Chemical Thinning of Fuji Apple

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Introduction

Fuji apple, the single most important apple cultivar in Japan, is now widely planted in Washington State and British Columbia. This high quality, high value dessert apple is precocious and productive and when grown on M.9 rootstock appears to be well suited to production in ultra high density plantation systems. However, Fuji has a tendency toward biennial cropping and this behavior, unless controlled, can seriously reduce profitability. The high cost of establishing high density plantation systems demands early and annual returns on investment.

Adequate return flowering of Fuji, like many other apple cultivars, requires the presence of a substantial number of "resting" spurs (spurs completely free of fruit) at the time of normal flower induction (during the first month or 6 weeks after flowering). This is best achieved by applying a bloom-time spray with the potential to eliminate fruit set on a substantial proportion of the flower clusters. Desiccants like ammonium thiosulphate (ATS) or endothall will likely prove useful in this context and research involving such chemicals is ongoing at several locations.

However, to achieve the high fruit quality expected of this cultivar, it is also necessary to produce most of the crop on single fruit spurs. This is potentially achievable by applying one or more hormone-type thinners in the days or weeks after full bloom but some detailed hand thinning will often be required to finish the job.

It is important to point out that the technology presently used to thin Fuji has been derived from experience with other apple cultivars. Therefore it is reasonable to expect that we will see important advances over the next few years in the development of technologies specific for this cultivar. This present communication reviews two recent British Columbia experiments conducted with this aim in mind.

The first experiment examined post-bloom applications of Accel® and carbaryl, alone and in combination. Accel® (a proprietary formulation containing mainly 6-benzyladenine; Abbott Laboratories, North Chicago, IL) has shown considerable promise as an apple thinner in eastern

North America. However, it has not been widely evaluated on Fuji, and especially not in the Pacific Northwest. Previous results with Accel® had suggested that it was most effective when used in combination with carbaryl.

The second experiment was designed to follow-up on Japanese experience suggesting that carbaryl is less effective on Fuji than on many other cultivars (Yokota et al., 1995). Dr. Yokota and others have been searching for alternatives to carbaryl and their trials with MCPB-ethyl, dating from 1992, have been especially promising. This chemical, a synthetic auxin with moderate to strong auxinic activity (roughly comparable to that of NAA), is registered and widely used in Japan for use as a stop-drop agent on apple.

These Japanese trials indicated that both NAA and MCPB-ethyl effectively thinned Fuji when applied just after full bloom of the king flowers. Both chemicals act as blossom thinners where the king flower is protected from thinning once it is pollinated and fertilized. Thus, the potential to achieve both thinning objectives (i.e., whole cluster thinning for return cropping and within-cluster thinning for fruit quality) with a single carefully timed hormone-type thinner appeared to be quite high.

Based on these reports, we were encouraged to evaluate MCPB-ethyl and NAA as blossom-time thinners for Fuji in North America. Our decision to include carbaryl in this experiment was based on the extensive and generally positive experience with this chemical in North America.

The Experiments

Accel® and carbaryl, 1995. Six-year-old Fuji/M.26 trees at the Summerland Research Centre were sprayed with a mist-blower applying about 1100 liters/ha of spray solution. Carbaryl (as Sevin XLR) was applied at a rate of 2250 g/ha and Accel® at 50, 75 or 100 g/ha of active ingredient. These chemicals were applied singly and in combination when the average diameter of the king fruit was 11 mm. Total fruit set and fruit set distribution were measured in early July. Fruit quality determinations were made on fruit harvested in mid-October.

MCPB-ethyl, NAA and carbaryl, 1997. Two experiments were conducted in young Fuji/M.9 orchards in the Okanagan Valley of British Columbia. The Osoyoos orchard bordered Washington State (49˚ north latitude). The second orchard was at Summerland, about 75 km north. At each location we compared whole-tree sprays of the hormone thinners applied one day after full bloom of the king flowers (about 80% of full bloom, Time 1) or at general petal fall (Time 2). We looked at several rates of both the sodium salt of NAA (as Fruitone N) and MCPB-

ethyl (a 3% a.i. liquid formulation provided by Agro-kanesho Co., Ltd. 4-2-19 Akasaka Minatoku, Tokyo, 107 Japan). Carbaryl (as Sevin XLR) at 800 ppm was applied when the average diameter of the king fruits was 10 mm.

The blossom counts, completed before treatment application, revealed that blossoming intensity was low to moderate at both locations. Fruit set was assessed after the completion of the "June drop" and was expressed as the number of fruits per cm^2 of trunk cross-sectional area. We also recorded the number of spurs that were totally defruited and determined the proportion of the cropping spurs that bore singles, doubles, or three or more fruits. Following these fruit set determinations, the trees were hand-thinned (if deemed necessary) to further reduce crop load or break up clusters.

Results

1995. Carbaryl reduced final fruit set but was most effective when combined with Accel® (all rates of Accel® were equally effective) (Table 1). On the other hand, Accel® alone was largely without effect on fruit thinning. With respect to crop distribution, even though most of the crop was present as "singles," carbaryl and carbaryl plus Accel® significantly reduced the proportion of doubles and triples (Table 1).

Neither chemical affected seed number in mature fruits but fruit shape as length/diameter (L/D) ratio was influenced by Accel® and average fruit weight was improved by carbaryl (especially when combined with Accel®) (Table 2).

Flowering in 1996 was improved by both carbaryl and Accel® and there was no significant interaction between the two chemicals (Table 3). Even where Accel® did not reduce fruit set (i.e., when applied without carbaryl) 75 g/ha Accel® significantly improved return flowering. Curiously, rates of Accel® lower and higher than 75 g/ha were much less effective, leading us to treat this result with some caution.

This experiment permitted us to determine the influence of fruiting on the return flowering of specific spurs. Note that those spurs that supported 2 fruit until early July were substantially less likely to flower than defruited spurs (Table 3). Interestingly, the influence of the chemical thinners on return flowering was expressed across all spur productivity classes (data not shown).

1997. In the 1997 experiments, overall fruit set was significantly higher at Osoyoos than at Summerland (Table 4). Still, there were clear and highly significant effects of both NAA and

MCPB-ethyl on final fruit set at both locations. We saw very little difference in effectiveness between the two spray times.

MCPB-ethyl at 15 ppm resulted in a desirable amount of total crop reduction at both locations whereas 30 ppm resulted in excessive thinning. NAA appeared to be somewhat less effective although 15 ppm NAA was roughly comparable in effect to 15 ppm MCPB-ethyl (Table 4). Carbaryl treatment further reduced total fruit set at both locations.

At first glance this would appear to be a very good result. However, when we looked in more detail at the distribution of the crop within the canopy we discovered that, whereas both NAA and MCPB-ethyl very effectively increased the number of totally defruited spurs (Table 5), too little of the final fruit set was set as singles (Table 6) and far too many spurs had 3 or more fruit at the time that these counts were made (Table 7).

Carbaryl treatment further increased the proportion of defruited clusters (Table 5; Summerland site) but did increase the proportion of single fruit spurs in both experimental orchards (Table 6). Carbaryl also reduced the number of fruiting sites with 3 or more fruit (Table 7).

Discussion

Accel® did not prove to be an effective fruitlet thinner in this experiment but, when used in combination with carbaryl, Accel® plus carbaryl was more effective than carbaryl alone. Much the same can be said for the effects of Accel® on fruit size at harvest. The beneficial effects of Accel® on return flowering, while not totally convincing in this trial, may prove to be a very good reason to consider the carbaryl-Accel® combination. We are of the opinion that there are still some important things to learn about how to make the best use of this new tool for regulating cropping of Fuji apple.

With respect to the blossom-time applications of NAA and MCPB-ethyl, these first experiments in Canada allow us to be cautiously optimistic. Sprays containing 15 ppm of either chemical applied either at 80% of full bloom or at first petal fall (only about 3 days apart under our conditions) did not over-thin but resulted in the total defruiting of a significant proportion of the flower clusters. This should result in enhanced return flowering. However, the tendency for some clusters to retain two or more fruits following these hormone sprays must be seen as a serious concern. Unless carbaryl was used to reduce these clusters to singles, a considerable amount of hand-thinning would have been required.

The results of both sets of experiments indicate that carbaryl is a useful tool to regulate cropping of Fuji apple. Accel® may prove to be a useful complement to carbaryl and deserves careful consideration by Fuji growers. Preceding carbaryl with a bloom-time spray of NAA or MCPB-ethyl may also prove to be a useful technology but these chemicals appear unlikely to replace the need for carbaryl in western North America.

Summary

In two sets of experiments conducted in British Columbia, carbaryl proved to be an effective thinner for Fuji apple. The addition of 6-benzyladenine (as Accel®; Abbott Laboratories) enhanced the thinning effect of carbaryl and Accel® appeared to improve return flowering with or without the addition of carbaryl. This latter effect was not always observed.

NAA and MCPB-ethyl, both synthetic auxins, proved to be effective whole-cluster thinners when applied during the bloom period. Total fruit set was reduced by both chemicals but the remaining crop was largely present as doubles and triples. A follow-up spray with carbaryl further reduced total crop load, both by increasing the number of defruited spurs and by reducing the incidence of doubles and triples.

References

Yokota, K., Q. Cao, M. Murakami and S. Koura. 1996. Effect of MCPB-ethyl on flower thinning for Fuji apple. Proc. Plant Growth Regulator Society of America (in press).

Table 1. Carbaryl and Accel® effects on fruit set (fruit/cm^2 branch cross-sectional area) and proportion of the crop borne as "singles." All sprays applied when king fruit average diameter was 11 mm. Summerland, B.C. 1995.

Treatment	Fruit set (fruit/cm^2)	Proportion (%) singles
Control	4.70	81.1
Accel® @ 50 to 100 g/ha	5.59	78.8
Carbaryl @ 2.25 kg/ha	3.78	85.6
Carbaryl + Accel®	2.56	89.2

Table 2. Effect of carbaryl and Accel® fruitlet thinning treatments on average seed number, mean fruit weight and fruit shape of Fuji apples. All sprays applied when king fruits averaged 11 mm diameter. Summerland, B.C. 1995.

Treatment	Seed No.	Fruit wt. (g)	Fruit length/diameter ratio
Control	10.7	182.7	0.89
Accel® @ 50 to 100 g/ha	11.4	178.6	0.90
Carbaryl @ 2.25 kg/ha	10.4	181.9	0.88
Carbaryl + Accel®	10.3	214.3	0.91

Table 3. Effect of Accel® and carbaryl treatments in 1995 differing in initial fruit set in 1995 on 1996 flowering of Fuji apple spurs.

Variable	% Flowering[z]
Carbaryl	
0	38.2
2.25 kg/ha	45.6
Accel®	
0	35.1
50 g/ha	32.8
75 g/ha	61.9
100 g/ha	37.9
Spur productivity class	
0 fruit	70.9
1 fruit	36.0
2 fruit	18.9

[z] Percentage of all counted spurs that flowered in 1996.

Table 4. Effects of bloom-time sprays of MCPB-ethyl and NAA and a post-bloom carbaryl spray on total fruit set on Fuji apple trees, 1997.

	Fruit set (fruit/cm^2)[z]						
		Thinning treatment (ppm)					
		MCPB-ethyl			NAA		
	Control	7.5	15	30	3.75	7.5	15
Location: Osoyoos							
Time 1	7.91	6.24	5.58	2.92	8.61	8.22	6.05
Time 1 + carbaryl	6.39	6.04	4.22	2.22	6.05	6.18	6.15
Time 2	8.10	7.33	5.27	2.43	7.10	7.43	6.33
Time 2 + carbaryl	5.61	4.60	4.95	2.21	6.18	5.81	5.09
Location: Summerland							
Time 1	5.14	5.11	4.75	2.60	5.46	4.79	3.77
Time 1+ carbaryl	3.82	3.87	2.57	1.04	3.40	3.55	3.68
Time 2	5.90	5.09	4.42	2.87	5.49	5.54	5.48
Time 2 + carbaryl	3.82	3.52	3.67	2.11	3.90	4.01	3.30

[z] Fruit per cm^2 of trunk cross-sectional area when counted after June drop but before hand thinning.

Table 5. Percent of flowering spurs that were totally defruited by bloom-time (MCPB-ethyl and NAA) and post-bloom (carbaryl) sprays applied to Fuji apples at Osoyoos and Summerland. 1997.

	Proportion of de-fruited flower clusters (% of initial)			
	Osoyoos		Summerland	
Treatment	No Carbaryl	With Carbaryl	No Carbaryl	With Carbaryl
Water	5.2	8.2	17.1	34.6
7.5 ppm MCPB	11.7	13.8	22.3	35.3
15 ppm MCPB	32.5	34.9	39.6	48.2
30 ppm MCPB	67.5	72.6	63.9	76.4
3.75 ppm NAA	8.3	6.8	12.8	32.8
7.5 ppm NAA	7.6	14.9	24.6	31.6
15 ppm NAA	16.8	17.1	37.9	45.8

Table 6. Effect of bloom-time (MCPB-ethyl and NAA) and post-bloom (carbaryl) thinning sprays on the proportion of Fuji apple fruiting sites with a single fruit at Osoyoos and Summerland, 1997.

	Proportion of fruit thinning sites with a single fruit			
	Osoyoos		Summerland	
Treatment	No Carbaryl	With Carbaryl	No Carbaryl	With Carbaryl
Water	23.5	38.4	59.9	64.6
7.5 ppm MCPB	31.6	46.0	52.7	69.9
15 ppm MCPB	31.6	39.5	54.1	68.2
30 ppm MCPB	33.6	38.0	44.2	60.3
3.75 ppm NAA	23.0	38.3	62.6	67.9
7.5 ppm NAA	25.0	37.2	56.2	64.5
15 ppm NAA	38.3	42.3	57.1	62.2

Table 7. Effect of bloom-time (MCPB-ethyl and NAA) and post-bloom (carbaryl) thinning sprays on the proportion of Fuji apple fruiting sites with 3 or more fruits at Osoyoos and Summerland, 1997.

	Proportion of sites with 3 or more fruits			
	Osoyoos		Summerland	
Treatment	No Carbaryl	With Carbaryl	No Carbaryl	With Carbaryl
Water	48.5	38.4	11.4	5.1
7.5 ppm MCPB	43.4	26.1	13.5	5.3
15 ppm MCPB	42.2	31.4	13.5	5.8
30 ppm MCPB	38.4	41.8	21.6	11.7
3.75 ppm NAA	51.2	35.7	9.9	6.4
7.5 ppm NAA	48.6	35.1	11.6	6.5
15 ppm NAA	34.3	35.3	15.2	8.4