Sulfcarbamide, A Blossom-thinning Agent for Apples

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Summary. In fruit-growing areas where pollination and fruit set conditions are optimum, biennial bearing is a regular occurrence unless steps are taken to reduce fruit set in the heavy bloom year. In the past, a two- or three-spray thinning program was used in the state of Washington on difficult cultivars, consisting of Elgetol at bloom time, followed by a petal fall spray of Amide-thin, followed by a later postbloom spray of NAA or Sevin. In 1989, Elgetol was removed from the market by the manufacturer because of the high cost of re-registration. In 1990, a search for an Elgetol replacement was initiated. Elgetol was a contact spray that damaged flower parts and prevented fertilization of the ovule. Thus, it was logical to look for other products that had a similar mode of action. Sulfcarbamide (monocarbamide dihydrogen sulfate) (D-88) (Wilthin), a foliage desiccant used on potatoes, onions, and alfalfa, and tested as a dilute full-volume spray on apple blossoms, was found to be an effective blossom thinner. Chemical rates of 0.25% to 0.5% (v/v) applied at 80% of bloom open reduced fruit set by 25% to 50% compared to controls.

Blossom-thinning of apple (*Malus domestica* Borkh.) has been an important part of fruit-thinning programs in Washington and other western states to help offset biennial bearing (Williams and Edgerton, 1981). Russel and Pickering (1919) showed convincingly that the alternate-bearing habit of apples could be controlled if thinning was practiced at time of bloom. In spite of this early knowledge and the need by the apple industry, the only chemical blossom

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thinner developed and used commercially was Elgetol, a dinitro-ortho-cresol compound. Elgetol was used extensively in western U.S. apple production areas from 1950 through the 1980s.

The first trials with D-88 (sulfcarbamide) on apples were in Australia in 1990. In 1991, 0.25-ha plots in Washington were treated with D-88. To date, testing has been conducted over four seasons—two in Australia and two in Washington. In all trials, full-bearing apple trees were selected for uniformity of growth and rated for amount of bloom. Only trees with 85% or more of the growing points with flowers were used for data collection. Single-tree replicates in uniform rows with buffer trees between rows and treatments were used; three uniformly blossoming limbs per tree were tagged, and blossom clusters were counted. Following treatment, and after the first wave of drop was over, the number of fruits on each of the count limbs was counted and recorded. Results are expressed as number of fruit per 100 blossom clusters. In the initial trials in Australia, three trees per treatment were used and, in the large 0.25-ha plots, 10 trees were used per treatment with two counted limbs per tree. Treatments in the Australia trials were applied with high-pressure handguns. The larger plots in Washington were sprayed with commercial air-blast sprayers. Dilute, full-volume sprays were used in all trials and the foliage was sprayed to runoff. The Waller-Duncan K-ratio *t* test was used to test for differences among treatments and controls (SAS Institute, 1987).

Sulfcarbamide was 79% a.i. formulated product. The concentrations tested experimentally were from 0.25% to 1.0% (v/v). The commercial-size plots were treated with concentrations of 0.25%, 0.375%, and 0.5% (v/v). In the 1991 Washington trials, two applications of 0.25% at 70% and 90% open blooms were compared with a single application. All other treatments were applied at 80% to 90% open bloom stage. Elgetol at 0.25% (v/v) was included as a comparison with D-88.

The 1992 tests in Australia and Washington were conducted to determine the effect of temperature and previous sprays, such as mineral elements, on potential fruit injury. In Australia, sprays were applied in early morning, at midday, and in early

Fig. 1. Sulfcarbamide (D-88) fruit set, blossom-thinning trials, Orange, New South Wales, Australia, 1990. Dotted line = standard 'Delicious'; dashed line = 'Granny Smith'; dashed/dotted line = 'Red Chief Delicious'.

evening; the temperature spread was 10 to 15C. In Washington, the mineral element sprays copper, boron, and zinc were applied 2 weeks before the D-88 treatments. Fruit injury ratings were made before harvest on 100 fruit/tree and scored for severity from 1 to 5; ratings of 4 and 5 were commercially unacceptable, with a 5 rating having total marks of five or more per fruit.

Results of the initial 1990 Australia trials on efficacy of D-88 on two strains of 'Delicious' and 'Granny Smith' are shown in Fig. 1. Trial 1 was with 20-year-old standard 'Delicious',

Trial 2 was with 7-year-old 'Granny Smith', and Trial 3 was with 4-year-old grafts of 'Red Chief Delicious'. Fruit set reduction occurred on all cultivars and at all chemical concentrations.

Results from the 1991 trials with commercial-size plots in Washington are presented in Tables 1 and 2. In all trials, D-88 was as effective a thinner as Elgetol and was not affected by weather after drying. On all cultivars, the 0.375% (v/v) rate of D-88 was as active as the 0.25% rate applied twice. The 0.5% rate caused over-thinning on

Table 1. Chemical thinning of 'Delicious' apples with sulfcarbamide (D-88), 1991.

Treatment ^a	Yakima, Wash.		Wenatchee, Wash.	
	No. fruit/100 blossom clusters	Percent of control	No. fruit/100 blossom clusters	Percent of control
Controls	196	100 a ^b	122	100 a
Elgetol, 0.25% (v/v)	165	84 bc	80	65 c
D-88, 0.25% (v/v)	177	90 ab	94	77 b
D-88, 0.25% (v/v) twice	146	74 c	78	64 c
D-88, 0.375% (v/v)	170	87 b	72	59 c
D-88, 0.5% (v/v)	127	65 d	44	36 d

^aTreatments applied at 70% to 90% open bloom.

^bTreatments with a common letter are different by Waller-Duncan analysis, K-ratio *t* test, *P* ≤ 0.05.

Table 2. Chemical thinning of 'Fuji' and 'Gala' apples with sulfcarbamide (D-88) at Vantage, Wash., 1991.

Treatment ^a	Fuji		Gala	
	No. fruit/100 blossom clusters	Percent of control	No. fruit/100 blossom clusters	Percent of control
Controls	232	100 a ^b	237	100 a
Elgetol, 0.25% (v/v)	203	87 ab	189	79 b
D-88, 0.25% (v/v)	171	73 bc	170	71 b
D-88, 0.25% (v/v) twice	152	65 c	140	59 c
D-88, 0.375% (v/v)	150	64 c	112	47 cd
D-88, 0.5% (v/v)	175	75 bc	105	44 d

^aTreatments applied at 70% to 90% open bloom.

^bTreatments with a common letter are different by Waller-Duncan analysis, K-ratio *t* test, *P* ≤ 0.05.

'Delicious' and 'Gala'. 'Fuji' was under-thinned by Elgetol and all concentrations of D-88. Ideal blossom thinning in Washington is when treated trees have between 50% and 75% as much fruit as control trees.

Fruit from the 'Delicious' trial in Yakima, Wash., were harvested, graded, and packed on a commercial line. The plot size was 0.25 ha/treatment. The yield for the 0.5% (v/v) rate was slightly less than other treatments due to thinning, but the number of packed boxes of Washington Extra Fancy fruit and the number of packed boxes of size 100 through 72 were higher in both the 0.375% and 0.5% D-88 treatments (Table 3). The overall packout for the treated fruit was much better than for the control. Some of the treated fruit had minor fruit markings similar to insect stings, but injury did not affect the packout. The larger amount of culls in the control was mainly because of small fruit.

In the 1991 tests in Australia, designed to determine the effect of temperature at time of spray application on fruit injury, there was no effect of temperatures between 18 and 30°C. In all except one trial the damage was <1%. The one exception was on 'Gala' treated with a delayed dormant spray of Kocide before the D-88 application. Apparently, the D-88 reactivated the copper deposit on fruit and resulted in nearly 50% of fruit with a russet deformation type of injury. Results of 1992 trials on 'Delicious' in Washington designed to determine effect of delayed dormant sprays and

Table 4. 'Delicious' fruit damage from D-88, 0.375% (v/v) treatments, 1992.

Treatments	Time applied (percent bloom)	Avg. no. of fruit/severity category ^a				
		1	2	3	4	5
Copper + D-88 ^y	90	16	15	12	6	20
Boron + D-88 ^y	90	24	6	9	2	9
Zinc + D-88 ^y	90	17	3	9	1	7
D-88 late	100	3	2	4	1	14
D-88 early	80	13	4	5	2	1
D-88 + Regulaid	85	8	3	4	0	1
Control	---	2	0	0	0	0

^aNumber of fruit injured/100 king fruit. Injury rating: 1 = one mark/fruit; 5 = five or more marks/fruit.

^yBoron, copper, and zinc sprayed 2 weeks before D-88.

early compared to late application of D-88 on fruit injury are presented in Table 4. In these trials, Kocide sprays applied 2 weeks before D-88 caused severe fruit injury. Late applications of D-88 after 100% of blossoms were open and king bloom fruit were formed resulted in more fruit injury than earlier sprays when only 80% of blossoms were open. Boron and zinc sprays followed by D-88 slightly increased fruit damage.

In conclusion, D-88 was an effective blossom-thinning agent, as consistent as Elgetol, was not affected by weather conditions before and after application, and was nonresidual.

In >90% of the experimental trials and commercial applications, fruit injury was not a problem. However, to avoid potential fruit damage, delayed dormant sprays of mineral elements should be applied before flower clusters begin to open.

Concentrations of 0.25% to 0.375% (v/v) of D-88 were effective on all apple cultivars tested except

'Fuji'. The degree of fruit reduction depends on the number of open blossoms and the number of flowers pollinated and fertilized before sprays are applied.

In 1992, the test plots and >200 acres of apples were treated in Washington and other western states. In 1993, sulcarbamide was available as Wilthin for commercial sales for 15% of total apple acreage in Washington, Oregon, and Idaho.

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Table 3. Packout summary of D-88-treated 'Delicious' trial at Yakima, Wash., 1991.

Yield and grade	Cks	0.375% (v/v)	0.5% (v/v)	Elgetol 0.25% (v/v)
Bins (25 box)	33 ^z	32	31	33
<i>Packout data</i>				
W × F ^y	432	489	488	472
Fancy ^y	61	51	57	51
Bags (5 kg)	161	111	99	134
Culls (kg)	871	617	792	792
Size 100-72 ^y	329	396	394	370

^zYield is from 0.25 ha.

^yWashington Extra Fancy and Fancy total number of packed boxes (18 kg).