Table 1. Effects of pine vole damage on yield, fruit size, and fruit grade of 3 apple cultivars.

Cultivar Condition	Yield-(bu[z]/tree)	Fruit size: Mean wt (g)	Fruit size: % < 6.4 cm	Fruit grade distribution (%): Fancy	Fruit grade distribution (%): U.S. No. 1	Fruit grade distribution (%): Utility	Avg. price per bu[z]	Gross return per tree
McIntosh								
Damaged	3.9a[x]	93.3a	54.1a	56.0a	39.4a	4.5a	$4.43a	$17.29a
Visually undamaged	5.6a	122.5b	10.2b	36.9b	51.1b	11.9b	$4.92b	$27.57b
Delicious								
Damaged	5.3a	145.2a	16.2a	73.2a	18.9a	7.9a	$5.77a	$30.56a
Visually undamaged	9.0b	154.2a	12.3a	70.5a	24.5a	5.0a	$5.92a	$53.25b
Rome Beauty								
Damaged	5.5a	117.9a	28.0a	77.8a	16.4a	5.8a	$4.90b	$26.95a
Visually undamaged	10.0b	176.9b	3.2b	36.9b	39.9b	23.1b	$4.65a	$46.54b

[z]1 bu = 18.2 kg.

[x]Mean separation for each cultivar by Duncan's multiple range test, 5% level.

pletely girdled, or that were so low in vigor that survival through the next year seemed unlikely, were avoided. The damaged trees were examined in detail to eliminate other factors, such as crown rot, N deficiency, and winter injury, that might cause leaf symptoms similar to vole damage.

Each of the 3 cultivars was examined for differences in fruit yield, size, and grade (Table 1). The yield was determined by counting the number of bushels harvested per tree and 10% of the fruit from each tree was weighed and graded according to New York State Department of Agriculture and Markets standards. There were significant losses in yield from pine vole damage in 'Rome Beauty' and 'Delicious' and significant reductions in fruit size in 'Rome Beauty' and 'McIntosh'. Fruit from pine vole damaged trees of 'McIntosh' and 'Rome Beauty' had better color than fruit from unaffected trees. Low vigor, and the related sparse foliage, permitting better light exposure of the fruit, are the probable explanations for the better color of fruit from vole-damaged trees. The average per bushel value was calculated from the % in each of 4 categories (U.S. No. 1 – 100's, 120's, and 140's; U.S. No. 1–12/3 poly bags; utilities; and ciders) and the market value of each. On the basis of color alone, the per bushel value of fruit from vole-infested trees was slightly higher than that from unaffected trees. However, with the exception of 'Rome Beauty', this effect was more than offset by the negative effects on fruit size. Reductions in yield further reduced the returns from pine vole-damaged trees.

Tree vigor was evaluated by measuring 30 terminal shoots, selected at random, around each tree. Pine vole-damage reduced extension growth by 38%, 59% and 36% for 'McIntosh', 'Delicious' and 'Rome Beauty', respectively. Shoot growth measurements might provide a simple technique for early evaluation of the degree of damage and the rate of recovery or decline in successive seasons.

On the basis of fruit grade alone, there was little difference in dollar value of fruit from damaged or unaffected trees. However, reductions in fruit size and yield resulted in significant dollar losses. These losses should be added to the other expenses involved in replacing and repairing trees damaged by pine voles. These costs can give the grower, chemical industry, and government regulatory agencies a better understanding of the pine vole problem, and a more accurate basis for evaluation and registration of various pine vole control measures.

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Breaking Bud Rest on Detached Apple Shoots: Interaction of Gibberellic Acid with Some Rest-breaking Chemicals[1]

Edilson Paiva[2] and Henry Robitaille

Department of Horticulture, Purdue University, West Lafayette, IN 47907

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Abstract. **The effectiveness of rest-breaking chemicals on detached shoots of apple (*Malus domestica* Borkh.) was dependent on the stage of bud rest at the time of chemical application. Thiourea (TU) and dinitro-ortho-cresol (DNOC) improved budbreak on September 9, the addition of gibberellic acid (GA_3) to either chemical having no additional effect. On September 23 only DNOC was effective, and its effectiveness was increased with addition of GA_3. DNOC + GA_3 was the only effective treatment on both October 9 and October 25 at the start of the deep rest period. TU + GA_3 improved budbreak on November 11, but no treatments were effective on December 4 and December 20. On January 14, as rest weakened, GA_3 alone or in combination with DNOC effectively improved budbreak. By February 5, budbreak on control shoots was good and treatment effects were not significant.**

The use of chemicals to break rest of deciduous fruit trees has been reviewed recently (2). Combinations of TU, KNO_3, and oil + DNOC emulsions significantly improved apple budbreak when applied at the end of insufficiently cold winters (2). The effectiveness on apple of DNOC, usually applied as an oil emulsion, was established as early as 1945 (6). GA_3 (3) as well as a GA_4 + GA_7 mixture (9) were reported as having no effect on breaking apple bud rest. In another study GA_3 replaced the chilling requirement of peach but not of apple buds (8). However trees may have received insufficient chilling prior to treatment, since GA_3 stimulated pear bud development only after the rest period had been partly broken by winter chilling (1). The importance of monitoring rest when reporting experiments on dormancy has been stressed (7). This study was undertaken to study the interaction between GA_3 and some rest breaking chemicals and the time of their application on termination of apple bud rest.

Uniform shoots were collected from

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[2]Present address: UEPAE/Brasilia, Caixa Postal 040-05/7, 70.000 Brasilia – DF – Brasil.

'Golden Delicious' apple trees at the Purdue Horticulture Farm on 10 dates between Sept. 9, 1976 and March 5, 1977. Leaves were removed manually through Oct. 9. Segments of 30 cm were obtained by cutting each shoot at 10 and 40 cm from the terminal bud. Chemical treatments were applied by soaking shoots for 3 min in aqueous solutions of 0.03% (300 ppm) GA_3, 2% TU, 2% TU + 0.03% GA_3, 0.2% DNOC, 0.2% DNOC + 0.03% GA_3, 2% KNO_3, 2% KNO_3 + 0.03% GA_3, and the 2 control treatments distilled H_2O, and 1% ethanol (used to dissolve GA_3). Each solution included 0.1% (by vol) Tween 20. These treatments were selected on the basis of results of preliminary experiments conducted the previous year. Five shoots per treatment were tested at each sampling date. Treated shoots were then held individually with their bases in distilled H_2O in 25 ml vials completely randomized in a growth chamber at 26°C, 16 hr photoperiod, and 43 klx. Exposed cuts were sealed with grafting wax to prevent dessication, and the water in the vials was changed every 3 days. Data, collected at 15 days, was expressed as the % break of the 8 lateral buds on the shoots above the tops of the vials. Commencement of leaf emergence through the bud scales signified budbreak.

Rest as a function of sampling date, in buds on control shoots, can be followed in Fig. 1. A 50% budbreak occurred between Sept. 9 and Oct. 9, before buds descended into a deep rest between Oct. 25 and Dec. 20, a period when only the uppermost buds developed. The uppermost 1 and occasionally 2 buds developed at all sampling dates, probably as a result of the apical cut (5, 7). After Dec. 20 budbreak gradually increased until rest was terminated shortly after March 5. Data accumulated between Sept. 9 and Oct. 9 may have been influenced by leaf removal, since it has been shown that rest can be circumvented by leaf stripping (4).

On Sept. 9 all treatments but GA_3 alone increased budbreak. On Sept. 23 only DNOC and DNOC + GA_3 increased budbreak, with the latter more effective. On Oct. 9 and Oct. 25, DNOC + GA_3 was the only effective treatment. Leaves were not manually removed on Oct. 25. TU + GA_3 was effective on Nov. 11, but no treatments improved budbreak on Dec. 4 and Dec. 20. On Jan. 14, as rest weakened, GA_3 alone

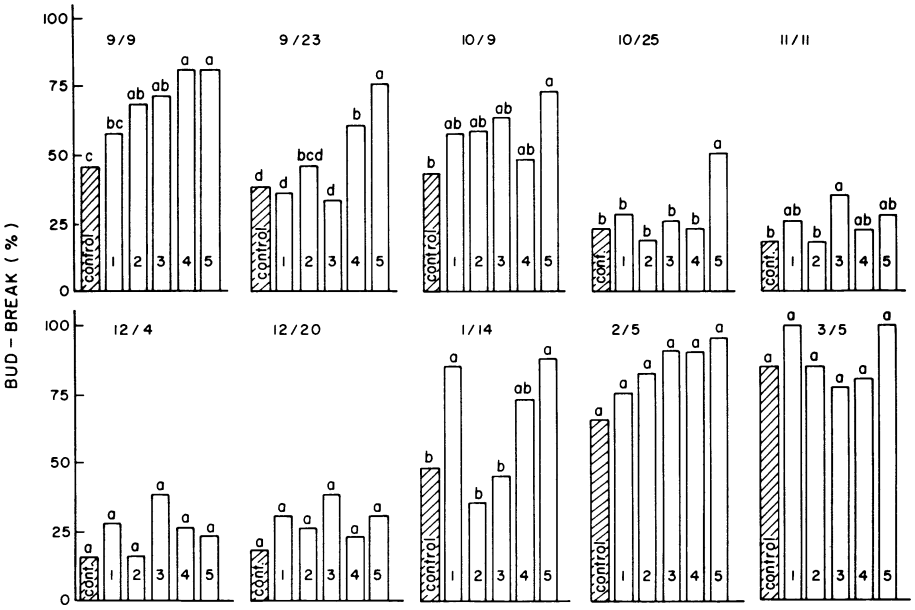

Fig. 1. Effectiveness of: 1) GA_3, 2) thiourea (TU), 3) TU + GA_3, 4) dinitro-ortho-cresol (DNOC), and 5) DNOC + GA_3 in stimulating budbreak on Golden Delicious apple shoots at various sampling dates during the rest period. Mean separation by Student-Newman-Keuls' multiple range test, 5% level.

or DNOC + GA_3 were very effective in increasing budbreak. On Feb. 5 budbreak on control shoots was such that no treatment effects were significant. Treatments with KNO_3 alone or in combination with GA_3 were never significant. The ethanol controls were identical to the distilled water controls at each sampling date.

No treatments resulted in satisfactory budbreak during deep rest, although DNOC + GA_3 on Oct. 25 and TU + GA_3 on Nov. 11 did significantly improve budbreak. DNOC + GA_3 was the most consistently effective treatment during the period preceding deep rest, resulting in improved budbreak when applied between Sept. 9 and Oct. 25. DNOC + GA_3 was also effective immediately after deep rest on Jan. 14. GA_3 alone was only effective immediately after deep rest, confirming the results of an earlier study on pears (1). The data suggest that DNOC, TU, or chilling were required to break bud rest before GA_3 could act to speed rate of bud development sufficiently to induce visible budbreak by day 15.

Our work re-emphasizes the fact that although these chemicals do increase budbreak on insufficiently chilled apple shoots, knowledge of the stage of bud rest at the time of their application is vitally important. Treatment application at the wrong stage will result in no benefit and, especially with GA_3, considerable monetary loss.

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