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Response of Young 'd'Anjou' Pear Trees to Triazine and Triazole Herbicides and Nitrogen[1]

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Abstract. **Weed control and supplemental N markedly increased vigor and yield of pear trees (*Pyrus communis* L. cv. d'Anjou). Under conditions of low soil N, simazine enhanced N uptake. Consequently, simazine increased tree vigor, leaf N, shoot growth, and fruit size in the absence of supplemental N. Fruit from the control (no N or simazine) treatment was denser, yellower, higher in soluble solids, and had less scald and rot than fruit from trees treated with simazine but no N. Amitrole plus simazine (A + S) produced the highest yield in trees receiving no N, and resulted in as much tree vigor as the other treatments with supplemental N. The data suggest that certain triazine and triazole herbicides may partially substitute for N fertilizer on young 'd'Anjou' trees.**

Nitrogen is necessary to insure vigor and adequate fruit set of 'd'Anjou' pears (1, 2, 10, 19). With production and fertilizer costs rising, methods for increasing the uptake of N by plants need to be investigated.

Triazole and triazine herbicides are 5- and 6-membered ring structures with 3 N atoms in the ring and 1- and 2-N atoms attached to the ring, respectively. Earlier reports (9, 11, 12) indicated that certain of these compounds increased growth and/or the efficiency of N uptake in fruit trees. Others (13) reported no increase in growth. Simazine (a triazine) increases the efficiency of nitrate utilization in tolerant plants at low levels of N and low temp (16) and does not inhibit growth or photosynthesis at low temp (15). The present study was designed to determine if triazine and triazole herbicides could partially substitute for N application under conditions of low soil N and similar weed control, as well as the effects of weed control and supplemental N on vigor and yield of young 'd'Anjou' pear trees.

Materials and Methods

Five-year-old 'd'Anjou' pear trees spaced 6×6 m in a Supplee very fine sandy loam at an elevation of 540 m were used in the experiment. Dryland wheat farming was previously practiced. Weeds within the tree rows consisted primarily of dandelions (*Taraxacum officinale* Weber.). The trees and recently-planted grass covercrop (red fescue, *Festuca rubra*) received a broadcast application of about 180 kg/ha of N in the autumn of 1971. Due to the importance of the interactions in this study, 3 tree plots were assigned to a randomized split block design; 5 herbicide treatments were the main plots and 3 levels of supplemental N (0, 227, and 454 g of actual N/tree as NH_4NO_3) were the subplots with 4 replications. Supplemental N was applied under the tree branches in March of 1972 and 1973. The herbicide treatments were (a) 3-amino-*s*-triazole (amitrole)[3] at 2.2 kg ai/ha in combination with 2-chloro-4,6-bis (ethylamino)-*s*-triazine (simazine) at 1.8 kg ai/ha, (b) simazine alone (both simazine treatments applied once each season in a 1-m spray band on each side of the tree row in the early spring, 1972 and 1973), (c) 1-1'dimethyl-4,4' bipyridinium ion (paraquat) at 1.1 kg ai/ha with X-77 spreader applied 3 or 4 times annually in 1972 and 1973 as needed to control weeds, (d) simazine and paraquat combination applied in the fall of 1972 with paraquat applied as needed in the summer, and (e) no herbicide. Because the soil was of coarse texture and low in organic matter, amitrole and simazine were applied at one-half the recommended rate to avoid possible injury to the trees in 1972; simazine was increased to 3.6 kg ai/ha in 1973. At the beginning of the experiment, soil tests showed that NO_3-N and organic matter were 0.1 ppm and 0.9% respectively.

Fifteen leaves per tree were collected in August of 1972 and 1973, and N was determined by a modified Nessler method (7) with selenium oxychloride for digestion. K, Ca, and Mg were determined by atomic absorption spectrophotometry. Methods for fruit quality determinations were described previously (11). Scald and storage decay were determined by estimating the proportion of skin and number of fruit affected.

Results and Discussion

Weed control. When no N was used, one spring application of amitrole (A) with simazine (S) resulted in adequate weed control, similar to that obtained with 3 or 4 annual applications of paraquat (P) alone (Table 1). Annual spring applications of S alone were not expected to control established weeds and resulted in essentially no control. Increased levels of N reduced the effects of the herbicides. A + S was the most effective treatment for controlling weeds on high N plots.

Leaf analyses. Supplemental N resulted in increased leaf N regardless of herbicide treatment, although the difference between N (227 and 454 g) levels was not significant for the interaction (Table 2). With no supplemental N, leaf N was significantly greater on trees treated with A + S and P + S than on trees with paraquat (P) alone, both showing nearly equal weed control, while S increased leaf N without affecting weed cover. A similar trend was evident the previous year. Therefore, S evidently increased N utilization regardless of weed competition. A + S treatment increased leaf N to a level greater than that of trees receiving 227 g of N with or without S.

For both years, leaf potassium (K) was significantly highest in the no herbicide treatment (data not included). For all 5 herbicide treatments, K was also significantly higher for the 0 and 227 g rates of N than for the 454 g rate during both years.

Tree growth. Tree growth and vigor were influenced markedly by weed control and supplemental N as evidenced by increases in linear shoot growth (Table 3), trunk circumference, and leaf wt (data not included). With weed control and no N, shoot growth was significantly greater on A + S-treated trees during the second season than on the P-treated trees. A similar trend occurred with S alone in comparison with the no herbicide treatment with no N. Shoot growth of A + S-treated trees with no N was nearly equal to that of trees receiving the other

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[3]In keeping with revised recommendations (18), amitrole was discontinued after only one application in the spring of 1972; it was replaced with paraquat in 1973.

Table 1. Effect of herbicides and supplemental N on weed control in 'd'Anjou' pear orchard rated Sept. 26, 1973.

Herbicide	Weed control (% bare ground)			
	Supplemental N per tree			
	0g	227g	454g	Mean
None	0.9a	0.6a	0.4a	0.6r
Simazine	5.4a	3.3a	2.8a	3.8r
Paraquat	70.5d	32.9b	21.3b	41.6s
Amitrole + simazine	83.6d	78.4d	73.8d	78.6t
Paraquat + simazine	56.3c	32.9b	23.6b	37.6s
Mean	43.3n	29.6m	24.4m	

[z]Mean separation within herbicide × N, herbicides, and N levels by Duncan's multiple range test, 5% level.

Table 3. Effect of herbicides and supplemental N on shoot growth of 'd'Anjou' pear trees, 1973.

Herbicide	Shoot growth (cm)			
	Supplemental N per tree			
	0g	227g	454g	Mean
None	12.7a	46.6cd	59.1de	39.5r
Simazine	24.3ab	51.5de	52.7de	42.8rs
Paraquat	34.4bc	52.9de	52.3de	46.5rs
Amitrole + simazine	57.0de	59.8de	65.0e	60.6t
Paraquat + simazine	32.4bc	53.3de	61.9de	49.2s
Mean	32.1m	52.8n	58.2n	

[z]Mean separation within herbicide × N, herbicides, and N levels by Duncan's multiple range test, 5% level.

herbicide treatments with high supplemental N. Supplemental N improved tree vigor and offset weed competition in the no herbicide plots.

Yield and fruit size. In 1972 (data not included) and 1973 (Table 4), the highest level of N increased yield. In the absence of supplemental N in 1973 yield, was significantly lower on plots with weed cover (S and no herbicide) than on those treated with P alone or A + S. Yield on A + S plots was only slightly greater than that on P plots.

Although yield was increased by reducing weed competition and by supplemental N (Table 4), it is not clear why yield was low on the A + S plots with 227 g of supplemental N for each of the 3 years. These plots contained few weeds and hence NH_4NO_3 was readily available in the spring. Possibly NH_4^+ interfered with nitrate uptake at a critical time for fruit set. Others (3, 6, 16) have shown that previous treatment with NH_4^+ restricts NO_3^- uptake. Nevertheless, yield on plots receiving A + S alone was significantly surpassed only by no herbicide plots with the highest rate of N (Table 4).

Yield was probably low on P + S treated trees because the treatments were not applied until the Fall of 1972, a full growing season late. Consequently, the trees were smaller and produced less yield than the other trees with comparable weed control and N.

Fruit size and density. Fruit was significantly larger on trees where weeds were controlled (A + S and P + S) than on trees without weed control (S and no herbicide) (table 5). Fruit from S-treated trees was larger than that from trees with no herbicide and no N. Supplemental N offset the effect of herbicides, which had no significant effect at the highest level of N.

Supplemental N and treatments containing S with no N decreased fruit density (Table 5). Very few fruit from A + S-treated trees sank even without supplemental N. Likewise, simazine alone reduced fruit density. In some cases, decreased density may have been a consequence of increased fruit size. At harvest, more yellowish-green fruit was produced on control trees or those treated with P alone than on trees treated with S alone or with combinations of S or N (data not included).

Postharvest fruit characteristics. In both 1973 and 1974, fruit from control trees had the highest soluble solids and flavor ratings (Table 5). The data suggest that S alone stimulated tree vigor and indirectly reduced soluble solids. Nevertheless, flavor was more desirable in fruit from control trees or trees treated with S alone than in those from any of the other treatments (Table 5).

N application increased scald and storage decay (data not included). More scald occurred on trees treated with A + S than with the other herbicide treatments, while fruit from trees receiving P without supplemental N had the least scald.

Fruit characteristics on A + S-treated trees with no N resembled those on trees receiving supplemental N (Table 5). Because the simazine and N treatments influenced tree vigor, leaf N was significantly correlated with all fruit variables tested during both years, except for firmness (Table 6). In contrast, Hewitt (4) reported no significant relationship between leaf N and fruit characteristics of 30-year-old 'Bartlett' pear trees. Fruit of young 'd'Anjou' pear trees are usually slower to mature and ripen in comparison with fruit from older trees. (Personal communication with W. M. Mellenthin, Superintendent, Mid-Columbia Experiment Station, Hood River, Oregon.)

Certain triazine and triazole herbicides stimulate various enzyme systems and alter or increase the protein content of various plant parts (5, 14, 16, 20, 21). Mellenthin and Wang (8) showed that lower quality of 'd'Anjou' fruit was associated with relatively high and low preharvest temp and high protein N. In the present study, low soluble solids of fruit from S-treated trees may have been associated with high protein N in the fruit. Viets and Hageman (17) concluded that stimulation of increased protein content induced by sublethal levels of certain herbicides emphasizes the importance of nitrate reduc-

Table 2. Effect of herbicides and supplemental N on leaf N of 'd'Anjou' pear leaves, 1973.

Herbicide	Leaf N (% dry wt)			
	Supplemental N per tree			
	0g	227g	454g	Mean
None	1.14a	2.17c	2.45def	1.92r
Simazine	1.79b	2.24cd	2.36c-f	2.13s
Paraquat	1.76b	2.25cde	2.42c-f	2.14s
Amitrole + simazine	2.52efg	2.57fg	2.75g	2.61u
Paraquat + simazine	2.16c	2.36c-f	2.54fg	2.35t
Mean	1.87m	2.32n	2.50o	

[z]Mean separation within herbicide × N, herbicides, and N levels by Duncan's multiple range test, 5% level.

Table 4. Effect of herbicides and supplemental N on yield (no. fruit/tree) of 'd'Anjou' pear trees, 1973.

Herbicide	Yield (no. fruit/tree)			
	Supplemental N per tree			
	0g	227g	454g	Mean
None	17a	102def	133f	84s
Simazine	18a	117ef	121ef	85s
Paraquat	75bcd	91cde	115ef	93s
Amitrole + simazine	85cde	60bc	110def	85s
Paraquat + simazine	48ab	60bc	55bc	54r
Mean	49m	86n	107o	

[z]Mean separation within herbicide × N, herbicides, and N levels by Duncan's multiple range test, 5% level.

Table 5. Effects of herbicides and supplemental N on fresh fruit wt, fruit density (% fruit which sank in H_2O), soluble solids, and flavor of 'd'Anjou' fruit, 1973.

Herbicide	N (g/tree)	Fresh fruit wt (g)	Fruit density (%)	Soluble solids (%)	Flavor rating[y] (0-6)
None	0	168a[z]	85.0e	15.8e	4.00a
	227	253c	12.5ab	14.0cd	2.75a
	454	254cd	2.5ab	13.6abcd	2.25a
	Mean	225r	33.3t	14.5s	3.00s
Simazine	0	207b	37.5cd	14.0cd	3.50a
	227	237bc	7.5ab	12.7a	2.00a
	454	242c	5.0ab	13.5abcd	2.25a
	Mean	229r	16.7rs	13.4r	2.58rs
Paraquat	0	233bc	50.0d	14.5d	2.50a
	227	234bc	17.5ab	13.1abc	2.00a
	454	241c	17.5ab	13.9abcd	1.25a
	Mean	236rs	28.3st	13.8rs	1.92r
Amitrole + simazine	0	251c	2.5ab	13.2abc	2.50a
	227	261cd	2.5ab	13.1abc	1.50a
	454	256cd	0.0a	13.1abc	2.00a
	Mean	256st	1.7r	13.1r	2.00r
Paraquat + simazine	0	248c	22.5b	13.9bcd	2.75a
	227	294e	5.0ab	13.6bcd	1.75a
	454	285d	5.0ab	12.8ab	1.75a
	Mean	276t	10.8r	13.4r	2.08r
Mean for N:	0	221m	39.5n	14.3n	3.05n
	227	256n	9.0m	13.3m	2.00m
	454	256n	6.0m	13.4m	1.90m

[z]Mean separation within herbicide x N, herbicide, and N by Duncan's multiple range test, 5% level.

[y]Flavor rating: 0 = objectionable, 6 = excellent.

tion in the metabolism of the plant, but the herbicidal effects are probably indirect and thus complex and variable.

With low soil NO_3-N, A and S without supplemental N had a marked effect on tree vigor, yield, and certain fruit characteristics. However, the highest levels of supplemental N gave highest yields, regardless of the degree of weed control. Correlation coefficients indicated that the N status of the tree, as determined by leaf N, was positively related to tree growth and development (Table 7). Herbicides are important in establishing young, vigorous 'd'Anjou' pear orchards in soils low in N. These results provide further impetus for conserving N fertilizer and clearly support the preliminary hypothesis (11, 12) that certain triazine and triazole herbicides increase tree vigor and uptake of N under suboptimal levels of soil N.

Table 6. Correlation coefficients between leaf N or K and fruit characteristics of 'd'Anjou' pears harvested in 1972 and 1973.

Variables		Date harvested: Sept. 5, 1972 df = 46	Sept. 10, 1973 df = 58
Leaf N vs.	fruit wt. (H)[z]	0.729**	0.736**
	fruit density (H)	–	–0.812**
	fruit firmness (AS)[z]	0.231	–0.244
	fruit color (H)	–0.838**	–0.688**
	soluble solids (A)	–0.740**	–0.708**
	flavor rating (AS)	–0.755**	–0.542**
	fruit scald (AS)	0.442**	0.601**
	stem end rot (AS)	–	0.224
Leaf K vs.	scald (AS)	–0.183	–0.574**

[z](H) = at harvest, (AS) = after 7 months storage.
*,**Significant at the 5 (*) or 1 (**) % level.

Table 7. Correlation coefficients between leaf N and various growth variables of 'd'Anjou' pear trees, 1972 and 1973.

Variables		Year sampled: 1972 df = 46	1973 df = 58
Leaf N vs.	trunk circum. increase	0.608**	0.739**
	linear shoot increase	0.498**	0.810**
	yield	0.375**	0.446**
	fruit circum.	0.446**	0.707**
	leaf wt	–	0.607**
	leaf color[z]	–0.703**	–0.828**
	leaf K	–0.437**	–0.659**
	leaf Ca	–0.192	0.353**
	leaf Mg	0.217	–0.347**

[z]Estimated from Munsell color values.
**Indicates significance at the 1% level.

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Effect of Daminozide on 'Concord' Grapes[1]

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Abstract. **Succinic acid-2,2-dimethylhydrazide (daminozide, SADH) applied to mature 'Concord' grape vines (*Vitis labrusca* L.) at 500 and 1000 ppm at first and at 50% bloom, was observed to increase fruitfulness and yield by increasing cluster weight. During 7 years cluster weight increases were associated with 2 to 6% decreases in berry size and 14 to 22% increases in berry number. Daminozide did not affect the number of seeds per berry, but did reduce weight per berry. Thus, increases in crop yield of up to 20 to 25% were obtained by increasing cluster weight and not by increasing cluster number. Daminozide increased total acid concentration slightly but had no effect on pH. Soluble solids were reduced by daminozide when yield increases, due to daminozide, were above 2 kg/vine. The effect on soluble solids appeared to result from increased productivity rather than from direct effect of the chemical. Daminozide reduced vine size more at the 1000-ppm than the 500-ppm rate.**

Year to year variability in 'Concord' grape yield results from fluctuations in cluster weight and number. The components of cluster weight variability are flower number per cluster, percentage set, and berry size. The classical technique of bloom-time removal of the shoot tip (3) increases fruit set, but decreases vine size. Conversely, clusters on rapidly elongating shoots generally set fewer fruits. Coombe (4) showed no growth retardant effect of increasing fruit set by application of (2-chloroethyl)trimethylammonium chloride (CCC) when shoot tips had been removed. This is in agreement with unpublished data from New York on 'Concord' showing that daminozide and shoot pinching were similar in increasing cluster weight. However, Naito et al. (10) has demonstrated that spraying 'Muscat of Alexandria' with CCC before anthesis significantly enhanced fruit set when shoot pinching had no effect. Also, treating only clusters with either daminozide or CCC increased set of seeded berries without retarding shoot growth. The relationship between grape berry set and rate of shoot elongation, is the basis for the viticultural interest in growth retardants such as daminozide.

In 1964, Bukovac et al. (1) showed that daminozide in the range of 500 to 6000 ppm retarded growth of shoots of potted, non-bearing 'Concord' grapevines. Weaver (14) showed that the effect of increasing the rate of daminozide prolonged the period of inhibition of internode elongation, rather than affecting the level of inhibition near the shoot tips. Huglin and Julliard (7) also found daminozide and CCC to have a growth retardant effect on shoots. This effect essentially ceased by veraison and the beginning of wood maturation.

Whether daminozide functions in the plant by reducing the "sink strength" of metabolites to the shoot tip or has a direct effect of its own is somewhat controversial. Monselise and Luckwill (9), using $^{14}CO_2$ have shown that daminozide increased the transport of assimilates to the roots of apples and that this was detectable before a reduction in growth rate.

Application of daminozide at 750 ppm by Tukey and Fleming (11, 12) and 500-1000 ppm by McCaskill (8) reduced 'Concord' vine size, shoot length, berry size and soluble solids, but increased yield per vine by increasing the number of berries per cluster. Haeseler (6), following a 3-year study on 'Concord' grapes, concluded that annual applications of daminozide did not result in significant yield increases or reductions in annual yield fluctuations within the range of 125-1000 ppm. Tukey and Fleming (8, 9) did not apply daminozide to the same vines in 1966 as those used in 1965 and, hence, afforded data for one-year tests.

To gain repeated use and cumulative effects of daminozide over a 4 to 6 year period (1967-1973), 'Concord' vineyards in major producing areas of New York and Ohio were used. Effects of daminozide on fruit yield and maturity and vine size were determined.

Materials and Methods

Three mature 'Concord' vineyards were selected as being above average in vine size and yield. Vineyard 1 was located at Fredonia, New York[4] and Vineyards 2 and 3 at Geneva, Ohio.[4]

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[4]Vineyard 1 was owned by Mr. Florian Spoden and operated by Mr. Merle West (present owner). The continuing cooperation of Mr. West, Mr. T. D. Jordan, extension grape specialist, and the Dept. of Pomology and Viticulture of the New York Agr. Expt. Sta. is acknowledged. Mr. Donald Crowe and Mrs. Sheldon Hubbard of the Viticultural Laboratory at Fredonia, N. Y., made all measurements in vineyard 1. Vineyards 2 and 3 were owned and operated by Mr. Glen Stoltz and Mr. Anthony Debevc. The authors are indebted to these individuals for their cooperation.

[5]Registered trade name of the product of Uniroyal Chemical, Division of Uniroyal, Inc., Naugatuck, Conn., it contains 85% daminozide.