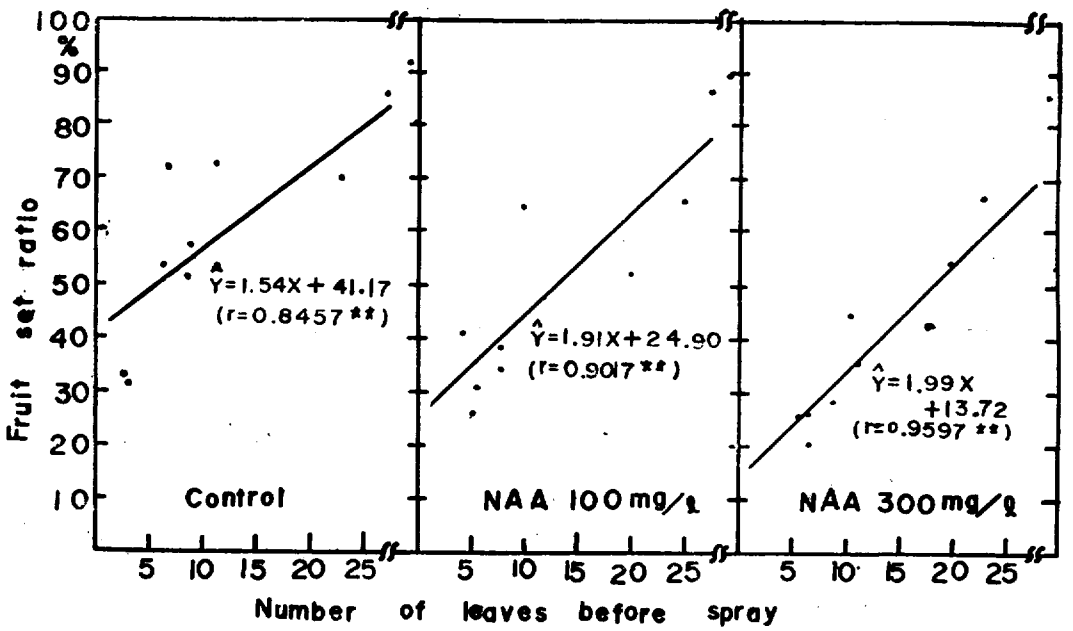

Fig. 1 Regression of fruit set ratio on number of leaves per fruit before NAA spray in Satsuma mandarin.

Regression equations of fruit set ratio on the number of leaves per fruit before spray were $\hat{Y}=1.54X+41.17$, $\hat{Y}=1.91X+24.90$ and $\hat{Y}=1.99X+13.72$, respectively in 0, 100 and 300 *mg/l* NAA spray (Fig.1).

Table 5. Correlation coefficients between the number of leaves per fruit and tree conditions observed in NAA sprayed Satsuma mandarin.

Variable	Before spray			After spray[1]		
	Control	100	300 *mg/l*	Control	100	300 *mg/l*
No. of leaves per fruit before spray				0.9806**	0.8798**	0.7416*
New leaf to old leaf ratio	0.7040*	0.5134	−0.0982	0.7291*	0.2467	−0.5117
No. of flushes per twig	0.5659	0.2908	0.1079	0.5516	0.1492	0.2025
No. of flushes per node of twig	0.1136	0.5191	−0.0919	0.1872	0.4224	−0.2937
Length of flush	0.7701**	0.6618*	0.5000	0.6937*	0.6661*	0.4421
Length of flush node	0.6777*	0.5441	0.4629	0.6217	0.6867*	0.6031
No. of nodes per flush	0.6564*	0.9196	0.5927	0.5878	0.4935	0.2821

*Significant at 5% level (>0.632)
**Significant at 1% level (>0.765)
[1]Observed on 50 days after spray.

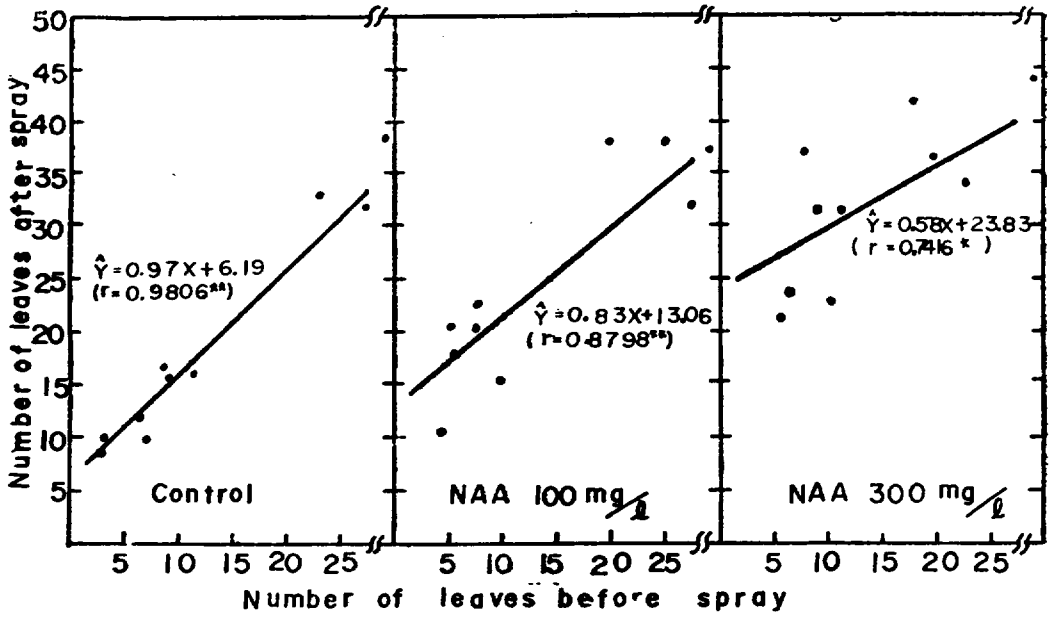

Fig. 2 Regression of number of leaves per fruit after NAA spray on that before spray in Satsuma mandarin.

The number of leaves per fruit on 50 days after NAA spray was also positively correlated with that before spray (Table 5), and their regression equations were $\hat{Y}=0.97X+6.19$, $\hat{Y}=0.83X+13.06$ and $\hat{Y}=0.58X+23.83$, respectively in 0, 100 and 300 *mg/l*. The mean length of flush or flush node seemed to be correlated with the number of leaves per fruit, but those relations were not so close. And other variables were not recognized to be correlated with fruit abscission after NAA spray.

Discussion

Fruit thinning effect of NAA was clearly recognized in this experiment. It was evident that NAA spray on 30 days after full bloom stimulated fruit abscission, and produced no influence on the harvested fruit quality except increasing fruit size. These results agree with the previous studies (2, 3, 7, 11) And any injury to tree by NAA spray, such as defoliation, leaf burn and leaf curling, was not observed.

The purpose of fruit thinning is to maintain the most desirable number of leaves per fruit for the current year's crop and the following year's fruiting; that is, 20 to 25 leaves per fruit in Satsuma mandarin on trifoliate orange stock (8). In this experiment, nearly 20 leaves per fruit was observed in Control (Table 2), and much more than 25 leaves in 300 *mg/l* NAA treatment. These mean numbers, however, are not important to selection of NAA concentration, because variations in fruit set ratio and number of leaves per fruit are highly significant among trees.

It is interesting that the number of leaves per fruit and fruit set ratio after NAA spray vary greatly with trees even under the same field conditions. Those variations would result from the different physiological conditions. If those different physiological conditions could be explained by the apparent variables, it should be helpful in deciding whether and how to use the chemical for fruit thinning agent. Among several variables checked in this experiment, only the number of leaves per fruit before chemical spray was highly correlaled with the fruit set ratio and the number of leaves after 'June drop' in all treatments (Table 4, 5 and Fig. 1, 2). Plots with fewer leaves per fruit before spray showed lower fruit set ratio and was more sensitive to NAA spray. But positive correlation between number of leaves per fruit before spray and that after spray was observed even in NAA srayed plots. From the regression equations (Fig.2), it may be explained that trees with more than 14 leaves per fruit on about 30 days after full bloom don't need fruit thinning, and those with fewer than 8 leaves need higher level of NAA concentration than 100 *mg/l*, but 300 *mg/l* NAA spray results in over-thinning. These data may not be directly applied to practical use because the environmental factors affecting NAA effects are variable. However, it is clear that number of leaves per fruit at beginning of 'June drop' can be used as an indicator of internal conditions of tree itself affecting NAA effect.

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