HortScience 15(6):745–747. 1980.

Naphthaleneacetic Acid as a Sprout Inhibitor on Pruning Cuts and Scaffold Limbs in 'Delicious' Apple Trees[1]

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Additional index words. auxin, *Malus domestica*

Abstract. **Naphthaleneacetic acid (NAA) ethyl ester was applied in the spring at 5 rates from 0.125% to 1.0% on vigorous 6-, 9-, and 13-year-old standard 'Delicious' apple (*Malus domestica* Borkh.) trees as either an individual pruning cut or scaffold limb treatment. NAA in a 40% white latex paint solution or as a 1% asphalt based aerosol significantly reduced the number of sprouts/100 cuts using both methods of application. There was no significant difference between the 1.0% latex paint solution and the asphalt based formulation. Scaffold limb treatment with NAA significantly reduced the number of sprouts per 122 cm of scaffold limb; however, some bark blistering and minor splitting was observed on trees treated with 1.0% NAA. Treating individual cuts was generally less effective in reducing the total number of sprouts at concentrations lower than 1%.**

NAA is an effective sprout inhibitor when applied to the trunk, limbs, or individual pruning cuts on various fruit (1, 2, 4, 7, 8, 9, 11), nut (8), ornamental (3), and nursery trees (5, 10). The ethyl ester formulation of NAA (72-A112)[4] has generally proven superior to the sodium salt formulation for sprout control (8, 11). Raese (11) reported that 1.0% NAA ethyl ester applied to the scaffold limbs of 15-, 20-, and 27-year-old apple trees would effectively control sprouts for two growing seasons. Brush application to individual pruning cuts on 5-, 8-, and 12-year-old apple trees at rates of 0.25% to 1.0% of NAA significantly reduced the number of sprouts per 100 pruning cuts; the number of sprouts per linear foot of scaffold limb was, however, no different from that on untreated trees (9).

The purpose of this study was to compare the effectiveness of 5 concentrations of NAA in latex paint, latex alone, and a 1.0% asphalt based aerosol NAA for sprout inhibition on 'Delicious' apple trees. In addition, two methods of application were compared: a) treatment of individual pruning cuts vs. b) thorough coverage of scaffold limbs.

Vigorous 6-, 9-, and 13-year-old standard 'Delicious' apple trees were selected for treatment in January 1976. Trees were pruned in February using commercially accepted methods. Applications were made to dormant trees on March 19 in a randomized block design using single whole-tree replicates in each age group. Two formulations of NAA ethyl ester were used: a 40% (by volume) white interior latex paint (Glidden 3470) solution containing 0, 0.125, 0.50, 0.75, and 1.0% NAA, and a 1.0% asphalt based aerosol (Tre-Hold)[4] spray. Each treatment was applied to either 12 individual pruning cuts on 4 replicate trees or to the first 5 major scaffold limbs on 8 replicate trees for each tree-age combination. All treatments were applied with a 5 cm paint brush except the aerosol spray, which was applied directly from the commercially packaged 368 g (13 oz) container. On individual pruning cuts, the newly cut surface and about 2.5 cm of the adjacent bark was treated. Scaffold limb treatments were applied from the point of attachment at the main trunk outward for a distance of at least 2 m. The number of sprouts produced on treated surfaces during the 1976 growing season was recorded in February 1977. Results were calculated as the mean number of sprouts per 100 pruning cuts and the total number of sprouts per 122 cm of scaffold limb. Analysis of variance was utilized for testing the effects of application method, treatment, and interaction for 6-, 9-, and 13-year-old trees. The treatment sum of squares was partitioned into single degree of freedom contrasts for comparing the effects of control, latex, Tre-Hold, and 1.0% NAA treatments. The Tre-Hold treatment was not applied to the 6-year-old trees due to a shortage of material. Response curves representing the relationship between sprouting and the concentration of NAA were examined using regression analysis. Separate equations were derived for response values for both pruning methods in the 6-, 9-, and 13-year-old trees.

Application method did not affect the number of sprouts per 100 pruning cuts regardless of tree age (Table 1). The 40% latex paint solution alone reduced significantly the number of sprouts per 100 cuts, but the degree of control was commercially unacceptable (Table 2). Sprouting on individual cuts was significantly reduced by the 1.0% NAA-latex paint solution and by the 1.0% NAA asphalt based aerosol in comparison with control trees or those treated with latex paint alone. Response to the 1.0% NAA-latex paint solution did not differ significantly from that to the asphalt based formulation. The 13-year-old trees had been trained to the open center system, while the 6- and 9-year-old trees were trained to a modified leader system. The older trees, being more open to light, produced an abundance of sprout growth in the center of the tree. The modified leader trees, while not quite as vigorous, still produced a large number of sprouts as a result of heavy annual pruning. This tree/vigor relationship is evident from the relative number of sprouts produced on control trees (Table 2).

The responses (Fig. 1) indicate that effective sprout control was achieved on individual cuts at 0.5% NAA. The number of sprouts per 100 cuts could be

Table 1. Effect of NAA application method on sprouting in 6-, 9-, and 13-year-old 'Delicious' apple trees.

Application method[z]	No. sprouts per 100 pruning cuts		
	Tree age (yr)		
	6	9	13
Individual cuts	57.0	44.9	67.1
Scaffold limb	81.2	46.7	61.2

[z]Summary of single degree of freedom contrasts used to determine significance between treatments is presented in the text.

Table 2. Effect of various sprout control treatments on sprouting in 6-, 9-, and 13-year-old 'Delicious' apple trees.

Treatment[z]	No. sprouts per 100 pruning cuts		
	Tree age (yr)		
	6	9	13
Control	117.5	99.4	133.3
Latex paint alone	84.8	80.6	117.1
Tre-Hold	–	1.0	5.2
1.0% NAA in latex paint	5.3	2.1	1.0

[z]Summary of single degree of freedom contrasts used to determine significance between treatments is presented in the text.

[1]Received for publication March 27, 1979. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

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[4]Amchem Emulsifiable Sprout Inhibitor, Amchem Products, Inc., Ambler, PA 19002.

significantly related to the concentration of NAA used by a second degree polynomial. For 6-, 9-, and 13-year-old trees both linear and quadratic components were significant ($P < 5\%$) and a test of homogeneity indicated no significant differences in response between the two application methods.

When 1.0% NAA-latex paint was applied to individual cuts or entire scaffolds on 6-year-old 'Delicious' apple trees, sprout numbers per 122 cm of scaffold limb were significantly reduced from 4.0 to 1.8; latex paint alone was ineffective. On 9-year-old trees differences between control, latex paint, Tre-Hold or 1.0% NAA-latex paint were not significant when individual cuts were treated, but treating entire scaffolds with paint alone or 1.0% NAA in paint significantly reduced the number of sprouts per 122 cm of scaffold limb from 4.0 to 1.9 or 0 respectively. Pruning vigorous trees often stimulates sprout production some distance removed from the area of the cut as well as at the cut. Under these conditions, treatment of individual pruning cuts may not effectively reduce the total number of sprouts on a given length of scaffold limb. Earlier studies showed no significant differences in the total number of sprouts per linear foot (30.5 cm) of scaffold limb when NAA was applied to individual cuts at rates of 0.06 to 1.0% (9).

Latex paint (40%) alone had no significant effect on the number of sprouts per 122 cm of scaffold surface when applied to individual cuts or scaffold limbs on the 13-year-old trees. NAA in latex paint or Tre-Hold significantly reduced the number of sprouts from 6.0 on control trees to 1.8 or 2.2 respectively in the case of individual cut treatments and from 5.4 to 0.6 or 2.1 for scaffold treatments. Treating scaffolds with 1.0% NAA-latex was more effective in reducing the number of sprouts than was treatment with a similar rate of Tre-Hold.

Significant ($P < 5\%$) linear and quadratic effects on the number of sprouts per 122 of scaffold limb were observed following scaffold limb treatment. A significant linear effect between sprouting and rate of NAA was detected for 13-year-old trees. Treating individual cuts did not significantly reduce the number of sprouts per 122 cm of scaffold except in the 13-year-old trees. The observed responses in Fig. 2 indicate NAA concentrations as low as 0.125% reduced sprouting by 66% when applied to entire scaffolds. An equal concentration reduced sprouting on scaffold limbs by 75 and 87% in 6- and 9-year-old trees, respectively, compared to individual cut treatment. At high rates (0.75 to 1.0%) NAA may be translocated from the site of application to affect growth in other areas (6, 10).

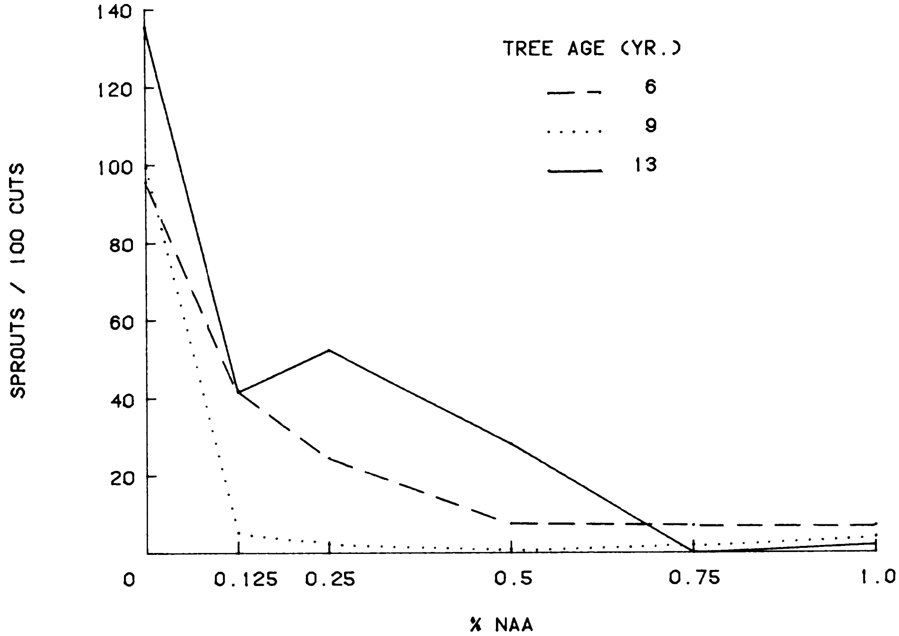

Fig. 1. Number of sprouts per 100 cuts on 6-, 9-, and 13-year-old 'Delicious' apple trees treated with an NAA-40% latex paint solution at the specified NAA concentration using two methods of application.

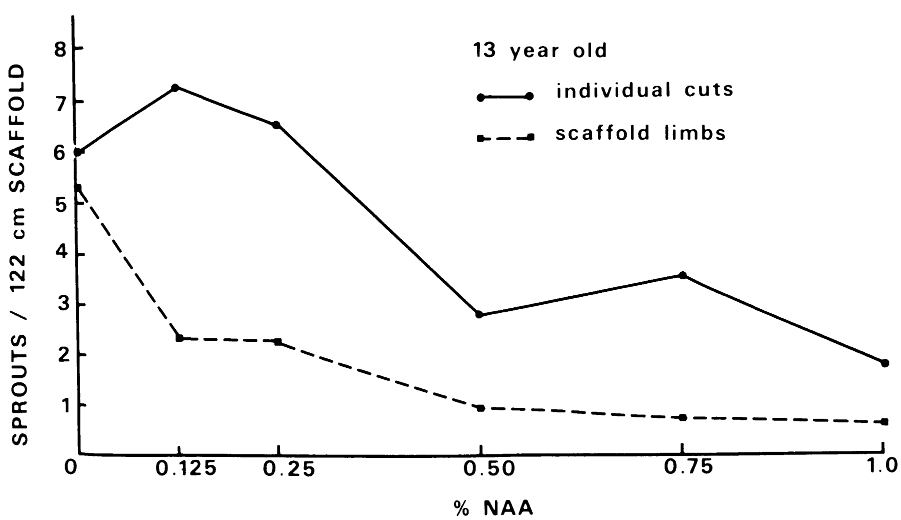

Fig. 2. Number of sprouts per 122 cm of scaffold surface on 13-year-old 'Delicious' apple trees treated with an NAA-40% latex paint solution at the specified NAA concentration using two methods of application.

Scaffold limb treatment with 1.0% NAA in either paint or asphalt based aerosol resulted in bark blistering, peeling, and mionr splitting on approximately 20% of the treated limb surfaces. About 80% of this injury occurred on limbs treated with the asphalt formulation and was observed as bark blistering. Although symptoms appeared on scaffold limbs exposed to direct and indirect light, heat buildup under the black asphalt material may have caused injury. Observations in 1978 revealed that 5% of the limbs treated with the 1.0% asphalt based NAA had died, apparently as a result of this treatment. No further injury was evident on those surfaces treated with the 1.0% NAA-latex paint solution and no loss in vigor or productivity was noted on trees in 1978.

Results indicate that equally effective sprout control can be obtained on the individual pruning cuts of vigorous trees with a 0.5 to 1.0% NAA ethyl ester-40% latex paint solution whether applied to individual cuts or entire scaffold limbs. Sprout control in excessively vigorous trees is best acheived by treating entire scaffold limbs. Lower rates are more effective in this method than in treating individual cuts and no bark injury occurred at rates of 0.5 or 0.75% NAA in latex paint.

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HortScience 15(6):747–748. 1980.

Reducing Energy Loss under an Orchard Heater[1]

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Additional index words. frost protection, energy conservation, soil heat flux

Abstract. **Energy used in orchard heating which moves into the soil under an orchard heater is wasted. To eliminate this loss of energy, gravel and aluminum foil were placed on the soil surface under an orchard heater. When an air gap existed between the heater base and the aluminum foil, heat flux and temperature measurements showed that the aluminum foil treatment reduced heat flux into the soil by 80-100%. The energy saved is reflected into the orchard and absorbed by the foliage in a manner similar to the radiant energy of the heater. The gravel treatment was ineffective.**

Orchard heating has historically been a favorite frost protection technique. With increasing fuel costs, however, this method must be made more energy efficient. The box model approach of Martsolf and Panofsky (2) provides a framework for such studies. In a study of orchard heater performance, Fritton and Martsolf (1) found that the energy used in an orchard heater which moved into the soil did not contribute to frost protection. Welles et al. (4) have shown that eliminating this loss provides the same level of protection with approximately a 10% reduction in the burn rate. Since much of the 6 million or more barrels of oil used in frost protection in a typical year (5) is used in orchard heating, this study was undertaken to find practical ways to reduce or eliminate energy loss to the soil. Two possible energy conservation techniques were studied experimentally and energy loss for each was compared with that of bare soil under an orchard heater.

The experimental site and instrumentation were described previously (1). The study was located in an experimental apple (*Malus domestica* Borkh. cv. Golden Delicious) orchard on Hagerstown silt loam (Typic Hapludalf) soil. A Scheu Auto-Clean-Stack orchard heater was used with its base located 2-3 cm above the soil surface. Oil was fed into the heater from a pipeline system through a nozzle and ignited on the inside upper surface of the base of the heater. The heater was lit and allowed to burn out and cool before each run in the spring of 1978 to guarantee that all old oil had been burned.

The heat flux at the soil surface was measured at 0.0, 0.5, and 1.0 m from the heater center using techniques described by Fritton and Martsolf (1). Briefly, heat flux plates buried at a 5-cm depth were corrected for heat stored above 5 cm using soil temperature data collected at depths of 0.0, 2.5, 5.0, 9.0, and 27.0 cm near each heat flux plate. Temperature data were measured with 4-thermocouple thermopiles with the reference junctions placed between iron plates buried at the 30-cm depth. The reference junction temperature was monitored with three thermocouples which were averaged. All heat flux and temperature data were collected at three minute intervals.

Soil samples were taken near each concentration of instruments for water content. Water content data were combined with previously taken soil bulk density data at this site and with specific heat capacity values for this soil series (1) to calculate the heat capacity of the 0 to 5-cm layer. The data analyses paralleled similar analyses made by Fritton and Martsolf (1) resulting in a surface soil heat flux at the 0.0, 0.5, and 1.0-m locations and a spatially integrated surface soil heat flux.

Experimental data were collected with 3 surface soil treatments: bare, gravel covered, and aluminum foil covered. The gravel treatment (Fig. 1) consisted of a 1-layer thickness of a white quartz landscaping gravel which covered about 80% of the soil surface. The heater base was located 2 cm above the soil, gravel, or aluminum foil surface during each run. The aluminum foil treatment (Fig. 1) consisted of Heavy-duty Reynolds Wrap aluminum foil placed on the soil surface for the fall 1977 run and of 0.001-cm aluminum foil laminated on to 0.01-cm black plastic (Stauffer Chemical Company, Westport, Conn.) for the spring 1978 experiment. The laminated aluminum foil proved to be inadequate immediately under the heater in the spring 1978 and was replaced with Heavy-Duty Reynolds Wrap aluminum foil after a few minutes. All materials covered an area about 1.5 m in radius. Experimental data collection lasted about 0.6 hr in the fall of 1977 and 2.7 hr in spring 1978. All runs were made on radiation cooling nights and heat flux data were collected between midnight and dawn. All runs after 1976 used a constant heater oil pressure of 80 PSI (0.54 megapascals).

The 2 bare soil surface treatments show the high temperature (Fig. 2) and large downward surface heat flux (Table 1) normally associated with an orchard heater. Experiments in 1976 generated soil surface temperatures beneath the heaters of nearly 250°C while the 1978 experiment produced temperatures around 150°C. These temperatures are lower than the stack temperatures

[1]Received for publication December 4, 1979. Paper No. 5873 of the Journal Series of the Pennsylvania Agricultural Experiment Station. Supported by U.S. Department of Energy Research Contract EC-77-S-02-4397, Northeast Regional Project NE-48, and Hatch Project 2207.

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

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