In 1970 all ethephon treatments increased the % seedlings flowering for the first time over unsprayed controls (Table 3). There were no statistically significant differences in % of seedlings flowering among concn or timings. Ethephon increased the no. of flower clusters on the 4-yr old trees more than the 5-yr old trees. Ethephon at 1000 and 2000 ppm significantly reduced shoot growth below control trees (Table 4).

Table 3. Effect of ethephon on the % trees flowering and number of flower clusters per tree of young apple seedlings, 1971.[z/]

Ethephon (ppm)	Date of Application (1970)	Age of Seedlings in 1970			
		4 years		5 years	
		Flowering (%)	No. flower clusters	Flowering (%)	No. flower clusters
0	--	40	8	11	6
1000	May 26	89**	122**	22**	31*
1000	June 11	67**	42*	56**	11
2000	May 26	100**	96**	44*	12
2000	June 11	78**	41*	67**	40*

* Statistical significance, P = 5%.
** Statistical significance, P = 1%.
z/ Data are means for 9 trees of each age class per treatment.

Table 4. Effect of ethephon on the mean shoot growth of apple seedlings, 1970.

Ethephon Treatment (ppm)	Date of application (1970)	Mean shoot growth (cm) Age of seedlings in 1970	
		4 years	5 years
0	--	29.8	35.1
1000	May 26	24.9*	28.7*
1000	June 11	25.2*	30.9
2000	May 26	21.9**	23.6**
2000	June 11	21.9**	24.4**

* Statistical significance, P = 5%.
** Statistical significance, P = 1%.

Since gibberellins inhibit flower bud initiation in fruit plants, it may be likely that ethephon in stimulating flowering in these studies acted as a gibberellin antagonist as suggested by Monselise (1). Zimmerman (4) has proposed that factors influencing the flowering of young seedlings may be acting not on a juvenile tree but rather on one in a post-juvenile, transitional stage. If ethephon acted as an anti-gibberellin it is not likely that the juvenile stage was influenced but a postjuvenile period prior to first flowering (readiness to flower). Unfortunately it was not possible to distinguish between these 2 phases. Nevertheless, ethephon shows promise as a means to reduce the time from seed germination to the first flowering of apple seedlings. If combined with other techniques (2) it may also further enchance the efficiency in apple breeding programs.

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Cultural Management of Pine Voles in Apple Orchards[1]

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Abstract. **Pine vole, *Microtus pinetorum* LeConte, activity in an apple orchard was reduced by cultivation of a 4 m-wide strip down the tree row. Bare-ground-culture using a single annual application of Simazine plus Amitrol (1964-71) or Paraquat (1972-73) herbicide for 10 years reduced pine vole activity.**

Pine vole damage to apple tree stems and large roots is a major cultural problem in orchards of the central-eastern U.S. The pine vole is adapted to a wide range of habitats covering at least 22 eastern states and Ontario. The animal is subterranean and exists in a tunnel system horizontally beneath that of other species. The ideal pine vole habitat includes a diversity of ground cover plant material, ground cover height 20-30 cm, grass density of 60-100%, adequate soil moisture for burrowing, thick litter, uniform soil temp and sparse or adjoining deciduous shrub or tree stands (1, 4). This study was initiated to determine if the orchard habitat could be sufficiently altered to have a marked influence on pine vole activity.

The experiment was conducted in a 14 year-old orchard near Batesville, Virginia planted 5 x 8 m. The Smitty Tree Hoe was used to cultivate 3 replicate plots of 40-45 trees each (approx 6 rows wide and 7 trees long). Comparison was made to 3 replicates of an uncultivated control where normal orchard practices were followed. Cultivations were performed May 8, July 2, and Nov. 21, 1973. The treatment effect was monitored using techniques developed by Horsfall (2). One activity site was established 5-15 cm below the soil surface in a pine vole tunnel at each of the interior 20-24 trees of each replicate. An apple with 2.5 cm sector removed from the cheek was placed at each site. All sites were covered with a rubber mat approx 0.15 m^2 weighing 2-3 kg. Twenty to 24 hr after placement, the apples were observed for characteristic vole tooth marks. The site was designated as highly active if a semi-sphere of 2.5 cm was removed from the apple in 24 hr. Apple consumption less than this was recorded as slightly active. The sum of slightly and highly active sites is presented as active sites per tree (Table 1). Sites in the cultivated area became progressively more difficult to find because of the destruction of the surface tunnel system and the collapse of abandoned tunnels in the undisturbed areas adjacent to the trunk. The no. of active sites per tree in the cultivated area rose to .21 to .30 during October and November 1973, respectively. Cultivation Nov. 21, 1973 reduced the activity to .08 by Dec. 4 and good control remained throughout the winter months.

Simazine at 4.5 kg ai/ha (4 lb./acre)

[1]Received for publication April 8, 1974. Grateful acknowledgement is made for the assistance of C. Y. Kramer, Professor of Statistics, V. P. I. and S. U., Blacksburg, for analysis of data. The partial support of the Virginia Agricultural Foundation was greatly appreciated.

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Table 1. Effect of cultivation by a Smitty Tree Hoe on pine vole activity.[z]

Treatment	No. of trees	Date of observation									
		May 8	May 15	June 26	July 13	Aug. 18	Oct. 16	Nov. 21	Dec. 4	Jan. 8	Mar. 26
		No. sites[x] found per tree									
Cultivated[w]	66	.99 a	.91 a	.91 a	.70 a	.80 a	.79 a	.91 a	.79 a	.85 a	.83 a
Uncultivated	70	.97 a	1.00 b	.99 b	.93 b	.90 b	.97 b	.92 a	.97 b	.97 b	.97 b
		No. active sites[y] per tree									
Cultivated[w]	66	.66 a	.46 a	.27 a	.10 a	.07 a	.21 a	.30 a	.08 a	.11 a	.03 a
Uncultivated	70	.73 a	.94 b	.50 b	.43 b	.37 b	.50 b	.86 b	.89 b	.96 b	.97 b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

[y]All sites having characteristic vole tooth marks on an apple placed in the run or hole approx 24 hr previous.

[x]A site refers to a vole run or hole below the soil level which appeared to be active. A limit of one site per tree was imposed for each observation date.

[w]Cultivations made May 8, July 2, and Nov. 21, 1973.

plus Amitrol (1964-71) at 1.11 kg ai/ha (1 lb./acre) or Paraquat (1972-73) at 0.56 kg ai/ha (0.5 lb./acre) was applied annually for 10 years to 4 replicates of 4 trees each in a single tree row width band presently 4 m wide. Presumably the orchard was not infested with voles when herbicides were first applied. In Nov. 1973 each tree was examined for vole runs, holes, and underground tunnels and 2 sites were established at each tree on opposite sides of the trunk where a vole tunnel system could be found (Table 2). An apple was placed in each site and all sites having characteristic vole tooth marks on apples were recorded after 24 hr. Victor house mouse traps were then placed at these sites for 4 days. Pine voles were removed once daily and no other animals were taken in the traps. All vole activity and catches in the herbicide treated plots were made at tree numbers 1 and 4 which were directly adjacent to the untreated controls in the same row. Considerable root suckering was apparent around most all trees with some leaf and other litter existing near the tree trunk even in the herbicide treated plots. Activity found at trees 1 and 4 of the herbicide treated plots was within about 1 m of the untreated control. No holes or activity were found in these root sucker areas near the tree trunks in the treated plots. Plots of other herbicide treatments in the same orchard in which bare soil was not completely maintained were infested with pine voles to varying degrees depending on the width of the strip, the level of vegetation control and litter existing in the tree row. In the same apple planting the grower had cultivated once in early summer and applied a narrow band (2 m wide) of paraquat and simazine in mid-June 1973. Pine voles burrowed underground from the trunk to the vegetation bordering the herbicide strip and did some damage to trees in the 1973-1974 winter. Evidence of vole nests and underground tunnel systems near the tree trunk were easily found. The vole surface tunnels in the bordering vegetation strip became deeper and were subsurface from the edge of the herbicide strip to the tree trunk.

Both cultivation and herbicide techniques have advantages and disadvantages in altering pine vole habitat. Cultivation destroyed the surface tunnel system where 70-80% of the tunnels existed and destroyed some nests, voles, food supplies, and cover. After harvest, cultivation incorporated fallen tree leaves into the soil which would normally create a winter mulch, and cut up the dropped apples. Herbicides, however, did not disturb the tunnel or nesting systems, did not control all the vegetation, and did not control an existing vole population.

Ground cover sprays of rodenticides have proven to be an excellent method of pine vole control in some orchards (2). The effectiveness of these sprays has been shown to be dependent on the type of orchard ground cover, timing, and application techniques (2, 3). The destruction of the ground cover under the tree with herbicides or cultivation methods may inhibit the effective use of ground sprays for mouse control, since the toxicants must be ingested with the ground cover plant material. However the ground cover spray may be applied adjacent to the bare-ground strip where a surface feeding system is evident.

The cultural control of voles is dependent on destruction of the habitat (cover, food supply, surface tunnel system, etc.), and we believe the vole population equilibrates at the point of starvation with the remaining habitat after each cultivation. During the spring, summer, and fall seasons plant growth, ground cover and tree leaf mulches develop an ideal habitat so that the existing vole population can re-establish itself within a few months. For this reason we believe cultivation after leaf drop to be most important so that plant growth and mulches do not create a vole habitat before the winter tree damaging period.

Table 2. Effect of herbicides applied annually for 10 years on pine vole activity in Nov. 1973.

Treatment	Total no. of trees	Tree no. in each replicate				Avg
		1	2	3	4	
		No. sites[z] found per tree				
Control	14	2.00	2.00	2.00	1.75	1.96
Herbicide	15	0.75	0.00	0.00	0.75	0.40
		No. active sites[y] per tree				
Control	14	1.00	1.75	1.50	1.75	1.50
Herbicide	15	0.25	0.00	0.00	0.25	0.13
		No. voles caught per tree				
Control	14	1.50	1.50	1.50	2.00	1.64
Herbicide	15	0.50	0.00	0.00	0.25	0.20

[z]A site refers to a vole run or hole below the soil level which appeared to be active. A limit of 2 sites per tree was imposed.

[z]All sites having characteristic vole tooth marks on an apple placed in a run or hole approx 24 hr previous.

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