Recent Trend of Utilization of Growth Regulators for Fruit Trees in Japan

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Table 1 shows a summarized list of the principal regulators utilized on the fruit tree. 1-naphthalen acetic acid (NAA) as a chemical fruit thinner for Satsuma mandarin orange (*Citrus unshu* Marco), Gibberellic acid A_3 (GA_3) as an autonomic parthenocarpy substance for grape (*Vitis labruscana Bailey*) Delaware and 2-chloroethylphosphonic acid (Ethrel) as a chemical ripening accelerator for Japanese pear (*Pyrus serotina* Rehder) Nijisseiki are the important chemical regulators used practically.

As to the NAA which is used as a chemical fruit thinner for Satsuma mandarin orange, Hirose et al.[1),2),3)] had reported on its selection and the author has described[4)] on its application.

The author has studied to find the safety application of NAA as a chemical fruit thinner investigating its fruits abscission mechanism besides its practicality. Yamamoto and Hirose[5)] have reported on the relation between the effect of NAA and temperature that the percentage of fruits drop increased according to the rising of temperature and this trend was also observed in the control plot. Therefore, it became evident that high temperature accelerates the physiological activity of the Satsuma mandarin orange tree and promotes fruits drop, and NAA increases the percentage of fruits drop.

Fig. 1 shows the relation between the cumulative maximum temperature after the application of NAA solution and the percentage of fruits drop. Since continuous high temperature increases the percentage of fruits drop

Table 1. Utility chemicals for fruit tree (Hirose)

Kind of fruit tree	Chemicals name	Utility object	Concentration	Spray time
Satsuma mandarin	NAA	Fruits thinning	200– 300 ppm	Full bloom after 20–30 days
	2, 4-D	Leaf fall control	20– 50	Dec.–Jan.
Navel orange	GA	Fruits drop control	100– 500	Full bloom after 2–3 weeks
Olive	Amidsin	Fruits thinning	50– 100	Full bloom after
Grape	GA	Parthenocarpy and ripening accelerate	100	Full bloom before 15 days and after 10–15 days
	B-995	Fruits drop control	0.5–1%	8–9 leafing
Japanese pear	Ethrel	Ripening accelerate	50– 100 ppm	Full bloom after 100 days
Japanese persimmon	Ethrel	Flower buds thinning	50	Full bloom before 5–10 days
Peach	3-CPA	Fruits thinning	200 ppm	Full bloom after 2–4 days
Apple	NAC	Fruits thinning	700–14000	Full bloom after 3 weeks
Apple	TIBA	Leaf fall	0.1%	Harvest before 20–30 days
Apple	TTP	Leaf fall	0.8	Harvest before 20–30 days

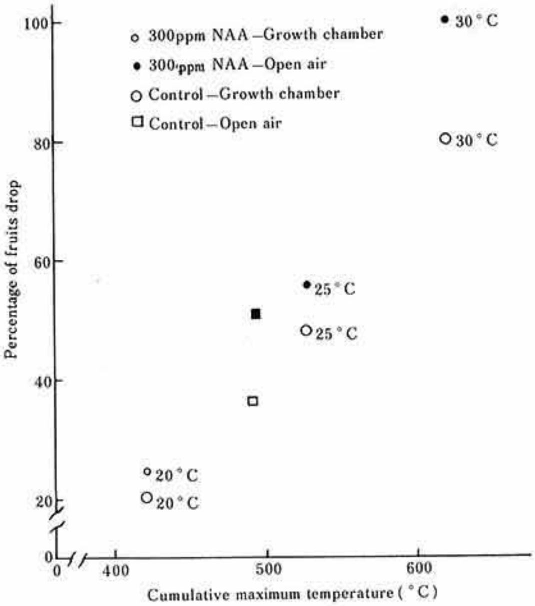

Fig. 1. The relationship of cumulative maximum temperature and fruits drop of 'Satsuma' mandarin at 42 days after NAA spray treatment. (Hirose 1972)

as is shown in Fig. 1 and the relation between field temperature and the percentage of fruits drop also shows the same trend, it is inferred that the practical application of NAA may cause an excess of fruits drop by the continuous maximum temperature of more than 30°C.

Table 2 shows the results[6] of the examination on the absorption and translocation of ^{14}C ring-labelled NAA and ^{14}C carboxyl-labelled NAA. The rate of absorption of NAA applied on leaf surface was about 20 per cent and the rate of its translocation was very slight, about one per cent. The NAA which has not been absorbed appears to have evaporated owing to photodecomposition.

The translocation of NAA applied on leaf was very little in the detection by means of the autoradiogram illustrating method, and no accumulated NAA was observed in the abscission layer.

The translocation of NAA applied on leaf by spot treatment was also observed but slightly along leaf veins.

From these facts it is inferred that the fruits drop is not caused by the direct action

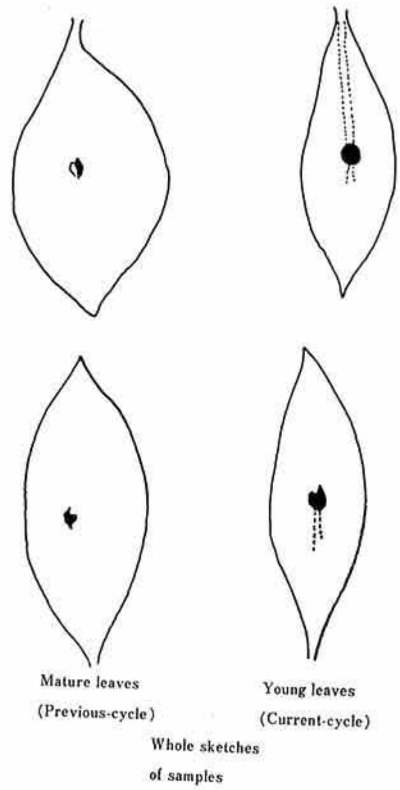

Fig. 2. Autoradiograms illustrating the absorption of ^{14}C from the ^{14}C ring-labelled NAA spotted on leaves of 'Satsuma' mandarin
Top and bottom represent ^{14}C spotted on surface of nervure of leaves on spring-cycle flush moved out of the spotted place and toward slightly leaf stalk along nervure, but a little or no translocation of ^{14}C in leaves on older flush 7 days after treatment (top) and 4 days after treatment (bottom). (Hirose 1972)

of NAA on the abscission layer of young fruits of Satsuma mandarin orange but is caused by the effect of NAA on the physiological metabolism of leaves and fruits.

Then the sugar, organic acid, free amino acid and protein in the fruits and leaves applied with NAA were examined[7], and it was established that unbalanced composition and ratio of composition of free amino acids were caused by NAA application, and this unbalance seemed to relate on the physiological fruits drop promoted by NAA.

Table 2. Absorption and translocation of ^{14}C ring-labelled NAA and ^{14}C carboxyl-labelled NAA applied severally to whole leaves of 'Natsudaidai' seedlings (Hirose 1972)

Treated leaf number[a)]	Amount of remaining NAA in the treated leaves[b)]	
	^{14}C ring-labelled NAA	^{14}C carboxyl-labelled NAA
	γ	γ
1	8.379	43.471
2	12.111	34.464
3	20.685	38.464
4	16.501	32.099
5	21.594	27.853
6	21.338	21.640
7	32.751	28.740
8	22.633	35.416
9	18.395	32.237
10	12.810	41.430
11	9.159	37.441
12	22.286	
13	20.286	
14	17.569	
15	16.515	
Total amount of NAA	273.012	373.255
Mean amount of NAA	18.201	33.932
Amount of translocation to various parts or tissue		
Developing leaves after treatment		
1′	0.109	0.021
2′	0.089	0.016
3′	0.066	0.022
Stems		
Bark	2.180	2.633
Pith	0.565	0.544
Total	3.009	3.236
Total amount of NAA ^{14}C applied to whole leaves	1,500	1,100
Total amount of NAA ^{14}C absorbed by plants	276.021	376.491
	%	%
Rate of absorption[c)]	18.401	34.226
Rate of translocation[d)]	1.090	0.945
Rate of translocation into stem	0.994	0.844
Rate of translocation into the developing leaves after treatment	0.100	0.020

a) Treated leaves shown in Fig. 9. 100 γ of NAA ^{14}C per leaf were applied to whole learves
b) The amount of NAA was obtained by remaining ^{14}C in leaves 27 days after treatment
c) Total amount of absorption/Total amount of application × 100
d) Total amount of translocation/Total amount of absorption × 100

Table 3 shows the results of examination on the effect of the benzyladenine (BA) and Atrox BI which are used for grape (Delaware) in addition to GA_3[8]. As the results, the addition of BA brought about fruits drop control and increased yield. And one per cent addition of Atrox BI into the GA solution could prevent the decline of effect which might be caused by the rainfall immediately after the application of the GA solution[9].

Table 3. Effect of dipping treatment with Gibbelleric acide (100 ppm) add Benzyladenine on 'Delaware' grape in polyvinyl house culture (Okada 1971)

Benzyladenine concentration	Rate of parthenocarpy	Ave. of fruit bunch weight	Ave. of a fruit weight
ppm	%	g	g
400	44.0	96.8	1.25
200	41.9	97.8	1.28
100	34.8	83.0	1.36
Control	9.2	26.7	1.58

Full bloom treated Benzyladenin
Harvest date: June 4

Table 5. Effect of spray treatment with Ethrel on the Japanese pear 'Nijisseiki' (Hirota 1971)

Ethrel concentration	Date of harvest	Ave. of fruit		
		Diameter	weight	Brix
ppm		cm	g	
100	Aug. 27	83.0	284	10.8
50	Aug. 27	85.0	310	10.4
Control	Oct. 15	85.0	308	10.5

Date of spray: July 30
Diameter of treatment: 60.6 cm

Table 4. Effect of dipping treatment with Gibbelleric acid add Atrox B1 on 'Delaware' grape (Dan 1971)

Treatment	Washing time after treatment					
	4	8	12	16	20	24
	Rate of parthenocarpy (%)					
GA 100 ppm						
+Atrox 1%	99.7	100	100	100	100	100
+Earol OP 100 ppm	79.8	82.4	98.1	100	100	100
	Length of peduncle (cm)					
+Atrox 1%	10.6	10.3	12.0	11.0	11.6	11.9
+Earol OP	9.2	9.7	9.9	12.2	12.3	12.7

Date of dipping: May 19, June 5

It was established by the examination on the accelerating effect of Ethrel on the ripening of Japanese pear (Nijisseiki) that ripening was promoted about 15 days earlier than control when the Ethrel solution of 50 to 100 ppm was applied on the hundredth day after full bloom, and no decline of quality was caused[9),10)].

During the process of examination it was observed that the application of high concentration solution hastened ripening time but the fruits became inferior in freshness, and if the application time was hastened, split fruits surface would appear.

As for the promising chemicals control for fruit tree, there may be listed the quality control, coloring, fruits drop control and abscission of ripening fruits for citrus, and as to the deciduous fruit tree, there may be the chemical thinning of pear, fruits drop control of grape, and chemicals flower buds thinning and ripening accelerator of persimmon.

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