Table 2. Yields of seven red raspberry cultivars from 1980 through 1982 at Bozeman, Montana.

	Fruit Yield (mt/ha)		
	1980	1981	1982
Killarney	1.3 b[z]	4.7 a	4.8 b
Gatineau	0.8 c	4.0 b	4.1 c
Boyne	1.6 a	4.5 a	6.1 a
Canby	0.3 d	2.9 c	3.5 d
Madawaska	0.7 c	2.7 c	3.8 cd
Taylor	0.9 c	2.6 c	3.6 cd
Latham	0.4 d	2.2 d	2.5 e

[z]Means within a column followed by the same letter are not significantly different at the 5% level using Newman-Keul's test.

Summary

Annual production of each cultivar at Bozeman was approximately less than half of the Corvallis yield. This has been generally observed at Corvallis and Bozeman with other fruit crops. Winter injury had a much greater effect on cultivar performance at Bozeman than Corvallis. 'Latham,' which is often found in the commercial trade, was consistently low yielding.

These data indicate that cultivars other than 'Latham' may have greater potential for production in Montana. Unfortunately, fruit quality and pest resistance were not evaluated in these studies. Further investigations are warranted in these areas with a thorough evaluation of plant vigor. Additionally, many newer cultivars from the Pacific Northwest and Canada are available and should be evaluated in Montana.

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Fruit Varieties Journal 40(2):41-45 1986

Effects of Postharvest and Postbloom Sprays of Daminozide on Apples[1]

DUANE W. GREENE, WILLIAM J. LORD, F. W. SOUTHWICK AND J. E. SINCUK[2]

Abstract

Application of 1500-3000 ppm butanedionic acid mono-(2,2-dimethylhydrazide) (daminozide) from mid-August to mid-October increased fruit set the following year on Mutsu, McIntosh, Cortland, Delicious, and Spencer apples. Fruit set was increased more from the carry-over effects from a fall treatment than from a postbloom spray. Fruit size and L/D ration were reduced following a fall treatment.

Introduction

Daminozide (Alar) is used to delay preharvest fruit drop on some apple cultivars (9, 11, 14). Applications made shortly after bloom also can reduce growth and fruit size and shorten pedicel length. The nearer daminozide is applied to harvest, the fewer detrimental effects it has on the harvested fruit (6, 11). When high rates of daminozide (2,000-4,000 ppm) are used or application is made late in the season, carry-over effects which include delayed bloom, reduced terminal growth, flattened fruit, reduced pedicel length and increased fruit set may occur the following year (6, 12). Therefore, the rate of daminozide used and its time of application have been adjusted to minimize negative fruit-effects the year of application and to minimize carry-over effects (11).

Early high yield in newly planted and vigorous older apple orchards is becoming increasingly important as

[1]Paper No. 2743 Massachusetts Agricultural Experiment Station, University of Massachusetts at Amherst.

[2]Department of Plant and Soil Sciences.

costs of establishing and maintaining orchards escalate (2). Rootstocks (10), cultural practices (7) and growth regulators (3) are frequently used to encourage early flower bud formation and fruit set. Although treatments often increase flower bud formation, increased fruit set does not always follow (3). There are relatively few techniques that effectively increase fruit set on apple trees especially those just coming into bearing. This investigation was undertaken to determine if increased fruit set and cropping could be realized on young bearing apple trees in the spring by applying daminozide after normal harvest the previous fall.

Materials and Methods

All trees used in this investigation were growing at the Horticultural Research Center in Belchertown, MA. Mutsu, Cortland, and Spencer were planted in 1964 on Malling 7 (M7) rootstock. McIntosh and Double Red Delicious (nonspur) were planted in 1970 on Malling Merton 106 (MM106) rootstock. Treatments were replicated 7-9 times in a randomized block design. Daminozide treatments were applied to whole trees as a dilute spray. Fall treatments were applied before appreciable foliar frost damage occurred.

The year following late summer or early fall treatments and during the year of postbloom treatments, bloom and fruit set was taken on 2 limbs per tree that were 10-15 cm in diameter. Terminal growth was taken on 20 shoots/tree in the fall when terminal growth had ceased. Thirty fruit per tree were randomly harvested and weighed. Fruit size on McIntosh and Delicious was determined by measuring 30 fruit on the tree on August 20.

Fruit was harvested at the normal time for control fruit (Sept. 25-Oct. 12). Flesh firmness was determined on 10 fruit using a Magness Taylor penetrometer. Soluble solids were determined with a hand refractometer from juice collected while pressure testing. Seed number and L/D ratios were determined on 30 fruit. All data was subjected to analyses of variance and where appropriate means were separated at the 5% level with Duncan's multiple range test.

Results and Discussion

Application of daminozide at 1500-3000 ppm in late summer or early fall increased fruit set the following year on Cortland (Table 1), Delicious (Table 2), Mutsu (Tables 1 and 3), and Spencer (Table 4) apple trees. Increased fruit set has been previously reported on apples when daminozide was applied late in the season (1, 5, 8, 12, 13). This has been attributed to delayed bloom which avoided frost (1, 13) or to restricted shoot growth which reduced competition between fruit and shoots (5, 8). Daminozide delayed bloom in this investigation from less than one day to 3 days (data not shown). Since no frost occurred during the years of this investigation, the effect on set can't be attributed to avoiding frost damage. Daminozide increased fruit set on Delicious only slightly (Table 2). We believe that this was due to inadequate pollination because of delayed bloom there was poor bloom overlap with pollinizers. Daminozide application as a postbloom spray in the spring increased fruit set on McIntosh only when expressed as fruit/cm limb circum. (Table 2) and not on Mutsu (Table 3), or Spencer (Table 4). Thus, it appears that the greatest effect on fruit set occurs when daminozide is applied in late September to mid-October. Generally, daminozide effects on fruit set do not occur the year of application (14).

Terminal growth on Mutsu and Cortland was reduced the year following the fall application of daminozide (Table 1). These treatments appeared as effective as postbloom sprays for reducing terminal growth (Tables 2 and 4).

Table 1. Effect of daminozide applied as a postharvest spray the previous fall on fruit set, fruit weight and terminal growth of Mutsu and Cortland apple trees in 1976.

Cultivar	Treatment (ppm)	Application date	Fruit/cm limb circum.	Fruit wt (g)	Terminal growth (cm)
		1975	----------1976----------		
Mutsu	Control	----------	1.3[z]	299	48
	Daminozide 1500	Oct. 12	3.8	285	37
	Daminozide 3000	Oct. 12	4.9	266	32
Significance			**	**	**
linear			**	**	**
quadratic			NS	NS	NS
Cortland	Control	.....	7.7	192	32
	Daminozide 1500	Oct. 9	9.6	138	24
	Daminozide 3000	Oct. 9	13.5	127	21
Significance			**	**	**
linear			**	**	**
quadratic			NS	**	NS

[z](**) significant at .01% level and (NS) nonsignificant.

The fall but not the spring application of daminozide may reduce L/D ratio (6, 15). All concentrations of fall-applied daminozide reduced the L/D ratio on Mutsu (Table 3), Spencer (Table 5), and Delicious (data not shown). Pedicels on these fruit were also shortened and thickened. Some fruit flattening would be acceptable on cultivars that are not naturally elongated. However, flattening on Delicious would undoubtedly be unacceptable since effective marketing of this cultivar depends in part on long "typey" fruit. Perhaps part of this problem could be alleviated by an early bloom application of the proprietory mixture of gibberellins A_{4+7} and 6-benzylaminopurine that is marketed by Abbott Laboratories as Promalin.

Fruit weight was reduced by fall-applied daminozide in most experiments (Tables 1, 3, and 5). Damino-

Table 2. Effect of daminozide applied in the fall or spring on fruit set, fruit size and terminal growth of McIntosh and Delicious apple trees, 1975.

Cultivar	Treatment (ppm)	Application date	Fruit per cm limb circum.	Fruit per 100 blossom clusters	Fruit diameter Aug. 20 (cm)	Terminal growth (cm)
			----------1975----------			
McIntosh	Control	----------	6.1c[y]	77b	6.12a	23.6a
	Daminozide 3000	8/19/74	7.2b	90ab	5.77b	16.9a
	Daminozide 3000	9/26/74	9.7a	104a	5.56c	12.9a
	Daminozide 3000	6/2/75[z]	8.2ab	91ab	5.61bc	18.3a
Delicious	Control	----------	2.0ab	22b	7.16a	31.9a
	Daminozide 3000	8/19/74	3.0a	30a	6.99a	13.3b
	Daminozide 3000	10/8/74	2.7a	41a	6.99a	21.0ab
	Daminozide 3000	6/21/75[z]	1.3b	20b	7.06a	21.0b

[z]Petal fall + 10 days was 6/2/75.
[y]Mean separation, within columns by Duncan's multiple range test, 5% level.

Table 3. Effect of daminozide applied either in the fall or spring on fruit set, fruit size and L/D ration of Mutsu apple trees, 1979.

Treatment (ppm)	Application date	Fruit per cm limb. circum.	Fruit per 100 blossom clusters	fruit weight (g)	L/D ratio
		----------1979----------			
Control		3.3bc[y]	52a	329a	.96a
Daminozide 1500	10/19/78	4.6a	86c	317ab	.92b
Daminozide 3000	10/19/78	3.9ab	82ab	287d	.92b
Daminozide 1500	5/10/79[z]	2.8c	66abc	309bc	.94a
Daminozide 3000	5/10/79	2.9bc	59bc	300cd	.96a

[z]Sprays applied at petal fall.
[y]Mean separation within columns Duncan's multiple range test, 5% level.

zide is known to reduce fruit size the year of application (6, 11) or from a carry-over effect from previous years application (4, 5, 6). Undoubtedly, some of the effect on reducing fruit size in this investigation is related to increased fruit set since all treatments where fruit size was reduced also had increased fruit set (Tables 1, 3, and 5).

The fall applications of daminozide on Spencer reduced the fruit L/D ratio and seed number the following year (Table 5). Both the spring and fall applications increased fruit flesh firmness, decreased fruit size, and lowered soluble solids comparably. Although these effects are well documented following postbloom applications (4, 5, 6, 11), there are usually few carry-over effects that influence fruit quality (5, 12). Daminozide was applied on October 15. The strong carry-over effect of daminozide on Spencer may have resulted from cold temperatures following treatment which restricted metabolism of daminozide.

There are relatively few treatments available for increasing fruit set on young trees. This study showed that a postharvest application of daminozide had greater promise for increasing fruit set than did postbloom treatments. Reduced terminal growth could be a beneficial effect, since it would encourage development of better fruiting wood and reduce the amount of pruning required on young trees. Reduced fruit size and increased flesh firmness is desirable on young trees, since they frequently produce fruit that is too large. It may be necessary to have late blooming pollinizers near treated trees or to treat some pollinizers with daminozide to insure adequate flowers for pollinization.

Table 4. Effect of daminozide applied either in the fall or spring on fruit set, yield and terminal growth on Spencer apple trees, 1978.

Treatment (ppm)	Application date	Fruit per cm limb. circum.	Fruit per 100 blossom clusters	Yield (Kg/tree)	Terminal growth (cm)
Control	----------	6.3c[y]	45c	278b	33.8a
Daminozide 1500	10/15/77	9.1b	75b	300ab	21.0b
Daminozide 3000	10/15/77	13.9a	87a	362a	10.6c
Daminozide 2000	5/23/78[z]	7.6bc	47c	342ab	18.8b

[z]Sprays applied at petal fall.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 5. Effect of daminozide applied either in the fall or spring on fruit size, shape and quality of Spencer apple trees, 1978.

Treatment (ppm)	Application date	Fruit wt. (g)	Flesh firmness (N)	Soluble solids (%)	L/D ratio	Seeds/ fruit
		----------	----------	1978	----------	----------
Control		190a[y]	65.1b	12.8a	.92a	5.8a
Daminozide 1500	10/15/77	148b	68.3a	12.0b	.88b	5.1b
Daminozide 3000	10/15/77	126c	70.6a	11.7b	.86c	4.3c
Daminozide 2000	5/23/78[z]	162b	70.6a	12.1b	.91a	5.4a

[z]Sprays applied at petal fall.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

The daminozide label permits use of up to 2000 ppm when applied between petal fall + 10 days and 60 days prior to normal harvest. The 2000 ppm rate in most cases would be adequate so that a label change would not be necessary. However, the label would have to be amended to allow application after harvest. This should pose no residue problems since fruit would be harvested nearly a year after application.

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