vars and cherry products. N.Z. J. Crop and Hort. Sci. 21:213-218.

Gough, R.E. 1994. The highbush blueberry and its management. Hayworth Press, Binghamton, N.Y.

Kader, F., B. Rovel, M. Girardin, and M. Metche. 1994. Composition of the fruit of highbush blueberry (*Vaccinium corymbosum* L.) grown in the East of France (Vosges). Sciences des Aliments 14:281-290.

Kondo, S. and H. Gemma. 1993. Relationship between abscisic acid (ABA) content and maturation of the sweet cherry. J. Jpn. Soc. Hort. Sci. 62:63-68.

Martinez del Rio, C., B.R. Stevens, D.A. Daneke, and P.T. Andreadis. 1988. Physiological correlates of preference and aversion for sugars in three bird species. Physiol. Zool. 61:222-229.

Ranwala, A.P., C. Suematsu, and H. Masuda. 1992. Soluble and wall-bound invertases in strawberry fruit. Plant Sci. (Limerick). 84:59-64.

Schuler, W. 1983. Responses to sugars and their behavioral mechanisms in the starling (*Sturnus vulgaris*). Behavioral Ecol. Sociobiol. 13:243-251.

Shaw, D.V. 1988. Genotypic variation and genotypic correlations for sugars and organic acids of strawberries. J. Amer. Soc. Hort. Sci. 113:770-774.

Tobin, M.E., R.A. Dolbeer, C.M. Webster, and T.W. Seamans. 1991. Cultivar differences in bird damage to cherries. Wildlife Soc. Bul. 19:190-194.

Woodruff, R.E., D.H. Dewey, and H.M. Sell. 1960. Chemical changes of Jersey and Rubel blueberry fruit associated with ripening and deterioration. Proc. Amer. Soc. Hort. Sci. 75:387-401.

Oxamyl Is an Effective Apple Fruit Thinner when Used Alone or when Combined with Other Thinners

Richard Marini

ADDITIONAL INDEX WORDS. Vydate, fruit set, *Malus domestica*, carbaryl, Accel, ethephon, NAA, oil, Tween 20

SUMMARY. In five experiments with 'Redchief Delicious' and one with 'Braeburn', oxamyl (Vydate 2L) was used alone or combined with other chemicals to thin apples. The thinning response to oxamyl depended on dose. In most cases, oxamyl at 600 mg·L⁻¹ and carbaryl at 900 mg·L⁻¹ thinned trees similarly, but the combination of oxamyl plus carbaryl was no more effective than either chemical alone. The combination of oxamyl plus NAA (2.5 to 5 mL·L⁻¹) was slightly more effective than either material alone. The thinning response to oxamyl and carbaryl was related to the concentration of superior oil added to the spray solution; for both chemicals, adding oil at 5 mg·L⁻¹ or Tween 20 at 1.25 mL·L⁻¹ gave equivalent thinning. Apples on trees sprayed with oxamyl plus oil had a dull finish. Adding Tween 20 at 1.25 mL·L⁻¹ improved the thinning activity of carbaryl (Sevin XLR-Plus) more than oxamyl. Similar thinning occurred whether oxamyl was applied when fruit diameter averaged 4 or 10 mm. On 'Braeburn' oxamyl, carbaryl, Accel, and NAA were mild thinners, but all combinations of oxamyl or carbaryl plus Accel or NAA overthinned the trees without improving fruit size. In general, oxamyl at 600 mg·L⁻¹ (2 pints of vydate 2L/100 gal.) and carbaryl thin apple trees similarly, and the efficacy of both chemicals is improved by adding a surfactant.

¹Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Carbaryl (Sevin) is a carbamate insecticide commonly used for thinning apples; its major attributes are fairly consistent results, the thinning response does not depend on dose, overthinning is uncommon, and it is relatively inexpensive. Unfortunately, the most common formulation, Sevin 50W, is highly toxic to honey bees and mite predators (Pfeiffer et al., 1995). The new carbaryl formulation (Sevin XLR-Plus) is less toxic to beneficial arthropods (L. Williams, Rhone-Poulenc Ag. Co., personal communication). When used at the same concentration of active ingredient, the two carbaryl formulations thin similarly (R.E. Byers, personal communication). Oxamyl (Vydate 2L) is a carbamate insecticide that was first registered as an apple thinner in Virginia in 1994, followed by Pennsylvania in 1995, and West Virginia and New Jersey in 1996. Federal registration is expected in the near future (D. Gansky, Dupont Co., personal communication).

When applied to fruit with mean diameters of 4 to 14 mm, oxamyl and carbaryl thinned similarly (Byers et al., 1982; Marini, 1996). Oxamyl fits well into the Virginia integrated orchard management program. It is rated only moderately toxic to honey bees and the primary mite predator (*Stethorus punctum*), it is a moderately effective acaricide, and, if applied near petal fall, it controls the first generations of spotted tentiform leafminer and white apple leafhopper (Pfeiffer et al., 1995). When used for thinning, Sevin 50W, but not oxamyl, increased European red mite populations (Byers et al., 1982).

Because oxamyl registration for thinning apple is being extended to additional states, fruit specialists, county agents, consultants, and fruit growers need information on its efficacy. The purpose of this paper is to report results from several unrelated experiments conducted over several years and designed to obtain information concerning the thinning response to oxamyl, alone and in combination with surfactants and other thinning chemicals. In addition, a new formulation of Vydate (Vydate 2L) was evaluated, as Vydate 2EC was used in previous studies (Byers, 1978; Byers et al., 1982).

Materials and methods

EXPERIMENT 1: DOSE RESPONSE, OXAMYL ALONE. On 23 Apr. 1991, dur-

ing full bloom, four uniform 9-year-old 'Campbell Redchief Delicious'/MM.111 trees growing at the Virginia Tech Horticultural Research Farm, Blacksburg, were selected. On each tree, five uniform scaffold branches, ≈ 4 cm in diameter, were assigned randomly to one of five treatments: oxamyl with the active ingredient at 0, 300, 600, 900, or 1200 mg·L⁻¹. Details for each experiment are presented in Table 1. Branch treatments were applied to runoff with a hand sprayer on 10 May, when fruit diameter averaged 10 mm. For all experiments in this study, average fruit diameters were calculated by randomly selecting two fruiting spurs per treatment tree. All spurs were placed in a bag, and a spur was randomly selected from the bag. The largest three fruit per spur were measured. If a spur had only one or two fruit, then measurements for only those fruit were recorded. Additional spurs were selected until 60 fruit were measured, and the mean was calculated. On 1 Sept., the number of fruit per branch and branch circumference were recorded and crop density (CD), the number of fruit per square centimeter of branch cross-sectional area, was calculated. The experiment design was a randomized complete block, where trees served as blocks. Data were analyzed with the SAS (SAS Institute, Cary, N.C.), general linear model (GLM) procedure to evaluate the linear and quadratic effects of oxamyl concentration on CD. Type III sums of squares were used to select the appropriate model.

EXPERIMENT 2: DOSE RESPONSE, OXAMYL WITH AND WITHOUT NAA. On 30 Apr. 1993, during full bloom, 10 branches on each of three uniform 11-year-old 'Campbell Redchief Delicious'/MM.111 trees were selected. One branch per tree was assigned randomly to each of 10 treatments. The experiment was a factorial of two rates of NAA (0 or 2.5 mg·L⁻¹) and five rates of oxamyl (0, 200, 400, 600, or 800 mg·L⁻¹). Treatment limbs were sprayed to runoff with a hand-held sprayer on 18 May, when fruit diameter averaged 10.3 mm. On 3 Sept., the number of fruit per limb was recorded and CD was calculated. Data were analyzed by covariance using the REG procedure of SAS (SAS Institute). NAA was the indicator variable and oxamyl concentration was the covariate. Because the NAA × oxamyl interaction was signifi-

cant ($P = 0.006$), regression models were fit for each NAA concentration.

EXPERIMENT 3: OXAMYL, CARBARYL, AND ETHEPHON COMBINATIONS. On 23 Apr. 1991, during bloom, six uniform 9-year-old 'Campbell Redchief Delicious' trees were selected. Eight limbs per tree were tagged. The experiment was a $2 \times 2 \times 2$ factorial [carbaryl (900 mg·L⁻¹) vs. no carbaryl, oxamyl (600 mg·L⁻¹) vs. no oxamyl, and ethephon (400 mg·L⁻¹) vs. no ethephon], and the design was a randomized complete block with trees serving as blocks. Branch treatments were applied to runoff with a hand-held sprayer on 10 May, when fruit diameter averaged 10 mm. On 1 Sept., the number of fruit per branch was recorded and CD was calculated. Data were analyzed with the analysis of variance procedure of SAS.

EXPERIMENT 4: OXAMYL WITH OIL VS. CARBARYL WITH OIL. On 25 Apr. 1994, during bloom, 54 six-year-old 'Campbell Redchief Delicious'/M.26 trees were selected for uniformity. Eighteen treatments (listed in Table 1) were assigned randomly to each of three trees in a completely randomized design. Three limbs (≈ 3 cm in diameter) per tree were tagged, and limb diameter and number of flower clusters per limb were recorded. Trees were sprayed to runoff with a hand-held sprayer on 11 May, when mean fruit diameter was 9.8 mm. On 12 Sept., the number of fruit per tagged limb and per tree were recorded. The number of fruit set per 100 flower clusters on tagged limbs and CD for whole trees were calculated. Fruit were graded into four size categories, and crop value was calculated for each tree.

Table 1. Description of five chemical thinning experiments using 'Campbell Redchief Delicious' apple trees.

Expt. ^a	Treatment date	Fruit diam at treatment (mm)	Thinning treatment ^b	
			Chemical	Concn (mg·L ⁻¹)
1	10 May 1991	10.0	Oxamyl	0, 300, 600, 900, 1200
2 ^y	18 May 1993	10.3	NAA +	0, 2.5
3 ^y	10 May 1991	10.0	Oxamyl	0, 200, 400, 600, 800
			Carbaryl	0, 900
			Oxamyl	0, 600
			Ethephon	0, 400
4 ^y	11 May 1994	9.8	Carbaryl +	0, 900
			Superior oil	0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0
			Oxamyl +	0, 600
			Superior oil	0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0
			Oxamyl	0, 600
5	26 Apr. 1995	4.0	Oxamyl	600
	7 May 1995	10.0	NAA	5.0
			Oxamyl +	600
			NAA	5.0

^aTween 20 at 1.25 mL·L⁻¹ was added to all treatments except where oil was used in Expt. 4.

^yThere was factorial structure to some or all treatments.

Table 2. Crop density (CD) of 'Redchief Delicious' limbs treated with oxamyl, carbaryl, ethephon, and combination thereof in 1991.

Chemical	CD (fruit/cm)	Analysis of variance	
		Source of variation	P value
Control	10.4	Oxamyl	0.003
Oxamyl (600 mg·L ⁻¹)	6.4	Carbaryl	0.027
Carbaryl (900 mg·L ⁻¹)	7.5	Ethephon	0.001
Ethephon (400 mg·L ⁻¹)	4.9	Oxamyl × carbaryl	0.105
Oxamyl + carbaryl	6.4	Oxamyl × ethephon	0.775
Oxamyl + ethephon	1.4	Carbaryl × ethephon	0.449
Carbaryl + ethephon	0.6	Oxamyl × carbaryl × ethephon	0.916
Oxamyl + carbaryl + ethephon	0.8		

Chain sizes of <69, 70 to 76, 77 to 82, and >82 mm had mean fruit mass (FM) of 100, 138, 169, and 216 g, respectively, and corresponded to box counts of 190, 138, 113, and 88 fruit/box, respectively. Boxes of fruit (19.07

kg/box) per size grade per tree were calculated, and the crop value was estimated using average prices for Virginia 'Delicious' U.S. extra-fancy-U.S. fancy combination for Sept. through Nov. 1994. Price per box was 190

count (bags) = \$9, 138 count = \$11, 113 count = \$12, and 88 count = \$13. Fruit finish was rated on a scale of 1 to 3, where 1 = bright red, 2 = moderately dull red, and 3 = dull red. The experiment was a factorial of two chemicals (carbaryl vs. oxamyl), and seven rates of oil. Data were analyzed with the GLM procedure of SAS, and preplanned treatment comparisons, including orthogonal polynomials for oil concentration, were evaluated with contrasts. To stabilize variances, proportion data were transformed with the complementary log-log transformation (Llewelyn, 1968).

EXPERIMENT 5: OXAMYL TIMING PLUS

NAA. On 26 Apr. 1995 at petal fall, 20 seven-year-old 'Campbell Redchief Delicious'/M.26 trees were selected. Four trees were assigned to each of five treatments in a CRD. The treatments were 1) control—water, 2) oxamyl applied at petal fall, 3) oxamyl applied on 7 May, when fruit diameter averaged 10 mm, 4) NAA on 7 May, and 5) oxamyl plus NAA on 7 May. The treatment structure was an augmented factorial (Lentner and Bishop, 1986). The factorial component (treatments 1, 3, 4, and 5) consisted of two levels of oxamyl (0 vs. 600 mg·L⁻¹) and two levels of NAA (0 vs. 5.0 mg·L⁻¹) applied on 7 May. Flower clusters were counted on three limbs per tree. On 13 June, all fruit per tagged limb were counted. On 13 Sept., fruit per limb and per tree were counted, weighed, and graded into four sizes (<64, 65 to 76, 77 to 83, and >83 mm). Crop value was calculated as in 1994 using the same prices. Data for yield per tree, CD, and percentage of fruit in each size category were analyzed with the GLM procedure of SAS, and preplanned single-degree-of-freedom contrasts were used to compare main effects and the interaction.

EXPERIMENT 6: OXAMYL, CARBARYL, NAA, AND ACCEL COMBINATIONS ON

'BRAEBURN'. On 28 Apr. 1995 at petal fall, 36 four-year-old 'Braeburn'/M.26 trees were selected for uniformity. Four trees were assigned to each of nine treatments (Table 6) in a CRD. Trees were sprayed to runoff with a hand-held sprayer on 7 May, when mean fruit diameter was 9 mm. On 13 June, fruit per tree was recorded, and, on 28 Sept., fruit were harvested, counted, weighed, and graded into four sizes. Data for yield, CD, FM, and percentage of fruit in each size were analyzed

Fig. 1. Scatter plot and regression line showing the effect of varying concentrations of oxamyl on crop density (fruit/cm² limb cross-sectional area) of limbs on 'Redchief Delicious' trees in 1991. Regression equation: $CD = 7.3 - 0.0023$ (mg active ingredient), $r^2 = 0.34$, $P = 0.007$, $n = 30$.

Fig. 2. Scatter plot and regression lines showing the effect of varying concentrations of oxamyl, with and without NAA (2.5 mg·L⁻¹), on crop density (fruit/cm² limb cross-sectional area) of limbs on 'Redchief Delicious' trees in 1993. Because analysis of covariance indicated that slopes and intercepts for the two NAA treatments were nonhomogeneous, regression was performed for each level of NAA. Regression equations: No NAA (◇), $CD = 11.5 - 0.008$ [mg active ingredient (a.i.)], $r^2 = 0.37$, $p = 0.016$, $n = 15$; plus NAA (□), $CD = 8.6 - 0.023$ (mg a.i.) + 0.00003 (mg a.i.)², $r^2 = 0.33$, $p = 0.038$, $n = 15$.

with the GLM procedure of SAS. Preplanned contrasts were used to compare treatments of interest.

Results and discussion

EXPERIMENTS 1 AND 2: OXAMYL DOSE RESPONSE. When Tween 20 was added as a surfactant in 1991, CD declined linearly with increasing oxamyl concentration (Fig. 1). An analysis of covariance in 1993 indicated that NAA interacted with oxamyl concentration; therefore, regression models were fitted for each treatment. As in 1991, when only Tween 20 was added to oxamyl, CD declined linearly with increasing oxamyl concentration (Fig. 2). However, when NAA was added, CD declined curvilinearly with increasing oxamyl concentration. At oxamyl concentrations of $<800 \text{ mg}\cdot\text{L}^{-1}$, add-

ing NAA reduced CD more than oxamyl alone; lowest CDs resulted from NAA plus oxamyl at concentrations of 200 to $400 \text{ mg}\cdot\text{L}^{-1}$. NAA plus oxamyl at $>800 \text{ mg}\cdot\text{L}^{-1}$ was no more effective than oxamyl alone.

When applied with an airblast sprayer, oxamyl and carbaryl thinned 'Golden Delicious' and 'Starkrimson Delicious' trees to a similar crop load, but the level of thinning was inadequate for both chemicals on both cultivars (Byers et al., 1982). These experiments also indicate that oxamyl is a mild thinner.

EXPERIMENT 3: OXAMYL, CARBARYL, AND ETHEPHON COMBINATIONS. In 1991, oxamyl and carbaryl thinned similarly, but ethephon was slightly more effective (Table 2). The combination of oxamyl plus carbaryl was no more ef-

fective than either material alone. All combinations of chemicals with ethephon overthinned.

EXPERIMENT 4: OXAMYL OR CARBARYL WITH OIL. With no surfactant carbaryl, but not oxamyl, reduced fruit per 100 flower clusters (Table 3). The significant interaction of chemical $\times$ Tween indicates that fruit set was reduced more by adding Tween to carbaryl than oxamyl; the same was true when oil at $2.5 \text{ mg}\cdot\text{L}^{-1}$ was added as a surfactant (Table 2). Fruit set declined linearly as oil concentration was increased. Pooled over all surfactant treatments, carbaryl and oxamyl reduced fruit set, fruit per tree, and yield similarly. With no surfactant, oxamyl, but not carbaryl, reduced fruit per tree, but yield was not reduced by either chemical. Fruit per tree and yield were

Table 3. Fruit set, fruit per tree, yield, crop density (CD), yield efficiency (YE), fruit mass (FM), crop value, and fruit finish for 'Redchief Delicious' trees sprayed with carbaryl or oxamyl as thinners and Tween 20 or varying concentrations of oil as surfactants.

Treatment	Thinner		Surfactant		Fruit/100 clusters	Fruit/tree	Yield (kg/tree)	CD	YE	FM/g	Crop value (\$/tree)	Fruit finish rating
	Material	Concn (mg·L ⁻¹)	Material	Concn (ml·L ⁻¹)								
1	Carbaryl	0	None	---	124	341	50	8.2	1.2	147	17.34	1.5
2		900	None	---	94	209	32	6.3	1.0	153	11.58	2.0
3			Tween	1.25	75	269	44	6.8	1.1	163	19.97	1.3
4			Oil	2.5	88	251	40	6.5	1.0	173	9.51	2.2
5				5.0	95	189	33	4.8	0.9	178	12.29	1.5
6				7.5	93	189	33	4.8	0.9	183	10.44	2.5
7				10.0	110	148	27	4.0	0.7	183	11.70	2.5
8				12.5	52	148	27	4.0	0.7	197	8.76	2.2
9				15.0	41	123	24	3.9	0.8	147	21.10	1.2
10	Oxamyl	0	None	---	126	418	62	8.2	1.2	158	17.07	1.8
11		600	None	---	118	264	42	7.6	1.2	160	12.08	2.5
12			Tween	1.25	113	238	37	6.3	1.0	151	16.91	2.3
13			Oil	2.5	92	264	40	8.3	1.2	175	15.63	2.5
14				5.0	65	223	39	5.7	1.0	178	13.49	3.0
15				7.5	50	176	31	4.6	0.8	174	11.18	3.0
16				10.0	132	165	29	5.2	0.9	203	7.03	3.0
17				12.5	38	98	20	2.1	0.4	165		
18				15.0	32	192	31	4.2	0.7			
Analysis of variance (<i>P</i> > <i>F</i>)					0.001	0.019	0.080	0.008	0.043	0.002	0.259	0.009
Contrasts (<i>P</i> > <i>F</i>)												
Control vs. carbaryl (1 vs. 2)					0.029	0.066	0.107	0.177	0.272	0.628	0.242	0.188
Control vs. oxamyl (10 vs. 11)					0.783	0.036	0.069	0.651	0.942	0.360	0.409	0.121
Carbaryl vs. oxamyl (2–9 vs. 11–18)					0.228	0.460	0.567	0.392	0.568	0.398	0.754	0.001
Tween vs. Tween (3 + 12 vs. 2 + 11)					0.007	0.719	0.632	0.726	0.869	0.424	0.619	0.999
Chemical × Tween (2 + 12 vs. 3 + 11)					0.012	0.377	0.270	0.355	0.233	0.620	0.062	0.036
Oil vs. no oil (4 + 13 vs. 2 + 11)					0.001	0.118	0.253	0.011	0.038	0.200	0.420	0.124
Oil _l					0.001	0.008	0.031	0.001	0.001	0.001	0.036	0.029
Oil _q					0.617	0.476	0.693	0.270	0.468	0.112	0.907	0.096
Chemical × oil					0.059	0.632	0.528	0.573	0.403	0.438	0.406	0.008
Tween vs. Oil(3 + 12 vs. 4 + 13)					0.846	0.946	0.939	0.423	0.552	0.429	0.767	0.021

Table 4. Effect of spraying Oxamyl and NAA on 'Redchief Delicious' trees on fruit set, crop density (CD), yield, yield efficiency (YE), fruit mass (FM), fruit size distribution, and crop value in 1995.

Treatment		Fruit/100 clusters	CD (fruit/cm ²)	Yield (kg/tree)	YE (kg·cm ⁻²)	FM (g)	Fruit size distribution (%)				Crop value (\$/tree)
Chemical	Date						<57	58-63	64-70	>70	
1 Control	---	137 ^a	9.3	62	6.4	145	2	8	25	45	27.00
2 Oxamyl	30 Apr.	116	6.4	53	5.1	168	3	13	23	40	22.30
3 Oxamyl	7 May	72	6.4	51	4.6	145	3	8	19	48	21.89
4 NAA	7 May	94	7.4	50	4.8	145	3	8	22	46	21.25
5 Oxamyl + NAA	7 May	68	7.0	42	4.8	141	2	5	16	54	17.85
Contrasts (P > F)											
Oxamyl vs. control (1 vs. 2 + 3)		0.001	0.019	0.003	0.005	0.027	0.386	0.321	0.001	0.019	0.004
NAA vs. control (1 vs. 4)		0.001	0.004	0.001	0.001	0.064	0.383	0.333	0.001	0.008	0.002
Oxamyl-date (2 vs. 3)		0.003	0.999	0.893	0.645	0.533	0.335	0.488	0.304	0.166	0.937
Oxamyl x NAA (1 + 5 vs 3 + 4)		0.001	0.047	0.004	0.014	0.123	0.594	0.001	0.001	0.016	0.006
Oxamyl vs. NAA (3 vs. 4)		0.002	0.445	0.648	0.180	0.207	0.338	0.209	0.346	0.075	0.600

^aAverage fruit diameter was 4.3 and 10 mm on 30 Apr. and 7 May, respectively.

^aValues are means of four trees.

not reduced more by adding Tween to either chemical, and these response variables were reduced similarly by adding Tween or oil at 2.5 mg·L⁻¹. The only contrasts that were significant for CD or yield efficiency (YE) was the effect of oil: both variables declined linearly as oil concentration increased, and the trend was similar for both chemicals. Only the linear effect of oil significantly affected FM and crop value. FM tended to increase, whereas crop value declined linearly as oil concentration increased. Fruit finish was not significantly affected by carbaryl or oxamyl with no surfactant. The chemical × Tween interaction indicates that fruit finish was affected when Tween was added to oxamyl but not carbaryl. Pooled over all surfactants, fruit finish was affected more by oxamyl than by carbaryl. The chemical × oil interaction was significant. As oil concentration increased, fruit finish rating increased linearly with carbaryl, but the response was quadratic for oxamyl (contrasts not shown).

EXPERIMENT 5: OXAMYL TIMING PLUS

NAA. When applied at 4 or 10 mm, oxamyl reduced fruit per 100 clusters 15% and 47%, respectively (Table 4). However, CD, yield, and YE were not effected by date of oxamyl application. In a previous study, oxamyl reduced fruit per 100 clusters and CD more when applied at an average fruit diameter of 10.3 mm than when applied at 3.6 mm (Marini, 1996). Oxamyl reduced yield, CD, and YE 17%, 31%, and 24%, respectively, regardless of application date (Table 4). When ap-

plied at 10 mm, oxamyl reduced fruit per 100 clusters more than NAA, but the other crop load indices were affected similarly by the two chemicals.

The interaction of NAA by oxamyl was significant for most response variables. The combination of oxamyl plus NAA reduced fruit per 100 clusters and yield,

Table 5. Yield, fruit size, and crop density (CD) of 'Braeburn' treated with four chemical thinners in 1995 when fruit diameter averaged 9 mm.

Treatment	Fruit/tree	Yield (kg/tree)	FM (g)	CD (fruit/cm ²)
1 Control ^a	37 ^a	5.3	145	3.5
2 Oxamyl	18	3.3	188	1.3
3 Carbaryl	14	2.1	162	1.2
4 Accel	20	3.3	162	1.8
5 NAA	22	3.7	175	2.0
6 Oxamyl + NAA	6	0.6	139	0.4
7 Carbaryl + NAA	13	1.8	151	0.8
8 Oxamyl + Accel	2	0.2	102	0.1
9 Carbaryl + Accel	4	0.5	157	0.3
Contrasts (P - value)				
Oxamyl vs. no oxamyl (2, 6, 8 vs. 1, 4, 5)		0.025	0.024	0.787
Carbaryl vs. no carbaryl (3, 7, 9 vs. 1, 4, 5)		0.878	0.500	0.582
Accel vs. no Accel (4, 8, 9 vs. 1, 2, 3)		0.004	0.005	0.246
NAA vs. no NAA (5, 6, 7 vs. 1, 2, 3)		0.042	0.051	0.364
Oxamyl × Accel (2, 4 vs. 1, 8)		0.042	0.018	0.137
Carbaryl × Accel (3, 4 vs. 1, 9)		0.002	0.003	0.868
Oxamyl × NAA (2, 5 vs. 1, 6)		0.054	0.021	0.108
Carbaryl × NAA (3, 5 vs. 1, 7)		0.005	0.009	0.909
Oxamyl vs. carbaryl (2, 6, 8 vs. 3, 7, 9)		0.052	0.112	0.844

^aChemical concentrations were 600 mg·L⁻¹ for oxamyl, 900 mg·L⁻¹ for carbaryl, 400 mg·L⁻¹ for ethephon, and 80 mg·L⁻¹ for Accel.

^aValues are means of four trees.

but not CD and YE, more than either chemical alone. When applied at 4.3 mm, but not 10 mm, oxamyl increased FM. The oxamyl $\times$ NAA interaction was evident for fruit distribution and crop value. Oxamyl and oxamyl plus NAA applied on 7 May increased the percentage of fruit in the largest size category, but all treatments reduced crop value by at least \$4.70 per tree. Results from several experiments in this study indicate that thinning treatments may not improve fruit size enough to offset reduced yield, and, thus, crop value may not be improved. Therefore, the major benefit from chemical thinning may be to improve return bloom.

EXPERIMENT 6: OXAMYL, CARBARYL, ACCEL, AND NAA COMBINATIONS. The young 'Braeburn' trees used for this experiment had a relatively light crop. Oxamyl, carbaryl, Accel, and NAA all reduced fruit per tree, yield, and CD at least 40%, 30%, and 43%, respectively (Table 5). When applied alone, all four thinners increased FM no more than 11%, which was not significant ($P \leq 0.2$). Combinations of oxamyl or carbaryl plus Accel or NAA tended to overthin, and four interactions were significant for most indices of crop load. Although most treatments reduced fruit per tree, yield, and CD, FM was not significantly affected by treatment. Lack of significance was probably due to small sample size ($n = 4$) and high tree-to-tree variation. Crop value was not calculated because so few 'Braeburn' are produced in the mid-Atlantic region that wholesale prices are not available. Fruit size distribution was not significantly affected by most treatments (data not shown). In this experiment, probably no thinning treatment would have been cost effective because the relatively small increase in fruit size would not have offset the decreased yields.

Conclusions

For this study, fruit per 100 flower clusters, CD, YE, number of fruit per tree, and yield were all used as indices of crop load to evaluate thinning treatments. As indicated in a previous report, these variables may not be influenced similarly by thinning treatments (Marini, 1996). Yield may not be a good indicator of thinning re-

sponse because it is influenced by tree size, fruit size, and number of flower clusters per tree. CD is influenced by flower clusters per tree, and YE is influenced by flower clusters per tree and fruit size, but number of fruit or yield, respectively, are adjusted for differences in trunk cross sectional area. Where tree size and bloom density are uniform, yield, CD, and YE should adequately reflect the response to different thinning treatments. However, under a wide range of conditions, fruit per 100 flower clusters is likely the most useful indicator of thinning because it adjusts number of fruit for differences in flower number per branch.

Results from these six experiments indicate that oxamyl (Vydate 2L) at insecticidal rates (300 to 600 mg·L⁻¹ or 1 to 2 pints of Vydate 2L/100 gal.) plus a surfactant will thin apples similarly to carbaryl. Superior oil should not be applied with oxamyl because fruit finish may become unattractive. When oxamyl is used at insecticidal rates, adding NAA at 2.5 to 5 mg·L⁻¹ may enhance thinning. Additional work is needed to evaluate combinations of oxamyl or carbaryl with other chemical thinners and to evaluate oxamyl as a thinner on other apple cultivars.

Literature cited

- Byers, R.E. 1978. Chemical thinning of spur 'Golden Delicious' and 'Starkrimson Delicious' with Sevin and Vydate. *HortScience* 13:59-61.
- Byers, R.E., C.G. Lyons, Jr., and R.L. Horsburgh. 1982. Comparisons of Sevin and Vydate for thinning apples. *HortScience* 17:777-778.
- Lentner, M. and T. Bishop. 1986. Experimental design and analysis. Valley Book Co., Blacksburg, Va.
- Llewellyn, R.W.M. 1968. The log (-log) transformation in the analysis of fruit retention records. *Biometrics* 24:627-638.
- Marini, R.P. 1996. Chemical thinning spur 'Delicious' apples with Carbaryl, NAA, and Ethephon at various stages of fruit development. *HortTechnology* 6:241-246.
- Pfeiffer, D.G. 1995. 1995 Spray bulletin for commercial tree fruit growers. Virginia Coop. Ext. Pub. 456-419.

Multiple Location Differences in Growth of Red Maple 'October Glory'

Jeff L. Sibley¹,
John M. Ruter², and
D. Joseph Eakes³

ADDITIONAL INDEX WORDS. *Acer rubrum* L., container production, climate, cultivars, ornamental tree production

SUMMARY. *Acer rubrum* 'October Glory' has grown well in field studies across the southeastern United States. However, there is limited information on container production for this cultivar. Our objective was to evaluate first-year growth of container-grown 'October Glory' at three locations with dissimilar climates in Georgia and Alabama. Rooted cuttings were planted in no. 3 containers at one location in Apr. 1995. Trees were transported the second week of June to Blairsville, Ga.; Auburn, Ala.; and Tifton, Ga. Trees were grown for 6 months until dormant and were harvested at the end of December. Location had no impact on final plant height increase (Blairsville, Auburn, and Tifton, 59.8, 53.0, and 60.2 cm, respectively). Increases in stem diameter and shoot dry mass were greatest at Tifton (8.4 mm, 17.5 g) and least at Blairsville (6.3 mm, 9.2 g), with Auburn similar to both locations (6.8 mm, 12.2 g). Root dry masses and root : shoot ratios were greatest in Tifton (17.2 g, 0.967), with no differences between Blairsville (4.9 g, 0.508) and Auburn (7.0 g, 0.641). Despite climatic dissimilarities

¹Graduate research assistant, University of Georgia, Department of Horticulture, Coastal Plain Experiment Station, Tifton, GA 31793.

²Associate professor, University of Georgia, Department of Horticulture, Coastal Plain Experiment Station, Tifton, GA 31793.

³Associate professor, Department of Horticulture, Auburn University, AL 36849.

Mention of a trademark or proprietary product does not imply endorsement of the products named or criticism of other products not named that may also be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.