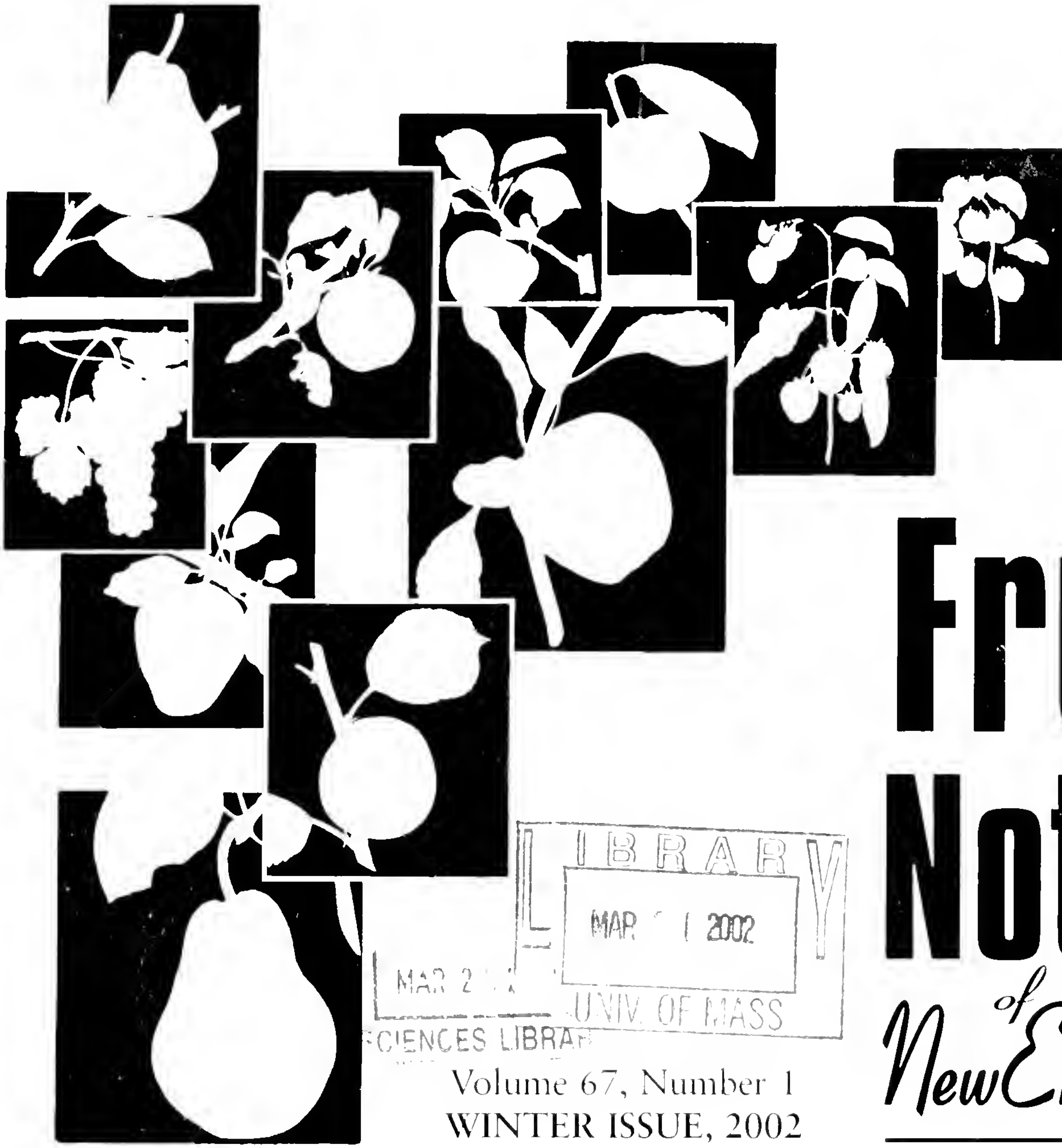

Fruit Notes of New England

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Fruit Notes of New England

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Apple-pomace Compost and Pre-plant Monoammonium Phosphate for Improving the Growth of Newly Planted Apple Trees

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Hudson Valley Laboratory, Cornell University

In many orchards in the Northeast, early yield is limited by tree growth, and trees are typically not cropped until the third or fourth season because growth is not vigorous. Management practices that encourage rapid early tree growth and early fruit production result in economic advantages to growers by hastening a return on investment. Decreasing the time required for trees to fill their space would allow growers to increase early yields.

Increasing early tree growth can be accomplished by adding organic matter or phosphorus fertilizer to the planting hole. Adding compost as a source of organic matter to planting holes affected young apple tree growth in experiments in Massachusetts and Maine. Organic matter is often low in many existing orchard soils. Increasing soil organic matter improves its water and nutrient holding capacities, which enhances root regeneration and promotes overall tree vigor, but the effects of planting-hole treatments are most visible during the year of planting. As root growth extends beyond the volume of the planting hole, the effects of planting-hole treatments diminish. If organic matter amendments were broadcast throughout the orchard soil, perhaps the beneficial growth response could be sustained for a longer period. For pre-plant compost to be a feasible management practice, an economical, local source of compost must be available. University of Maine Cooperative Extension developed an apple-pomace composting project in cooperation with Chick Orchards in Monmouth, Maine. Apple pomace from the cider operation was mixed with leaf waste from the local waste transfer station, and chicken manure from a local egg farm at a 2:6:1 ratio by volume. Wood ash was used to adjust the pH to 5.8 prior to composting. Composting reduced the volume of apple-pomace waste by 50% and converted it into a soil amendment with highly desirable characteristics.

Newly transplanted trees have impaired root systems, so P fertilizer is often recommended for new plantings. Since P is very immobile in soil, this nutrient is more beneficial when it can be incorporated prior to planting. Research in British Columbia has shown that monoammonium phosphate (MAP 11-55-0) fertilizer, incorporated into the soil used to fill the planting hole, increased tree growth in the first 2years after planting and increased flower production and fruit set in the early years of the planting. The addition of MAP to the planting hole has become a common practice in B.C. orchards, especially when replant problems are anticipated. It has been suggested that root uptake or utilization of P may be more efficient in the presence of ammonium. Moreover, MAP could be influencing tree growth by providing N. This study was performed to determine if pre-plant-incorporated apple-pomace compost and MAP, either alone or in combination, would improve early apple tree growth and precocity.

Methods

This experiment was conducted at Highmoor Farm in Monmouth, Maine, on land which had been fallow for 6 years, but in continuous apple production for the previous 37 years. The soil was a fine sandy loam, with a pH of 6.8 and an organic matter content of 4.7% before the addition of fertilizer or compost. Macoun/B. 9 apple trees were planted using a tractor-mounted tree planter on May 1, 1998 into plots that had received one of the following combinations of pre-plant treatments: 1) urea fertilizer without compost; 2) MAP fertilizer without compost; 3) both compost and urea; and 4) both compost and MAP. Each plot consisted of three trees at a spacing of 6 feet between trees and 18 feet between rows. Cortland/B. 9 trees were planted as a buffer between plots. Prior to planting, MAP was applied to the plots at a rate of 332 lbs. per acre and urea at a rate of 79 lbs. per acre, so that each treatment received an equivalent amount of N (1.44 oz. per tree). Apple-pomace compost was spread over the planting strip and leveled to a uniform thickness of 4 inches. All plots were then roto-tilled to a depth of 6 inches. The trees were unfeathered whips, headed to a height of 28 inches at planting. The trees were attached to a galvanized conduit stake supported by a single wire at 7 feet. The trees were minimally pruned, and trained to the vertical axis system. Insecticides, fungicides, and herbicides were applied as needed.

Results

Tree growth was increased by compost, but not by MAP. Compost increased trunk diameter in the first two seasons, but by the third season, trunk diameter was similar in both plots (Figure 1). Annual shoot

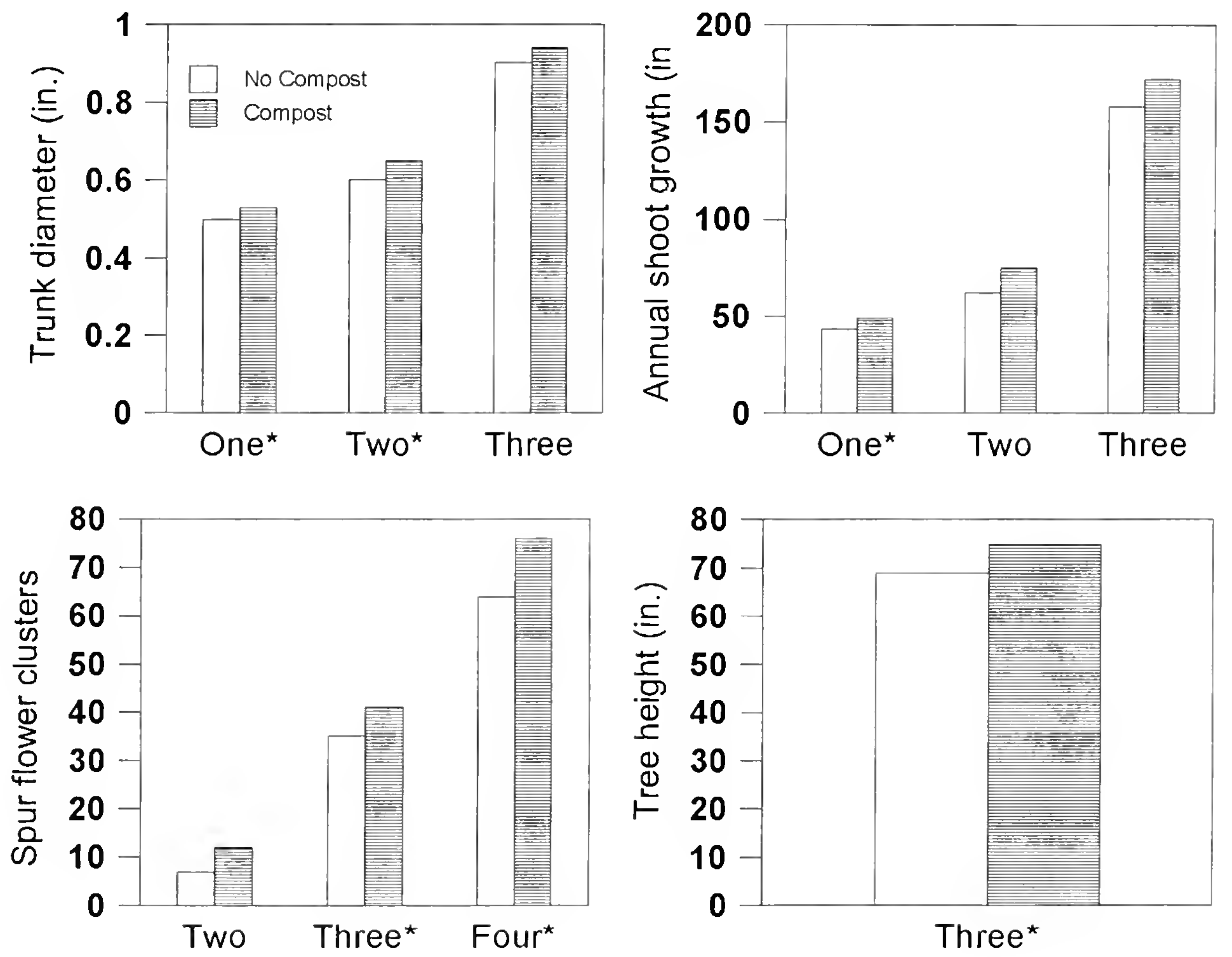

Figure 1. Tree growth characteristics with and without pre-plant-incorporated compost. * Indicates that compost had a significant effect in the indicated year after planting.

Table 1. Orchard soil properties following soil incorporation of phosphorous or apple pomace compost (year of planting).

Treatment	pH	Organic matter (%)	P (lbs / acre)	K (lbs / acre)	Mg (lbs / acre)	Ca (lbs / acre)
Urea	6.4	4.5	9.9	285	291	2144
MAP	6.4	4.4	13.0	272	301	2071
Compost-Urea	6.9*	5.3*	79.6*	679*	496*	3258*
Compost-MAP	6.8*	5.6*	86.8*	612*	457*	3093*

* Indicates a significant effect due to compost, at odds of 19 to 1.

growth was increased by compost in the first season, but not significantly in the second or third season. By the third season, tree height was greater with compost. Compost increased the amount of bloom. MAP had no effect on trunk growth, shoot growth, number of growing points, or tree height in any season of the study. We were unable to determine if the increases in tree size and flowering were large enough to increase early yield, because the trees did not attain sufficient size to permit cropping until after the third growing season. The trees in this study were on B.9 rootstock, which is less vigorous than M.9 EMLA, and may be insufficiently vigorous for spur-type varieties such as Macoun in northern New York and New England.

Tree growth was increased by pre-plant-incorporated apple-pomace compost, similar to results of other studies that showed organic matter added to the planting hole increased shoot growth and trunk girth. In those studies, the effect of planting hole treatments was no longer evident by the second or third season, and this result was attributed to roots growing beyond the planting hole. In our study, the effect of pre-plant organic matter on trunk diameter and shoot growth also diminished with time. The diminished effects observed in our study were possibly due to the depletion of soil K, Mg, and Ca (data not shown). Soil K in the compost plots was twice as great as in non-compost plots, but this difference was much smaller by the third season. Although trunk and shoot growth differences diminished with time,

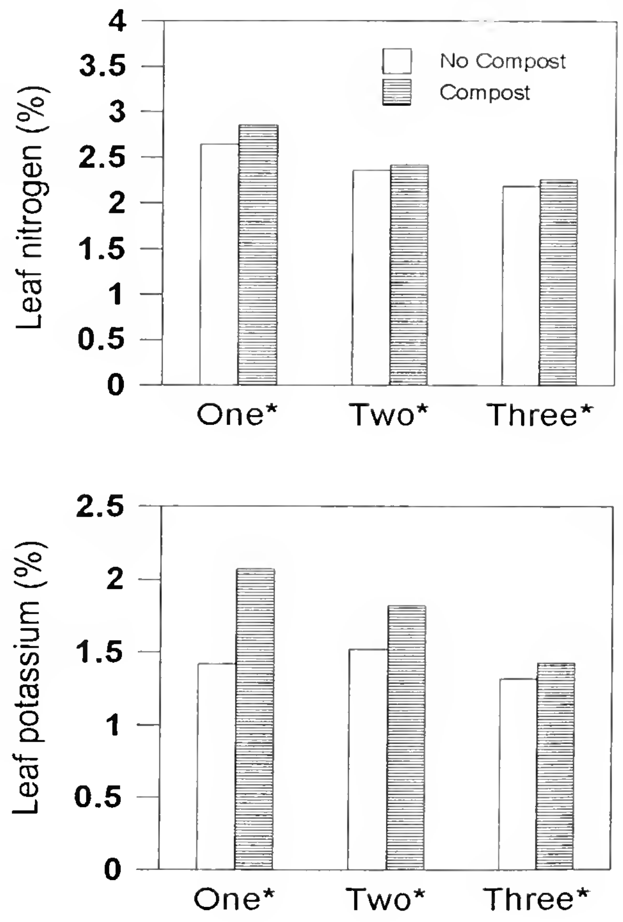

Figure 2. Leaf nitrogen and potassium with and without pre-plant-incorporated compost. *Indicates that compost had a significant effect in the indicated year after planting.

the greater tree height and bloom were evident in the third season indicating that the cumulative effect of compost on tree size was not short-lived.

Soil fertility was enhanced by the addition of compost, but little influenced by the addition of MAP, as shown for the year of planting in Table 1. The addition of compost resulted in higher soil pH and cation exchange capacity in each of the three seasons after planting, compared to the plots without compost (data not shown). Compost increased both soil organic matter and P, while MAP and urea had no effect. Compost also increased soil Mg, Ca, and K.

Compost increased tree growth and flowering by improving soil fertility and tree nutrient status, and most likely, by increasing soil water holding capacity and soil aeration. An increase in the water holding capacity of the soil would have been advantageous in 1998, when the newly planted trees were generating new roots to replace those lost in transplanting, and in 1999, a season in which little precipitation occurred before September. Foliar nutrient status was favorably affected by compost (Figure 2). Compost increased leaf N and K compared to trees in plots without compost in all three seasons after planting. Leaf P and Ca were not affected by compost. There was no difference between urea and MAP in their effect on leaf N or K, or leaf P, Ca, or Mg. Compost decreased leaf Mg in the first season after planting, but had no effect in the second or third season. The large increase in soil K following compost incorporation may have interfered with Ca and Mg uptake, so that even though soil Ca and Mg were greater, foliar levels were not. Leaf micronutrients were not affected by any of the pre-plant treatments.

Pre-plant incorporation of P fertilizer had no effect on tree growth or flowering in this study. In British Columbia, P fertilization previously has been shown to increase flowering when it results in greater leaf P. In our study the soil level of P was within the optimum range before treatment, and was increased to above optimum by compost. Although the level of P in the soil was increased with compost, there was no increase in foliar P. These results are consistent with most previous studies in showing no benefit from P fertilization for apple.

Conclusions

Pre-plant compost incorporation was more effective than P fertilization for increasing tree growth during the establishment years. The practice of adding P to the planting hole may not be appropriate for Northeastern sites, particularly those where the soil test indicates that P is adequate before planting. Soil incorporation of compost increased tree growth and flowering into the third year after planting. This was most likely due to improved N and K status of the trees, and through improved soil aeration and water-holding capacity. Our results suggest that trees planted in soil amended with apple-pomace compost would potentially fill their space more quickly and be able to support more fruit growth in the first years of cropping.

Acknowledgements

This project was supported in part by a grant from the New England Tree Fruit Growers Research Committee. The authors wish to thank Chick Orchards for supplying the compost, and the technical staff at Highmoor Farm for their assistance with this research. Special thanks go to John McCue, Sheri Koller, and Michelle Handley for maintaining this project during the transition between project leaders.

* * * * *

Development of a Model for Predicting Flyspeck Risks in Blocks of Apple Trees

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University of Massachusetts

For several years, we have been working toward the elimination of summer fungicide applications in apple orchards. The positive economic and environmental impacts of achieving this goal are considerable. Unfortunately, in the absence of fungicides, the severity of flyspeck disease, and to a lesser extent sooty blotch, can be significant. In apple trees which are not sprayed in the summer, flyspeck incidence varies dramatically, from barely existing in some blocks of apple trees to infesting more than half the fruit in others.

How do we decide which trees need spraying and which do not in a given year or month? We know that the flyspeck fungus needs very high relative humidity (97-100 %) to develop. By tracking leaf wetness, rainfall, relative humidity, and temperature we can estimate when specks will first show up in unsprayed trees in or near an orchard. We can also estimate when spray residues will be removed from apple trees by rain, thanks to studies performed by Dave Rosenberger at Cornell University's Hudson Valley Laboratory. It remains a challenge, however, to estimate severity of symptoms at harvest for a given block of trees.

Certain characteristics of blocks of apple trees, such as slope, relative altitude in the orchard, and spacing of rows and alleys are likely to influence air drainage and relative humidity in the blocks. The size and openness of tree canopies will also affect the humidity surrounding an apple. The consensus among plant pathologists working with apples is that the inoculum for flyspeck disease overwinters on the waxy cuticle of alternate host plants like blackberry, oak, grape, and maple in wooded or shrubby borders near the apple trees. Within the orchard block, flyspeck does not colonize apple twigs. Flyspeck that grows on fruit is removed at harvest or decays over the winter on drops. The orchard border is home to over 100 species that maintain waxy cuticle suitable for flyspeck and sooty blotch over a 12-month period on first year growth.

Many relationships involving the block and the borders seem worthy of investigation. Number and size of borders around a block, distance between a block and its borders, density of alternate host plants in the borders, and density of the fungus on those hosts might all have significant impacts on summer diseases in fruit at harvest. We study these factors and their relationships to flyspeck disease development in order to create a predictive model to help growers safely reduce fungicide inputs.

We reported on the first part of this study in the Spring 1996 issue of *Fruit Notes*. This experiment took place in six orchards over the 1995 and 1996 growing seasons. In each orchard, pairs of similar blocks of apple trees were chosen. Some orchards dedicated as many as 13 pairs of blocks to this experiment. At each orchard, one block received no fungicide after primary scab season (approximately June 15), while the other block was managed according to the grower's preferences using standard first-level IPM. Flyspeck incidence was recorded weekly by examining 200 fruit in each block from late-July through mid-September. For each block, the following orchard site characteristics were evaluated and compared statistically to the flyspeck incidence or severity data: slope of the ground, relative elevation of the block compared to other blocks in the orchard, closeness of shrubby or wooded borders to the apple trees, density of a major alternate host plant in the borders (blackberry), severity of flyspeck infestation on those host plants, and density of apple tree canopies.

Table 1 lists the orchard site factors that had the greatest effects on the flyspeck counts that were done in the in 2-week period leading up to harvest in 1995 and 1996. Unless otherwise noted, analyses for this report were performed on data from the blocks which

Table 1. Characteristics of blocks of apple trees or adjacent wooded or shrubby borders that positively affected the amount of flyspeck on apples: in order of significance.

August 20 through harvest 1995	August 20 through harvest 1996	August 29 through harvest 1995, 1996, 1998, and 1999
1. Lack of slope of block	1. Density of flyspeck on brambles in border	1. Density of flyspeck on border host plants
2. Low relative elevation within the orchard	2. Lack of slope of block	2. Number of borders
3. Height of apple trees		3. Closeness of apples to borders
4. Density of brambles in border		4. Lack of slope of block
5. Closeness of apple trees to a border		

received no summer fungicide. First-level IPM blocks did not have enough flyspeck to analyze. In 1995, there were more flyspeck symptoms in blocks that were relatively flat than in steep-sloped blocks (r^2, or amount of variation explained, was 0.17, or 17%), and the amount of flyspeck was higher in blocks that were relatively low in elevation within the orchard (r^2 = 0.12). Other factors that had positive but less significant impacts ($r^2 < 0.03$) were height of apple trees, proximity of apples to border areas, and density of host-plants in the borders.

In 1996, the significant site factors (Table 1) were density of flyspeck on host-plants in borders ($r^2 = 0.13$), lack of slope of the block ($r^2 = 0.05$), and height of the apple trees ($r^2 = 0.04$). The factors which contributed only marginally to explaining the variability in flyspeck incidence ($r^2 < 0.03$) were number of borders adjacent to a block of apple trees and proximity of brambles in the borders to the apples.

In summary, the site factors that were the most important during 1995 and 1996 (explained at least 10% of the variability) were **slope** and relative **elevation** in 1995 and **density of flyspeck** on host-plants in borders in 1996.

In 1997-1999, a different group of blocks was evaluated for site factors and flyspeck infection. In this experiment, two of the key factors were planting density/tree size and IPM level. A main objective of the study was to evaluate the effectiveness of the range of IPM strategies that had been developed using fairly large semi-dwarf trees on plantings that included dwarf trees at high densities. Each of eight participating orchards provided two blocks of low density/large trees, two blocks of medium density/medium-sized trees, and two blocks of high density/small trees. The blocks that had the same planting density were divided into two groups: half were managed with first-level IPM strategies and half with "third-level" IPM strategies. The progression to third-level IPM was marked by the integration of advance pest-management strategies with horticultural strategies at the level of the whole orchard. The third-level blocks, which were seeded with beneficial mites and were managed with biologically-based third-level strategies for insects, received reduced rates or frequencies of fungicide applications, little or no EBDC fungicide, and only captan or benomyl after June 15. The first-level blocks were managed with the growers' choices of materials and frequencies of application. The blocks within a pair were not contiguous. They were often at either end of a long section of 'McIntosh' or 'Cortland' rows and were bordered by a wide variety of habitats. Some of the 48 blocks were surrounded by other rows of apple trees, some by grassy fields, others by dense woods or shrubby hedgerows.

During each growing season, the blocks and their surrounding borders were rated for static orchard factors which had proved significant in the earlier study.

These included: number of borders potentially influencing flyspeck development in an orchard block, distance between the trees and the borders, severity of flyspeck in alternate host plants in the borders, density of host plants themselves, foliar density of trees, height and diameter of tree canopies, slope and relative elevation of the block with respect to the orchard as a whole, and planting density of the block (no. trees/ acre). We examined all known host plants (from the ground to 6 ft. above ground), not just blackberry. Apples in the adjacent blocks were examined weekly or bi-weekly from mid-July to harvest.

At the end of each growing season we looked at the effect of each of the above-mentioned site factors (and all factors combined) on the amount of flyspeck on the apples, to begin deriving a predictive model for flyspeck incidence at harvest. Preliminary stepwise regression analyses done separately for each year suggested the importance of four variables: **density of flyspeck on alternate host plants in the borders, number of borders, distance from apples to border, and slope of the block**. The other site factors did not explain substantial amounts of the variation in flyspeck incidence.

Combining data collected from unsprayed control trees from the years 1995, 1996, 1998, and 1999, we conducted a preliminary assessment usingg flyspeck incidence data from various dates. Data from 1997 were not used, because all blocks received summer fungicide sprays. Dates at or near harvest varied from year to year primarily due to cultivar and weather factors. Ultimately, we decided on a range of dates allowing maximum inclusion of orchards in the data set. Data from harvest or near-harvest ranged from 29 August to 23 September for the 4 years used in the analysis.

We concluded the static factor phase of model building by combining these four independent variables with the most inclusive range of harvest dates and a fifth derived variable, inoculum index. Inoculum index was expressed as the product of amount of flyspeck on alternate host plants and the density of those plants in

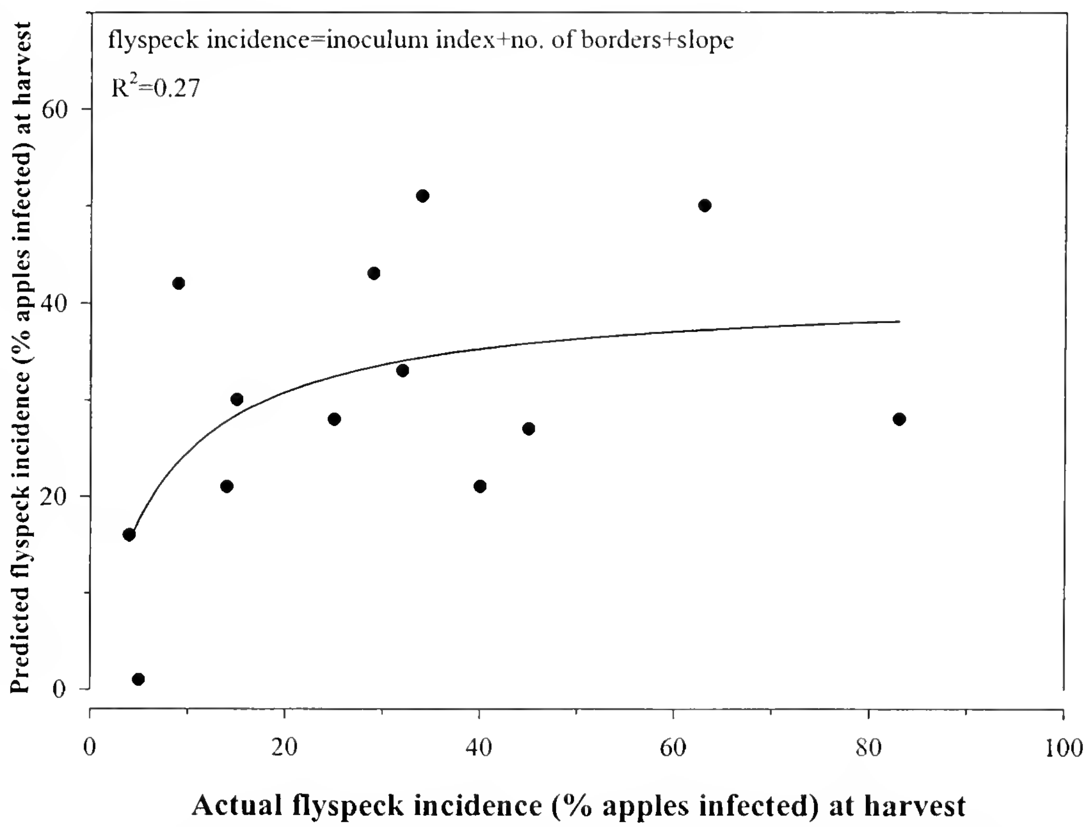

Figure 1. Predicted versus actual flyspect at harvest in Massachusetts orchards, 2000.

orchard borders. The best flyspeck prediction model included inoculum index, number of borders, and slope. We applied the model parameters derived here to flyspeck incidence at 13 orchards in 2000 and compared the resulting predicted values with observed flyspeck incidence. The best-fit regression for the data (R^2=0.27) is presented in Figure 1. Given the high "background noise" of variability in this kind of investigation (different years, orchards, blocks, sizes of trees, cultivars, pruning regimens, types of borders, etc.), we were gratified to see almost 30% of the variability in flyspeck incidence explained by these three site factors.

We applied the same model in 2001 to predict flyspeck in 11 of the same orchard blocks used in 2000. The relationship between model-predicted flyspeck and actual flyspeck in the apples was not close (only 2% of the variability was explained). However, 2001 was very dry during most of the growing season, and 2000 was a very wet year. Weather factors as well as differences in blocks at the different sites may have made a bigger difference in a drier year. We plan to develop a more comprehensive flyspeck model that combines static orchard factors with dynamic weather factors such as leaf wetness and rainfall. It would be useful to adjust for accumulations in moisture during a growing season. We may find that we need different models for wet years as opposed to dry years. The starting point, however, and key factor in rating a block for flyspeck risk will probably always be a measure of how much inoculum is in the orchard border areas at the beginning of the growing season.

This study identifies several factors which can combine to produce an environment which supports flyspeck: **density of flyspeck on alternate host plants in borders, number of borders, distance from apples to border, and slope of the block**. Modification of this environment in a number of ways, such as summer pruning, clearing-back borders or removing host plants or inoculum, or using high-density dwarf plantings could reduce flyspeck pressure considerably. The most stable management plans will involve several strategies, such as border management, orchard design, aggressive pruning, monitoring weather components, and careful fungicide selection and timing.

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* * * * *

Effects of Gibberellin Synthesis Inhibition on Feeding Injury by Potato Leafhopper on Apple

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Overview

Although the gibberellin synthesis inhibitor Apogee (prohexadione-calcium) was introduced in apple primarily as a horticultural tool to reduce shoot length and thereby decrease the amount of necessary pruning and associated costs, the inhibition of gibberellin synthesis has also shown beneficial effects in controlling some important pests of apple. The most dramatic effect has been seen on the shoot-blight phase of the bacterial disease fire blight, but some effects have also been seen on flush-growth-feeding insects such as green apple aphid and obliquebanded leafroller. To date, however, no studies have been published on the effects of Apogee on potato leafhoppers *Empoasca fabae* (Harris) (Byers et al., 1997; Paulson and Hull, 1999; Yoder et al., 1999).

Potato leafhoppers are occasional orchard pests in the mid-Atlantic and Northeast. These insects are not able to winter in the north. They overwinter in the southern United States and migrate northward on storm systems over the course of the spring and early summer. In apple, they feed in vascular tissue in rapidly-developing shoot tissue. In mature trees, this injury is not generally considered serious, although in young trees it may be necessary to apply control measures for a moderate to severe infestation. There is, however, some evidence that potato leafhoppers may play a role in facilitating the shoot-blight phase of fire blight, by introducing feeding wounds in susceptible tissue on which *Erwinia amylovora*, the bacterium which causes fire blight, is growing epiphytically (on leaf surfaces), allowing the bacteria to invade the leaf and cause infection (Koehler, 2000; Pfeiffer et al., 1999).

Since potato leafhoppers feed directly on tissue likely to be affected by gibberellin synthesis inhibition, we thought that the possibility of suppressing or even completely controlling these leafhoppers with Apogee or a similar gibberellin synthesis inhibitor was strong enough to warrant further study. This work was done as part of a larger study looking at the interactions of gibberellin synthesis and potato leafhoppers with fire blight.

Materials & Methods

A 200-tree section of a block of 15-year-old McIntosh/M.7 at Scott Farm in Dummerston, Vermont was used for the study. A randomized-complete-block design was used, with ten replications and two trees per treatment within each replication. Buffer trees were employed within the row, and a buffer row was employed between treated rows. Apogee was applied at the rate and timings recommended for commercial growers in this area, 12 oz per 100 gallons dilute at early petal fall (May 12) and a second application at the same rate when growth would have been expected to resume, June 1.

There were two levels of two treatments used in this experiment: Apogee treated and non-treated, and potato leafhoppers excluded or permitted. The insecticide Provado (imidacloprid) was used for exclusion, at the highly reduced rate of 0.5 oz per 100 gallons dilute recommended by researchers at the Cornell Hudson Valley Laboratory (Scaffolds newsletter, June 2001). Provado was applied when potato leafhoppers began to appear in the orchard, June 22, and was re-applied when numbers appeared to be resurging, July 20.

Shoot length was measured using a measuring tape on five shoots per tree (10 shoots per tree for the first two sample sessions) at 10-day intervals beginning at petal fall to assess the effectiveness of the Apogee treatment. Potato leafhopper injury was evaluated with a spectrophotometer early in the season, but this method became cumbersome and was eventually supplemented with a visual rating scale of injury, with 0 being no visible injury and 5 being severe injury. Because of the high mobility of potato leafhopper adults, which were the predominant life stage, we did not succeed in getting a reliable count of leafhopper numbers per shoot. In future studies a field-adapted vacuum cleaner device may be used for this purpose.

Results & Discussion

Shoot length measurements showed that Apogee had a highly significant effect on shoot growth (Figure 1), both in the presence and absence of potato leafhoppers. Potato leafhoppers arrived later than usual in New England and did not reach high numbers in any location, leading to a fairly low damage level in the control. Using the visual rating scale assessment of leafhopper injury, Apogee and Provado, individually, had a highly significant effect on reducing leafhopper injury (Figure 2). Where both materials were used together, leafhopper injury was singificantly lower than where either material was used alone. On the last assessment date, August 15, 2001, the average level of feeding injury where Apogee was used alone was 0.83, where Provado was used alone was 0.78, and where both were used together was 0.31. Untreated control trees showed an injury level of 2.13 for this date. Thus, there appears to be a substantial benefit to potato leafhopper control using Apogee either alone or in combination with insecticide.

The mechanism by which gibberellin inhibition affects leafhopper feeding is not known and will be investigated further. The enhanced effect of Apogee plus insecticide may be due to the reduction in new,

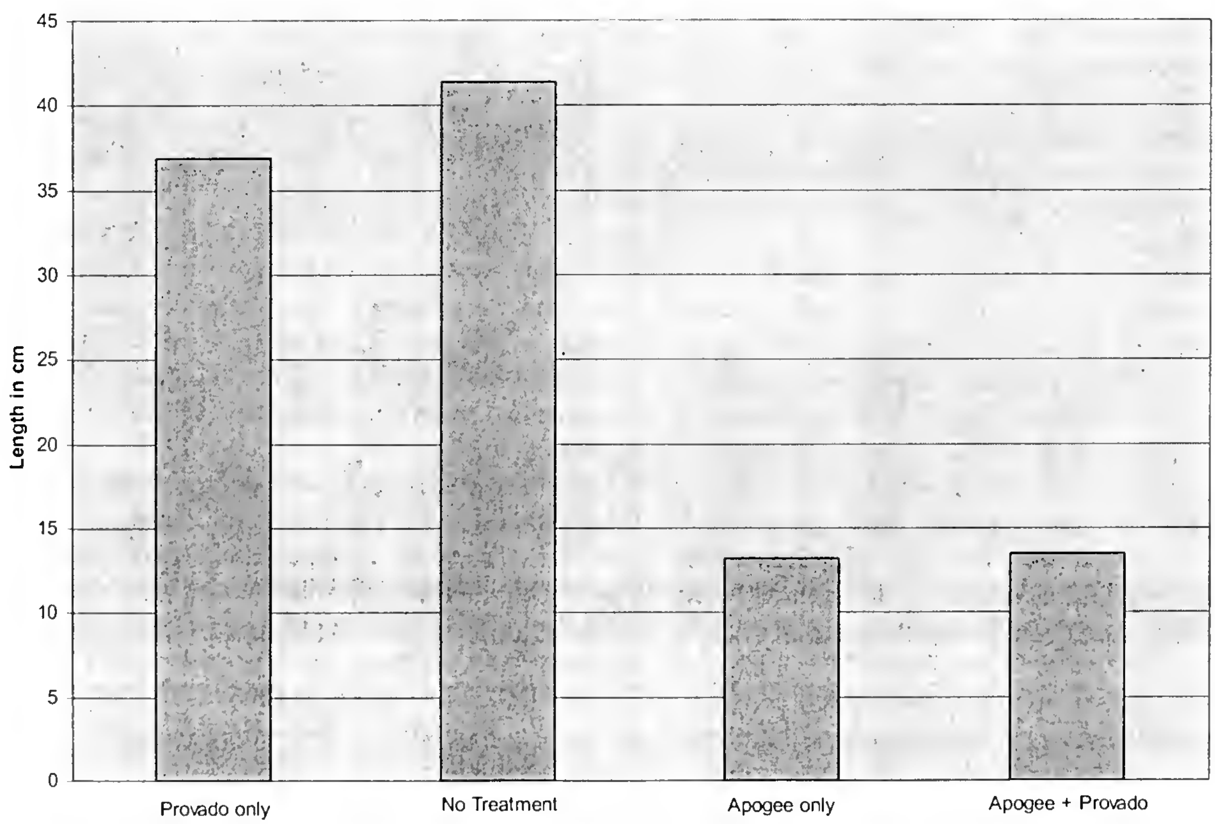

Figure 1. The effects of Apogee and Provado on shoot growth of 15-year-old McIntosh/M.7 trees.

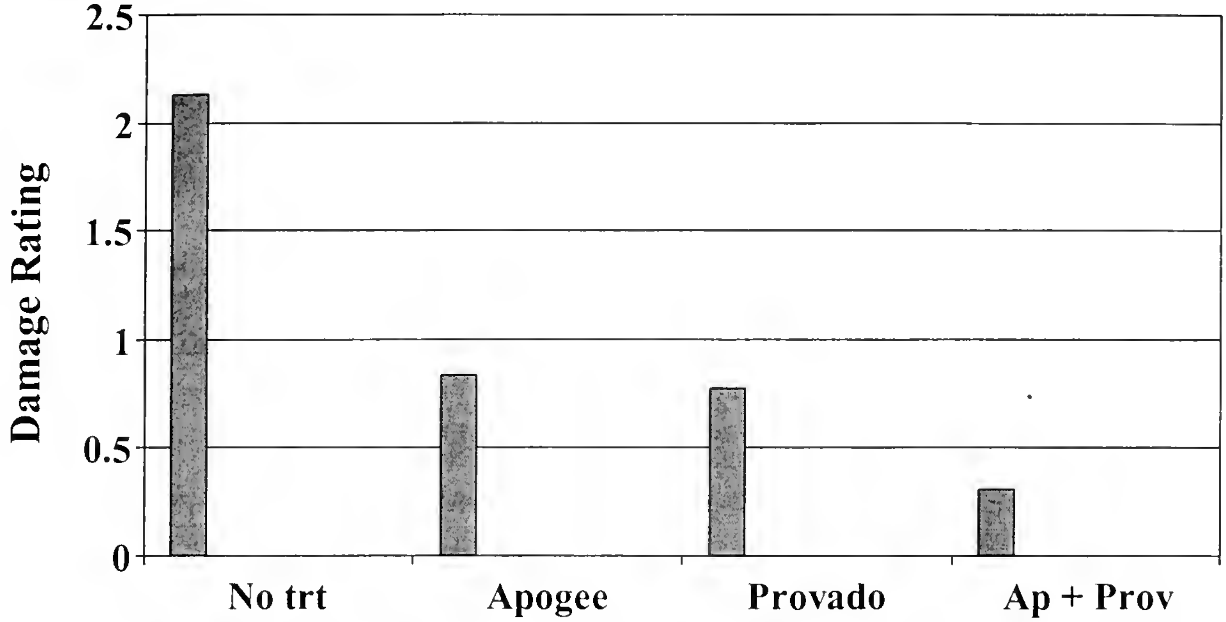

Figure 2. Potato leafhopper damage (0-5 scale, with 0 being no injury and 5 being severe injury) on 15-year-old McIntosh/M.7 trees as affected by Apogee and Provado.

untreated leaf area where shoot growth is inhibited. For Apogee alone, it is possible that visual or chemical cues used by the insects are muted by the treatment, or it could be that the leafhoppers begin feeding but find the treated plant unpalatable. Behavioral studies of potato leafhoppers exposed to Apogee-treated and nontreated foliage separately and in choice situations will be conducted to try to elucidate the nature of the response.

Regardless of the reason, however, the fact that injury appears to be reduced by the inhibition of gibberellin synthesis is of significance for growers needing to control this insect. Specifically, where Apogee has been used and leafhopper numbers are not exceptionally high, there may be no need for an insecticide directed at the leafhoppers. In cases where a severe fire blight outbreak is in progress and leafhopper numbers are high, an insecticide may still be warranted, and should hopefully have greater efficacy in combination with the Apogee.

More work needs to be done to understand the nature of the effects of gibberellin synthesis inhibition on leafhoppers and on to understand the relationship between potato leafhoppers and fire blight. In addition, it would be enlightening to repeat the experiment under higher populations of potato leafhopper and see whether or not the effects continues to hold true, or are muted or enhanced under such conditions.

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Food Quality Protection Act: An Organophosphate Update - February 2002

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As the six-year anniversary of the Food Quality Protection Act (FQPA) approaches, EPA continues to focus on the regulation of the organophosphate (OP) compounds. The protocols for tolerance reassessment mandated by the FQPA were previously not described, and the methodology by which they are ultimately evaluated will be used to review the other classes of compounds in the future. Therefore, EPA has proceeded cautiously, opened the procedure to public review, and provided for stakeholder input at each step of the six-phase review process.

This process allows for the development of risk-management recommendations by EPA and, when combined with the previously ongoing re-registration process, ultimately results in the publication of a Re-registration Eligibility Document (RED). The RED finalizes the regulatory process and outlines the conditions under which continued use of the product may occur.

In the case of the organophosphates, which must still undergo a cumulative risk assessment as a class of compounds (see related article in this issue of *Fruit Notes*), EPA has issued Interim Re-registration Documents (IRED). These documents may include risk reduction measures and other label changes that will take effect prior to the final RED, which will be released once the cumulative risks of the OP's have been considered fully. It is anticipated that EPA will conclude its review of the organophosphates sometime later this year.

All seven of the active ingredients most commonly used in commercial tree fruit production are currently in the final phase of the individual risk assessment process. The following is a summary of EPA's findings and actions as of February 18, 2002.

Azinphos methyl – Initial label amendments for azinphos methyl (Guthion) that effected tree fruit production were voluntarily put in place by the registrants prior to the 1999 growing season primarily in response to EPA's concerns regarding dietary risk to children. Further discussions among the registrants, EPA, and the stakeholder community directed at reducing the risk to agricultural workers and the environment have continued since the release of the revised risk assessment in the summer of 2000.

The results of these discussions were made available for public comment on November 28, 2001 in the form of an IRED. This document proposes the cancellation of 28 crop uses (including nectarines), a four-year phase out of seven crop uses (including peaches) and a 4-year, time-limited registration for eight crop uses (including apples, pears, and sweet cherries). Some highlights of the proposed label changes concerning **apple** production are as follows:

- limit of 3.5 lbs ai/acre per season east of the Mississippi, 4.0 lbs ai/acre west of the Mississippi;
- increase REI to 14 days for all activities;
- require enclosed cabs **or** maximum personal protective equipment (PPE) for applicators;
- require closed mixing systems **or** water soluble bags and closed transfer systems for mixing/loading;
- add 25-foot buffer zones for permanent surface water;
- add spray drift language; and
- prohibit pick-your-own (PYO) usage **or** restrict application to early season **or** establish 30 day pre harvest interval (PHI) for PYO operations.

The public comment period for this document ended on January 28, 2002. Questions concerning which label amendments will ultimately be required, the timeframe for implementing these changes, and the disposition of product already in the distribution system remain unanswered at this time. However, the registrant is optimistic that no label changes will take effect for the upcoming growing season.

Phosmet – EPA released its revised risk assessment for phosmet (Imidan) at a technical briefing in February 2000. This document indicated that dietary risk was not an issue for this compound and that exposure to handlers could be managed satisfactorily with increased PPE and engineering controls.

An IRED for phosmet was made public simultaneously with that of azinphos methyl (AZM) in the fall of 2001. Similar to AZM, EPA's present concerns center around risks to agricultural workers and ecological risks. Proposed agricultural use changes that affect tree-fruit producers fall into two categories: 1) continued registration with new labeling requirements for 33 crop uses (including sweet and tart cherries) and 2) a 5-year, time-limited registration for nine crop uses (including apples, apricots, nectarines, peaches, pears, and plum/prunes). Some highlights of the proposed label changes concerning apple production are as follows:

- increase REI to 3 days;
- require enclosed cabs **or** maximum PPE for applicators;
- require water soluble bags and closed transfer systems;
- add spray drift language; and
- prohibit application during bloom period.

The registrant has reached an agreement with EPA that allows for all product currently in the distribution system or in possession at the farm level to be used under the current label until all inventories have been depleted. All product sold by the registrant after June 30, 2002 will reflect the changes mandated by the IRED.

Diazinon - In December of 2000, EPA released its revised risk assessment for this active ingredient. EPA concluded this active ingredient posed significant risk to birdlife as currently labeled and was a common contaminant of surface water. Risk mitigation measures center largely on phasing out, over the next three years, most residential uses of products containing diazinon (Spectracide) whether applied for structural or lawn-care purposes.

Although agricultural uses contributed little in this regard, risk to agricultural workers who apply these products or harvest treated crops was of concern. When the IRED is made public, it is expected that EPA will proposed the cancellation of about 30% of the current agricultural uses and require "Restricted Use" classification for the remaining uses so that applications will be limited to trained, certified applicators. Discussions with the registrant and other stakeholders are ongoing.

Malathion – The revised risk assessment for malathion was presented at a technical briefing in November, 2000. Malathion is a lower priority for regulatory action since it is used on less than 10% of the nation's apple acreage. EPA's analysis suggested that dietary risk, drinking water risk, and ecological risks were of little or no concern. However, risks to mixers/loaders/applicators and risk to workers entering treated areas for post-application activities were cited. Although the IRED has yet to be posted, additional personal protective equipment (PPE) for handlers and longer restricted entry intervals (up to 6 days) are expected to be included.

Methyl parathion (Penncap-M) - EPA has previously announced acceptance of the registrant's voluntary cancellation of many of the significant food crop uses for this material including apples, peaches, pears, nectarines, cherries, and plums in order to address the Agency's concern of dietary risk to children.

Chlorpyrifos (Lorsban) – EPA severely restricted the use of this material on apples, tomatoes, and grapes shortly after the release of the revised risk assessment in August of 2000, again, due to dietary-risk issues. Post-bloom use on apples has been prohibited since December 31, 2000. The IRED was published in the Federal Register on November 14, 2001 for which the public comment period ended in mid January.

The first step of the review process mandated by the FQPA is drawing to a close for the organphosphate compounds. EPA will soon conclude the evaluation of these active ingredients on an individual basis. This initial evaluation contains a risk assessment that considers all potential routes of exposure including dietary, drinking water, residential, and occupational means.

The second phase, cumulative assessment of the risk posed by OPs as a class of compounds, has already begun. EPA and USDA convened an advisory panel, the Committee to Advise on Reassessment and Transition (CARAT), to assist in this process in February 2000. Dr. Robin Spitko of New England Fruit Consultants is a member of this committee and has been monitoring the proceedings for the tree-fruit industry in the Northeast.

Further information can be found at http://www.epa.gov/pesticides.

* * * * *

Food Quality Protection Act: Cumulative Risk Assessment for the Organophosphate Pesticides

Roberta Spitko
New England Fruit Consultants, Montague, MA

The primary focus of EPA's Office of Pesticide Programs activities over the past year has been the development of a cumulative risk assessment for the organophosphate pesticides (OPCRA). This risk assessment is the most complicated, comprehensive attempt to measure cumulative exposure to a particular group of pesticides that has ever been undertaken.

The OPCRA final document exceeds 5,000 pages in length. The methodologies developed by EPA to collect and analyze the data are extremely sophisticated and complex and have also been a source of much controversy in the agricultural stakeholder community. EPA is relying heavily on the advice of the FIFRA Science Advisory Panel, a panel of expert scientists, especially those in statistical modeling and toxicology, for validation of the methods used. These methodologies have been developed over the past 5 years, and represent a significant advance in EPA's abilities to evaluate pesticides in a comprehensive manner. It must be emphasized that the current risk assessment, which was released in January 2002 for public and scientific comment, is a ***preliminary*** assessment. The Agency expects a large number of comments to be submitted until the comment period closes on March 8, 2002.

A cumulative risk assessment is the process of combining exposure (the amount of pesticide to which an individual is exposed) and hazard (the health effects a pesticide could cause) from all substances that share a common mechanism of toxicity. In assessing hazard associated with the organophosphate pesticides, EPA analyzed their common method of toxicity, inhibition of acetylcholinesterase, as the means for assessing risk.

The goal of the organophosphate cumulative risk assessment (OPCRA) is to measure the probability of exposure to more than one organophosphate pesticide and to assess the effects of this combined exposure. The assessment incorporates possible OP exposures from structural, recreational, and drinking water, as well as from OP residues in consumed food. Each component of the risk assessment uses the best available data: data from surveys of what people eat and drink, of their activities involving pesticide use around the home and workplace, and monitoring studies of pesticide residues in these environments.

A comprehensive assessment of the organophosphates may raise concerns with growers about further restrictions on materials available for crop production. However, the results of the OPCRA may not have much effect on current OP use. Much work has been done previously on the individual organophosphates to reduce their risks as they go through the FQPA-mandated tolerance reassessment process.

The risks for the individual OPs will be factored into the cumulative equation at these lower levels. Most structural and home-garden uses have already been cancelled or significantly curtailed. Routes of exposure through drinking water have already been determined to be negligible.

It must be noted again that the recently released OP cumulative risk assessment is preliminary. EPA is continuing to seek input from the scientific community and stakeholders and is aware that revisions and refinements will be necessary. Determining cumulative exposure is a huge task, and this is the first time EPA has attempted develop a comprehensive profile of human exposure to a group of chemicals with common modes of toxicity. It will be an evolving process that will take years to refine.

Following the comment period closure of March 8, 2002, EPA will consider submitted comments and plans to issue a revised risk assessment in the summer of 2002.

The preliminary OPCRA may be accessed at www.epa.gov/pesticides/cumulative.

* * * * *

Commercial-orchard Evaluation of Traps for Monitoring Plum Curculio: 2001 Results

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Department of Entomology, University of Massachusetts

In the 2000 issue of *Fruit Notes*, we reported our year 2000 tests in which we compared odor-baited with unbaited traps of three types (pyramid, cylinder, and Circle) for monitoring plum curculios (PC's) in commercial apple orchards. Results suggested that traps baited with grandisoic acid alone (= synthetic male sex pheromone) captured no more PC's than unbaited traps. However, when grandisoic acid was combined with any one of three different synthetic host fruit volatiles (benzaldehyde, ethyl isovalerate, or limonene), captures by baited traps were about twice as great as captures by unbaited traps. Addition of the synthetic fruit volatiles decanal, hexyl acetate, and trans-2-hexenal to grandisoic acid did not enhance captures.

Here, we report results of 2001 studies in commercial orchards in which we further evaluated the best odor combinations found in 2000, again in association with pyramid, cylinder, and Circle traps.

Materials & Methods

The three types of traps were: (a) black pyramid traps (24 inches wide at base x 48 inches tall) placed on the ground next to apple tree trunks, (b) black cylinder traps (3 inches diameter x 12 inches tall) fixed vertically onto horizontal branches within tree canopies, and (c) aluminum-screen "Circle" traps (developed by a grower named Edmund Circle in Alabama for pecan weevil), wrapped tightly around the base of tree trunks so as to completely encircle the trunk and afford maximum chance of intercepting adults walking upward.

The three synthetic components of host fruit odor were benzaldehyde, ethyl isovalerate, and limonene. Each was purchased from Aldrich Chemical Company and was deployed in small polyethylene vials that fit into the screen-funnel top of a boll weevil trap that capped each pyramid, cylinder, or Circle trap. The release rate of each compound was about 10 milligrams per day (achieved by adjusting the type or number of vials per trap according to compound volatility). Each baited trap also contained a plastic dispenser of grandisoic acid (obtained from Great Lakes IPM) designed to release about 1 milligram of pheromone per day.

Traps were deployed in four plots of apple trees in each of 12 commercial orchards. Each plot consisted of seven perimeter trees. Each tree (save one) contained one baited or one unbaited trap of the above three types. All three baited traps in a plot received the same odor. In each orchard, each of three plots received a synthetic fruit volatile in combination with grandisoic acid. The fourth plot received grandisoic acid alone.

All traps were deployed at pink (May 2-4). Traps were examined for captured PC's beginning at petal fall (May 14-16) and every 3-4 days thereafter for 7 weeks until June 28-30. Vials of benzaldehyde and dispensers of grandisoic acid were renewed on May 28-30 (about mid-way through the experiment). At each trap examination, 10 fruit on each of the six trapped trees per plot (= row 1 trees) and five fruit on each of six corresponding but untrapped trees on interior rows 3, 5, and 7 were examined for PC oviposition scars. In all, 102,800 fruit were examined for PC injury. All plots received two or three sprays of azinphosmethyl or phosmet to control PC.

Results

Figure 1 shows that across the entire PC season, Circle traps baited with benzaldehyde plus grandisoic acid (GA) captured numerically more PC's than any other type of baited or unbaited trap, although not significantly more than unbaited Circle traps in the

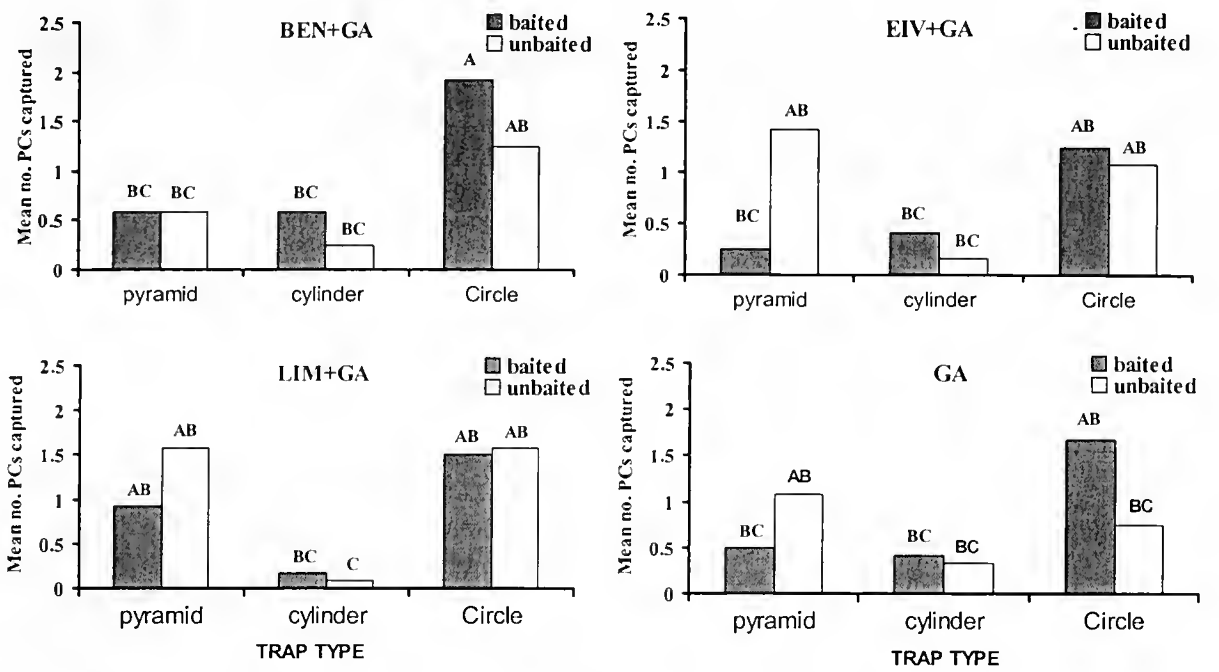

Figure 1. Mean number of PC's captured by each type of odor-baited and unbaited trap placed on perimeter-row trees. Among all bars in this figure, those superscribed by the same letter are not significantly different from one-another at odds of 19 to 1.

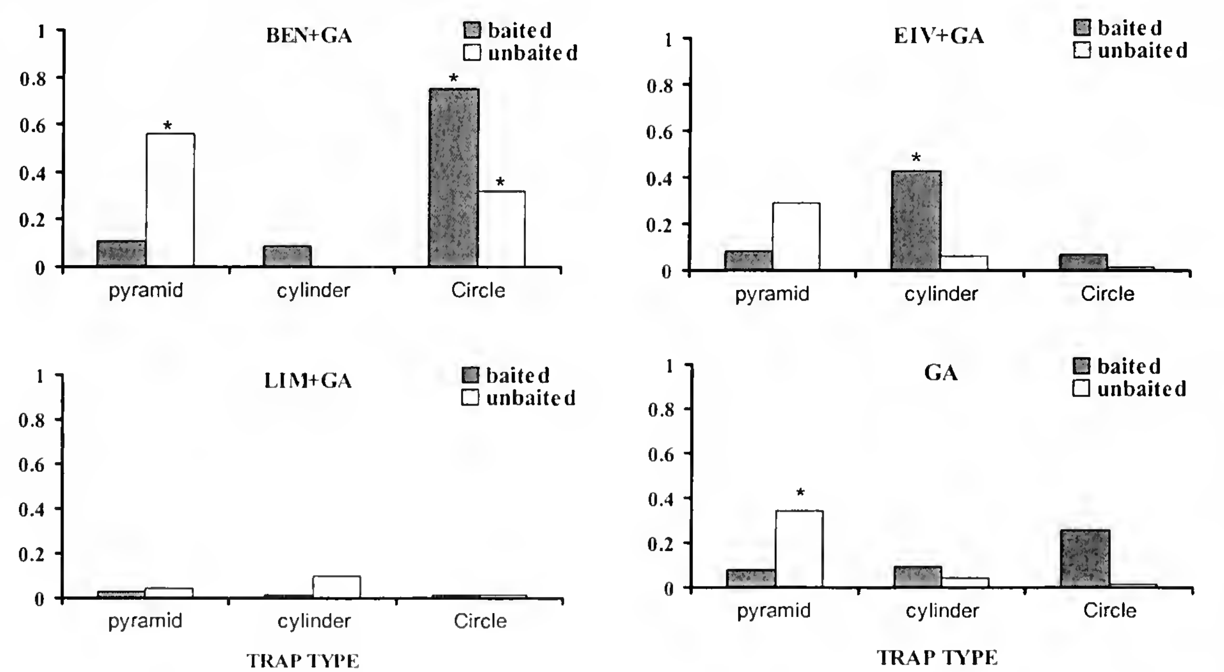

Figure 2. For each trap type, degree of correlation between total amount of PC captures on perimeter-row traps and percent sampled PC injury to fruit on perimeter-row trees in plots having that odor. The higher the R^2 value, the greater the extent of the correlation. An asterisk (*) indicates a statistically significant correlation at odds of 19 to 1.

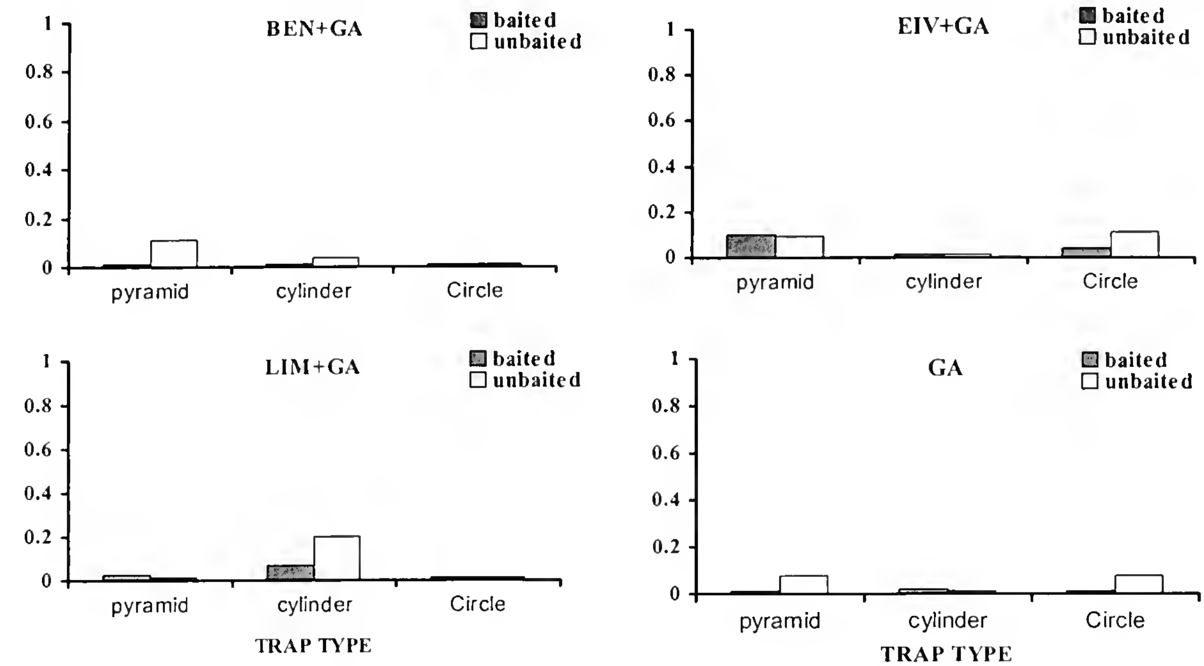

Figure 3. For each trap type, degree of correlation between phenology (time during the season) of PC captures on perimeter-row traps and phenology of injury to fruit on perimeter-row trees in plots having that odor. The higher the R^2 value, the greater the extent of the correlation. There were no statistically significant positive correlations.

same plots, or Circle traps baited with ethyl isovalerate plus GA, limonene plus GA, or GA alone. For each type of odor bait, pyramid and cylinder traps captured numerically fewer PC's than Circle traps.

Figure 2 shows, for each odor and trap type, the degree of correlation between the total (season-long) amount of PC captures and the percent sampled perimeter-row fruit injured by PC's in plots having that odor and trap type. A significant positive correlation would indicate that orchards which showed comparatively many captures for a given odor and trap type also showed a comparatively large amount of PC injury, whereas orchards which showed comparatively few captures also showed a comparatively small amount of PC injury. Among all odors and trap types, Circle traps baited with benzaldehyde plus GA showed the highest degree of positive correlation (0.75) between trap captures and injury. What this means is that after the PC season has ended, one can look back and say with high confidence that the extent of PC captures by Circle traps baited with benzaldehyde plus GA reflected quite well the extent of PC injury that occurred on trapped and other trees in the same plot.

Figure 3 shows, for each odor and trap type, the degree of correlation between the phenology (time of season) of PC captures and the phenology of PC injury to perimeter-row fruit in plots having that odor and trap type. A significant positive correlation would indicate that a sampling period during which comparatively many trap captures occurred also was a sampling period in which a comparatively large amount of injury was initiated, whereas a sampling period during which comparatively few (or no) trap captures occurred was a sampling period in which comparatively little (or no) fruit injury was initiated. Among all odor and trap types, no trap showed a significant positive correlation between phenology of captures and phenology of injury. In fact, the highest degree of positive correlation for any trap type was only 0.20, and the correlation for Circle traps baited with benzaldehyde plus GA was a mere 0.01. What this means is that during the PC season, one could not have any confidence whatsoever that the extent of PC captures during any particular 3- to 4-day period reflected the amount of PC injury that was initiated during that period, even for the best-performing trap.

A deeper look into the phenology of captures by Circle traps baited with benzaldehyde plus GA and the

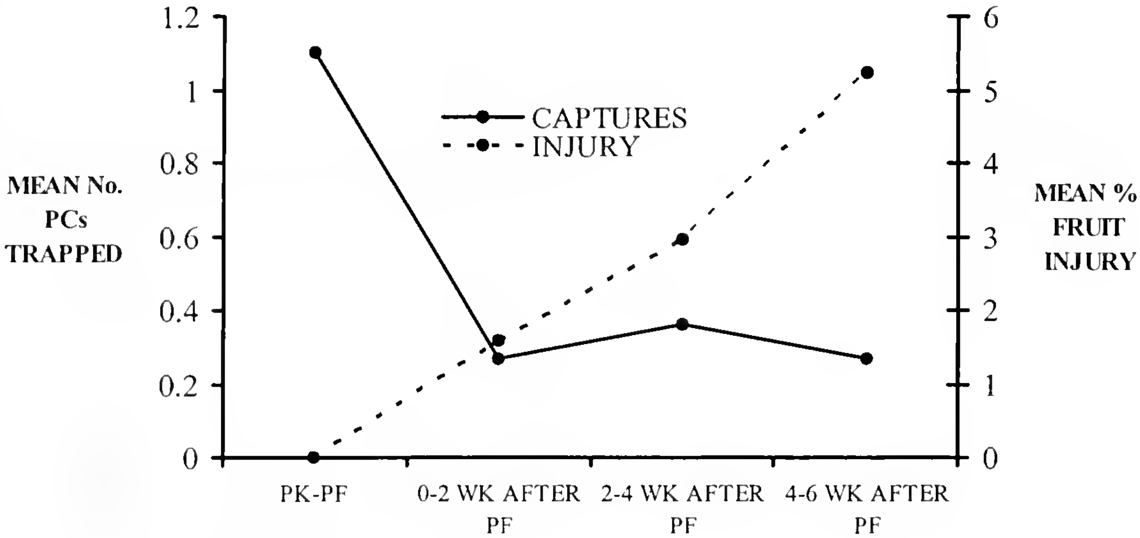

Figure 4. For Circle traps baited with benzaldehyde plus GA, a graphic display of PC captures and amount of PC injury to fruit during each of four 2-week periods from pink (PK) to 6 weeks after petal fall (PF).

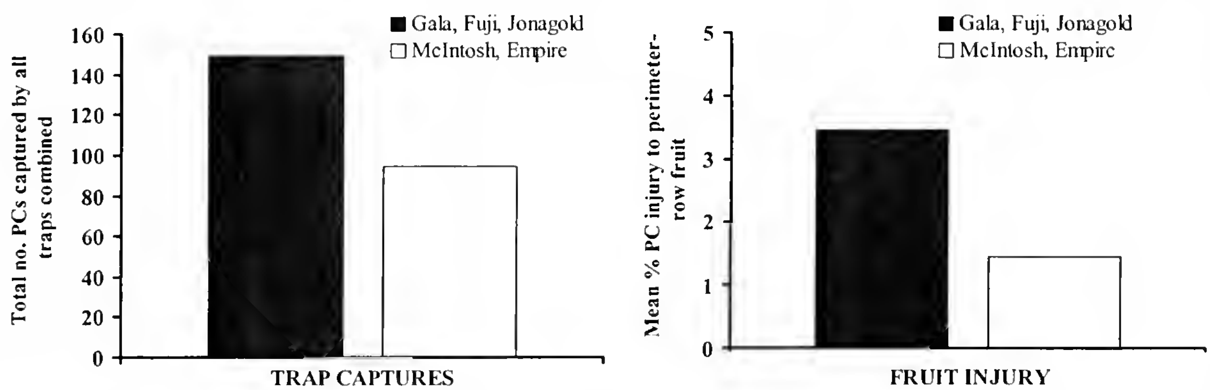

Figure 5. Total captures of PC's on perimeter-row traps and PC injury to perimeter-row fruit in six blocks of apple trees comprised of Gala, Fuji, or Jonagold as perimeter-row cultivars versus six blocks comprised of McIntosh or Empire as perimeter-row cultivars.

phenology of PC injury is helpful in understanding the lack of relationship between these two entities. As shown in Figure 4, PC captures were greatest during the period of pink to petal fall but were low during each 2-week period thereafter. Conversely, PC injury to fruit was low (about 1.5%) during the first 2 weeks after petal fall, but increased in essentially a linear fashion until 4 to 6 weeks after petal fall, when it reached about 5.3%. Thus, the trends depicted in Figure 4 show clearly that the steady rise in PC fruit injury on perimeter-row trees from petal fall to 6 weeks thereafter was not accompanied by a rise in PC captures by perimeter-row Circle traps baited with benzaldehyde plus GA, accounting for the lack of correlation between these variables.

Figure 5 shows that PC captures by all perimeter-row traps combined and PC injury to perimeter-row fruit were about 60% and 140% greater, respectively,

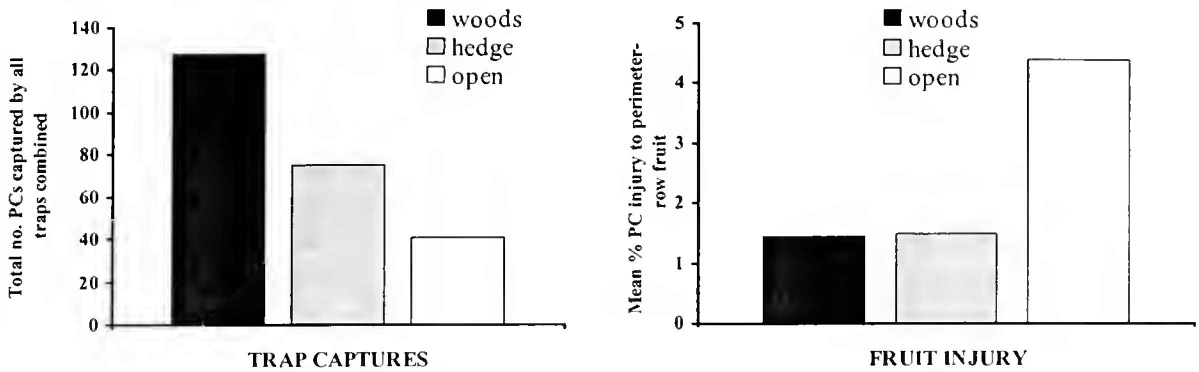

Figure 6. Total captures of PC's on perimeter-row traps and PC injury to perimeter-row fruit in blocks of apple trees whose front rows bordered woods, hedgerow, or open field (four blocks of each type).

in blocks having Gala, Jonagold, or Fuji as perimeter-row cultivars, compared with blocks having McIntosh or Empire as perimeter-row cultivars. The average number of insecticide sprays applied against PC was the same in each case (2.7).

Figure 6 shows that PC captures by all perimeter-row traps combined were greatest for blocks bordered by woods, intermediate for blocks bordered by hedgerows, and least for blocks bordered by open field. However, PC injury to perimeter-row fruit was greatest for blocks bordered by open field. The average number of insecticide sprays applied against PC was about the same in each case (2.8, 2.8, and 2.5, respectively).

Figure 7 shows that season-long PC injury to fruit on perimeter-row trees (row 1) averaged about 12 times greater than on trees of interior rows 3, 5, or 7.

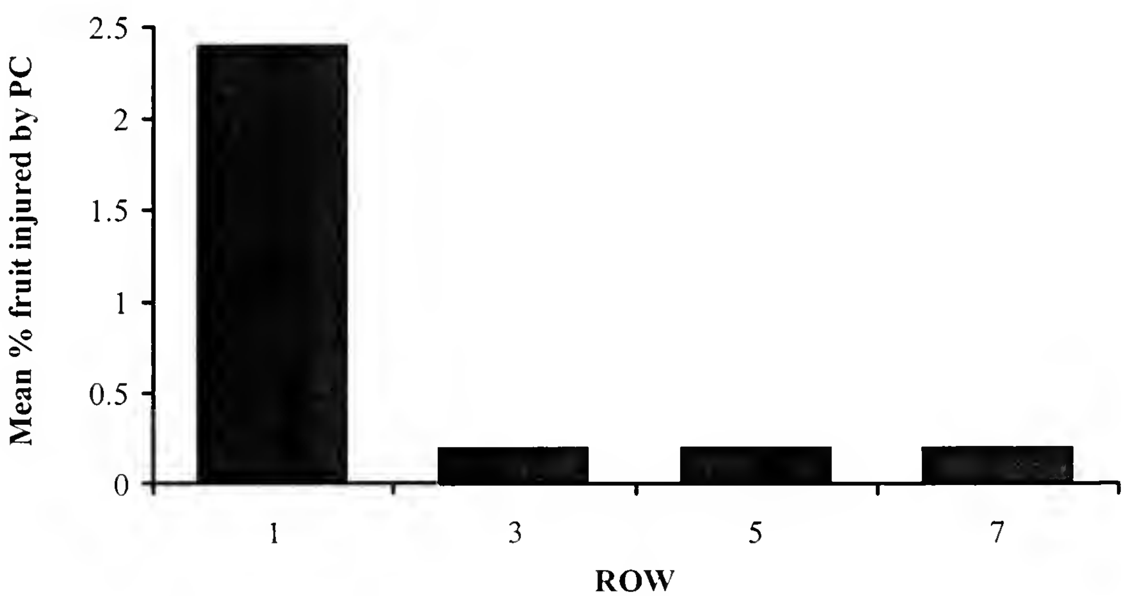

Figure 7. Mean percent PC-injured fruit on perimeter-row trapped trees(row 1) compared with injury on non-trapped trees of interior rows 3, 5, and 7.

Conclusions

Circle traps baited with benzaldehyde plus GA, when positioned so as to completely surround trunks of perimeter-row apple trees, captured numerically more PC's than any other trap type and afforded a strong positive correlation between total amount of trap captures and total amount of PC injury to perimeter-row fruit. The year 2001 was the first year we used Circle traps in this position on a tree (formerly they were placed on lower limbs near the trunk and provided a weaker correlation between total captures and total injury). The strong correlation obtained in 2001 suggests that tree-trunk Circle traps baited with benzaldehyde plus GA, if distributed along perimeter-row apple trees, can be an excellent indicator of "hot spots" requiring special attention for controlling PC as well as "cool spots" requiring lesser attention.

Unfortunately, no trap type showed even a moderate positive relationship between the time of occurrence of PC captures and the time of occurrence of PC injury to fruit. As depicted in Figure 4, even for our best trap type (tree-trunk Circle traps baited with benzaldehyde plus GA), captures fell off dramatically soon after petal fall, whereas fruit injury rose steadily. Thus, even for this best trap, the data obtained in 2001 indicate that low trap captures after petal fall cannot be relied upon as indicative of the lack of need to spray against PC.

As revealed by other studies that we conducted in 2001, there are at least three reasons why all three types of traps used here may fail to capture representative numbers of PC's active in canopies of commercial orchard trees after petal fall. First, organophosphate insecticide spray droplets falling on traps can be repellent to PC's for 10 days or more after application. Such droplets can also be repellent when on tree limbs and branches, but repellency apparently is substantially overcome by positive chemical stimuli inherent to surfaces of limbs and branches. Such positive stimuli are lacking on surfaces of current traps. Second, at temperatures greater than about 70°F, especially when accompanied by sun, PC's tend to fly directly into tree canopies, thereby bypassing Circle and pyramid traps associated with tree trunks. Temperatures tend to be higher than 70°F after petal fall. Third, the release rate of benzaldehyde from vials placed inside of trap tops (10 milligrams per day) is sufficient to attract PC's from a distance, but may be repellent at close range. As tree fruit grow and themselves release increasing amounts of benzaldehyde and other attractants, there may be an increasing tendency for attractive volatiles from the fruit to outcompete attractive volatiles placed in traps. Our attempts to increase the amount of benzaldehyde used in association with traps, so as to be more competitive with fruit volatiles, have been accompanied by a decrease (rather than an increase) in PC captures owing to repellency. Together, these three shortcomings may limit the usefulness of Circle, pyramid, and cylinder traps placed at or within canopies of commercial-orchard trees for monitoring the extent of threat by PC's after petal fall.

Both cultivar composition of perimeter-row trees and border area composition had an influence on extent of trap captures and fruit injury by PC. As in 2000, perimeter-row trees of Gala, Jonagold, or Fuji experienced considerably more PC pressure than perimeter-row trees of McIntosh or Empire, even though there was no difference in frequency of insecticide applications. Also, as in 2000, trap captures were greater in blocks bordering woods than in blocks bordering hedgerows or open field. Finally, PC injury to fruit on trees that received traps was far greater than PC injury to fruit on interior trees, suggesting that attractive odor placed on perimeter-row trees acts to concentrate PC's there and reduce penetration into the orchard interior.

Acknowledgments.

We are grateful to the following growers for participating in this study: Keith Arsenault, Gerry Beirne, Bill Broderick, Dave Chandler, Tom Clark, Don Green, Tony Lincoln, Joe Sincuk, Mo Tougas, and Steve Ware. This work was supported by Massachusetts State Integrated Pest Management Funds, Northeast Regional Competitive Integrated Pest Management Funds, Northeast Regional Sustainable Agricultural Research and Education Funds, and the New England Tree Fruit Growers Research Committee.

* * * * *

An Odor-baited "Trap-tree" Approach to Monitoring Plum Curculio

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As described in the preceding article, there are shortcomings associated with placement of plum curculio (PC) monitoring traps in commercial orchards for purposes of determining when a spray is needed to protect fruit against PC damage. Shortcomings are particularly evident during the middle and latter part of the PC season, when trap captures remain low irrespective of trap type or attractive odor, but damage increases. One of the principal shortcomings involves need for baiting traps with an increasing amount of synthetic attractive fruit odor as the PC season progresses in order that odor might compete effectively with the increasing amount of attractive odor emitted by developing fruit in the tree canopy. When used in association with traps, increasing amounts of synthetic fruit odor become repellent at close range.

One possible solution to this dilemma could be to create a "trap tree" where the tree canopy itself is baited with a high amount of attractive fruit odor. Rather than using amounts of PC's captured by traps as a potential but indirect indicator of level of PC egglaying activity, one would use amount of freshly injured fruit on the trap tree as a direct indicator. A few such trap trees per orchard could provide valuable information on sudden rises in PC damage and hence on the need to apply a protective spray. Placement of attractive odor directly on tree branches would eliminate problems of close-range repellency associated with placement of odor on or in traps.

In 2001, I conducted a preliminary trial of this new

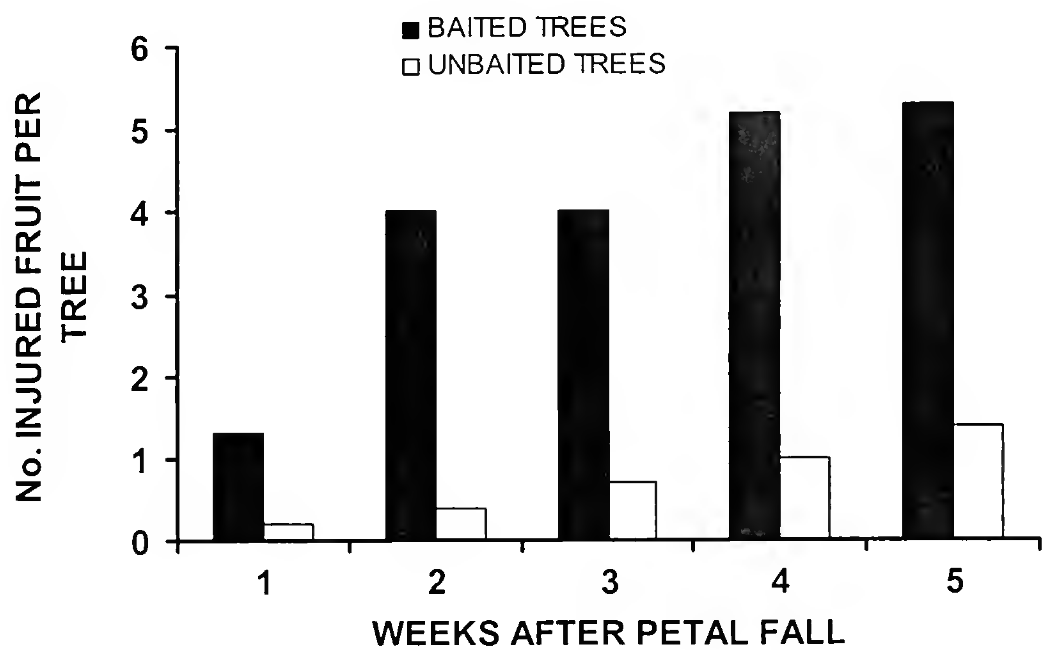

Figure I. Amount of fruit injured by plum curculio on baited perimeter-row trap trees and on unbaited trees midway between trap trees.

approach to monitoring PC's in a small block of apple trees in Clarkdale Fruit Farm in Deerfield.

Materials & Methods

The entire study was conducted along a 125-yard section of perimeter-row apple trees bordered by woods. The trees were mixed cultivars on M.26 rootstock. On May 2 (mid-pink), every sixth tree was baited with two dispensers of grandisoic acid (each releasing about 1 mg per day) and eight dispensers of benzaldehyde (each releasing about 10 mg per day). All dispensers were replaced with fresh ones on May 30.

One week after petal fall and weekly for 4 more weeks, 20 fruit were examined on each of the five trap trees and on each of four unbaited trees midway between trap trees. Fruit were counted as injured if a PC egglaying scar was evident. The trees received two applications of insecticide to control PC without use of fruit sampling information in guiding timing of spray.

Results

Figure 1 shows that fruit injury on the baited-trees averaged about eight times greater than on unbaited trees for samples taken at weeks 1 and 2 after petal fall and about five times greater than on unbaited trees for samples taken at weeks 3, 4, and 5 after petal fall. As the PC season progressed, some of the injured fruit on both types of trees fell to the ground, but total injury remained the same or increased owing to appearance of fresh injury.

Conclusions

The results of this preliminary test are very encouraging in that baiting perimeter-row trees with attractive odor acted to concentrate immigrating PC's on the "trap trees." Further research is necessary to optimize the composition and amount of attractive odor before this approach can be recommended for widespread use in monitoring PC's in commercial orchards. Conceivably, a few odor-baited "trap trees" along perimeter rows of an orchard might serve not only as focal trees for monitoring extent of fresh injury caused by PC but, if sufficiently attractive, might also serve to aggregate enough of the immigrating PC population to permit spraying only trap trees, allowing other trees to remain unsprayed against PC.

Acknowledgments

Thanks to Tom Clark for cooperating in this experiment, and Jaime Piñero for preparing the figure.

* * * * *

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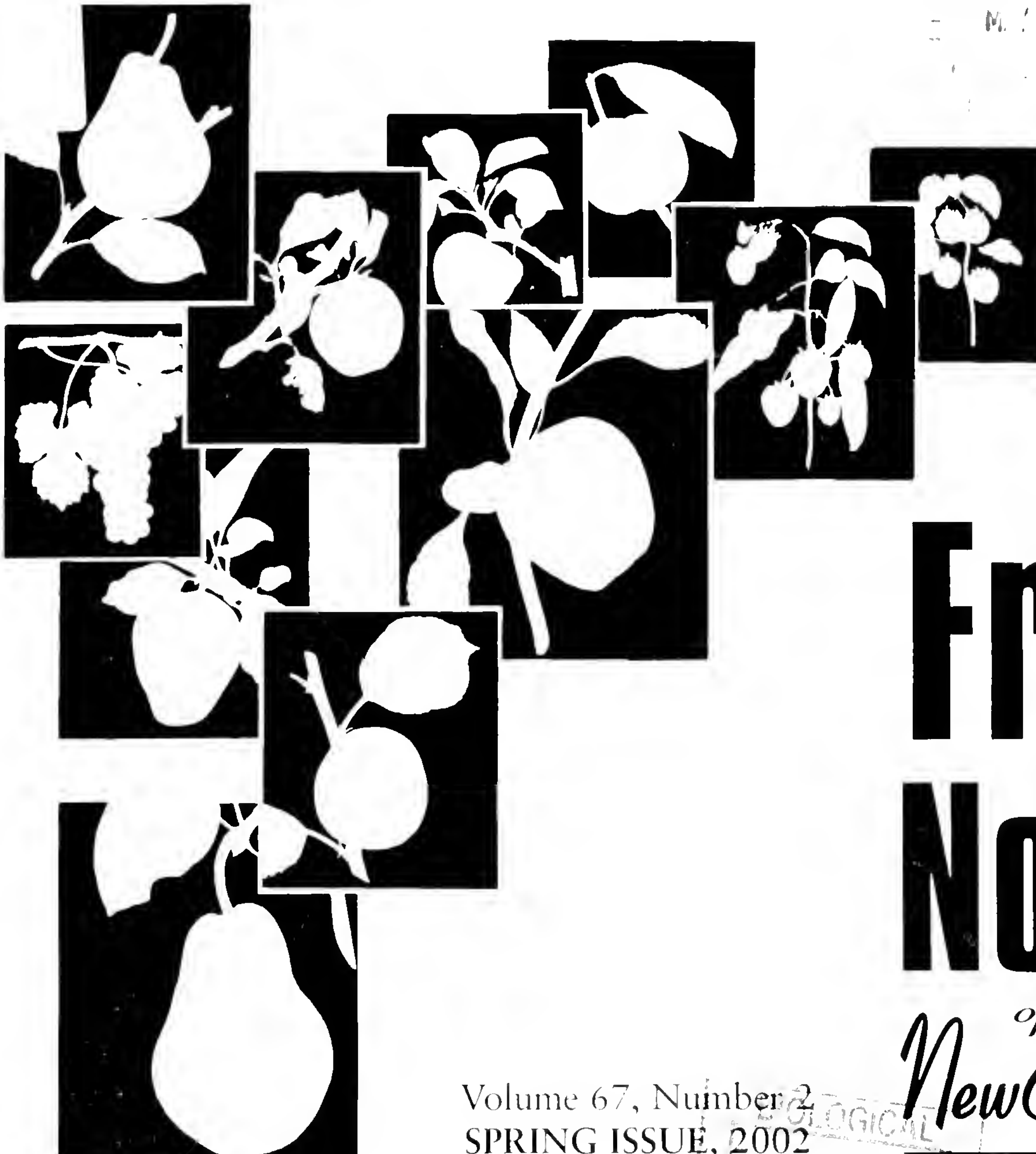

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Flyspeck Disease Management: Comparison of Flint versus Captan in Every-row versus Perimeter-row Sprays

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In 2001, we began a 4-year study to evaluate new pesticides (in this case, the environmentally benign fungicide, Flint, for flyspeck disease) for apple pests and a pesticide-reduction strategy (spraying only the two rows of apple trees on the perimeter of the block). Flyspeck (FS) disease, like apple maggot fly and plum curculio, survives the winter on or in plant material in the wooded or hedgerow borders and often infests an orchard block with a significant disease gradient which decreases with distance into the block (Cooley, 1996). The 2001 insect pest management results of the study were reported in *Fruit Notes* 66:14-18.

This study seeks to determine if the strategy of spraying only the two perimeter-rows in blocks of apple trees during the summer months is adequate to manage the disease at six orchards in Massachusetts. If proven efficacious, this strategy could help offset high costs of new materials and help reduce the pesticide load on the environment.

Materials & Methods

The experiment took place in blocks of apple trees at orchards in six Massachusetts towns: Harvard, Ber-

XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXX	XXXXXXXXXXXXXX
XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXX
XXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXXX
XXXXXXXXXXXXX	XXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXX
Border area	Border area	Border area	Border area
Flint (2.0 oz./acre)	Captan 80 (2.5 lb./acre)	Flint (2.0 oz./acre)	Captan 80 (2.5 lb./acre)
+ + + + + + + + +	+ + + + + + + + +	+ + + + + + + + +	+ + + + + + + + +
+ + + + + + + + +	+ + + + + + + + +	+ + + + + + + + +	+ + + + + + + + +
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Key: + = sprayed tree, -- = unsprayed tree, X = trees, shrubs, and vines

Figure 1. An example of a perimeter-row spray block with fungicide rates in six Massachusetts apple orchards, 2001.

Key: Each block below represents a block of apple trees 7 rows deep by approx. 35 trees wide. Cardinal directions are noted with a capital letter. Principal border is shown at top of block. Host density ratings ranged from 1 (none to very few scattered) to 4 (continous deep patches of host plants). Flyspeck (FS) density ratings range from 0 (none) to 3 (high).

Harvard Site

W Woods Host den. 4
FS den. 2

S Woods
Host den. 4
FS den. 2

N Woods
Host den. 3.5
FS den. 1

Berlin Site

S Hedgerow Host den. 2
FS den. 0 (ns)

W Hedgerow
Host den. 3
FS den. 1

Hawley Site

E Woods Host den. 4
FS den. 0 (ns)

S Woods
Host den. 4
FS den. 0 (ns)

N. Brookfield Site

N Woods Host den. 3.5
FS den. 1

W Hedgerow
Host den. 2.5
FS den. 1

Warren Site

W Woods Host den. 3.5
FS den. 1

Shelburne Site

E

No Borders within 100m

Figure 2. Evaluation of alternate host density and flyspeck (FS) density in border area habitats at six apple orchards in Massachusetts, 2001.

Table 1. Fungicide application schedule for 6 orchards in Massachusetts, 2001.

Site					
Harvard	**23-May**	**31-May**		18-Jul	08-Aug
Berlin	**23-May**	**31-May**	**13-Jun**	18-Jul	08-Aug
Warren	**25-May**	**02-Jun**	**16-Jun**	19-Jul	10-Aug
N. Brookfield	**25-May**	**02-Jun**	**24-Jun**	19-Jul	10-Aug
Shelburne	**24-May**	**01-Jun**		18-Jul	09-Aug
Hawley		**10-Jun**		18-Jul	09-Aug

* Bold-face font indicates full cover spray; otherwise 2 row vs. 7 row spray applied.

lin, Warren, North Brookfield, Shelburne, and Hawley. Cultivars within the blocks were primarily mid-to-late season, with planting densities ranging from 100 to 1000 trees per acre. The minimum block size was seven rows deep by 28 trees long (Figure 1). Rows of trees were divided into four sections, by colored flagging, to correspond with the four separate post-petal-fall pesticide treatments. There were two treatments using new, environmentally friendly materials (the fungicide, Flint, and the insecticide, Avaunt) and two treatments using conventional materials (the fungicide, captan, and the insecticide, Guthion). For each of these treatments, there was a two-row perimeter-spray plot and a full seven-row spray plot.

During the early season (up through petal-fall) the growers applied fungicides of their choice. Petal-fall occurred in mid-May at five of the six sites, with the exception being Hawley, which reached petal-fall on May 31. After petal-fall, the sites were sprayed according to the experimental protocol with the University's air-blast sprayer.

In early June, border areas within 100m of the experimental blocks were surveyed for alternate FS-host density and density of FS on such hosts. Host density was estimated on a four-point scale, and FS density was estimated on a three-point scale after examining known host plants throughout the border for fifteen minutes (Figure 2). If any FS was found, a more precise measure was taken by examining 25 stems on alternate hosts every 10m along the border.

Sprays applied by the University (Table 1) prior to June 10 were full cover sprays, meaning all trees received fungicide. Captan 80 was applied at 1.75 pounds/acre and Rubigan at 4.0 ounces/acre. At three sites, scab persisted, so one additional unplanned cover spray was needed in mid-June. For such applications, Flint was applied at 2 ounces/acre.

Fungicides were applied twice in the summer, with one spray on July 18 or 19 and the other on August 8 or 9. The two Flint treatments were applied to trees at a rate of 2.0 ounces/acre, and Captan 80 was applied at 2.5 pounds/acre. All sprays were delivered with the equivalent of 150 gallons per acre.

FS counts began July 15. One hundred fruit were sampled in rows 1, 3, 5, and 7, in each of the four spray treatments. Four hundred fruit were counted per treatment, and 1600 fruit per block. Distance between rows ranged from 8m (Shelburne) to 3m (Hawley). The sample area was comprised of the bottom 6 feet of fruit, on all sides of the tree. The typical sample was 20 fruit, from five trees, within each row. Also, the first and last tree of each row, for each treatment, was not sampled, since such trees could have been affected by spray drift. Samples occurred weekly or semiweekly until early September, when they were conducted weekly. Counts continued until harvest, with the last count on October 1.

Table 2 Treatment and border area parameters, and percentage of apples infected with flyspeck at harvest in 6 commerical apple blocks in Massachusetts, 2001

Site	Fungicide treatment	Perimeter or full block	Significant borders*	Distance to border(m)**	Flyspeck density in border***	Fruit infected at harvest (%) Whole Treatment	Fruit infected (%)	
							Row 1	Row 7
Harvard	Captan 80	perimeter	West	3.1	2	44%	100%	11%
			North	19.5	1			
		full	West	3.1	2	8%	8%	9%
			North	56.1	1			
	Flint	perimeter	West	3.1	2	4%	8%	1%
			South	53.4	2			
		full	West	3.1	2	3%	11%	0%
			South	9.8	2			
Berlin	Captan 80	perimeter	South	4.4	0	7%	0%	9%
		full	South	4.4	0	1%	1%	0%
	Flint	perimeter	South	4.4	0	8%	0%	6%
			West	44.2	1			
		full	South	4.4	0	2%	0%	4%
			West	3.9	1			
Warren	Captan 80	perimeter	West	7.3	1	1%	3%	0%
		full	West	7.3	1	5%	21%	0%
	Flint	perimeter	West	7.3	1	1%	0%	3%
		full	West	7.3	1	<1%	1%	0%
N. Brookfield	Captan 80	perimeter	North	7.9	1	<1%	0%	1%
			West	79.8	1			
		full	North	7.9	1	0%	0%	0%
			West	39.9	1			
	Flint	perimeter	North	7.9	1	<1%	1%	0%
			West	7.9	1			
		full	North	7.9	1	3%	0	4%
Shelburne	Captan 80	perimeter	None within 100m	N/A	N/A	2%	0%	0%
		full	None within 100m	N/A	N/A	0%	0%	0%
	Flint	perimeter	None within 100m	N/A	N/A	1%	0%	0%
		full	None within 100m	N/A	N/A	<1%	1%	0%
Hawley	Captan 80	perimeter	East	9.1	0	0%	0%	0%
		full	East	9.1	0	0%	0%	0%
			South	9.1				
	Flint	perimeter	East	9.1	0	0%	0%	0%
			South	53.0				
		Full	East	9.1	0	0%	0%	0%

* principal border listed first
** distance from edge of woods or hedgerow in principal border to first row of apple trees
*** 0=none, 1=low, 2=medium, 3=high

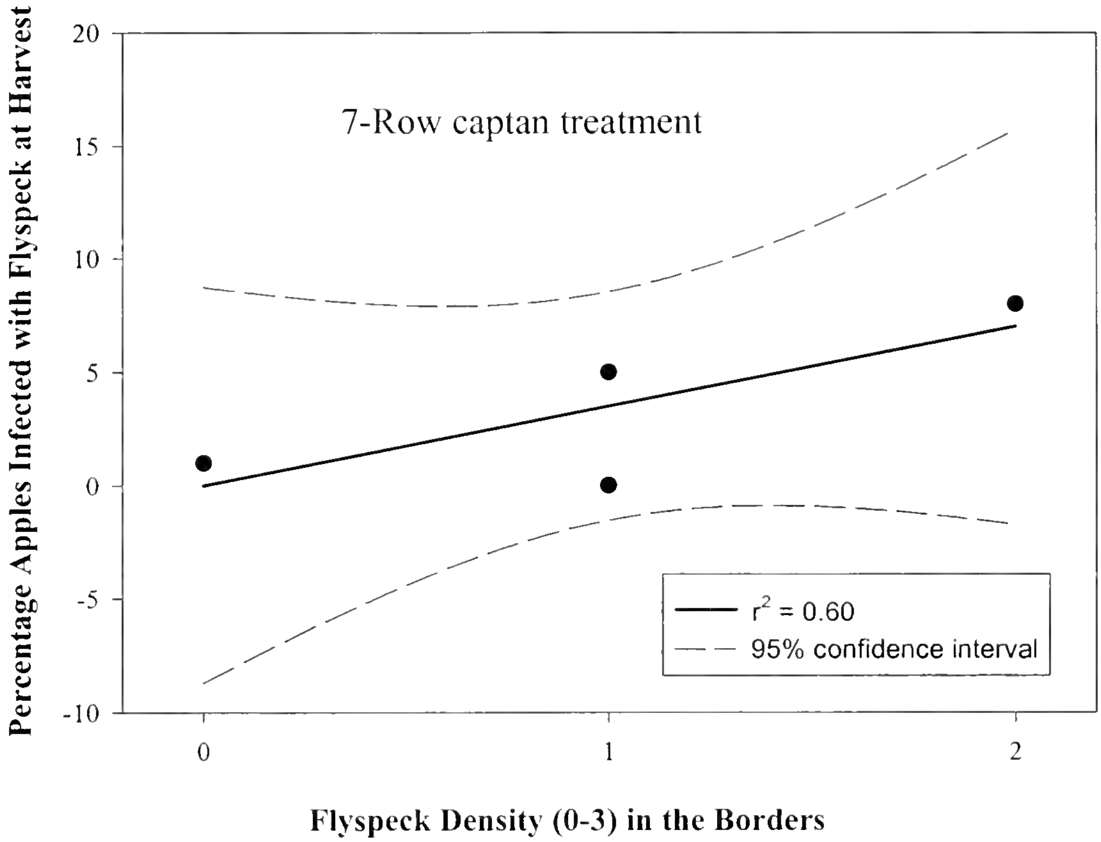


Figure 3. Flyspeck density observed on alternate host plants in the border area in June versus the percentage of apples infected with flyspeck at harvest in the seven-row captan treatment.

Results

In the June border survey, host density ranged from very high (4) at Harvard and Hawley, to moderate (2.2) at Berlin, to none at Shelburne (Figure 2). FS density on hosts ranged from moderate (2) at Harvard to low (1) at N. Brookfield to none (0) at Hawley. Twenty two percent of alternate host stems examined contained FS at Harvard, while 6-9% of stems inspected contained FS at Berlin, Warren, and N. Brookfield.

The Harvard block, with the highest rating for density of FS in the border, had the most FS in the apples at harvest (Table 2). When data for the four sites with the most FS at harvest were combined and tested, it was clear that the amount of FS observed in the borders in June had a major influence on the amount of infection in the apples at harvest. In the perimeter-rows and seven-rows captan treatments, 53% and 60%, respectively, of the variability in FS disease symptoms at harvest was explained by this relationship (Figure 3 shows the seven-row captan treatment). In the Flint treatments, the relationship was extant, but weaker (31% and 10% of the variability explained).

Distance to principal border ranged from 3.1m at Harvard, to 9.1m at Hawley (Table 2). Distance to perpendicular end borders ranged from 3.9m at Berlin to 53m at Hawley. At the Shelburne site, there were no significant borders within 100 meters of the block. The importance of the distance to a principal border on the level of infection in the apples was less than the importance of the amount of FS in the borders, but it is worth noting. As Figure 4 shows for the perimeter-rows captan treatment, 10% of the variability in fruit infection counts was explained by this relationship. Within the other three treatments, this relationship was weaker.

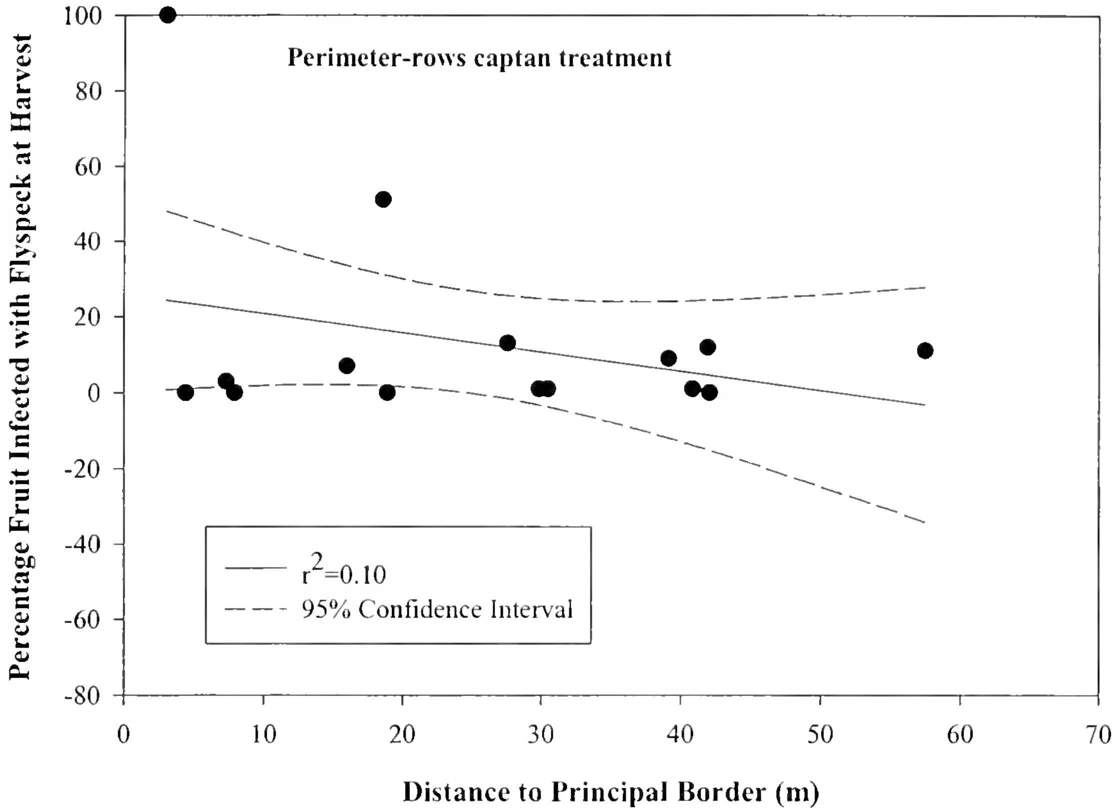
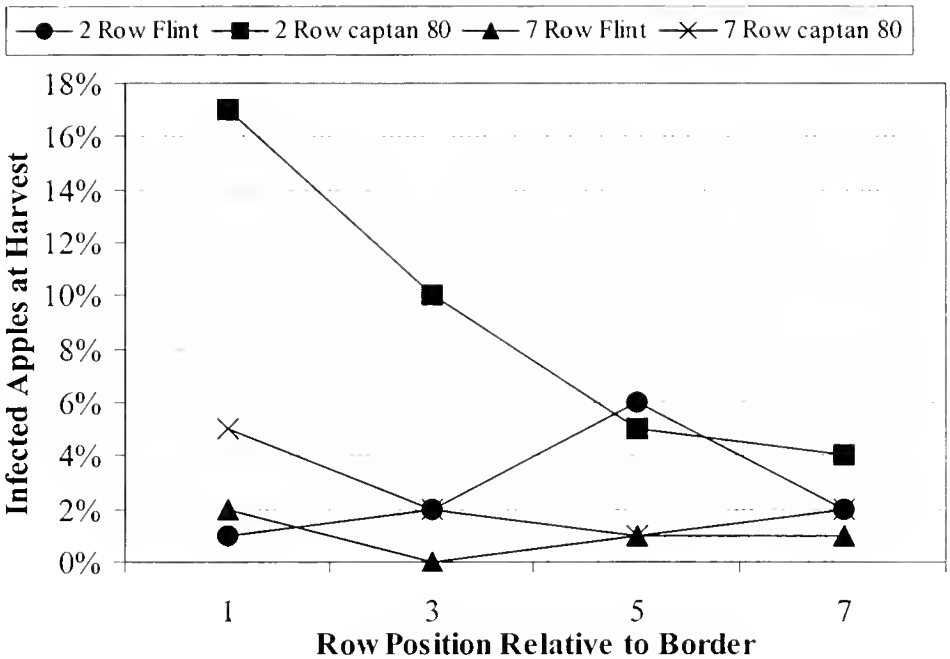


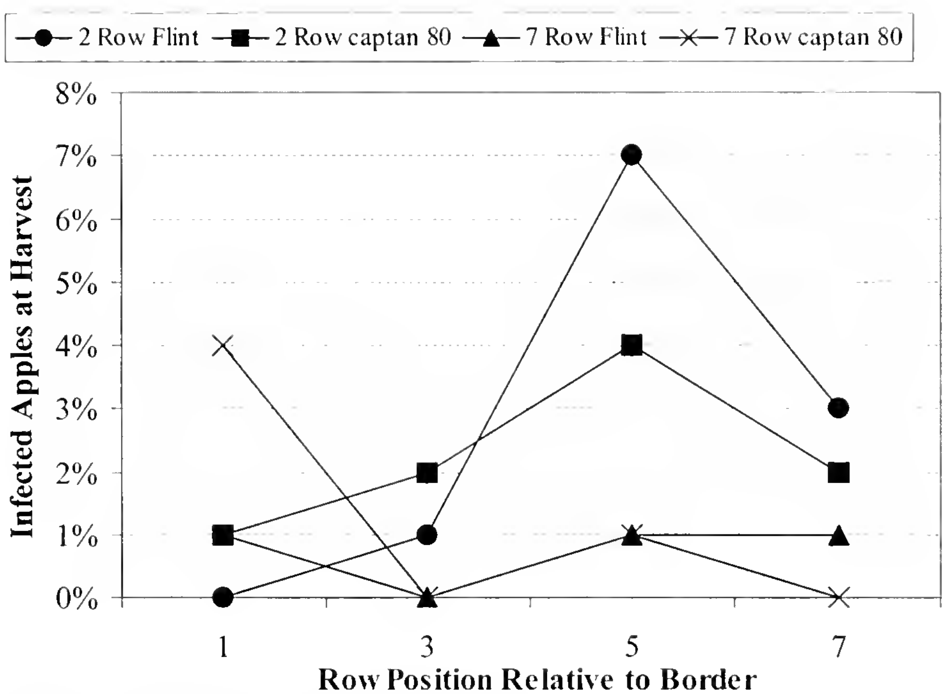
Figure 4. Percentage of apples infected with flyspeck at harvest versus the distance to principal border (parallel to the block): Harvard, Berlin, Warren, North Brookfield, perimeter-rows captan treatment, 2001.

FS was discovered in row 1 at the Harvard site on July 16, in both the Flint (9%) and captan (13%) perimeter-rows spray treatments. At the Berlin site, FS was found initially on August 27, in rows 3, 5, and 7, of all but the seven-row Flint treatment. FS was first discovered at the Warren site on August 29, in row 5 of the perimeter-row captan treatment. At the North Brookfield site, FS was found on August 15, in both the perimeter-rows Flint and captan treatments. The Shelburne site first had apples infected with FS on August 16, in the unsprayed rows of the perimeter-row spray treatments of Flint and captan. FS was not found at the Hawley site, despite counts continuing into early October. It was not surprising, given the absence of FS on alternate host plants within the surrounding border in June.

When harvest counts (September 6 to 13) from all treatments and all rows of all sites were compared (Figure 5, upper graph), Flint treatments had as little or less FS than captan treatments in rows 1, 3, and 7. The perimeter-rows Flint count (6% infected fruit) was slightly higher than the perimeter-rows captan treatment (5%), but overall, Flint compared favorably to captan. The lowest average FS incidence was found in the seven-row Flint treatment. The perimeter-row captan treatment had the most FS, with 17% of fruit infected in row one. This high average number was greatly influenced by the 100% incidence in this treatment and row at the Harvard site. When the Harvard data were omitted (Figure 5, lower graph), FS incidence in this row and treatment was reduced to 1%. Row 5 of the perimeter-row Flint treatment had the next highest FS incidence, with 7% of fruit infected. With Harvard omitted, FS incidence in row 5 of all treatments was greater or equal to the FS incidence in rows 3 and 7 of the respective treatment.



All 6 Sites 9/6-9/13



5 Sites (Harvard Omitted)

Figure 5. Percentage of apples infected with flyspeck at harvest in rows one (next to border) through row seven (from border) in Massachusetts apple orchards with four fungicide treatments, 2001.

Conclusions

The new environmentally benign fungicide, Flint, performed as well or better than the older broad spectrum fungicide, captan. This finding was supported by similar results in our twelve-block "Orchard Architecture" experiment in which a Flint-captan-Flint three-spray summer program was as effective as a first-Level IPM program. Other work of ours in small plot trials in MA and RI and work reported by Dave Rosenberger in New York indicate Flint and the other new strobilurin fungicide, Sovran, are quite effective against FS and scab. A task for 2002 is to determine the minimum amount strobilurin necessary to control different levels of FS infection.

At two of the sites, the perimeter-rows spray treatment worked as well as the seven-row spray treatment. These were sites with relatively low levels of FS in the borders adjacent to the blocks. At the other four sites, there was more FS in the apples in rows 3, 5, and 7 of the perimeter-rows spray treatment blocks than in the corresponding rows of the seven-row spray treatment blocks. Among unsprayed rows, row 5 had the most FS, while row 3 had less (presumably due to spray drift from rows 1 and 2), and row 7 had even less than row 3. FS showed-up earliest in the site which had the highest amount of FS in the border in June (Harvard).

For adequate management of FS, blocks with relatively high FS levels in the border areas will either require spraying further into a block than row 2 or removal or treatment of FS in the borders. We will test these findings further in the second year of the study. We will also attempt to control for spores that might be entering the research blocks from border areas to the sides and rear of the blocks.

References

Cooley, D.R. et al. 1996. Orchard site factors related to incidence of FS in apples. *Fruit Notes* 61(2): 1-4.

Acknowledgements

We thank the following cooperating growers for their participation in this study: Jerry Bierne, Dave Bishop, Aaron Clark, Don and Chris Green, Tony Lincoln, and Bob and Mark Tuttle. We also thank Andy Hamilton for applying post-petal-fall sprays, and Bayer Corporation for supplying the Flint. This study was supported by a grant from the USDA CSREES Crops at Risk Program.

* * * * *

Thinning McIntosh Apple Trees With Blossom Thinners, With and Without Post-bloom NAA: A Report to the New England Tree Fruit Growers Research Committee

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The objective of these studies was to test the efficacy of blossom thinners to replace carbaryl for obtaining selective thinning of McIntosh apples.

Evaluation in Maine

Materials & Method

Mature Rogers McIntosh/M.7 apple trees growing at Highmoor Farm, Monmouth, ME were selected for uniform bloom. Treatment plots were surrounded on all sides by one or more buffer trees, to prevent over-spray. All thinning treatments were applied with an airblast sprayer calibrated to apply 135 gallons of dilute spray per acre, with 70% of the spray delivered to the top half of the tree canopy. Blossom thinning treatments were applied May 12, 1998 when 70 to 80% of the blossoms were open. The weather at the time of application was sunny, temperatures was 72° F, with a 4 to 6 mph wind from the west. Blossom thinning treatments were:

1. Untreated control
2. Ammonium thiosulfate (National Chelating), 5 gallons per acre
3. Wilthin (Entek Corp.), 12 quarts per acre
4. Endothall (Elf Atochem), 2 pints per 100 gallons
5. NAA, 12.5 ppm

For plots that received post-bloom thinner, six ppm NAA was applied on May 27, 1998 when fruitlet diameter was 10 mm. The weather at the time of application was sunny, temperature 64° F, with a 1 to 2 mph west wind. The treatments were arranged as a split plot design. Blossom thinners were the main plot treatment, postbloom NAA was the sub-plot treatment, and there were five replications.

Fruit set was evaluated by limb counts and by cluster counts. All the flower clusters on one or two limbs per tree were counted at pink. The limb circumference was measured, and limb cross-sectional area (LCA) was calculated. The number of fruit on each limb was counted, and fruit set was calculated as the number of fruit per 100 clusters and as the number of fruit per LCA. Fruit counts were done shortly after petal fall and again in July to evaluate both initial and final set. Twenty-five flower clusters on each tree were tagged, and the number of flowers on each cluster was recorded. The number of fruit on each cluster was counted and fruit set was calculated as the ratio of fruit to flowers for each cluster.

Yield per tree was determined in a single picking

The Maine portion of this study was conducted at the University of Maine Highmoor Farm, during the time that Dr. Schupp was with the University of Maine.

at harvest. Fruit size distribution was categorized using a FMC Weight Sizer (FMC Corp. Lakeland, FL). The weight sizer was adjusted to divide the fruit into four diameter size categories: 57-63 mm, 64-69 mm, 70-75 mm, and greater than 75 mm. Twenty fruits of the 70-75 mm category were selected from each tree for fruit quality analysis. Red fruit color and russet were estimated visually. Fruit firmness was measured on the EPT-1 firmness tester (Lake City Technical Products, Inc. Kelowna, BC, Canada), with two opposing punctures per fruit. The soluble solids of the fruit were determined using an Atago PR-101 digital refractometer (Misco Products Divn., Cleveland, OH). Seed number was counted.

Results

Fruit set was reduced by all blossom thinners, while post-bloom NAA had no effect on fruit set (Table 1). Final fruit set was much less than the initial set, especially on control trees, however, the rankings of the treatments remained essentially unchanged. There were no treatment interactions on fruit set, yield or fruit characteristics between blossom thinners and post-bloom NAA in this study. Wilthin, endothall and NAA applied at bloom reduced yield (Table 1). Postbloom NAA had no effect on yield. There were no significant effects of thinners on fruit size distribution (data not presented). There were no treatment effects on fruit red color, fruit firmness, soluble solids concentration, or seed number (data not presented). Fruit from trees treated with Wilthin had higher incidence of russet than fruit from NAA- or endothall-treated trees (Table 1).

Discussion

Environmental conditions during bloom and for the following month were characterized by warm temperatures and high sunlight, making favorable

Table 1. Effect of ammonium thiosulfate (ATS), Wilthin, endothall, and NAA used as blossom thinners and NAA used as a postbloom thinner on fruit set and fruit size of 'Rogers McIntosh'. Maine.

	Initial set		Final set			
Treatment	Fruit/cm^2 limb cross-sectional area	Fruit/100 blossom clusters	Fruit/cm^2 limb cross-sectional area	Fruit/100 blossom clusters	Russet Skin surface (%)	Yield/ tree (kg)
Blossom thinners						
Control	17 a	143 a	3.4 a	31 a	15 ab	67 a
ATS 5 gal/acre	8 b	91 b	2.5 ab	28 ab	13 ab	60 ab
Wilthin 12 qt/acre	4 b	43 c	1.5 b	17 c	28 a	50 c
Endothall 2 pt/acre	8 b	93 b	1.4 b	16 c	9 b	40 d
NAA 12.5 ppm	8 b	105 b	2.0 b	24 b	10 b	55 bc
Postbloom NAA						
None	9	95	2.1	22	12	52
NAA 6 ppm	9	95	2.2	24	18	57
Significance						
Blossom thinner (BT)	*	***	**	*	*	*
Postbloom thinner (PBT)	NS	NS	NS	NS	NS	NS
BT x PBT	NS	NS	NS	NS	NS	NS

conditions for initial fruit set. All the blossom thinners were effective in reducing the initial fruit set and number of fruit per flower cluster during this period. A prolonged period of heavy cloud cover from June 13 to June 17, 1998 resulted in heavy June drop for all the trees in this study. This episode of fruit drop commenced on June 23, and was more severe than the fruit drop caused by blossom thinners. Much of the potential effect of chemical thinners on yield and fruit characteristics at harvest was obscured by this natural fruit drop.

The most effective blossom thinner, Wilthin, caused severe phytotoxicity and fruit russet. Future studies should address this concern by evaluating the effect of lower rates of Wilthin. These data indicate that blossom thinners show some promise. More study is needed to select the best chemicals and to optimize their use.

Evaluation in Massachusetts

Materials & Methods

A block of mature Marshall McIntosh/M.26 apple trees growing at the University of Massachusetts Horticultural Research Center, Belchertown, MA were selected. Treatment trees were selected so that a buffer tree was located on each side of a treatment tree to prevent spray drift. Prior to bloom 2 limbs per tree, 10 to 15 cm in diameter, were selected and tagged. At

Table 2. Effects of Ammonium thiosulfate (ATS), Wilthin, endothall and NAA used as blossom thinner alone or combined with a postbloom NAA application.

		Fruit set		
Treatment	Postbloom NAA (6 ppm)	Fruit/cm^2 limb cross-sectional area	Fruit/ 100 blossom clusters	Fruit weight (g)
Control	-	6.9 a	66 a	146 e
NAA	+	5.9 a	55 a	158 d
ATS 6 gal/acre	-	1.9 b	23 b	175 abc
ATS 6 gal/acre	+	2.6 b	22 b	184 a
Wilthin 12qt/acre	-	2.6 b	28 b	170 bc
Wilthin 12 qt/acre	+	2.2 b	21 b	182 ab
Endothall 2 pt/100 gal	-	3.1 b	25 b	164 cd
Endothall 2 pt/100 gal	+	3.3 b	37 b	158 d
NAA 12 ppm	-	6.1 a	62 a	171 bc
NAA 12 ppm	+	5.7 a	61 a	177 ab
Significance				
Blossom thinner (BT)		***	***	***
NAA		NS	NS	**
BT x NAA		NS	NS	NS

Within columns, means not followed by the same letter are significantly different at odds of 19 to 1.

the pink stage of flower development all blossom clusters were counted on the two tagged limbs. Blossom cluster density was calculated using LCA. Trees were replicated based upon blossom cluster density. All thinning treatments were applied with an airblast sprayer calibrated to apply 125 gallons of dilute spray per acre. Blossom thinner treatments were applied May 4, 1998. Full bloom occurred about 0.5 day before application. Weather at the time of application was partly sunny and warm with temperature reaching 70°F soon after application. Blossom thinning treatments were:

1. Untreated control
2. Ammonium thiosulfate (National Chelating) 6 gallons/acre
3. Wilthin (Entek Corp.), 12 quarts per acre
4. Endothall (Elf Atochem), 2 pints per 100 gallons
5. NAA 12 ppm

For plots that received post-bloom thinner, 6 ppm NAA was applied on May 18, 1998 when fruit size averaged 9.0 mm. Weather at the time of application was sunny, warm and breezy with temperature at 76 to 78°F at application time and a high temperature of 80° F was reached later in the day. Treatments were arranged as a split plot design. Blossom thinners were the main plot treatment, postbloom NAA was the sub-plot treatment, and there were seven replications.

Fruit set was evaluated by first counting all persisting fruit on the tagged limbs at the end of June drop in July. The fruit set was calculated by dividing the number of fruit by the LCA. At the normal harvest time on September 10, 40 fruit from each tree were harvested randomly from around the periphery of the tree. The harvested fruit were then taken to the lab where total weight was taken and the average fruit size calculated. Observation of the harvested fruit indicated that there appeared to be no russet attributed to treatment.

Results

Soon after application phytotoxic effects were observed on the flower petals and leaves of all blossom-thinned trees except those receiving NAA. ATS, Wilthin, and endothall thinned significantly and comparably (Table 2). NAA did not thin when applied as a bloom thinner. NAA at 6 ppm did not thin when applied alone at the traditional postbloom timing or when applied following any of the blossom thinner treatments. All blossom thinning treatments increased fruit size. NAA, when applied as a bloom thinner, increased fruit size even though it did not significantly reduce crop load. Likewise, the postbloom 6 ppm application of NAA alone increased fruit size although crop load was not significantly reduced. There were no blossom thinner X NAA interactions.

Discussion

ATS, Wilthin, and endothall were used in previous years on apples at rates of 1%, 6 qts/acre and 1.5 pints/ 100 gallons, respectively, with disappointing results. Little phytotoxicity was noted and minimal thinning recorded. Higher rates were used this year in an attempt to locate a rate where some thinning would be achieved. Cool, damp, rainy weather immediately preceded the application of blossom thinners in Massachusetts. We speculate that the large amount of phytotoxicity was attributed to greater penetration of the thinner into the leaves because of the cool, cloudy, and rainy weather the week before application rather than due to an excessively high amounts of thinner. While we have noted for years that absorption following a cool wet period can be increased, this may be even more important when the thinner of choice, thins by burning.

It is also interesting to note that fruit size was increased significantly even though crop load was not reduced significantly. Crop load may have been reduced enough to increase fruit size. It is also interesting to note that early thinning at bloom time may actually increase fruit size more than by thinning later. Note fruit size on trees treated with post bloom NAA as compared with NAA used as a blossom thinner.

These data suggest that blossom thinning is a viable and effective way to reduce crop load. More study is necessary to select the best chemical and concentration to achieve appropriate thinning.

Evaluation of New Apple Varieties, 1998 Observations: A Report to the New England Tree Fruit Growers Research Committee

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During the growing season I evaluated about 125 named varieties and numbered selections. Below are my observations on the performance of many of these in 1998.

Arlet

I continue to be on the fence with this apple. It has good, but not outstanding flavor. It does not suffer from biennial bearing, and fruit size is good. It russets here, up to 25% of the surface, it drops and it does become greasy. A drop control compound is appropriate with Arlet. I am cooperating with Sarah Weis on storage of Arlet this year to get a better assessment of its postharvest life.

Autumn Gold

This is my first year with this cultivar and I had just a couple of fruit. I believe that I harvested it too late, October 19. It is a medium to large apple with some russet and is not too attractive. The ones I tasted were neither crisp nor juicy but I believe that they were overmature. There were longitudinal cracks in the pedicel end, throwing up a red flag. Flavor was of bananas, fruity and very pleasant. It had a good sugar to acid ratio. I rated the flavor very high, even with the faults.

AA 62 (Stellar)

I continue to favor this attractive lemon yellow apple. It is extremely attractive and has a large L/D ratio (over 1.05) even here. It has no russet but it is extremely susceptible to apple scab. Flesh is crisp, juicy, fruity, and very good. One thing that I did note this year is that at harvest it had an ethanol (aldehyde) taste that detracted from the flavor. It did have some moldy core this year. I have noted this in other apples in the past including HoneyCrisp. I will continue to look at this one.

AA 122

This is the first year of evaluation of this oblate deep yellow apple. It has white inconspicuous lenticels and yellow flesh. The flavor was OK, being slightly sweet with a bitter after taste. It was rated in the middle of the pack. If it does not have outstanding flavor or crispness, the evaluation time of this apple will be short.

Braeburn

It is a somewhat unlikely candidate to be grown in New England because of late maturity. It blooms profusely and set can be excessive if not thinned very well. I have used three applications of 6 ppm NAA with or without carbaryl on Braeburn with success. Fruit size is good and color is acceptable. It is not very good at harvest but after a period of cold storage it does taste very good. It has good postharvest life. I do recommend planting this apple in New England.

*Cameo****

I consider this to be one of the best new cultivars. It ripens in mid-October here. It has good L/D ratio and quite good if not quite different color. It is a highly striped apple with about 80% of the surface a dark reddish brown color. It is a very grower-friendly tree. This tastes like a very good Delicious but the taste is very mild. While I never hope that is will be sold as Delicious, I think that it will appeal to people who actually do have taste for it but are attached to the unfortunate versions of Delicious available today. I am high on this apple and think that it will sell here in the East. It does have biennial bearing tendencies.

COOP 25 (Scarlet O'Hara)

This is a medium sized brownish red apple that I have liked for two years. It can be picked, and actually tastes very similar when harvested over a 4-week period from late September to late October. It is one of the crispest and best storing apples I evaluate. It stores better than Fuji or Braeburn but not quite as well as HoneyCrisp. It has a mild, fruity, vanilla flavor with a good sugar to acid ratio. I would plant this even if it were not a scab resistant apple. Anyone who is looking for a versatile scab resistant apple should be looking at this. It is very susceptible to fire blight so areas where this is a problem should proceed very carefully.

COOP 37

I have looked at this cultivar for three years now. It is very similar to GoldRush in appearance and time of ripening. It is somewhat attractive with a 20 to 30% orange cheek. It has a strong vanilla taste, very juicy, and medium in size. I rate it good but not exceptional, although my tasting notes include the comment 'look at again'.

Creston

This was a difficult year for apples that are not highly colored because of the heat. Creston suffered, and consequently it was not very attractive. However, compared with other apples evaluated it was one of the crispest and juiciest. It was also rated very high in flavor, and overall as being very desirable. It was also large. We should continue to evaluate this apple.

Dalrouval

This is one of the several selections of apples that were sent to me by Stark from the Delbard Nursery in France that fruited for the first time this year. It has an 80% dark maroon surface and looks like a Delicious. Harvest date was on August 24, just about with Ginger Gold. It has a distinctive sweet perfumy flavor. It is quite crisp and very juicy but the skin in tough. I rated it quite high and noted that it was a very good apple.

Delgorov

This is an extremely attractive bright orange-red apple that is about 80% red striped. It is medium small, fairly crisp, juicy, but the flesh seems somewhat dry. I noted that it was a fairly good apple with a good sugar to acid ratio. Harvest is 2 weeks before Gala.

Deljoron

The color of this apple is almost 100% dark burgundy red. It in many ways reminds me of an Empire in appearance and taste. The flesh is white with a tinge of green. The skin is smooth somewhat tough, with many tan lenticels. It ripens about with Delicious. I was favorably enough impressed with it at harvest to note that I should continue to look at it.

Delorina

A small dark cherry red apple ripening with and looking somewhat like Delicious. It has yellow flesh with yellow flecks, slightly sweet, moderate acidity, and is somewhat crisp and juicy. Flavor is tangy and slightly fruity. I rated it fairly high.

Delshel

This is a an extremely dark red, medium to small apple that is
Gala-like in appearance. It has scarf skin and reminds me to a very large extent of Buckeye Gala. It has prominent tan lenticels and a pleasant fruity taste. It ripens about two weeks before Gala. I rated this quite high.

Enterprise

The quality of this apple improved immensely this year. It was near the bottom of the list last year. While not on the top, it did move up quite a bit. What is the difference? We had a very hot summer and I believe that was the difference. It was extremely attractive, medium size, sweet, crisp, juicy, and slightly fruity. Last year I described its flesh as tough, dry, and sawdust-like. The bottom line here is that it is meant to be grown in warmer climates. In warm years it will be very good.

Florina

I hear very little about this apple, but it is very good, especially for a disease resistant apple. It is very attractive and its skin is glossy like a HoneyCrisp. It is somewhat crisp, very juicy, with a good mild buttery flavor. Fruit size is medium. I rated it very high.

Fortune

Although red color development was delayed, it did come along. It was not very firm or crisp this year and acidity was rather high. Although it was not at the top of the list flavor, overall I rate it as an above average apple. The irregular shape is a problem as is its mammoth size. I have serious reservations about whether this will make it with all of the good competition.

Fuknishiki

This is the first year I evaluated this apple and it may be my last. It is not attractive with 70% pinkish red color. It has scarf skin and the flesh is greenish yellow. The skin is extremely tough, and the flesh is a nondescript, chalky and astringent flavor. It is not very good.

Fukutami

A small bright cherry red apple. While the cosmetics are good, the taste is not. Although it is somewhat sweet, the flavor is masked by extremely high acidity even when it has watercore. It is not good enough.

Gala Supreme

A year ago I was quite impressed with Gala Supreme. I am out of favor with this apple now for several reasons. It has no better than "good" appearance. It can be quite tart at harvest even though sugars are quite high. The flesh is grainy and the taste is nothing spectacular. It has a chalky aftertaste that I attribute to high tannins. It has problems in storage in that it loses firmness rapidly.

Ginger Gold

The luster of this apple was not tarnished this year. It remains a very crisp, juicy, mild tasting apple that has a great deal of customer appeal. It is often harvested too early, when it is still too green. Even at this stage it is good, certainly better than most. It does not hold up well in storage so only those that can be sold at harvest should be planted. It holds up well on the tree. If one follows starch ratings, it loses starch very slowly. It may go from 2 to 5 (on a scale of 8) over a 2.5 week period, whereas others lose starch much faster. This is definitely a winner in New England.

Golden Supreme

This is a very high quality apple, both in looks and in quality, but its faults may kill it. It is not precocious, and it is quite biennial. It ripens irregularly and extensive preharvest drop is possible. Under ideal conditions it is an absolutely beautiful apple. I still like this one a lot and I am not willing to give up on it. It does store quite well.

GoldRush

We had a hot summer and consequently this did much better than it has in the past. Normally it is small, russeted, with high acidity. Acidity does mellow in storage, but not enough. This year it did do better, but it will never be a good apple for us unless global warming pushes the mid-Atlantic region weather up to New England. I do not recommend it for this area.

Hampshire

For New England or for cooler areas, I believe that Hampshire has a place. It is medium size plus, quite uniform in size, and attractive. It has a very mild taste at harvest. The apple mellows after 4 to 6 weeks in storage giving it a very tender yet pleasing taste and texture. It holds up well in CA storage. I recommend planting Hampshire, at least on a limited basis until we get more out there to evaluate.

Hardy Cumberland

This is a very attractive nearly 100% blush dark red apple. It has somewhat of an irregular shape. Flavor is good but mild, not sweet, crisp, or juicy. I evaluated it over a 3-week period from the end of September to October 19, with similar results. I will continue to look at this, since I have not formed an opinion yet, other than it is good.

HoneyCrisp

The popularity of this apple is amazing but it has so many things going for it that it deserves it. It is the crispest and best storing apple that I have ever worked with. Fuji is not even in the same category, but neither are any other apples currently under test. Its faults or problem are surfacing including leaf hopper susceptibility???, poor growth, lack of color, off tastes to mention a few. However, this apple has staying power and it will be a dominant player at least in the East for many years to come. We must work through the apparent problems. I could mention many things here but I believe that this apple has so much potential that a whole article should be devoted to it. I am on my third planting of HoneyCrisp, with no intention of slowing down.

Huanguan

This is not an attractive or visually appealing apple. It has 70% brownish red color that is somewhat striped and mottled. It is quite crisp and very juicy. The juice is extremely thick, unlike most other apples. It has an extremely strong vanilla taste, to the point of being objectionable. It is no better than medium size. The poor appearance, the size problem and the very strong flavor lead me to conclude that this is an apple that will not make it.

Huashuai

Huashuai is in the middle of the pack on too many characteristics. It lacks too many distinguishing features to have a bright future. It is very Delicious-like in appearance and taste. It lacks character/flavor. It is not crisp enough or juicy enough to overcome other deficiencies. It is similar to Cameo in some respects, but Cameo will win because it is larger, has better color, is more attractive, and I believe it tastes better.

Hudson's Golden Gem

I have fruited this wonderful apple for several years but have not reported on it because it is different, a fringe apple. It is a completely russeted apple that ripens in Golden Delicious time. The size is medium to large, and the shape somewhat oblate to conic. The taste is pear-like, but lacking the grit. Everyone that tastes this apple just loves it. It is somewhat sweet but with enough acid and tannins to give it character. The appearance is so different that it attracts attention. We are planting two apple varieties in quantity this year, Honeycrisp is one and Hudson's Golden Gem is the other one.

Kinsei

This is quite an unattractive apple that has very good flavor. Where does it fit in? I do not know. I still favor it and feel that it can develop a following if properly promoted. It is not large enough or attractive enough to be a dominant apple, but it may have a place. It stores very well. I found out this year that it is very susceptible to apple scab, in the McIntosh category.

Kitanosachi

This is another one of the Japanese apples that makes me ask why? It is small with dirty red striping. Flesh is green with a whitish tinge and the flesh feels soft even though it is not. Even in the third week in August there are better apples.

Monidel

This is the first year of evaluation of this apple. Shape is oblate to truncate, size medium to large, with a light striped cherry red color, but only moderately attractive. It is crisp, juicy, spicy, with a good sugar to acid ratio. Vanilla and licorice are quite prominent. It ripens at the end of August when the only real competition is Paulared, Ginger Gold, and Sansa. My notes indicate that this is a good apple that should be evaluated more, and I underlined it.

Murasaki

Quite irregular in shape and 100% muddy red color characterize the appearance of this apple. It had watercore in the second week of October but it was still not sweet. Even though this was the first year of evaluation, I believe that I will pull it out.

NJ 55 (Suncrisp)

I put Suncrisp in the same category as some of the other apples that originated from the mid-Atlantic region. We had a hot year last year and it did much better than it has in the past. It develops a very attractive orange red color in mid-October. Acidity was down, sugars were up and flavor was very good. It was a very good apple. It also stores well. In warm years we can look forward to a very good tasting apple in Suncrisp.

NJ 90

There are few apples evaluated this year that are as attractive as NJ 90. It is a flat McIntosh type that has a deep dark red color. It has excellent flavor that I characterize as perfumy vanilla. It is extremely crisp, slightly sweet, with a generous dose of acid and tannins. The major drawback to this apple is that the skin is extremely tough, so much so that it may be fatally flawed.

NJ 100

This is a fairly attractive yellow apple that has no russet. I rated it quite high in appearance, flavor, and overall, with good sugars and acid. It is somewhat crisp and very juicy. It has a very distinctive flavor. It ripens at the end of September. Last year I did not rate it too high so further testing is necessary to see how this one sorts out.

NJ 107

This is an extremely attractive white-yellow apple. It is medium in size and bruises easily. Flesh is somewhat soft. It has an anise flavor that is almost completely masked by very high acidity. It ripens about with Pristine, and if given a choice, I would select Pristine.

NJ 109

An extremely attractive glossy yellow color characterizes this apple. It is crisp, juicy with a very mild flavor, so mild that I hardly taste anything. It ripens just after Ginger Gold so the competition may be too great for this apple. Although it is more attractive than Ginger Gold, it is not better in any other attribute.

NJ 112

I rated NJ 112 in the middle of the pack in a number of areas. It has a fairly attractive red color covering 80 to 90 % of the surface. The flavor is OK but not outstanding and the skin is a little chewy. Fruit have moldy core. It ripens in the first week in October when there are many good fruit available. Just because there are many better ones, this will not make it.

NJ 116

I evaluated this apple four times over a three week period starting on August 3. It acts like a summer apple in that ripening is uneven, and there can be mealy apples on the tree while others are not ripe yet. It is an extremely attractive yellow apple, that for the most part I rated very high. It is crisp and juicy, and perhaps its best trait is its earliness. It is similar to other NJ yellow apples in that it is tart, has very weak flavor, and is very attractive in that it is russet free. It is a viable option for an early apple.

NY 460

I suspect that no one will comment on this apple. However, I think that it is an excellent one. It has the same parents as Fortune, Schoharie Spy X Empire. It is very attractive, somewhat ribbed with some fruit having an irregular shape. Size is large but not too large. It is crisp, firm, juicy and a very pleasant apple to eat. It is very susceptible to apple scab. It also inherited the lack of precocity associated with Northern Spy. It is a great apple to eat, and I guess I will be one of the few who will have that opportunity. I understand that this was one of Roger Ways personal favorites.

NY 73334-35

I evaluated a number of NY scab resistant apples this year and this is probably the best. It ripens in mid October. It is large, extremely crisp and juicy and quite attractive with 80 to 90% red color. The acidity is fairly high and this may mask some of the flavor. Essentially, it is a good apple.

Natco 3

This is a very distinctive apple and for that reason alone it deserves comment. It is a very typey yellow apple that has cosmetic/russet problems. It has prominent tan lenticels and an orange red cheek similar to Suncrisp. Other than the shape the distinctive feature of this apple is its very strong taste. It has a strong perfume-banana flavor with juice that is buttery and extremely thick. It is one that I think that you would either love or hate. The skin is chewy with elevated levels of tannins.

Pristine

I am not a big fan of Pristine but in the first week in August there are not too many choices of yellow apples. This year the Pristine in my NE-183 block was totally off. They can be very biennial. If it is harvested when not completely yellow the acids will be very high and it will have very little flavor. It does have licorice taste when it is ripe. I do believe that this is another one of those apples that will do better in a warmer climate.

Runkel

Runkel develops good red color before it is ready to harvest. It is large with 80 to 90% red color at harvest time in October. The flavor is good, fruity, tropical. When it is ripe the flesh may be somewhat soft and the skin appears to be tough. It is quite susceptible to apple scab. Overall it was a good apple.

Sansa

This is still one of the top apples that I recommend. It is very Gala-like, only ripening 2 weeks earlier. It is a lousy looking tree and it has the appearance of having apple mosaic virus, but this is genetic. I am totally convinced that an apple such as this has a place early in the season. Some people like it better than Gala. It is a weak tree and we must work to keep it growing well. In taste evaluation it comes out very high.

Shizuka

I continue to like this apple although I am seeing more of its faults. At harvest it was rated highest of all of the good apples in NE-183 for crispness, juiciness and flavor. The only apples that were rated higher, relative to being overall desirable, were Sansa and Golden Supreme. This is one of the apples in our storage test this year. It is softer than Mutsu at harvest and it does not hold up in storage as well as Mutsu. I have not tried it in CA storage yet, but in regular storage it is pretty well shot by the end of January or earlier.

Sunrise

Sunrise is an excellent apple if you harvest it on the right day. It acts like a summer apple in that it ripens variably, and when it develops good red color it has lost much shelf life. I agree with research in British Columbia that reports that it must be harvested much earlier, at starch level readings of 2 to 3 (on a scale of 8) to have good shelf life. If placed in cold storage it will deteriorate rapidly. I do not recommend this apple because of the multiple harvests and the problem with short shelf life.

Takane

It is very similar to Fuji. It is medium size, with a rather unattractive pinkish red color. The taste is similar to Fuji but perhaps better in that it may be sweeter and have more fruity aromatic flavor. It does not have the flesh firmness of Fuji. I will continue to look at this apple but I think that Fuji has the edge in appearance, and firmness.

Zestar (MN 1824)

This was another pleasant surprise from Minnesota. It is a large apple that has about 60% of the surface with a pinkish red color. It is not very attractive but it does have other attributes. It is my understanding that it is meant to compete with Paulared. It ripens about 5 days ahead of Paulared. It is crisp and juicy but the flesh does not seem as dense as others, almost pithy but not necessarily objectionable. It is a very pleasant apple to taste. It is slightly perfumy, sprightly, and yes, zesty. It is an apple that grows on you, almost addictive. I believe that it will compete successfully with Paulared even though it is not as attractive.

* * * * *

Influence of Odor-bait, Cultivar Type, and Adjacent Habitat Composition on Performance of Perimeter Traps for Controlling Apple Maggot Flies

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Department of Entomology, University of Massachusetts

Apple maggot flies (AMF) that immigrate into commercial apple orchard blocks from surrounding areas containing unmanaged host trees are the flies responsible for the great majority of infestation of fruit in commercial orchards. Previously, we have found that using perimeter-row, odor-baited red spheres to intercept immigrating AMF is an effective control method. More specifically, our findings have suggested that surrounding an apple orchard block with spheres baited with butyl hexanoate (BH) and placed 5 m apart will effectively prevent AMF from penetrating into the block.

Here, we present the results of experiments conducted in 2000 and 2001 designed to determine whether (1) spacing spheres 10 m apart on perimeter-row apple trees is as effective as spacing spheres 5 m apart in preventing AMF penetration into orchard blocks, (2) perimeter-row spheres baited with a five-compound blend of fruit odor volatiles are more effective than traditional BH-baited spheres in preventing AMF penetration into interiors of blocks, (3) the presence of AMF-susceptible compared with AMF-tolerant cultivars comprising front-row apple trees affects front-row-trap captures and AMF penetration into interiors of blocks, and (4) adjacent habitat affects AMF population numbers immigrating into commercial orchards.

Materials & Methods

In 2001, 10 Massachusetts commercial orchard blocks were involved in our experiment (initially, we used 12 commercial orchard blocks in 2001, but for the purpose of this article, we excluded two of them due to unusually high AMF populations that would blur data trends in the remaining 10 blocks). Five blocks had front-row cultivars that were comparatively susceptible to AMF (Gala, Jonagold, or Fuji) and five blocks had comparatively tolerant front-row cultivars (McIntosh or Empire). Each orchard block had an adjacent habitat of woods, hedgerow, or open field. Each block in the 10 commercial orchards was divided into three plots (Figure 1). Plots A and B had a 45m length of front row and a depth of seven rows. The front row in plots A and B contained five sticky red spheres, spaced 10m apart. Each was baited with either the five-compound blend (BH, hexyl butanoate, butyl butanoate, pentyl hexanoate, and propyl hexanoate) or BH alone. Plots A and B received no insecticide spray to control AMF. Plot C (termed grower sprayed) had a 30m length of front row and a depth of seven rows. It was sprayed by the grower two or three times with an organophosphate insecticide to control AMF. Each of the two sides of plots A and B, as well as the back row (row 7), contained red spheres spaced 5 m apart, baited with butyl hexanoate. Plot C had no perimeter, side, or back-row spheres. Rows 3 and 4 contained six unbaited sticky red spheres (four in the grower-sprayed plot due to the smaller size) to monitor AMF penetration into the interior of plots. Traps were deployed in late June and remained through the beginning of October. Every 2 weeks, traps were cleaned and captured AMF were counted.

The protocol for our 2001 experiment was based on results of a test conducted in 2000, in which we evaluated AMF penetration into orchard blocks by

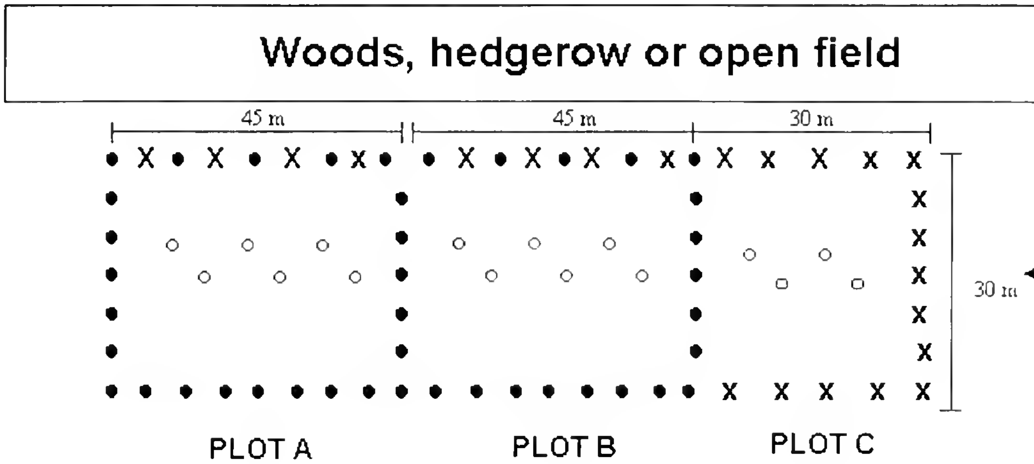

Figure 1. Schematic illustration of the 2001 season block layout for evaluation of sticky red sphere traps for controlling AMF: ? = odor-baited traps, wherein front-row traps in Plot A were baited with a five-component blend, front-row traps in Plot B were baited with butyl hexanoate, and all other baited traps received butyl hexanoate; ? = unbaited interior monitoring traps in rows three and four; **x** = unbaited apple trees. No insecticide was applied to any tree in Plot A or Plot B, but was applied two to three times to all trees in Plot C in July and August.

comparing AMF captures on red spheres baited with the five-compound blend and placed either 5 or 10 m apart on front-row trees. Methods were, in general, similar to those for 2001 with the following differences: (1) for 2000, we included data for all 12 orchard blocks initially considered for 2001, (2) in 2000, the perimeter row of each plot was only 30 m long, and (3) in 2000, traps placed on sides and back rows were spaced 10 m apart. Results of that study are also presented in this article.

Results

Results from 2000. Experiments that we conducted in 2000 show that across all five sample periods and all 12 orchard blocks, about 26% more wild AMF were captured per trap on front-row traps that were spaced 5 m apart (mean=27) than 10 m apart (mean=22), but there was virtually no difference in wild AMF penetration into interiors of the plots (respective means of 9 and 8/trap/plot) (Figure 2A). Thus, front-row traps that were spaced at 5 m or 10 m apart captured about three times more wild AMF per trap than interior monitoring traps. Interior-row traps in grower-sprayed plots captured 33 and 12% fewer AMF, respectively, than interior-row traps in plots with perimeter traps 5 or 10 m apart. The ratio of front-row/interior-row trap captures was markedly higher for tolerant cultivars (3.8:1) than for susceptible cultivars (2.3:1) (Figure 2C and E). For susceptible cultivars, interior monitoring traps in trapped plots captured about 45% more AMF than interior monitoring traps in grower-sprayed plots (Figure 2C). For tolerant cultivars, interior traps in trapped plots captured about 6% fewer AMF than interior traps in grower-sprayed plots (Figure 2E).

Overall AMF captures in 2001. In 2001 (with much higher AMF population numbers than in 2000), across all six sample periods and all 10 orchard blocks, 57% more wild AMF per trap were captured by front-row traps baited with the five-compound blend (termed blend plots) than by front-row traps baited with BH (termed BH plots)(Figure 2B). Unbaited interior monitoring traps in BH plots captured about 13% more AMF than interior traps in blend plots and about 47% more AMF than interior traps in the grower-sprayed plots (about 7/trap/plot). About seven times more wild AMF per trap were caught by front-row traps in blend plots than by interior monitoring traps, whereas only about five times more wild AMF were caught by front-row traps in BH plots than by interior traps.

The effect of front-row cultivar type on AMF

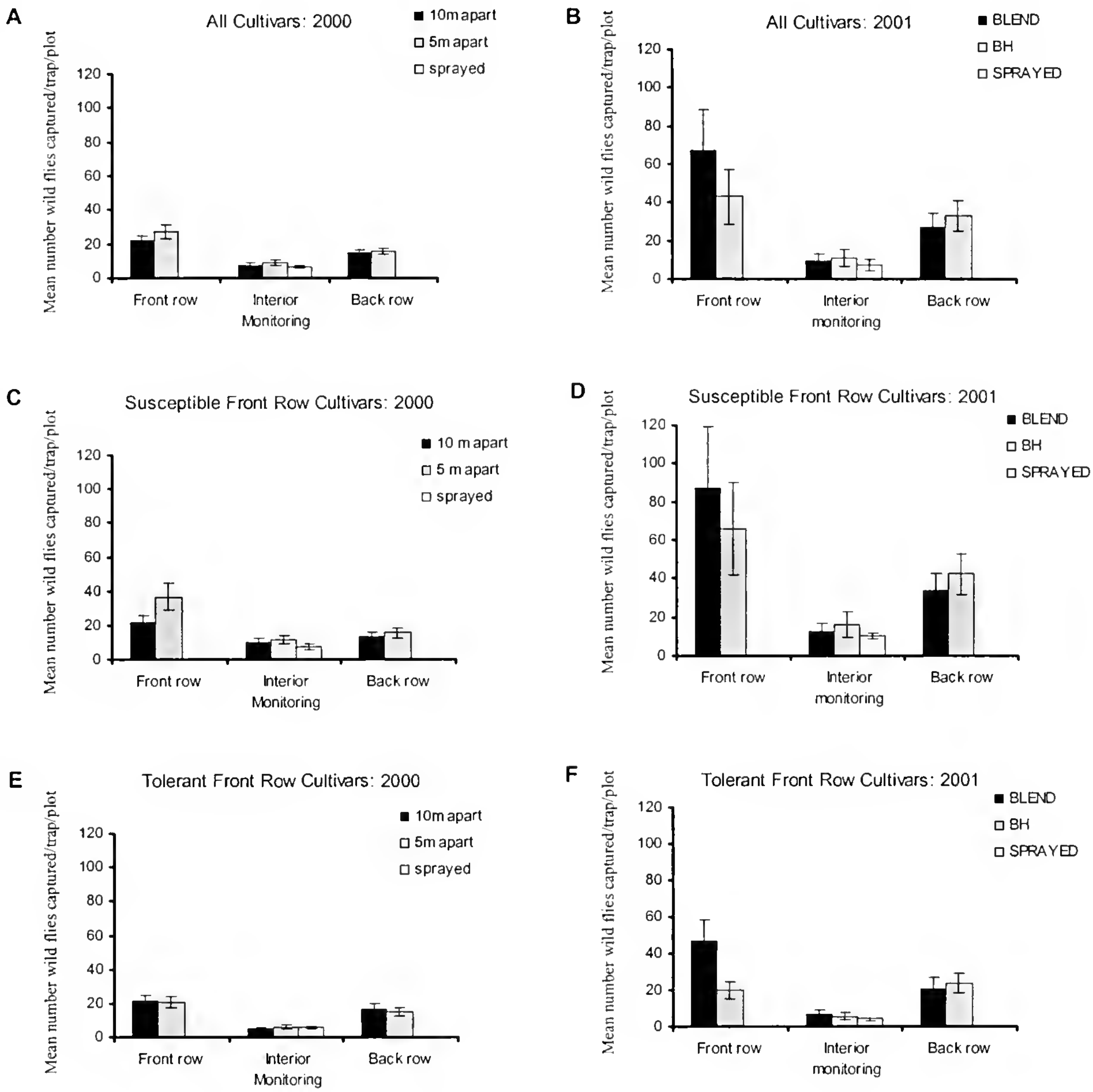

Figure 2. For 2000 and 2001, across all sample periods, sum of mean numbers of wild AMF captured by odor-baited spheres placed on front rows or back rows of plots or unbaited spheres placed at interior of plots for all plots (A and B) and for plots where the front rows were composed of susceptible (C and D) or tolerant cultivars (E and F). In 2000, only the five-compound blend was evaluated. In 2001, all front-row traps were placed 10 m apart.

captures in 2001. For susceptible cultivars, front-row traps in blend plots captured somewhat more wild AMF per trap than front-row traps in BH plots (about 33% more), whereas for tolerant cultivars, front-row traps in blend plots captured substantially more (136% more) wild AMF than front-row traps in BH plots (Figure 2D and F). Front-row traps in blend and BH plots of susceptible cultivars captured substantially more AMF (85% and 228% more, respectively) than front-row traps in corresponding plots in tolerant cultivars. When averaged across both types of trapped plots and grower-sprayed plots, interior monitoring traps in susceptible cultivars captured substantially more (130% more) wild AMF than in tolerant cultivars. The ratio of front-row-trap/interior-row-trap captures in blend and BH plots was the same within each cultivar type as it was for both cultivars together (about 7:1 for blend and about 5:1 for BH).

Effects of adjacent habitat in 2000 and 2001. In 2000, of the total number of AMF captured by all traps in all orchards, 41% were captured in blocks adjacent to woods (Figure 3). A similar percentage (37%) was captured in blocks bordering hedgerows. The smallest percentage of total captured flies was found in blocks bordering open fields (21%).

In 2001, blocks bordering hedgerows had the highest percentage (47%) of total fly captures, followed by orchard blocks bordering woods (32%), and blocks that were adjacent to open fields (21%) (Figure 3).

Conclusions

In 2000, in the same orchards studied in 2001, data suggested that there was virtually no difference in AMF penetration into orchard blocks when front-row traps baited with the five-compound blend were placed either 10 m or 5 m apart. In 2001 (with front-row traps spaced 10 m apart), front-row traps in blend plots captured more flies than front-row traps in BH plots. Although there was little difference in the mean number of wild AMF that penetrated into the interior of the two baited plots, the ratio of front-row to interior-row-trap captures was higher when front-row traps were baited with blend. Inasmuch as blend appears to be more capable than BH of drawing AMF to the vicinity of traps (based on front-row-trap captures), these data suggest that blend odor-bait is better than BH in preventing AMF from penetrating into the interior of orchards.

Orchard blocks with tolerant front-row cultivars experienced substantially more AMF captures on front-row traps baited with blend than BH. The difference was much less for blocks with susceptible front-row cultivars. This suggests that baiting front-row traps with blend in tolerant cultivars attracts many more flies than baiting tolerant trees with BH. In both 2000 and 2001, and in trapped as well as grower-sprayed plots, more total AMF were captured in orchard blocks with susceptible front-row cultivars than in those with tolerant front-row cultivars. However, the ratio of front-row to interior-row-trap captures remained the same regardless of cultivar. This suggests that each odor bait is just as effective in one cultivar type as it is in the other cultivar type in preventing AMF penetration into the orchard interior.

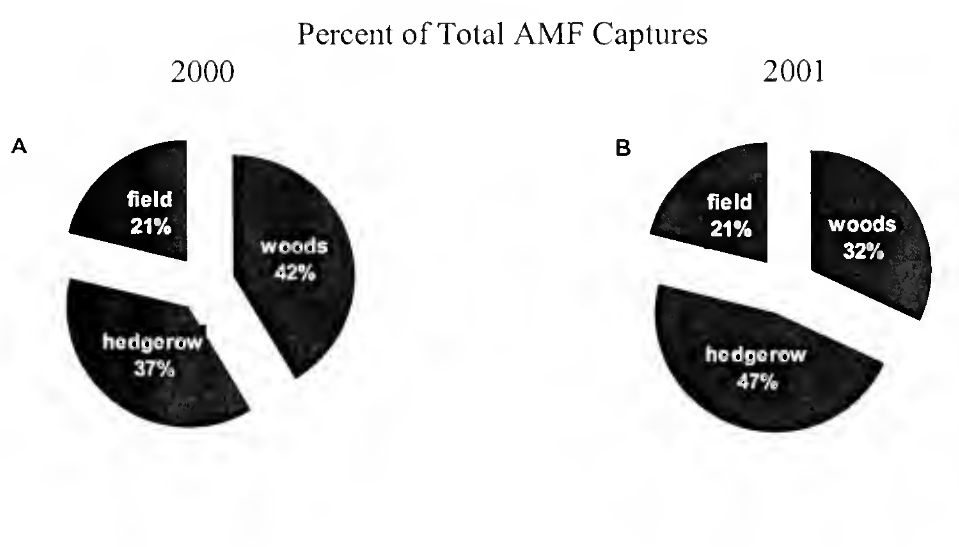

Figure 3. In 2000 and 2001, across all blocks, all traps, and all sample periods, percentage of the total AMF captures according to adjacent habitat (woods, hedgerow, or open field). For the purpose of this figure, all 12 orchard blocks were considered in 2001.

Results from both 2000 and 2001 show that orchard blocks that have woods or hedgerow as adjacent habitat are subject to higher AMF pressure than blocks bordered by open field. Orchard blocks that bordered an open field had consistently lower fly captures than blocks that bordered either woods or hedgerow (habitats that typically support wild host plants).

Based on our findings, it appears that odor-baited red sphere traps are effective in preventing AMF penetration into orchard blocks when they are spaced at 10 m apart on the perimeter row, especially when baited with blend. Regardless of cultivar type, the blend bait appears to be better than the BH bait at preventing flies from penetrating into the interiors of orchard blocks. In 2002, we plan to evaluate further the capability of different odors on perimeter-row traps for intercepting wild AMF immigrating into commercial orchards.

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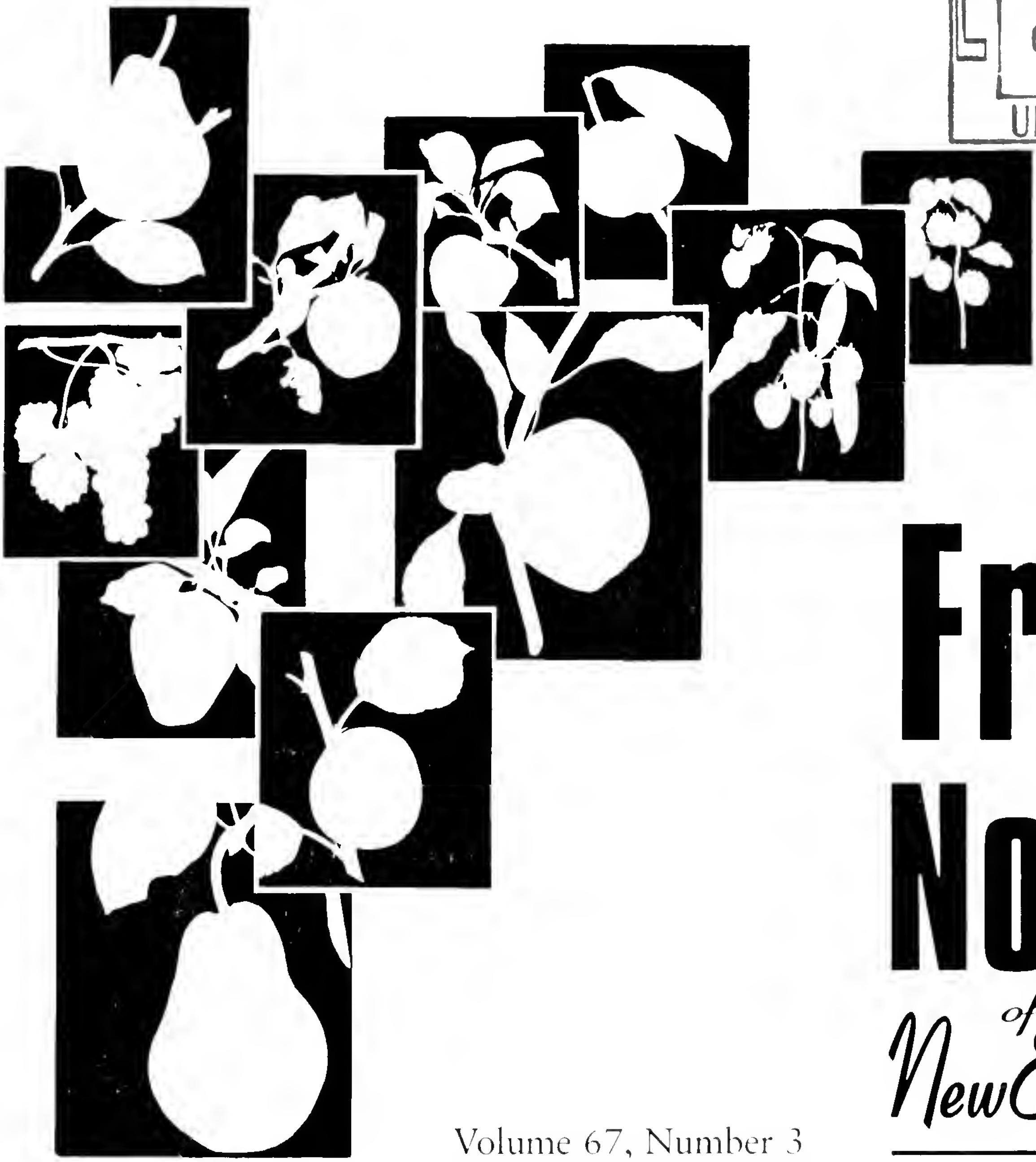

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Comparing the Harvest and Storage Characteristics of Mutsu and Shizuka Apples

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There is interest, especially among apple growers who are retailing fruit, to find new "niche" varieties which consumers like and which can be profitably grown and sold. A green/yellow Fall cultivar is something customers look for (the Granny Smith influence). We have been attempting to identify some of the most promising varieties suitable for growing in the northeast by planting and systematically evaluating apples at the University of Massachusetts' Cold Spring Orchard Research & Education Center (CSOREC) in Belchertown, MA. For the past four years we have been evaluating storage qualities of Mutsu and Shizuka. Mutsu, also known as Crispin, is a variety which has consumer following, but it is susceptible to Blister Spot, a bacterial disease which renders fruit unsaleable. Shizuka is a similar apple (same parents, Golden Delicious x Indo) which appears to be resistant to Blister Spot and has been suggested to be an alternative to Mutsu. The two apples are quite similar in appearance. They are large fairly round green/yellow fruit which often develop a pink blush. Shizuka may be considered slightly more attractive as its skin is smoother and it has less tendency to russet (although russet is not severe on Mutsu, either). Lenticels are attractive and are more noticeable on Shizuka than on Mutsu. We have compared storage qualities of these two varieties over the past four seasons.

Harvest Information

Three trees of each cultivar from a block at CSOREC were used for the evaluations. Trees were planted in 1991, and all are on Mark rootstock. Each tree produced 3 to 4 bushels of fruit in each of the four years.

Table 1. Assessments of Mutsu and Shizuka fruit at harvest, 1998-2001.

Harvest year	Grams per fruit		Internal ethylene (ppm)		Starch index		Firmness (pounds)	
	Mutsu	Shizuka	Mutsu	Shizuka	Mutsu	Shizuka	Mutsu	Shizuka
1998	282	290	1	3	3.9	4.4	19.6	16.7
1999	333	292	4	1	3.2	4.8	19.1	16.2
2000	345	268	2	6	3.8	5.3	18.3	15.8
2001	311	213	9	3	3.2	3.9	20.0	18.1
Average	318	266	4	3	3.5	4.6	19.3	16.7
Comment	Mutsu larger		Not different		Shizuka "riper"		Mutsu firmer	

Table 2. Changes in average starch index and firmness of Mutsu and Shizuka apples as harvest progressed, 1998-2001.

Harvest date	Starch index		Firmness (pounds)	
	Mutsu	Shizuka	Mutsu	Shizuka
Sept 22-25	2.6	3.5	20.4	16.8
Sept 26-29	3.2	3.9	20.5	17.6
Sept 30- Oct 3	3.3	4.5	19.3	16.7
Oct 4-7	4.0	5.2	18.1	16.1
Oct 8-11	4.4	5.9	18.5	15.9
Oct 12-16	4.8	6.3	17.5	15.9
Oct 23	6.5	8.0	17.0	15.2

In an attempt to determine optimum time of harvest for stored fruit, both varieties were harvested over the period of late September through mid October in 1998, 1999, 2000, and 2001. At each harvest, ten to thirty representative fruit were selected from each variety, and brought to the lab for measurement of size, internal ethylene and starch hydrolysis to estimate fruit maturity, and firmness as a crude indicator of quality. Internal ethylene was measured by gas chromatography, starch degradation was rated using the Cornell Generic Starch Index, and firmness was measured with either a Wagner pressure tester or an EPT1 pressure tester. A bushel or more of fruit was harvested from each cultivar on selected harvest dates and placed in refrigerated air storage at 32°F. Fruit from one harvest in 1998 were also stored in controlled atmosphere storage (CA), at 38°F, 2.8%O_2, and varying CO_2 up to 5%.

Harvest data are presented in Tables 1 and 2. Table 1 shows extensive year-to-year differences in harvest qualities of the fruit. All factors listed in the table varied significantly from year to year. Harvest dates were not exactly the same every year (as shown in Table 2), but the same time span was evaluated. The fact that the Shizuka were not as firm as the Mutsu may be attributed in part to earlier ripening rather than being inherently less firm.

Table 2 illustrates the influence of harvest date on firmness of Mutsu and Shizuka. Starch Index is an indicator of progression of ripening. As expected, firmness decreased with later harvest of both cultivars, and Starch Index increased with later harvest. Year-to-year differences in all three measurements were found, but in all years Mutsu was the firmer apple and had a lower starch index on any given date. Starch degradation appears to be a good indicator of fruit ripening in both Mutsu and Shizuka. Even taking into consideration that Shizuka could probably have been harvested up to a week earlier than Mutsu at comparable starch scores, Shizuka was never as firm an apple as Mutsu. Internal ethylene concentrations were quite variable and are not shown.

Since Mutsu and Shizuka are both green to yellow fruit, color should be a minor factor in choosing time of harvest, although both cultivars can develop an attractive pink blush during the ripening period. Over half of the fruit of both cultivars did develop this pink blush covering at least 5% of the fruit's surface area. Further, the conversion from green to yellow would be

Table 3. Firmness (lbs)[z] of Mutsu and Shizuka fruit on removal from storage.

Harvest year	Mutsu		Shizuka	
	December	January	December	January
1998	14.7	12.8	12.1	11.1
1999	14.3	13.1	12.4	11.0
2000	15.4	14.0	12.9	12.0
2001	16.8	15.8	15.2	14.7

[z] Firmness was measured with a Wagner penetrometer in 1998 and with an EPT1 in 1999, 2000, and 2001.

Table 4. Results of poststorage taste tests to assess flavor and overall desirability of 32F air-stored Mutsu and Shizuka apples.

Harvest year	Desirability[z]			
	December		January	
	Mutsu	Shizuka	Mutsu	Shizuka
1998	3.2	2.7	2.1	2.3
1999	3.8	3.6	3.2	2.5
2000	3.8	3.2	3.3	2.7

[z] Rating is on a scale of 1 to 5, with 1=poor, 2=fair, 3=acceptable, 4=very good, 5=outstanding, and, incorporates firmness, flavor, acidity, crispness, and appearance components.

influenced by nitrogen level, as well as by fruit maturity.

Storage Information

Fruit were placed in cold storage immediately following harvest. Half the fruit were removed from storage for evaluation in mid December and the other half were removed a month later (7 weeks later 1998-99). In addition, some fruit were stored in controlled atmosphere (CA: 38°F, 2.8%O_2, up to 5%CO_2) for the 1998-99 season. Those fruit were removed for evaluation on February 12, 1999. Results of CA storage will be discussed separately.

There were three parts to the fruit evaluation. (1) At the time of each removal from storage, half the removed fruit were immediately pressure tested. (2) The pressure tested fruit were kept refrigerated and were taste tested over a few days following removal from the cold storage. (3) The removed fruit which were not pressure tested were kept at room temperature (68°F) for a week and then evaluated for storage disorders.

Table 3 shows the condition of the fruit on removal from cold storage. Fruit firmness after storage was greater for Mutsu than for Shizuka, and these differed significantly from year to year. There was a significant drop in firmness from mid-December to mid-January for both varieties. The Mutsu lost more firmness between December and January than did the Shizuka, but still remained the firmer apple in January. If we arbitrarily assign a firmness of 12 pounds at removal from storage to be the lower limit of acceptability, then the Shizuka were dropping below the level of acceptability by mid January. Taste tests, results of which are shown in Table 4, confirm this. Unfortunately no taste tests were done in the 2001-02 season in which the fruit were firmest.

"Desirability" incorporates assessments of firmness, flavor, crispness, attractiveness, acidity, juiciness, and astringency. A score of less than 3 is considered less than acceptable. In the December ratings, time of harvest was not a factor, but in the January ratings, the earlier harvests were judged higher for both varieties. Both varieties were in the acceptable range in December (except for Shizuka in 1998), but a month later even the Mutsu were not consistently acceptable. Some of the poor showing for desirability in the January rating of the 1998 fruit may be because the mid-January removal

Table 5. Poststorage disorders of Mutsu and Shizuka apples rated after 32F storage until mid-December and mid-January followed by 1 week at 70F.

Harvest year	Percent breakdown		Percent superficial scald	
	Mutsu	Shizuka	Mutsu	Shizuka
1998	2	3	43	12
1999	26	8	12	0
2000	0	1	10	0
2001	0	0	0	2

Table 6. Some storage characteristics of Mutsu and Shizuka apples harvested October 2, 1998.

	Superficial scald (%)		Firmness[z]		Desirability[zy]	
Storage through:	Mutsu	Shizuka	Mutsu	Shizuka	Mutsu	Shizuka
12/15/98 (32F air)	25	0	3.0	1.8	3.3	2.5
2/1/99 (32F air)	83	0	1.5	1.5	2.0	2.2
2/8/99 (CA)	4	0	2.3	2.5	3.5	3.0

[z] Firmness and desirability are both rated on a scale of 1 to 5, with 1=poor, 2=fair, 3=acceptable, 4=very good, 5=outstanding.
[y] Desirability includes firmness, flavor, acidity, crispness, and appearance components.

from storage actually happened on February 1, 1999.

Assessment of poststorage fruit disorders was made following a week at room temperature, and results of the assessments are shown in Table 5. Because findings were similar for fruit removed from cold storage in December and January, results have been combined. Table 5 shows that poststorage disorders did not occur with consistency. Senescent breakdown was a problem in Mutsu following the 1999-2000 storage season. However, no significant senescent breakdown was found in either variety following storage and a week at room temperature the following two years, and very little developed in the 1998-99 storage season. There was a substantial amount of superficial scald following storage in 1998-99, but much less in the following years. Mutsu was more scald susceptible than was Shizuka. Neither scald nor breakdown could be attributed to time of harvest, although the year with the most scald (1998) was one in which there was no late harvest, and scald is most likely to develop on early harvested fruit. Other disorders assessed were bitter pit and decay, neither of which occurred with enough frequency to analyze. We did note moderate skin greasiness on Shizuka from the late harvests of 2000 and 2001 after they had spent a week at room temperature in January.

Controlled Atmosphere (CA) Storage

Fruit were stored in CA as well as in refrigerated air during the 1998-99 storage season. The CA was a "soft" room; 38°F, 2.8%O_2, varying CO_2 to 5%. Table 6 shows how dramatically CA storage improved some poststorage characteristics of Mutsu and Shizuka. The reduction in superficial scald development on Mutsu is of particular interest.

Conclusions

Based on the 1998-99 storage season's data, CA appears to be necessary for both Mutsu and Shizuka if they are to be stored beyond mid-December. Even in mid-December the Shizuka did not emerge from air storage in good condition in 1998, although they did better in subsequent years. The Shizuka had probably reached the limit of their quality CA life in 1998-99 when they were tested in February, while the Mutsu could have gone longer in CA and emerged in acceptable condition. The quality difference between air and CA storage was dramatic for both cultivars.

Mutsu retains good quality in storage longer than Shizuka. The areas in which Shizuka fared better were appearance (3.1 vs 2.7 on the 1 to 5 scale) and scald resistance. Shizuka does tend to be a smaller apple which could be an advantage, since both cultivars can be very large. Where blister spot is not a limiting factor, Mutsu would be the more highly recommended cultivar in a marginal storage situation. Shizuka could be an acceptable substitute if the fruit were marketed primarily in the fall or stored in CA. It is a more attractive fruit than Mutsu, and for the September market, Shizuka has the advantage of ripening slightly earlier. If Shizuka is to be stored longer than mid-December, it should be placed in CA.

Either Mutsu or Shizuka can be an acceptable large green/yellow apple for the autumn market if handled properly after harvest.

1-MCP: How Useful Can It Be on New England Apples?

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Fruit ripening is initiated by ethylene, and to some extent, the rate at which ripening proceeds is regulated by its concentration in the fruit. Fruit generally soften faster at high ethylene levels, but ethylene is also needed to stimulate formation of flavor producing volatiles in the fruit. Low temperature air storage slows the progress of ripening but does not prevent the changes it produces. Controlled atmosphere (CA) storage, however, can interfere with ethylene actions and alter the quality of ripened fruit.

For ethylene to have an effect, it must first be bound on the surface of the cells. 1-Methylcyclopropene (1-MCP) is a new compound that can block this ethylene binding and prevent or seriously interfere with ethylene induced fruit ripening and its effects on fruit quality. Recent studies of 1-MCP treatment of apples have produced some exciting results, including substantial retention of firmness and dramatic reduction of superficial scald. However, effects have not been entirely consistent, especially on McIntosh, and further tests to characterize responses to 1-MCP are clearly needed.

1-MCP is obtained as a powder that is used to generate 1-MCP gas within a closed area containing harvested fruit. Following treatment the fruit can be placed into air or CA storage and will require no follow-up 1-MCP treatment. The material is not yet commercially available, but since it does not leave any residue on the fruit and is incorporated into the fruit in minute concentrations, no health issues have arisen to our knowledge, so its labeling might occur soon

There are many questions surrounding potential use of 1-MCP. Results do not appear to be uniform across cultivars. If ripening has begun before a fruit is treated, presumably it will continue despite treatment, making time of harvest a crucial concern. If ripening is blocked, will a fruit recover sufficiently to develop quality attributes, especially flavor? For these reasons, in Fall 2001 we initiated experiments to evaluate 1-MCP effects on apples under New England conditions.

We surveyed 1-MCP effects on a range of cultivars from early- to late-maturing, and at different harvest times for individual cultivars. Cultivars reported here are Ginger Gold, Gala, McIntosh, Delicious, and Spigold. All fruit were stored in 32F air following treatment, the durations of storage varying among cultivars. For all cultivars, internal ethylene concentration and fruit firmness were evaluated. Occurrence of storage disorders was recorded, and, for Delicious, fruit weight loss was determined since there is some evidence that 1-MCP reduces it during and following storage.

Application

The 1-MCP is provided as a powder. When mixed with water, 1-MCP is released as a gas. This is not an instantaneous reaction. Apples were harvested and cooled overnight at 32F. A sample of approximately one bushel was then removed from the cold storage and placed in a 33 gallon plastic trash barrel. A petri dish with 200 mg of the 1-MCP powder was then placed on top of the apples and was mixed with 5 ml of warm water. The barrel was immediately covered with plexiglass and sealed with silicon vacuum grease. This procedure was to produce a concentration of 1 part per million 1-MCP in the barrel. The barrel was then returned to cold storage. After 24 hours the barrel was removed from cold storage, the apples were removed, returned to conventional boxes, and put back into cold storage.

We looked at only some of the known effects of 1-MCP on fruit. Internal ethylene and fruit firmness were measured at harvest and following storage. Some fruit were weighed at these times as well, as it had been reported that 1-MCP could influence weight loss in apple. Background color was recorded for Royal Gala.

Table 1. Effects of 1-MCP on ethylene content and firmness GingerGold apples after 32F air storage for 3 or 8 weeks, each followed by a week at 70F to evaluate shelf life.

Treatment	Harvest date	At harvest	After 3 wks at 32F	Plus 1 wk at 70F	After 8 wks at 32F	Plus 1 wk at 70F
			Internal ethylene concentration (ppm)			
Check	8/20	0	101	710	109	483
	8/27	7		474	335	663
1-MCP	8/20	0	0.4	1.1	1.4	4.4
	8/27	7		1.5	3.3	13.2
			Firmness (pounds pressure)			
Check	8/20	19.8	16.3	11.6	15.4	13.8
	8/27	18.9	15.0	11.1	14.3	12.0
1-MCP	8/20	19.8	17.9	19.7	16.6	17.9
	8/27	18.9	17.9	18.2	16.3	15.6

Table 2. Effects of 1-MCP on internal ethylene concentration, firmness, and background color of Royal Gala apples after 32F air storage for 90 or 150 days, each followed by 1 week at 70F to evaluate shelf life.

Treatment	Harvest date	At harvest	After 90 days at 32F	Plus 1 wk at 70F	After 150 days at 32F	Plus 1 wk at 70F
			Internal ethylene concentration (ppm)			
	9/4	0.8	62	195	65	169
Check	9/11	2.3	48	169	32	215
1-MCP	9/4	0.8	0.3	0.7	0.5	0.4
	9/11	2.3	0.8	0.6	0.3	0.4
			Firmness (pounds pressure)			
Check	9/4	20.4	17.5	16.4	16.1	15.3
	9/11	19.4	16.9	14.9	15.1	14.9
1-MCP	9/4	20.4	18.9	18.8	17.9	17.3
	9/11	19.4	17.1	17.2	16.5	16.6
			Background color[z]			
Check	9/4		6.5	7.4	7.8	7.7
	9/11	6.4	7.8	8.3	8.1	8.1
1-MCP	9/4		6.0	6.8	7.2	7.2
	9/11	6.4	7.1	6.5	7.9	7.9

[z] Background color ratings of 1-10 move from green (1) through white-green to yellow (10). The dividing line between green/white-green and yellow was between 6 and 7.

Results by Cultivar

Ginger Gold. Ginger Gold is not a cultivar normally associated with long storage. We tested it primarily to test the application method, but results were striking (Table 1). Fruit were stored for either three or eight weeks in 32F air, after which half the fruit were evaluated and the rest were kept at room temperature for a week before being evaluated.

1-MCP greatly suppressed ethylene levels in the fruit. In fact, for the August 27 harvest it caused the ethylene present at harvest to drop sharply during and following storage. However, over time, both in storage and after storage, the ethylene gradually rose as the fruit slowly overcame the 1-MCP effect.

Firmness of untreated fruit predictably dropped rapidly during and following storage, producing unacceptably soft apples. 1-MCP treated fruit also softened during storage, but far less. In particular, little additional softening occurred at room temperature following storage, whereas untreated fruit softened greatly after storage.

Table 3. Effects of 1-MCP on ethylene concentration, fruit firmness, and superficial scald development of McIntosh apples in two experiments. Data were collected after 7 days at 70F following each air storage period at 32F to evaluate shelf life.

Treatment	Days in 32F storage	After 7 days at 70F Ethylene (ppm)	Firmness (lbs)	Scald (%)
		Mean of three strains harvested 9/10		
Check	0	0.04	17.2	0
	90	743	10.7	3
	175	972	9.2	100
1-MCP	0	0.04	17.2	0
	90	52	12.4	3
	175	816	11.6	0
		Retain[tm]-treated fruit harvested 10/1		
Check	0	2.2	14.4	0
	90	381	10.1	0
	150	649	9.1	0
1-MCP	0	2.2	14.4	0
	90	1	12.3	0
	150	35	10.8	0

Ginger Gold apples treated with 1-MCP were still firm and appealing after eight weeks in air storage plus one week at room temperature, whereas untreated fruit were unacceptable.

Royal Gala. Royal Gala were harvested on two dates, treated with 1-MCP like Ginger Gold, and stored in 32F air, but for longer times, i.e., 90 and 150 days. Untreated fruit increased in ethylene content during and following storage, but their maximum levels were only about one-third the maximum levels in Ginger Gold (Table 2). 1-MCP treatment severely suppressed ethylene levels in Royal Gala. Again, at second harvest 1-MCP suppressed the ethylene levels in treated frui to below what was there at harvest, but in this cultivar, ethylene levels never gave any indication of increasing following treatment.

Untreated fruit softened during and following storage, and also developed a progressively yellower background color. Treated fruit also softened during storage, but like Ginger Gold, did not soften at room temperature following storage and were substantially firmer than the untreated ones at all evaluations. Treated fruit also became yellower with time, but were generally less yellow than the controls. Harvest date did not influence the effect of 1-MCP; harvest differences were retained, but not changed.

McIntosh. McIntosh is of particular interest in New England and two experiments were conducted. In the first, three strains (Rogers, Morspur, and SpurMac) were harvested on September 10 when the fruit were just beginning to produce ethylene. The strains were all treated as described above, and stored at 32F in air for 90 or 175 days, plus 7 days at 70F prior to evaluation. In the second experiment, some Retain[tm] treated fruit were harvested on October 1, and treated and stored the same as the strains, except for a maximum of 150 rather than 175 days. This is a late harvest date, and fruit averaged over 2 ppm internal ethylene at harvest.

The three strains all responded similarly to 1-MCP so only their averages are presented in Table 3. (Note that Rogers were about 3/4 pound softer than the others, but this was true across time and treatment and was not treatment-related). Untreated fruit accumulated very high ethylene concentrations, and 1-MCP only delayed the rise, the fruit eventually reaching about the same level as the untreated ones. Untreated ones softened excessively, although it should be noted that they were stored beyond the normal limits for McIntosh. 1-MCP-treated fruit also softened, but much less, and were still acceptably firm after the longer storage time. The untreated fruit also scalded during the longer storage time, whereas 1-MCP treatment prevented this from happening.

Table 4. Effects of 1-MCP on internal ethylene concentration, fruit firmness, and weight loss of Redchief Delicious apples after 32F air storage for 90 or 150 days, each followed by 1 week at 70F to evaluate shelf life.

Treatment	Storage time (days)	Ethylene (ppm)	Firmness (lbs)	Fruit weight (grams)	Weight loss (%)
Check	0	32	17.4	164	
	90	159	14.8	158	3.2
	90+7	309	13.9	156	4.6
	150	266	13.2		
	150+7	401	12.7		
1-MCP	0	32	17.4	166	
	90	12	15.9	162	2.7
	90+7	62	16.1	159	4.0
	150	41	15.4		
	150+7	93	15.2		

The Retain™ treated fruit harvested three weeks later responded much the same as the three strains, except that ethylene increased far less and no scald developed. These differences are not likely associated with 1-MCP, but rather occurred because Retain™ has the effect of reducing ethylene, and late harvest reduces scald.

Delicious. Redchief Delicious were harvested on October 1 and October 11, treated with 1-MCP, and stored in 32F air for 90 or 150 days, and then for 7 more days at 70F. Subsamples were weighed at harvest, placed in paper bags, and stored like the others, and reweighed at removal from storage and again after 7 days at room temperature.

Fruit from the two harvests responded the same to treatment and storage, so in Table 4 the means of the two harvests are presented. Ethylene content of untreated fruit increased substantially with storage time and after transfer to 70F. 1-MCP again caused ethylene content during storage to fall below that at harvest, but it rose over time and during fruit warming, although it never approached the ethylene levels of untreated fruit. Untreated fruit softened greatly during storage and at room temperature. 1-MCP treated fruit also softened, but not nearly as much as the untreated fruit. Both treated and untreated Delicious lost weight during and following storage, but 1-MCP reduced the size of this loss.

Spigold. In order to determine if 1-MCP could inhibit ethylene production even if fruit were already producing substantial ethylene, Spigold were harvested October 22 (very late!) with average Starch Index of 7.6 (Cornell generic chart) and average internal ethylene concentration of 31 ppm. Fruit were treated like the other cultivars, and stored for 90 or 150 days in 32F air, plus 7 days at 70F. Table 5 shows that the ability of 1-MCP to reduce ethylene production was significant despite the fact that the fruit were already producing a substantial amount of ethylene prior to the 1-MCP treatment. 1-MCP treated fruit were firmer, too, although there was substantial fruit-to-fruit variation in firmness due to very large fruit sizes.

Discussion

Treatment with 1-MCP consistently resulted in firmer fruit following cold storage. This firmness advantage remained or was enhanced after fruit were left at room temperature for a week. 1-MCP-treated fruit did, however, soften over time, just not as much as did the untreated fruit. Ethylene production was suppressed well into the storage period. The duration of this suppression was cultivar dependent. Ethylene production was essentially shut down by 1-MCP

Table 5. Effects of 1-MCP on internal ethylene concentration and fruit firmness on Spigold apples harvested October 22 following 32F air storage for 90 or 150 days, each followed by 1 week at 70F to evaluate shelf life.

1-MCP applied	At harvest	90 days cold storage: 1 day warm	90 days cold storage: 7 days warm	150 days cold storage: 1 day warm	150 days cold storage: 7 days warm
Internal ethylene concentration (ppm)					
Check	31	180	359	209	384
1-MCP		49	39	64	185
Firmness (pounds)					
Check	14.6	10.2	10.0	9.4	9.1
1-MCP		11.0	11.8	10.6	10.0

treatment for at least 150 days in Gala. Ethylene production in 1-MCP treated McIntosh reached levels of control fruit by 175 days of cold storage in fruit which had not been treated with Retain™. Weight loss during cold storage was significantly reduced in Delicious, and weight loss during a week at room temperature following cold storage was reduced by 1-MCP treatment of McIntosh (data not shown) and Delicious. A very significant result was that all cultivars harvested on different dates showed the same results between harvest dates, except that changes that occurred before harvest were not reversed. Thus, 1-MCP had some benefit regardless of ripeness at harvest. Two important effects were not measured. We did not measure volatile production (or aroma), although we did observe that aroma was lacking in the 1-MCP-treated Gala following storage. We did not do taste tests, as the product is not registered for use. The only 1-MCP-treated fruit which fully recovered ethylene production were the non-Retain™ McIntosh harvested on September 10 and stored for 175 days in 32F air. Even these fruit retained their firmness advantage over untreated fruit and did not develop superficial scald as the other fruit did. The Ginger Gold, Retain™-treated McIntosh, Delicious, and Spigold which had been treated with 1-MCP all started producing more ethylene after a time in storage, but did not come close to catching up with their untreated counterparts.

Based on this preliminary investigation, 1-MCP treatment appears promising for increased firmness retention in a broad spectrum of apple cultivars, including McIntosh as well as for scald control. We observed scald only on McIntosh in this study, but others have observed similar results on other cultivars, so a general response may exist although further tests are essential. Since maximum 1-MCP effect may depend on early harvest, at least in some cultivars, scald protection would be an extremely valuable benefit. Combining 1-MCP treatment with CA might enhance the effect of either one alone. Taste tests will be essential to determine if the firmness advantage is offset by losses in flavor or aroma. If so, this is likely to be cultivar dependent. Seasonal variation in effectiveness of 1-MCP has been reported, so we need to determine how repeatable these results are. Finally it remains to be determined how 1-MCP can be applied efficiently on a commercial scale. Nevertheless, despite these issues, this is an extremely interesting new material.

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Species Composition of Third-generation Leafminers in Massachusetts Apple Orchards: 1997-1999

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In Massachusetts, leafminers (LM) have been a consistent threat to the quality of apple foliage in commercial orchards ever since their initial rise to prominence in the late 1970s due largely to the onset of resistance to organophosphate insecticides. Over the past 10 years or so, LM in Massachusetts orchards exhibited three rather distinctly different patterns of population growth. In some orchards, growth has been slight or at most moderate, never exceeding a threshold requiring insecticide treatment. In other orchards, growth also has been slight, owing to annual or biannual application of a preventative insecticide spray against LM. In still other orchards, populations have undergone a period of explosive growth, followed by rapid decline subsequent to insecticide treatment, only to be followed by another period of explosive growth.

Several factors might account for these observed differences in characteristic form of LM population growth. They include: (1) amounts, types and timings of pesticides directed against other orchard pests, (2) amounts, types and timings of pesticides directed against LM, (3) the nature of the habitat adjacent to commercial orchards, (4) the species composition and diversity of parasitoids that can provide biocontrol of LM, and (5) the species composition of LM themselves.

In regard to the latter, through the 1980s, commercial orchards in Massachusetts were dominated by the apple blotch leafminers (ABLM) *Phyllonorycter crataegella*, which is native to the USA and infests a rather wide variety of plant species. During the 1990s, however, we saw a rise in numbers of spotted tentiform leafminers (STLM) *Phyllonorycter blancardella*, which is an introduced species from Europe and infests only apples and crabapples.

Here, we report results of a study conducted from 1997-1999 aimed primarily at characterizing the species composition of third-generation LM in 12 commercial apple orchards in Massachusetts during this three-year period. Our secondary aim was to attempt to relate LM species composition with LM population density and patterns of insecticide use against LM. Other articles in this and future issues of *Fruit Notes* will deal with LM populations as influenced by parasitism, border area composition, and type of perimeter-row cultivar.

Materials & Methods

In November in each of three years (1997-1999), we sampled 10 leaves on each of 30 trees in each of 12 commercial orchards, pointing blindly toward the tree canopy and picking the first leaf encountered by hand. We counted the total number of third-generation mines in the 300-leaf sample. After this, we picked as many mine-infested leaves as could be found in a one-hour search of the orchard (maximum of 300 leaves) and returned them to the laboratory for examination of pupae under a microscope. Pupae can be classified according to LM species on the basis of the structure of minute "hooks" present on the posterior end. In 1999, we also sampled mined leaves from four orchards that had been abandoned for at least 5 years.

Results

To facilitate presentation of results, sampled commercial orchards are grouped according to three geographical areas in Massachusetts: Orchards A, B, and C in the west, orchards D, E, F, and G in the center, and orchards H, I, J, K, and L in the east.

Data in Table 1 show that in each of these three geographical regions, at least one sampled orchard experienced a rather high LM density level in at least one of the three years, and at least one sampled orchard

Table 1. Density of third-generation leafminers in 12 commercial and 4 unmanaged apple orchards in Massachusetts (1997-1999).

		Number of. mines per 100 leaves		
Orchard	Location	1997	1998	1999
A	Ashfield	54	104	21
B	Shelburne	11	3	15
C	Colrain	5	6	9
D	Belchertown	31	11	13
E	Brimfield	65	38	23
F	Warren	304	80	89
G	Brookfield	51	191	11
H	Princeton	9	33	7
I	Leominster	203	311	22
J	Sterling	11	9	7
K	Sterling	6	7	11
L	Northboro	--	305	5
M	Ashfield*	--	--	15
N	Deerfield*	--	--	23
O	Leominster*	--	--	8
P	Sterling*	--	--	11

* Abandoned orchards.

remained at a rather low LM density throughout the three years. Similarly, data in Table 2 show that in each of the three geographical regions, at least one sampled orchard was dominated by ABLM across the three years and at least one other commercial orchard was dominated by STLM across the three years. Thus, neither the population density nor the species composition of LM appeared to be affected by geographical location within Massachusetts.

In all, there were five commercial orchards (A, F, G, I, L) wherein the density of third-generation mines reached 100 per 100 leaves in at least one of the three years (Table 1). In three of these five orchards (A, F, I), the dominant species each year was STLM (Table 2). In the fourth orchard (G), ABLM dominated in 1997 but STLM in 1998 and 1999. In the fifth orchard (L), ABLM dominated each year. In the remaining seven orchards (B, C, D, E, H, J, K), the density of third-generation mines did not reach 100 mines per 100 leaves in any of the three years (Table 1). In six of these seven orchards, the dominant species each year was ABLM (Table 2). In the seventh orchard (D), ABLM was distinctly dominant in 1997 but STLM was distinctly dominant in 1998 and 1999. Thus, the highest densities of leafminers were associated largely with dominance by STLM, whereas lower densities were associated largely with dominance by ABLM.

As summarized in Table 3, none of the four abandoned orchards (M, N, O, P) received an insecticide treatment against LM during any of the three years, and five of the commercial orchards (A, D, F, G, I) received no insecticide treatment against LM in 1997 and 1998, although four of the five received such treatment in 1999. All nine of these orchards were dominated by STLM in 1998 and 1999. In contrast, seven of the commercial orchards (B, C, E, H, J, K, L) received an insecticide treatment targeted against LM in two or all three years. Each year, all seven of these orchards were dominated by ABLM.

Thus, no or infrequent spraying against leafminers appears to be associated with the rise of STLM to the status of dominance, whereas frequent spraying seems to be associated with dominance by ABLM. Our data are insufficient for establishing a relationship between time since application of an insecticide against leafminers and the rise of ABLM to dominance, although the data in Table 3 for 1999 for orchards A, D, G, and I suggest that such a rise to dominance by ABLM does not occur during the same year that insecticide is applied.

Conclusions

Results of this three-year study suggest that dominance in species composition of LM in Massachusetts orchards was (1) not associated with any particular geographical region within the state, (2) was apparently associated with LM density, and (3) was apparently associated with frequency of insecticide

Table 2. Species composition of third-generation leafminer pupae in 12 commercial apple orchards (1997-1999) and four abandoned apple orchards (1999) in Massachusetts. Apple blotch leafminer = ABLM. Spotted tentiform leafminer = STLM.

		1997			1998			1999		
Orchard	Location	No. pupae	ABLM (%)	STLM (%)	No. pupae	ABLM (%)	STLM (%)	No. pupae	ABLM (%)	STLM (%)
A	Ashfield	25	16	84	20	20	80	245*	4	96
B	Shelburne	19*	100	0	20	100	0	90*	100	0
C	Colrain	24	100	0	33*	91	9	178*	100	0
D	Belchertown	109	80	20	90	28	72	121*	8	92
E	Brimfield	181*	98	2	76*	96	4	139*	93	7
F	Warren	250	29	71	83	11	89	86	24	76
G	Brookfield	199	71	29	124	2	98	13*	8	92
H	Princeton	18*	100	0	44*	98	2	161*	89	11
I	Leominster	19	11	89	94	14	86	164*	4	96
J	Sterling	113*	90	10	84*	94	6	189*	69	31
K	Sterling	102*	95	5	58*	99	1	184*	87	13
L	Northboro	23*	100	0	33	100	0	79*	100	0
M**	Ashfield	--	--	--	--	--	--	18	0	100
N**	Deerfield	--	--	--	--	--	--	122	0	100
O**	Leominster	--	--	--	--	--	--	14	0	100
P**	Sterling	--	--	--	--	--	--	58	14	86

* Indicates that either Pounce, Asana, Provado, or Agri-Mek was applied against first-generation LM that year.
** Abandoned orchards.

Table 3. Relationship between frequency of application of insecticide against leafminers and dominant leafminer species in Massachusetts orchards.

	Insecticide applied against LM			Dominant species of LM		
Orchards	1997	1998	1999	1997	1998	1999
Abandoned (M,N,O,P)	None	None	None	STLM	STLM	STLM
Commercial (A,D,F,G,I)	None	None	A,D,G,I	STLM*	STLM	STLM
Commercial (B,C,E,H,J,K,L)	B, E,H,J,K,L	C,E,H,J,K	B,C,E,H,J,K,L	ABLM	ABLM	ABLM

* ABLM in orchards D and G

application targeted against LM. With little exception, dominance by STLM in commercial orchards was associated with higher LM population density and no or infrequent use of insecticide to control LM. Conversely, dominance by ABLM was associated with lower LM population density and rather frequent use of insecticide to control LM.

In any scientific investigation, establishment of a strong association or correlation between two variables should not be taken to imply cause and effect. Further study is needed to determine the true cause or causes underlying the dominance of ABLM or STLM in a given orchard.

Even so, one can postulate a possible scenario with the following steps: (1) dominance of STLM in abandoned apple orchards either because of apple being a more favored host of STLM than it is of ABLM, because STLM is less susceptible to parasitism than is ABLM, because STLM is a better competitor for host resources than is ABLM, or a combination of these, (2) movement of STLM adults into an orchard currently colonized by ABLM, (3) more rapid and extensive buildup of STLM in commercial orchards than is characteristic of ABLM, leading to (4) application of a targeted insecticide against LM that exerts a greater effect on STLM than ABLM and results in (5) temporary dominance by ABLM. Further study is needed to evaluate this possible scenario.

Acknowledgements

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* * * * *

Population Dynamics of Leafminers and Their Parasitoids in Massachusetts Apple Orchards: 1999 Studies

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In the preceding article, we presented information on the species composition of third-generation leafminers found in 12 commercial and four abandoned Massachusetts apple orchards during 1997, 1998, and 1999. Results showed that each year, all four abandoned orchards and three of the commercial orchards were dominated by spotted tentiform leafminers (STLM). Conversely, each year seven of the commercial orchards were dominated by apple blotch leafminers (ABLM). Two of the commercial orchards were dominated by ABLM in 1997 but by STLM in 1998 and 1999. We concluded that the degree to which apple is a preferred host of STLM relative to ABLM and the degree to which STLM relative to ABLM is susceptible to insecticides could be principal factors associated with dominance by STLM vs. ABLM but suggested that parasitoid species composition and abundance might also be contributing factors.

Here, we present information on the species composition and abundance of leafminers and their principal parasitoids for each of the three generations of leafminers that occurred in 1999 in these 12 commercial and four abandoned orchards.

Materials & Methods

In June, August, and November of 1999, we sampled 10 leaves on each of 30 trees in each commercial and abandoned orchard for total numbers of first-, second-, and third-generation mines, respectively, in each 300-leaf sample. After taking each sample, we collected as many infested leaves (containing tissue-feeding mines) as possible during a 1-hour search of the orchard up to a maximum of 100 mines per orchard for the first and second generations and 300 mines per orchard for the third generation.

Mined leaves were returned to the laboratory for examination under a microscope to determine presence and identity of parasitoids and identity of leafminers. A complete categorization of the extent of parasitism of mined leaves would include presence of holes in leaf tissue made by parasitoid adults seeking to feed upon leafminer larvae as well as presence or evidence of parasitoid eggs. Because such evidence of parasitism was very difficult to determine with certainty, we confined our confirmation of parasitism to presence of parasitoid larvae, pupae (or their remains), and adults. Consequently, the values presented here for extent of parasitism of leafminers were undoubtedly lower than actual percentages occurring in orchards.

Results

Data in Table 1 show the abundance of leafminers in each generation in each orchard. Data in Table 2 show the species composition of leafminers and percentages of leafminer larvae parasitized by the two dominant parasitoids (*Sympiesis marylandensis* and *Pholetesor ornigis*) in each generation in each orchard. Owing to insufficient abundance of first-generation mines in some orchards, there are some unfortunate gaps in the data set for this generation of leafminers.

In the four abandoned orchards (M, N, O, P), STLM was the exclusive (or nearly exclusive) leafminer species present in each of the three generations. In five of the commercial orchards (A, D, F, G, I), STLM dominated in the second and third generations. STLM dominated also in the first generation in two of these orchards (A and I). ABLM slightly dominated STLM in the first generation in Orchard D, and no first-generation data were available for Orchards F and G. In the other seven commercial orchards (B, C, E, H, J, K, L), ABLM was markedly dominant in the second and third generations as well

Table 1. Density of first-, second-, and third-generation leafminers in 12 commercial and four abandoned apple orchards in Massachusetts in 1999.

Orchard	Number of mines per 100 leaves		
	First generation	Second generation	Third generation
A	6.7	2.5	21.0
B	4.3	9.5	14.5
C	0.7	22.5	8.5
D	1.3	0.5	12.5
E	1.0	5.0	23.0
F	0.3	29.0	89.0
G	0.0	2.5	10.5
H	1.0	3.0	7.0
I	19.7	6.5	21.5
J	0.0	0.0	7.0
K	0.3	2.0	10.5
L	5.3	0.5	4.5
M*	23.7	8.0	15.0
N*	17.5	4.5	23.0
O*	70.0	17.0	8.0
P*	15.7	2.0	11.0

* Abandoned orchards.

as in the first generation where data were available (B, C, E, J). Thus, with the exception of Orchard D, data indicate that the leafminer species that dominated in the first generation remained dominant in the second and third generations.

To facilitate comparisons, the 16 orchards were categorized into four groups (Table 3). Data in Table 3 show that for abandoned orchards M, N, O, and P, all of which were dominated by STLM and none of which received insecticide in 1999, LM population density decreased (on average) by more than half from the first to the third leafminer generation. In contrast, for commercial orchard F, likewise dominated by STLM and likewise having received no insecticide treatment against LM in 1999, LM population density increased 89-fold from the first to the third leafminer generation. In commercial orchards A, D, G, and I, also dominated by STLM but having received an insecticide treatment against LM in May of 1999, LM population density increased by an average of about two-fold from the first to the third leafminer generation. Finally, in commercial orchards B, C, E, H, J, K, and L, dominated by ABLM and having received an insecticide treatment against LM in May of 1999, LM population density increased by an average of about five-fold from the first to the third leafminer generation.

For all four categories of orchards, parasitism by *S. marylandensis* decreased progressively from the first to the third LM generation, averaging (across all generations) 36% for abandoned orchards, 26% for commercial orchards dominated by STLM and treated against LM in 1999, and 18% for commercial orchards dominated by ABLM. Parasitism by *P. ornigis* across all three generations averaged 11% for abandoned orchards, 9% for commercial orchards dominated by STLM and treated against LM in 1999, and 2% for commercial orchards dominated by ABLM, with no consistent trend toward increasing or decreasing abundance across generations.

Together, data in Table 3 suggest that the high amount of total parasitism of LM (47%) in the abandoned orchards may have been a principal factor associated with the decrease rather than an increase in LM population density from the first to the third LM generation. The level of total parasitism in Orchard F was only about one-third that in the abandoned orchards and was insufficient to prevent the 89-fold increase in LM population density from the first to the third generation. The substantially greater amount of total parasitism (35%) in STLM-dominated orchards treated against LM in 1999 than total parasitism (20%) in ABLM-dominated orchards treated against LM in 1999 may have played a role in the lower rate of first-to-third-generation LM population growth in the former (two-fold) compared with the latter (five-fold).

Finally, the data in Table 3 indicate that *P. ornigis* parasitoids were considerably more abundant in abandoned as well as LM-treated orchards dominated by STLM than in LM-treated orchards dominated by

Table 2. Species composition of leafminers and percentages of leafminer larvae parasitized during the first, second, and third generations of leafminers in 12 commercial and four abandoned apple orchards in Massachusetts in 1999.

	First generation (%)				Second generation (%)				Third generation (%)			
Orchard	No.*	ABLM**	S.m.***	P.o***	No.	ABLM	S.m.	P.o.	No.	ABLM	S.m.	P.o.
A	87	13	26	20	98	20	15	4	58	4	6	38
B	103	100	9	0	100	100	12	0	57	100	23	7
C	43	100	9	7	93	100	10	2	88	100	9	2
D	100	55	53	0	68	42	31	2	57	8	1	7
E	88	100	55	0	98	97	15	0	145	93	2	0
F	-	-	-	-	104	7	15	1	15	24	10	0
G	-	-	-	-	100	18	47	2	8	8	0	0
H	-	-	-	-	100	98	15	0	126	89	-	-
I	38	17	50	16	102	8	39	4	202	4	4	6
J	50	100	22	2	97	70	32	0	177	69	8	0
K	-	-	-	-	102	100	26	9	113	87	2	0
L	-	-	-	-	90	79	43	0	49	100	7	0
M	100	0	52	11	103	0	41	18	12	0	43	12
N	88	0	46	14	50	0	12	2	86	0	27	6
O	92	0	69	1	58	0	52	2	8	0	0	13
P	-	-	-	-	77	0	30	12	47	14	6	30

* Numbers of mature mines examined.
** Percent of total pupae identified as ABLM; remaining percent was STLM.
*** Percent of LM larvae parasitized by *Sympiesis marylandensis* (S.m.) *or Pholetesor ornigis* (P.o.).

Table 3. Relationship between leafminer-targeted insecticide treatments, dominant species, and population buildup of leafminers and extent of parasitism of leafminers in Massachusetts orchards in 1999.

Orchards	Insecticide treatment against LM in 1999	Dominant species of LM	Number of mines per 100 leaves			Parasitism by *S. marylandensis* (%)			Parasitism by *P. ornigis* (%)		
			First gen.	Second gen.	Third gen.	First gen.	Second gen.	Third gen.	First gen.	Second gen.	Third gen.
Abandoned (M,N,O,P)	No	STLM	32	8	14	56	34	19	9	9	15
Commercial (F)	No	STLM	1	29	89	--	15	10	--	1	0
Commercial (A,D,G,I)	Yes	STLM	7	3	16	43	33	3	12	3	13
Commercial (B,C,E,H,J,K,L)	Yes	ABLM	2	6	11	24	22	9	2	2	2

ABLM, suggesting a possible preference *of P. ornigis* for STLM.

Conclusions

Several of the data trends shown and discussed here and in the preceding article for Massachusetts orchards are similar to trends reported earlier by Chris Maier, whose outstanding work on leafminers in Connecticut orchards inspired our studies. Notable among the trends for both Connecticut and Massachusetts are (1) a strong tendency toward a shift in dominance from ABLM to STLM with decreasing frequency of annual insecticide treatment against LM, (2) a strong tendency toward lower parasitism of LM in sprayed than unsprayed (abandoned) orchards, and (3) generally greater levels of LM parasitism by *S. marylandensis* than by *P. ornigis*, especially among populations of ABLM.

Parasitoids alone appear to be sufficient to exert effective population suppression of LM in abandoned orchards and may have contributed to population suppression of LM in those commercial orchards designated here as A, D, F, G, and I, which received no insecticide treatments against LM in 1997 and 1998. Even so, four of these five STLM-dominated orchards (A, D, G, I) did require a LM-targeted treatment in 1999, suggesting that parasitoids alone were insufficient to effectively suppress STLM below potentially damaging levels. The lowest levels of LM parasitism found in 1999 were in orchards designated here as B, C, E, H, J, K, and L, all of which were dominated by ABLM and all of which received a LM-targeted insecticide in 1999 (all seven of these orchards also received a LM-targeted insecticide in 1997 and/or 1998).

The 89-fold level of first- to third-generation population increase in STLM-dominated Orchard F in 1999 was explosive in comparison with the decrease in average first- to third-generation population density that characterized STLM-dominated abandoned orchards in 1999. For reasons yet unknown but possibly associated with apple being the principal host of STLM and only one among many different hosts of ABLM, unattended populations of STLM in commercial orchards could represent a greater threat than populations of ABLM. We hope to explore this possibility in future research.

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* * * * *

Performance of the V Series Apple Rootstocks During Six Growing Seasons

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The Vineland (V) series of apple rootstocks was from open pollinated seeds from Kerr applecrab (a cross between Dolgo crabapple and Haralson apple). Dr. Aleck Hutchinson collected seeds from 1957 through 1960. Trees were planted in Vineland, Ontario, and seedlings were selected based on the potential for dwarfing, hardiness, ease of propagation, and field resistance to powdery mildew, fireblight, and wooly apple aphid. By 1971, when the rootstock breeding project was terminated in Vineland, seven clones (V.1, V.2, V.3, V.4, V.5, V.6, and V.7) had been selected. The first evaluation of these clones as rootstocks began with a trial in 1974. In these early evaluations, V.1 and V.3 were determined to produce trees similar to M.9 in size, V.2 produced M.26-sized trees, and V.4 resulted in trees similar in size to those on M.7. The Vineland rootstocks were almost forgotten for a number of years, but interest was rekindled in the early-mid 1990s. V.1 and V.3 were included in NC-140 trials, a New England/Nova Scotia trial, and a Northeastern U.S. trial. (For more details of the history of the Vineland series, see the following article: Elfving, D.C., I. Schecter, and A. Hutchinson. 1993. The history of the Vineland (V.) apple rootstocks. *Fruit Varieties Journal* 47:52-58.)

To study performance of the V rootstocks under Massachusetts conditions, a small trial was established in 1996 at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown, including Rogers Red McIntosh on V.1, V.2, V.3, V.4, V.7, and M.26 EMLA. Trees were individually staked and generally maintained as slender spindles. Each year, trunk circumference was measured and total yield was assessed.

After six growing seasons, dramatic differences in tree size existed. Trees on V.4 were more than twice as large as the next largest trees (Table 1). Under our conditions, these trees likely would be larger than

Table 1. Performance of Rogers Red McIntosh apple trees on several rootstocks planted in 1996 at the University of Massachusetts Cold Spring Orchard Research & Education Center.

Rootstock	Trunk cross-sectional area (cm^2)	Yield per tree (kg)		Yield efficiency (kg/cm^2 TCA)		Fruit weight (g)	
		2001	Cumulative (1998-2001)	2001	Cumulative (1998-2001)	2001	Average (1998-2001)
V.1	13.1	9	21	0.7	1.7	138	147
V.2	17.3	12	23	0.6	1.3	147	148
V.3	10.6	7	22	0.6	2.1	135	140
V.4	48.2	16	33	0.3	0.7	155	148
V.7	19.6	5	24	0.3	1.3	121	139
M.26 EMLA	18.0	12	25	0.7	1.5	148	154

comparable trees on M.7. Trees on V.2 and V.7 were similar in size to those on M.26 EMLA. Next smallest were trees on V.1. In another trial at the UMass Cold Spring Orchard, trees on V.1 were somewhat larger thna trees on M.26 EMLA. The smallest trees were on V.3, likely similar in size to comparable trees on M.9.

To date, cumulative yield (1998-2001) was highest from the largest trees (Table 1). However, when adjusted for tree size, the most yield efficient trees were on V.3, V.1, and M.26 EMLA (Table 1). The least yield efficient trees were on V.4. In 2001, V.4 resulted in significantly larger fruit than did V.7, but overall, there was no consistent effect of rootstock on fruit size

.

These trees are too young to make a great number of conclusions, but these results along with those from three other trials at the UMass Cold Spring Orchard suggest that V.1 and V.3 are promising, dwarfing rootstocks. Their hardiness, potential disease resistance, and yield efficiency make them worthy of continued trial.

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Evaluation of Formulations and Release Rates of Benzaldehyde, an Attractive Fruit Odor for Plum Curculios

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In the 2000 Issue of *Fruit Notes*, we reported on a 2000 study showing that benzaldehyde in association with plum curculio (PC) pheromone (grandisoic acid) was the most attractive odor bait combination for PCs when compared with other odor baits affixed to panel and pyramid traps. In that study, we also found that although traps baited with benzaldehyde plus pheromone were very effective at determining the beginning, peak, and end of PC immigration into apple orchards from overwintering sites, benzaldehyde seemed to be less attractive to PCs after ~10 days of exposure to sunlight. Subsequently, we found that the clear high-density polyethylene vials used in that study allowed UV-polymerization of about 10% of the benzaldehyde contained in the vials, which may have diminished or masked some of the attractiveness of benzaldehyde. We concluded from that study that research should be aimed at improving the formulation and longevity of benzaldehyde and optimizing the amount of benzaldehyde used as odor bait.

Here, in an attempt to improve trap ability to capture PCs, we compared different formulations, release rates, and positions of benzaldehyde-releasing dispensers in tops of branch-mimicking cylinder traps placed on apple tree limbs. We also evaluated different amounts of benzaldehyde in association with PC pheromone in Circle traps, which are wrapped completely and tightly around apple tree trunks and are designed to intercept adults crawling up tree trunks.

Materials & Methods

We performed four different experiments. The first three were conducted in 2001 and involved use of black cylinder traps. The fourth was carried out in 2002 and involved use of Circle traps. All evaluations were performed in unsprayed sections of apple orchards or in backyards containing unsprayed apple trees.

Experiment 1. In this test, conducted from June 6 to July 3 (2001) in Atkins orchard (Belchertown, MA), we evaluated (using cylinder traps) four different formulations of benzaldehyde alone (without pheromone) released from dispensers placed either inside or outside of the trap tops. Formulations tested were: (1) Great Lakes IPM (Vestaburg, MI), (2) IPM Technologies (Portland, OR), (3) four 400-¼l high-density clear polyethylene vials (VWR Scientific Products; Boston, MA), each filled with 400¼l of benzaldehyde (as in 2000), and (4) one 1-ml low-density white polyethylene vial (Wheaton; Millville, NJ) filled with 1 ml of benzaldehyde. Unbaited traps served as a control treatment. For each formulation, the estimated release rate of benzaldehyde was about 10 mg per day except for the white vials, which released about 2.5 mg of benzaldehyde per day. Each treatment was replicated 4-5 times.

Traps were deployed in perimeter-row apple trees and on apple trees located in rows 2, 3, and 4. Traps were inspected for PC captures 2 to 3 times per week. At each inspection session, trap tops were rotated (within a replicate) one position (clockwise).

Experiment 2. This test, conducted from May 29 to July 3, 2001 in Atkins orchard, was aimed at evaluating different amounts of benzaldehyde released from 1-ml low-density white polyethylene vials in association with cylinder traps. Each white vial released about 2.5 mg of benzaldehyde per day.

Treatments evaluated were: (1) one white vial (placed inside a trap top), (2) one white vial (placed outside a trap top), (3), five white vials (inside), (4) five white vials (outside), (5) 15 white vials (outside), and (6) unbaited traps as a control treatment. For treatments 2 and 4, vials were hung vertically from the periphery of the trap top using copper wire, about 2 inches away from the trap base. For treatment 5, the 15 vials were hung from a wooden stick (about 10 inches long) using wire. The stick holding benzaldehyde-releasing vials was then attached horizontally to apple tree branches using wire so that bases of vials were located about 4 inches above a cylinder trap top.

In this test, benzaldehyde was evaluated in combination with grandisoic acid (PC pheromone) (ChemTica Internacional, S.A., San Jose, Costa Rica). One pheromone dispenser, releasing about 1 mg of grandisoic acid per day, was placed inside each benzaldehyde-baited trap top.

All vials containing benzaldehyde were replaced on June 15. Traps were deployed within a single row of apple trees and were inspected for PC captures 2-3 times per week. Trap tops were rotated one position (clockwise) at each inspection.

Experiment 3. This evaluation was performed from May 25 to June 20, 2001, simultaneously at the UMASS Cold Spring Orchard Research & Education Center in Belchertown, Atkins orchard, and in backyard trees in Amherst, MA. The experiment was aimed at determining the longevity of four different formulations of benzaldehyde alone (without pheromone) using cylinder traps. The formulations evaluated were the same as those described in experiment 1. All benzaldehyde-releasing dispensers were positioned inside cylinder trap tops. Traps were inspected for PC captures 2 to 3 times per week, rotating the trap tops one position (clockwise) at each inspection.

Experiment 4. This test was conducted from June 26 to July 2, 2002 in backyard trees in South Deerfield, MA, using Circle traps. The purpose was to determine the influence of different release rates of benzaldehyde, in association with PC pheromone, on PC captures. We evaluated three different release rates of benzaldehyde (10, 20, and 40 mg/day) together with a control treatment without benzaldehyde.

Benzaldehyde was released from 15-ml low-density white polyethylene vials (Wheaton, Millville NJ). Each vial was filled with 15 ml of benzaldehyde to achieve a release rate of ~10 mg/day. Each vial was hung by its neck from a wire and placed inside an inverted, green 266-ml plastic cup to provide additional protection for this chemical against polymerization by UV light and rainfall. Cups were hung from tree trunks using wire in such a way that bases of cups were about 4 inches above Circle trap tops. Depending on the treatment, either no, one, two, or four cups were positioned above the Circle trap tops.

In all, 32 Circle traps were deployed on unsprayed apple tree trunks. Each was baited with one of the abovementioned treatments and one dispenser releasing PC pheromone (release rate: 1 mg/day) placed inside the Circle trap top. Traps were inspected for PC captures one week after bait deployment.

Results

In the first experiment, no appreciable differences among odor-formulations were noticed when comparisons were made among vials placed outside of trap tops (Table 1). However, when vials were placed inside of trap tops, the '4 clear vials' formulation proved to be the most attractive formulation for PCs, followed by the '1 white vial' formulation. When PC captures by traps were compared according to position of vials

Table 2. PC captures by cylinder traps baited with benzaldehyde (in combination with PC pheromone) according to the number and position of 1-ml white vials.

Number of vials	Amount of benzaldehyde released per day (mg)	Inside	Outside	Total PCs
1	2.5	2	4	6
5	12.5	2	11	13
15	37.5	---	3	3
unbaited traps	0.0	---	---	1
TOTAL		4	18	23

Table 1. PC captures by black cylinder traps baited with four different formulations of benzaldehyde alone (without pheromone), positioned inside or outside of trap tops.

Formulation	Amount of benzaldehyde released per day (mg)	Inside	Outside	Total PCs
Great Lakes IPM	10.0	2	7	9
IPM Technologies	10.0	2	9	11
White vial	2.5	5	6	11
4 Clear vials	10.0	8	7	15
Unbaited traps	0.00	---	---	2
TOTAL		17	29	48

within the same formulation, we found that traps baited with the 'Great Lakes IPM' and 'IPM Tech' formulations deployed outside the trap tops captured 3.5 and 4.5 times (respectively) more PCs than traps having the same type of formulation but placed inside the trap tops. For both clear and white vials, no differences in captures were noticed between vials placed inside or outside the trap top (Table 1).

In the second experiment, traps having five white vials placed outside of trap tops captured the most PCs (Table 2). Traps having 15 vials (which released a total of ~37.5 mg of benzaldehyde per day) captured the fewest PCs, only slighter more than unbaited traps. Overall, about four times more PCs were captured when vials were positioned outside of trap tops than inside.

In the third experiment, wherein all formulations of benzaldehyde were placed inside of cylinder trap tops, results indicated that during the first 8 days of evaluation, traps baited with one white vial captured numerically more PCs than any other bait treatment (Table 3). From days 9-16, clear vials outperformed the other formulations. During this time

Table 3. PC captures by black cylinder traps baited with different formulations of benzaldehyde (placed inside of trap tops and without pheromone) according to the number of days elapsed after bait deployment.

Treatment	Amount of benzaldehyde released per day (mg)	1-8	9-16	17-24	25-32	Total PCs
Great Lakes IPM	10.0	6	4	5	4	19
IPM Technologies	10.0	4	0	5	0	9
1 White 1-ml vial	2.5	9	4	2	2	17
4 Clear vials	10.0	5	8	1	3	17
Unbaited traps	0.0	5	1	6	4	16
TOTAL		29	17	19	13	78

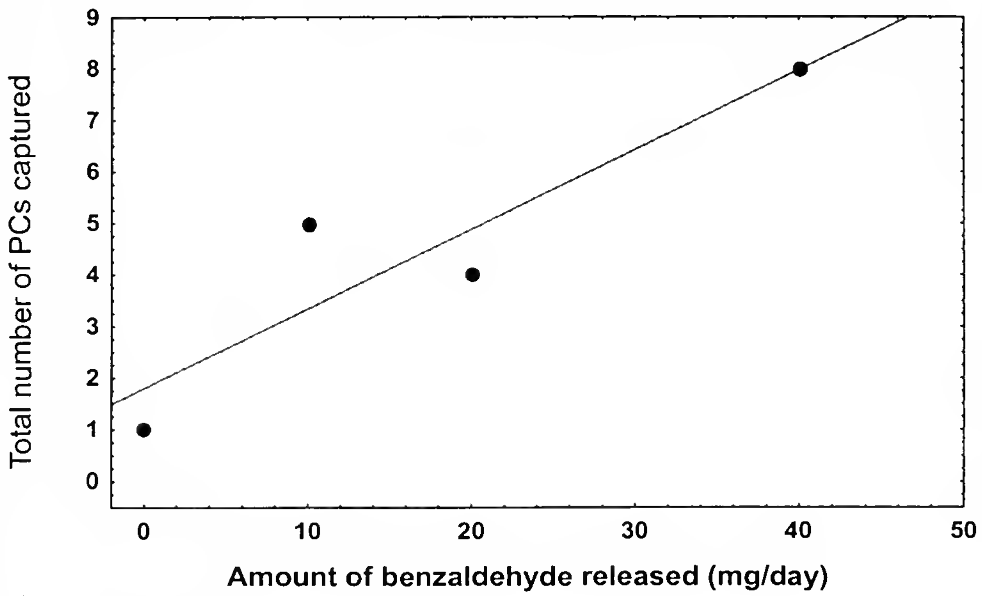

Figure 1. Relationship between total PC captures by Circle traps and amount of benzaldehyde released from 15-ml white polyethylene vials positioned ~4 inches above trap tops. Amounts of benzaldehyde released were 0, 10, 20, and 40 mg/day, each in association with PC pheromone (1 mg of grandisoic acid per day).

period, traps baited with the 'IPM Technologies' formulation did not capture any PCs. However, 17-24 days after the initial baiting, the 'IPM Technologies' and the 'Great Lakes IPM' formulations performed better than the white vial and the clear vials but, nevertheless, did not perform better than unbaited traps. From 25-32 days, all traps captured similar numbers of PCs except traps baited with the 'IPM Technologies' formulation, which captured no PCs. Overall, the formulations '4 clear vials', '1 white vial', and the 'Great Lakes IPM' were about equally attractive to PCs, whereas the 'IPM Technologies' formulation was the least attractive.

In the fourth experiment, wherein all dispensers of benzaldehyde were placed 4 inches above Circle trap tops, results show a strong linear relationship between the amount of benzaldehyde released (in association with PC pheromone) and the total number of PCs captured by Circle traps (Fig. 1). This suggests that, at least for Circle traps, the response of PCs to benzaldehyde in association with PC pheromone increases as the amount of benzaldehyde increases (up to the maximum release rate tested of about 40 mg per day).

Conclusions

Four conclusions can be drawn from this series of experiments.

First, white polyethylene vials releasing benzaldehyde performed as well as either the clear vials used in the 2000 field test or the other formulations of benzaldehyde evaluated (Great Lakes IPM and IPM Technologies). Therefore, white polyethylene vials (particularly the UV-light-protected 15-ml vials [see below]) can be used as devices to dispense benzaldehyde effectively in future tests.

Second, results from the first and second experiments suggest, for the most part, that when dispensers are placed inside of cylinder trap tops, the odor of benzaldehyde may become repellent at close range, thus reducing the ability of cylinder traps to capture PCs. This was particularly true for both the 'Great Lakes IPM' and 'IPM Technologies' formulations but not for the '1-white-vial' or '4-clear-vials' formulations (in experiment 1), and the '5-white-vials' treatment (in experiment 2). Consequently, we believe that benzaldehyde-releasing dispensers should be placed outside of trap tops to avoid close-range negative effects while preserving (or even enhancing) attractiveness to PCs. Results from experiment 4 (involving Circle traps), in which vials were placed outside of trap tops, further support this conclusion.

Third, 1-ml white vials releasing benzaldehyde were found to perform best during the first 8 days after deployment (experiment 3) and, after that time, their attractiveness decreased considerably. A close examination of the 1-ml white polyethylene vials revealed the formation of whitish/yellowish crystals in the area of necks of vials after 8 days of use. In contrast, the 15-ml white polyethylene vials used in experiment 4 showed no signs of such crystals on any parts of the vials after one week (experiment 4) or several weeks (data from other field studies) of use. This difference may be due largely to the type of screw cap used in association with the white vials in each year. In 2001, the 1-ml white polyethylene vials were enclosed by white polypropylene caps that lacked Teflon® liner as a sealant, and thus oxygen may have interacted with benzaldehyde altering its chemical composition. On the contrary, in 2002 the 15-ml white vials were enclosed by black phenolic Teflon®-lined caps, which apparently prevented oxygen from interacting with the benzaldehyde contained in the vials. Also, in 2002 the use of plastic cups provided extra protection against UV light and rainfall.

Fourth, results from the fourth experiment strongly suggest that there was an increase in PC captures by Circle traps associated with an increase in the concentration of benzaldehyde. In this experiment, the maximum release rate of benzaldehyde tested was ~40 mg per day. Hence, it is possible that even higher amounts of benzaldehyde may increase the attractiveness of benzaldehyde to PCs. This aspect is particularly important not only in relation to the determination of amount of benzaldehyde to be used to bait traps to monitor the onset, course, and end of PC immigration, but also to the determination of amount of benzaldehyde to be employed in perimeter-row odor-baited trap trees (see the 2002 winter issue of Fruit Notes) to follow accurately the course of plum curculio injury to fruit in commercial apple orchards in Massachusetts.

Acknowledgments

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Influence of Insecticide on the Ability of Traps to Capture Plum Curculios

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Several factors may influence the effectiveness of different types of traps for capturing and monitoring plum curculios (PCs). We have determined, for example, that temperature is an important factor influencing the ability of both Plexiglas panels (traps capturing flying PCs) and pyramid traps (traps capturing crawling PCs) to monitor extent and timing of PC immigration when traps are deployed at the edges of an orchard, in close proximity to woods. We found that panel traps are more effective than pyramid traps on warm days and, conversely, that pyramid traps outperform panel traps on cool days.

For both branch-mimicking cylinder traps (which are positioned vertically on apple tree branches) and Circle traps (which are wrapped around orchard tree trunks), weather may have a lesser effect because the purpose of such traps is either to capture PCs already present within tree canopies (cylinder traps), or to intercept adults crawling up tree trunks into canopies (Circle traps). However, as indicated in the 2002 Winter issue of Fruit Notes, odor-baited cylinder traps have yet to demonstrate value for predicting extent of PC injury to fruit when deployed in commercial orchards. Similarly, odor-baited Circle traps, although able to capture numerous PCs under unsprayed orchard conditions, have not proven to be effective as a tool for predicting, in commercial orchards, the timing of PC injury to fruit based on extent of PC captures.

The principal aim of this study was to determine the influence of insecticide presence (via orchard spray application) on surfaces of cylinder, pyramid, and Circle traps on trap performance.

Materials & Methods

Field studies. Studies were performed from May 16 to June 28 (2001) at the UMASS Cold Spring Orchard Research & Education Center, and from May 22 to June 6 (2002) at Atkin's Farm. Both orchards are located in Belchertown, MA. The UMASS orchard block consisted of Delicious/M.7 and Cortland/M.7. The Atkins' block consisted of Idared/M.7.

2001 Field study. In 2001, we evaluated two trap types: (1) a black cylinder trap (3 inches diameter x 12 inches tall) and (2) a reduced version of a pyramid trap (6.5 inches at base x 12 inches tall). Cylinders were made from PVC pipe. Pyramids were made from plywood. Both trap types were painted black using flat black latex paint.

On May 16, just after petal fall, 14 traps of each type were deployed on branches of perimeter-row trees. Only one trap was used per tree. For every tree bearing a trap (central tree), there were two trees without traps (adjacent trees), one on either side (Figure 1). A few hours before an insecticide application was made (using a tractor-driven mist blower delivering 150 gallons of water per acre), seven traps of each type were covered with plastic bags. Traps were uncovered the morning after spray application. These traps will be referred as "unsprayed" traps. The remaining 14 traps, along with all tree canopies, received an application of Imidan® (70% WSB) at 3/4 pound per 100 gallons water. These traps will be referred as "sprayed" traps. This procedure (trap covering and uncovering) was repeated three times, once in association with each insecticide application against PC: May 16, May 25, and June 14.

Each trap was baited with one 1-ml white, low-density polyethylene vial containing 1 ml of benzaldehyde (release rate: ~2.5 mg per day) and one dispenser releasing PC pheromone (1 mg of grandisoic acid per day). Both baits were placed inside the trap tops that capped cylinder traps. Benzaldehyde and pheromone dispensers were replaced once (on June 11).

All traps were inspected twice per week (11 inspections in total) to determine PC captures. At every inspection, 20 fruit were sampled for PC injury in each trap-bearing tree and each of two adjacent trees (Figure 1). For presentation of results, we arranged data on

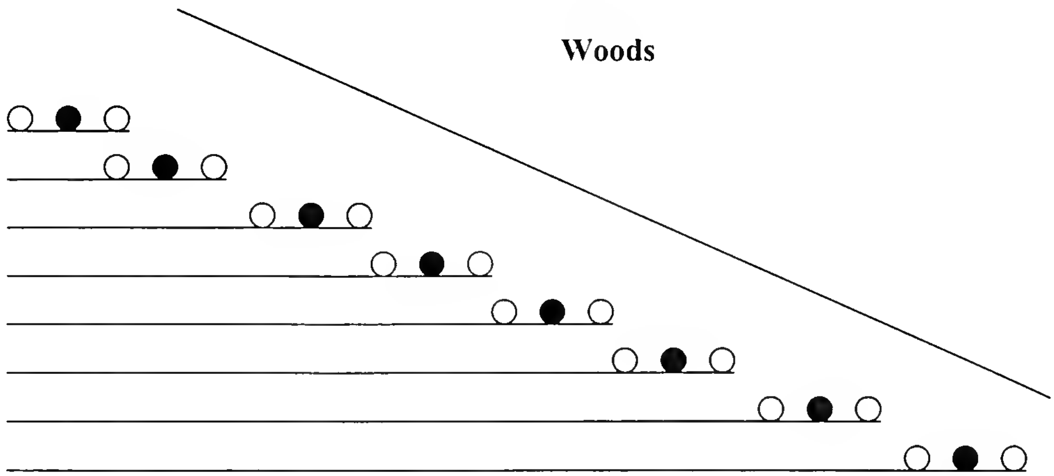

Figure 1. Schematic illustration of the plot used for the experiment. Trees were Cortland and Delicious in alternating rows. For each row, the first three perimeter-row trees were used. A small pyramid or cylinder trap was placed in the central tree (black dot). Twenty fruit were inspected for PC damage in each trap-bearing tree and each adjacent non-trapped tree (white dots).

captures and PC damage in the following manner: (1) 1-10 days after an application of insecticide, (2) 11-20 days after application, and (3) more than 20 days after application.

2002 Field study. In 2002 we evaluated four trap types: (a) black cylinders, (b) small black pyramids, (c) Circle traps made of aluminum screen and wrapped entirely and tightly around tree trunks, and (d) Circle traps as above but made of plastic screen.

On May 24, just after petal fall, eight traps of each type were deployed on apple trees located in a sprayed section of the orchard that received an application of Imidan® (as above). After application, all traps were removed and deployed, along with unsprayed traps, on branches (cylinders and small pyramids) or tree trunks (Circle traps) of perimeter-row trees located in an unsprayed section of the orchard. Traps were deployed in pairs (i.e., one sprayed trap of one type adjacent to one unsprayed trap of the same type). There were eight replicates for each trap type and insecticide regime.

In 2002, all traps were baited with one 15 ml white low-density polyethylene vial containing 15 ml of benzaldehyde (release rate: ~10 mg per day) and one dispenser releasing PC pheromone (~1 mg of grandisoic acid per day). To protect benzaldehyde from sunlight and rainfall, each vial was hung by the neck using a wire and placed inside an inverted plastic cup. Each plastic cup was suspended from the tree trunk using wire in such a way that its base was ~10 cm above each trap top. Each pheromone-releasing dispenser was placed inside the trap top. Benzaldehyde and pheromone dispensers were not replaced during the study.

All traps were inspected on a daily basis for 12 days after application of insecticide. On June 10, all sprayed traps were removed and transported to the sprayed section of the orchard, where they received a second spray of Imidan®. Afterwards, traps were deployed again in the unsprayed section of the orchard but the position of each member of pair of sprayed and unsprayed traps was inverted.

This study differed from the 2001 study in that 1) all traps were inspected on a daily basis for 12 days after application of insecticide, and 2) we did not inspect fruit to determine injury by PC. For presentation of results, we organized data on PC captures in the following manner: (1) 1-6 days after an application of insecticide, (2) 7-12 days after application.

Laboratory observations. Behavioral observations were conducted in a laboratory during July 2000 and July 2001 to assess the effects of insecticide application on the propensity of PCs to crawl upon sprayed traps. For comparative purposes, in 2000 the insecticide evaluated was Guthion®, and in 2001, Imidan® was used (same dose as above). PC behavior was observed inside of Plexiglas cages with no top. Traps evaluated were as described above, but we also evaluated sprayed and unsprayed apple tree limbs (diameter: 2 inches; length: 12 inches). No attractive odors were used in these tests. In all instances, observations were performed 1-3 days after traps or limbs (taken from trees in the orchard) received an application of insecticide. For the observations, we placed a PC on the floor facing one of the test traps and recorded, for a time period of up to10 minutes, whether the PC was able to reach the top of the trap.

Table 1. Total PC captures by sprayed (Imidan®) and unsprayed small pyramid and cylinder traps (field study, 2001). Data are presented according to the number of days elapsed after an application of insecticide.

Days after spray	Pyramid unsprayed	Pyramid sprayed	Cylinder unsprayed	Cylinder sprayed
0-10	5	1	1	0
11-20	3	2	2	3
> 20	0	0	0	1
TOTAL	8	3	3	4

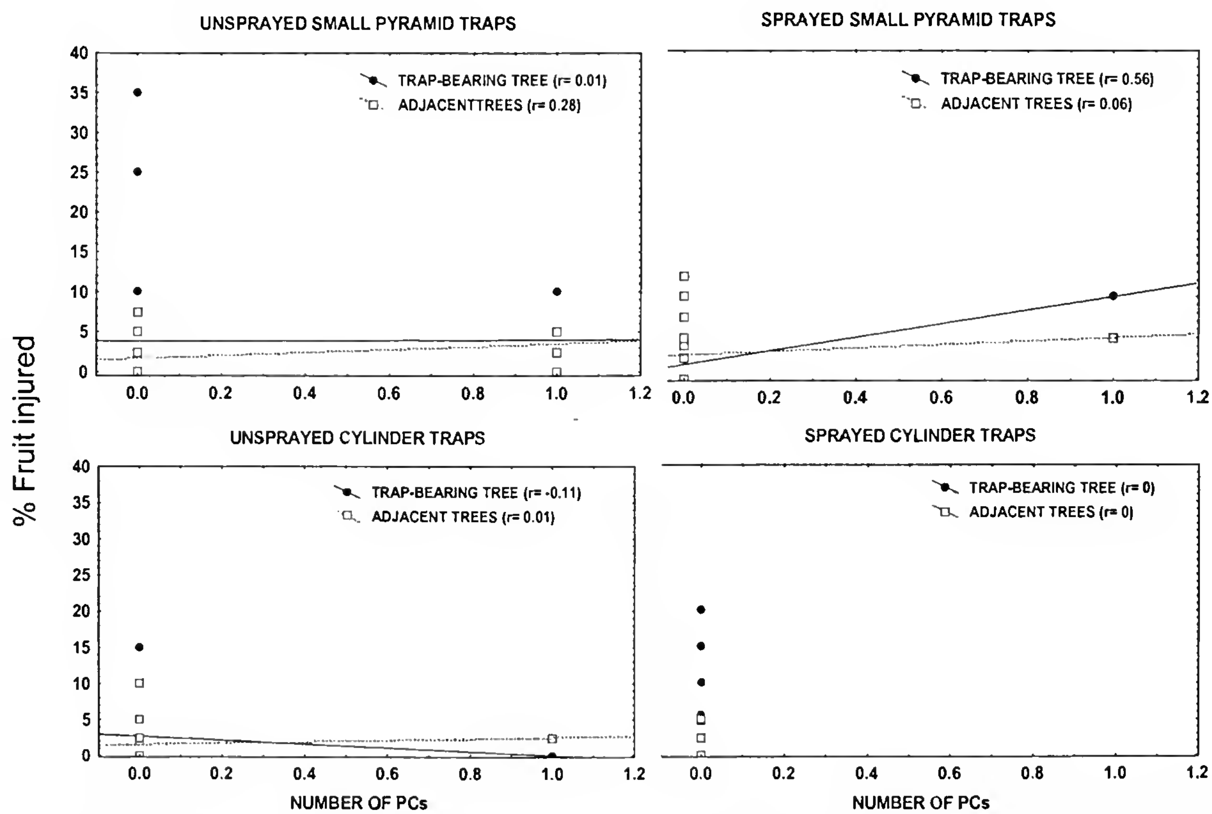

Figure 2. Degree of correlation between the total number of PCs captured by traps of each type and the percent fruit injured by PCs in trees bearing a trap and in adjacent trees. The higher the *r* value, the greater the extent of correlation.

Results

2001 Field study. Table 1 shows that within the first 10 days after spraying, unsprayed traps (particularly pyramids) captured more PCs than sprayed traps. From 11 to 20 days after insecticide application, all traps captured similar numbers of PCs. Only one PC was captured after 20 days (by a sprayed cylinder trap). Overall, at least twice as many PCs were captured by unsprayed small pyramid traps than by any other trap type.

Figure 2 depicts, for the first 10 days after insecticide application, the degree of correlation between the extent of PC captures by a trap and the

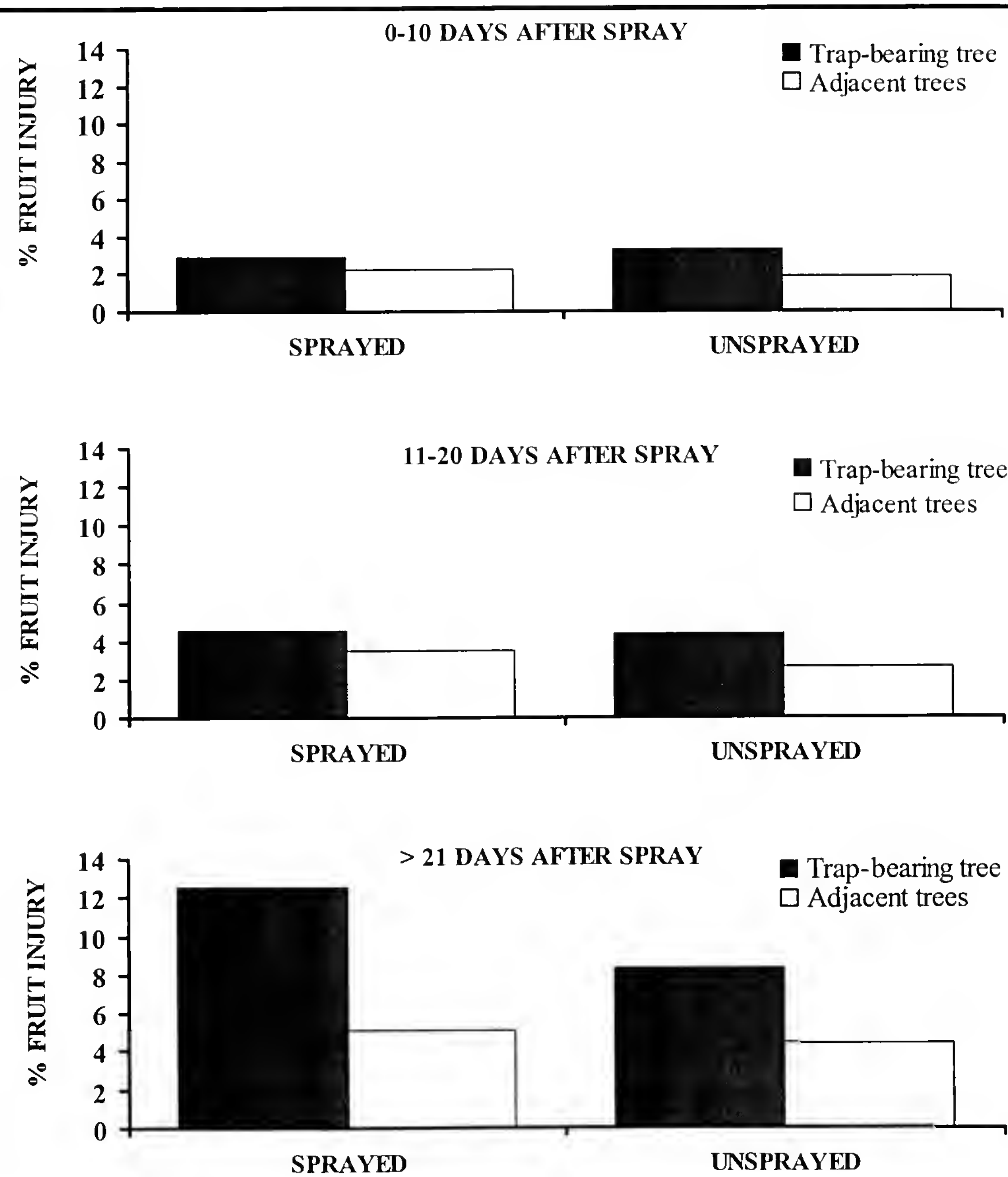

Figure 3. Amount of fruit injured by PCs on perimeter-row apple trees having a trap (i.e., trap-bearing tree) or on two adjacent non-trapped trees (adjacent trees). Data combined for pyramid and cylinder traps (2001 field study).

amount of PC injury to fruit located in trees having a trap or in adjacent trees. A strong positive correlation (i.e., a value close to 1) would indicate that high PC captures reflect high damage to fruit by PC, and that low PC captures reflect low damage to fruit. If a strong correlation were found, we would be able to predict fruit injury based on trap captures. However, we found that all trap types (even the unsprayed ones) showed a poor ability to predict injury to fruit by PCs based on captures. Even though the strongest correlation (0.56) was found in the case of sprayed pyramid traps, the fact that few PCs were captured by traps of this type during the first 10 days does not allow us to consider such a correlation as convincing.

Figure 3 shows that, in each one of the three time periods after insecticide application, fruit located in trees bearing both sprayed and unsprayed traps received consistently more damage than fruit located in adjacent trees. Such a pattern was especially pronounced after 20 days, when fruit injury was 2.4 times greater on trees bearing sprayed traps than on adjacent trees and about 1.9 times greater on trees bearing unsprayed traps than on adjacent trees.

2002 Field study. Figure 4 reveals that regardless of the time period elapsed since insecticide spray, the application of Imidan® seems to have had little influence on the ability of any trap type to capture PCs. Both types of Circle traps captured similar numbers of PCs, and these two trap types captured substantially more PCs than small pyramid or cylinder traps.

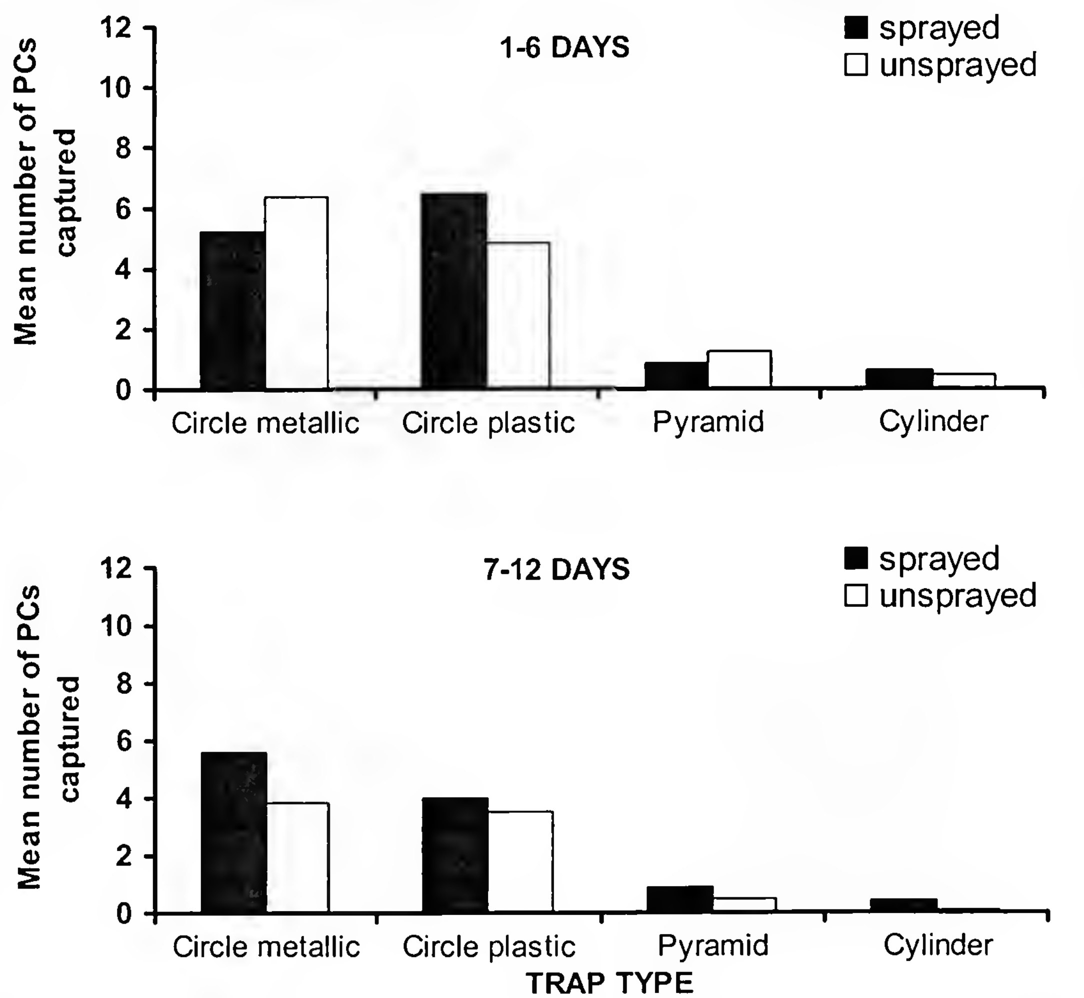

Figure 4. PC captures by each type of odor-baited trap placed on perimeter-row trees (2002 field study).

Table 2. In laboratory tests, proportions of PCs that reached the top of unsprayed and sprayed tree limbs, small pyramid traps, and black cylinders. The insecticide evaluated in 2000 was Guthion®, and in 2001 was Imidan®.

	2000		2001	
Trap type	% TOP	No PCs tested	% TOP	No PCs tested
Limb unsprayed	91%	11	100%	16
Limb sprayed	44%	16	65%	20
Pyramid unsprayed	67%	6	100%	17
Pyramid sprayed	0%	12	59%	22
Cylinder unsprayed	75%	4	94%	16
Cylinder sprayed	25%	4	50%	22

Laboratory observations. Table 2 shows that in 2000 (when Guthion® was evaluated), 91, 67, and 75 % of total PCs reached the top of unsprayed limbs, pyramids, and cylinders, respectively, whereas for sprayed counterparts, only 44, 0, and 25%, respectively, reached the top. Table 2 also reveals that in 2001 (when Imidan® was evaluated), 100, 100, and 94% of total PCs reached the top of unsprayed limbs, pyramids, and cylinders, respectively, whereas for sprayed counterparts, only 65, 59, and 50%, respectively, reached the top. Comparatively, Guthion® exerted a greater negative effect than Imidan® on the propensity of PCs to crawl up the structures evaluated.

Conclusions

Results from the 2001 field experiment suggest that when orchard trees are sprayed with Imidan® to protect against PC damage, PC captures by cylinder traps are strongly compromised during the first 10 days after application. This suggests that, particularly during this period of time, PC captures by cylinder traps would be very poor indicators of PC population levels in tree canopies, with a remarkably poor ability to forecast PC injury to fruit. In 2001, the negative effects of insecticide application were not apparent after 10 days following an application of Imidan®.

Several of our studies have shown that odor-baited cylinder traps, when deployed in commercial orchards, offer little or no value for predicting extent of PC injury to fruit, which we have attributed, in part, to the presence of insecticide on the trap surface. As found in the 2001 study, even unsprayed traps failed to reflect the amount of PC injury to fruit located in trap-bearing or adjacent trees. Such poor ability could have been due then to the possibility that very few PCs were present on sprayed trees. Even so, PC presence was sufficiently great to inflict damage to fruit.

In both 2001 and 2002, unsprayed black pyramids captured numerically more PCs than unsprayed black cylinders, which suggests that small pyramids offer a stronger visual stimulus to PCs than cylinders.

Results from the laboratory observations confirmed the negative effect of organophosphate insecticide application on trap performance found in the 2001 field study. Here, there was strong evidence that, in the absence of any odor bait, PCs are reluctant to crawl upward on traps sprayed with Guthion® or Imidan®. Nonetheless, tree limbs sprayed with organophosphate insecticide proved considerably less deterrent to PCs, possibly because tree limbs possess positive contact stimuli that tend to override negative effects of insecticide.

Results from the 2002 field study, however, failed to show an effect of insecticide application on trap captures even when the same insecticide (Imidan®) and dose (3/4 pound per 100 gallons water) was utilized as in the 2001 study. This may be due to the fact that the amount of benzaldehyde used to bait traps in 2002 was four times greater than in 2001 (2.5 mg/day vs. 10 mg/day in 2001 and 2002, respectively). Therefore, in 2002 PCs may have been more strongly drawn to enter the trap tops, overcoming the negative effect of insecticide.

Combined results suggest that, in the absence of any odor (as in our lab study), PCs are substantially repelled from climbing up organophosphate-sprayed traps. However, such negative effect seems to be less pronounced as the amount of odor bait (i.e.

benzaldehyde) is increased, as found in the field studies. As mentioned, the amount of benzaldehyde used in the field studies was increased from 2.5 mg/day (in 2001) to 10 mg/day (in 2002), which seems to have overcome negative effects of the presence of insecticide on the trap surface.

Based on our findings, we conclude that (1) unsprayed cylinder or small pyramid traps may be more effective in capturing PCs than sprayed cylinder or small pyramid traps, and (2) even though Circle traps may offer more promise for capturing PCs than unsprayed cylinders or small pyramids, other approaches to monitoring PC, such as an 'odor-baited trap tree' approach (see the 2002 winter issue of Fruit Notes), may be much more rewarding.

Acknowledgments.

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Devising an Attractive Bait to Monitor the Seasonal Course of Plum Curculio Immigration into Apple Orchards using Traps

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To reduce insecticide use against plum curculio (PC), management strategies should consider the time of first appearance of PCs on host trees after overwintering in woods, as well as the peak and the end of immigration. One approach to tracking the seasonal course of PC immigration is the use of a trap baited with a lure that is highly attractive to PCs. In the 2000 issue of *Fruit Notes*, we reported that both panel and pyramid traps baited with benzaldehyde (BEN) in combination with PC pheromone called grandisoic acid (GA) were very good indicators of the seasonal course of immigration into apple orchards when deployed in close proximity to woods. In that study, we also found that ethyl isovalerate (EIV) and limonene (LIM), in combination with GA, showed some degree of attractiveness to PCs, but to a lesser extent when compared to the high luring power of BEN+GA.

Here, we report on two field studies performed in Massachusetts in 2001 and 2002 using panel and pyramid traps. The 2001 study was aimed at evaluating the three most attractive fruit odors (BEN, EIV, and LIM) found in our 2000 study to confirm the high attractiveness of the combination BEN+GA to PCs. The 2002 study was performed to evaluate PC response to four different amounts of BEN (the most attractive fruit odor found in the 2001 study) and two different amounts of GA to determine the amount of each odor needed to maximize the performance of monitoring traps.

Materials & Methods

Both studies were conducted in an unsprayed section of a commercial apple orchard at the UMASS Cold Spring Orchard Research & Education Center (Belchertown, MA). As in 2000, traps evaluated in 2001 and 2002 were clear Plexiglas panels (2 x 2 feet, with the woods-facing side coated with Tangletrap) and black pyramid traps (24 inches wide at base x 48 inches tall) (Figure 1). Whereas panel traps capture mainly PCs in flight (particularly on warm days), pyramid traps capture primarily crawling PCs (mostly during cool days or at night).

2001 Study. This study was undertaken from April 30 to June 30, 2001. Host plant odors evaluated were benzaldehyde (BEN), ethyl isovalerate (EIV), and limonene (LIM), all purchased from Sigma-Aldrich Chemical Co. (Milwaukee, WI). Three different groups of odor treatments were arranged, each involving a single host volatile alone, GA alone, a combination of host volatile and GA, and a no-odor (control) treatment. By testing each fruit odor alone and in combination with GA, we sought to determine the extent to which each of the synthetic host plant volatiles tested enhanced PC responsiveness to GA. There were four replicates for each trap type and odor combination.

BEN was released from 1-ml low-density white polyethylene vials in order to prevent polymerization of this chemical by UV light (as found in 2000 when using high-density clear polyethylene vials). Because this problem was not found for EIV and LIM, these two chemicals were tested (as in 2000) using 400¼l high-density clear polyethylene vials. A white vial filled with 1 ml of BEN released ~2.5 mg/day of BEN. Only one vial of this type was used per trap. Two vials containing LIM and three vials containing EIV were needed per trap to accomplish a release rate of ~10 mg/day of each chemical. Each pheromone dispenser released ~1 mg/day of GA.

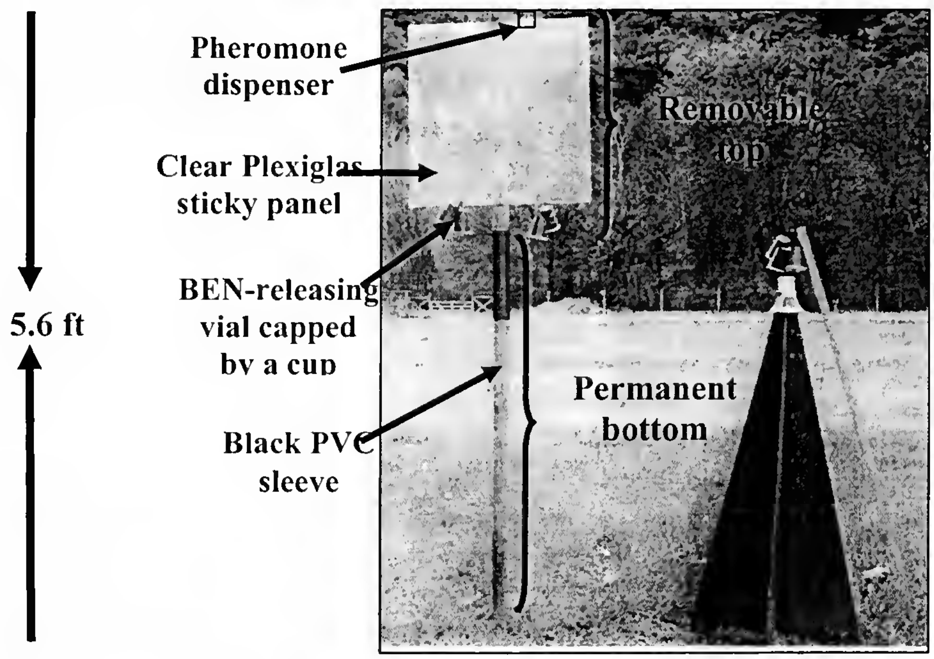

Figure 1. View of a panel and a pyramid trap used in the 2001 and 2002 studies to evaluate synthetic odors for attractiveness to PCs. Traps were deployed in pairs in close proximity (~1m) to woods to intercept immigrating PCs.

Vials containing fruit volatiles were attached to the lower edge of a panel using binder clips, whereas one GA dispenser was attached to the upper edge of a panel. For pyramid traps, both fruit volatile- and GA-releasing dispensers were placed inside a boll weevil trap top. Vials containing BEN were replaced every 2 weeks to maintain a consistent release rate. Vials containing EIV and LIM, along with GA dispensers, were replaced twice (3 and 6 weeks after trap deployment).

2002 Study. In 2002, we evaluated four different amounts of BEN (0, 2.5, 10, and 40 mg/day), hereafter referred to as no-BEN, low, medium, and high release rates, respectively, and two amounts of GA (1 and 2 mg/day), hereafter referred to as low and high release rates, respectively. The low release rate of BEN (~2.5 mg/day) was achieved by filling 1-ml low-density white polyethylene vials with 1 ml of BEN (1 vial/trap), as in 2001. The medium release rate (~10 mg/day) was achieved by using one 15-ml low-density white polyethylene vial filled with 15 ml of BEN (1 vial/trap). The high release rate (~40 mg/day) was achieved by using four such 15-ml vials per trap. Since each pheromone dispenser released ~1 mg of GA per day, the high release rate of GA (2 mg/day) was achieved by using two GA dispensers per trap. In total, eight treatments were evaluated. Each was replicated six times for each trap type.

In 2002, besides using white vials to protect BEN from UV light, we employed green 266-ml plastic cups to provide additional protection against UV light and rainfall. Each vial containing BEN was hung by its neck from a wire and positioned inside a plastic cup. For use with pyramid traps, cups were hung in inverted position from the end of a wooden pole (buried in the ground at a 45° angle) in such a way that bases of cups were ~ 4 inches above pyramid trap tops (see Figure 1). Depending on the treatment, either one or four cups were attached to each pole. Cups holding BEN-dispensing vials were attached to the bottom edge of panels using wire and steel binder clips. GA dispensers were attached to the upper edge of panels using binder clips, or were placed inside the inverted screen funnel capping pyramid traps. All vials releasing BEN and all GA dispensers were replaced once (four weeks after initial trap deployment).

Trap deployment. In both years, panel and pyramid traps were deployed in pairs (1 yard apart) along the periphery of the apple orchard, in close proximity (~1 yard) to woods. This approach allowed traps to intercept PC adults presumably immigrating into the orchard after overwintering in the woods. Each pair of traps was baited with the same odor combination and spaced 10 yards from other trap pairs on either side. Traps were inspected for PC captures on a daily basis, although for the purposes of this article, results for each year show PC captures by panel or pyramid traps across the entire period of immigration. In both years, traps were baited during the tight cluster stage of apple tree phenology (on April 29 in 2001 and on April 16 in 2002).

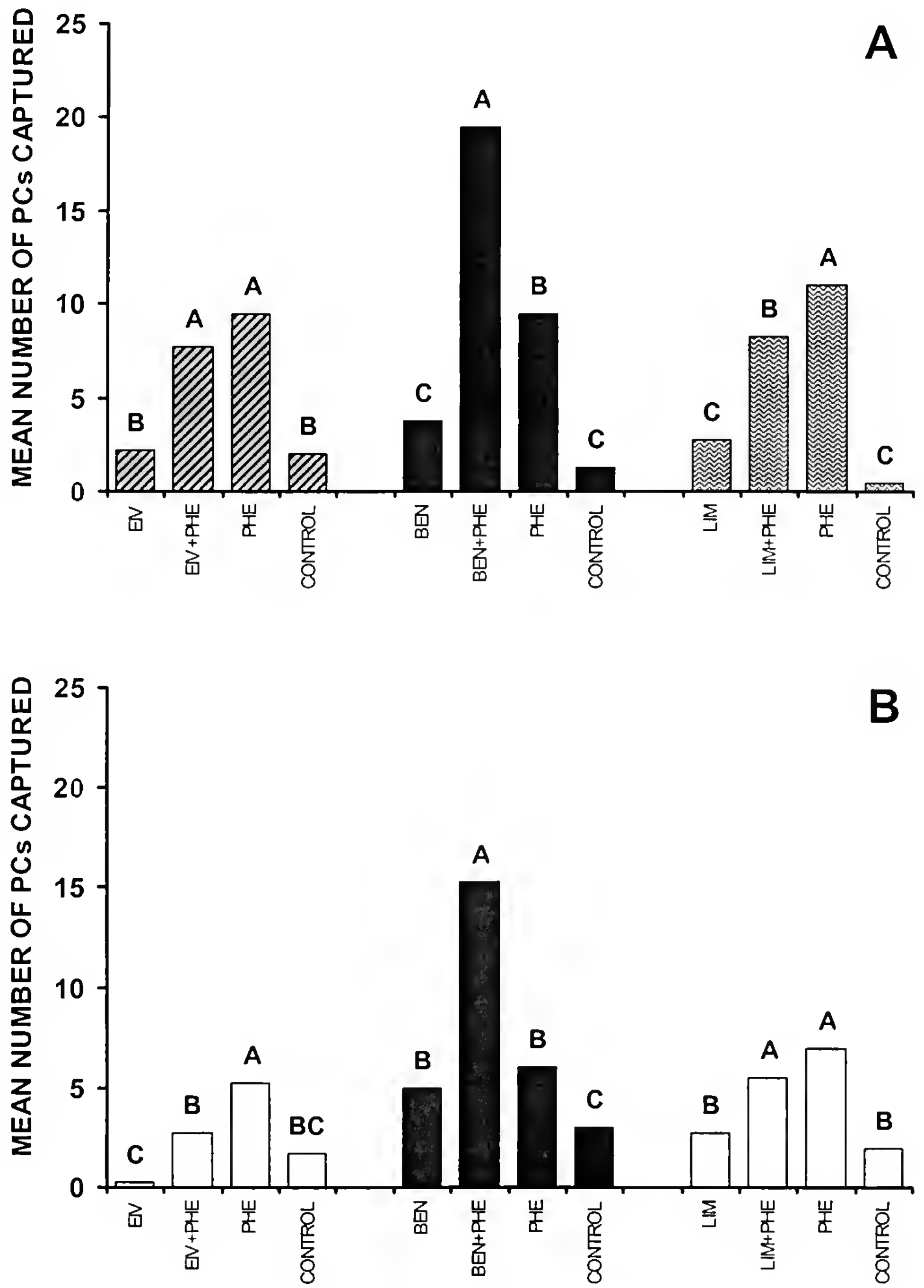

Figure 2. PC captures by A) panel traps and B) pyramid traps in the 2001 study. For each graph, bars in each group not superscribed by the same letter are significantly different at odds of 19:1.

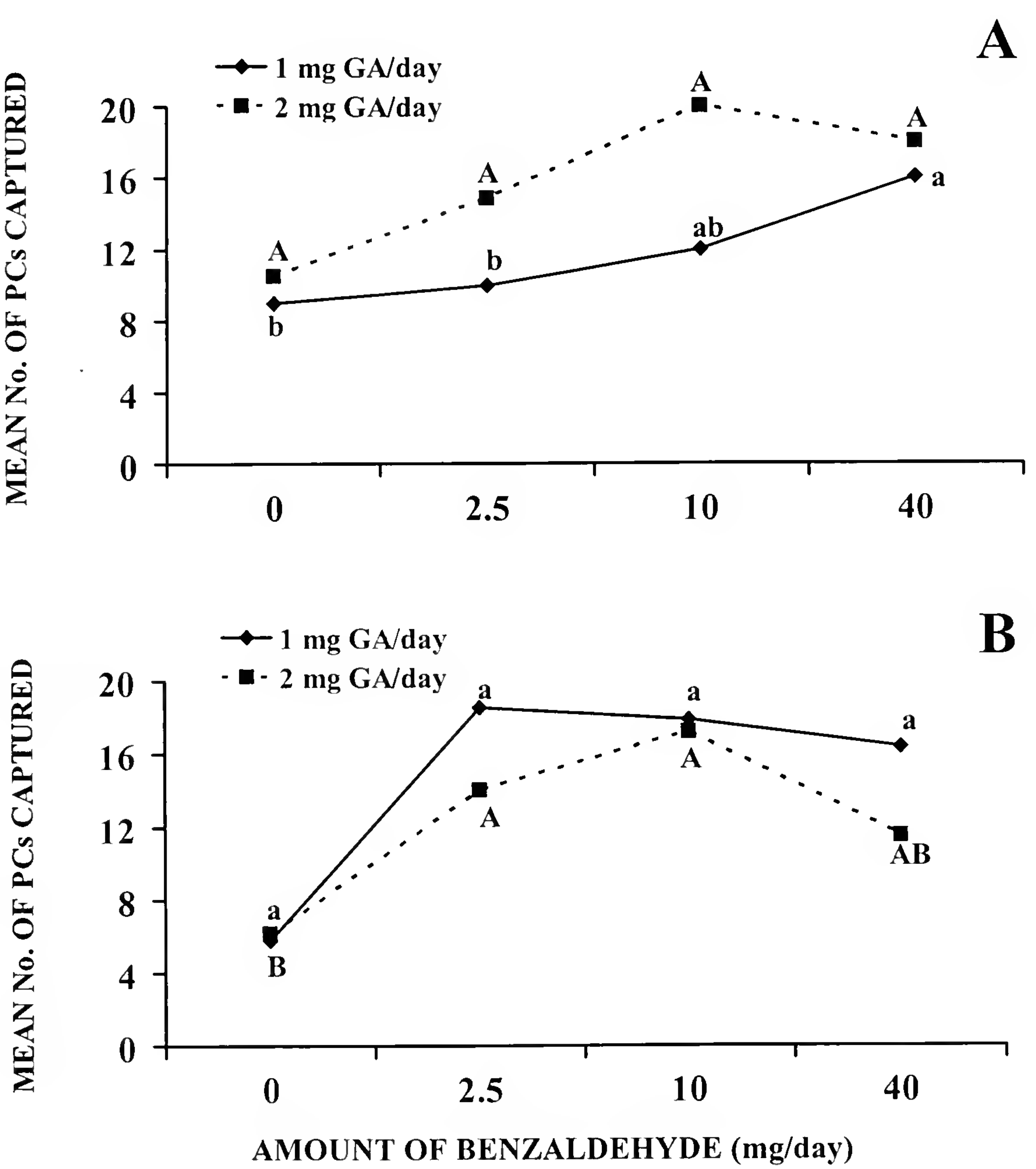

Figure 3. PC captures by A) panel traps and B) pyramid traps in the 2002 study as a function of amounts of BEN (benzaldehyde) and GA (grandisoic acid) used. For each graph, points in each line not superscribed by the same letter are significantly different at odds of 19:1.

Results

2001 Study. Overall, 538 PCs were captured by traps (312 PCs by panels and 226 PCs by pyramids) over the period of 62 days that encompassed the PC season in 2001 (April 30–June 30).

In 2001, BEN was the only host volatile that for both trap types significantly enhanced the response of PCs to GA. To illustrate, panel traps baited with BEN+GA captured 15 times more PCs than unbaited traps of the same type, and captured twice as many PCs as traps baited with GA alone (Figure 2A). Panel traps baited with GA alone captured more PCs than panel traps baited with BEN alone or unbaited traps. Pyramid traps baited with BEN+GA captured 5 times more PCs than unbaited pyramid traps and 2.5 times more PCs than pyramid traps baited with GA alone. Pyramid traps baited with BEN alone or GA alone captured more PCs than unbaited pyramid traps (Figure 2B).

For both trap types, the presence of EIV or LIM did not enhance the attractiveness of GA to PCs (Figure 2A and B). Also, for both trap types, consistently more PCs were captured by traps baited with GA alone than by traps baited with EIV alone, LIM alone, or unbaited traps. In no case did EIV or LIM alone significantly enhance adult response above that to control traps.

2002 Study. In all, 1,305 PCs were captured by traps (662 PCs by panels and 643 PCs by pyramids) over the period of 82 days that comprised the PC season in 2002 (April 17 – July 8).

Figure 3A shows PC captures by panel traps according to amounts of BEN and GA evaluated. Overall, panel traps baited with the high release rate of GA captured about 35% more PCs than panel traps baited with the low release rate of GA. When we examined PC captures by panel traps baited with the low release rate of GA, we found a significant positive linear relationship between the amount of BEN and the extent of captures. As depicted in Figure 3A, increases in the amount of BEN released corresponded to increases in captures by panel traps, with the maximum number of PCs captured corresponding to the high release rate of BEN (40 mg/day). For panel traps baited with the high release rate of GA, we found that the most attractive release rate of BEN was again 40 mg/day, although differences among BEN treatments were only numerical.

Figure 3B presents PC captures by pyramid traps according to amounts of BEN and GA used. Pyramid traps captured similar numbers of PCs regardless of the amount of GA used. For pyramid traps baited with the low release rate of GA, we found that the mere addition of BEN, regardless of the dose, enhanced PC captures relative to traps baited with GA alone (Figure 3B). For pyramid traps baited with the high release rate of GA, we found an increase in captures as the amount of BEN released increased but only up to a maximum of 10 mg/day. Beyond that amount, BEN did not enhance, but rather decreased the attractiveness of GA.

Conclusions

Our results from the 2001 study indicate that, among all odor combinations evaluated, BEN in association with GA was the most attractive bait for PCs. Results from the 2002 study, as well as an assessment of cost of both BEN (as formulated by us) and GA (obtained from Great Lakes IPM), indicate that a high release rate of BEN (40 mg/day/trap) in association with a low release rate of GA (1 mg/day/trap) seems to be the most cost-effective bait combination to be used for panel as well as pyramid traps. With our approach, BEN provided sustained attractiveness to PCs across the entire period of immigration (82 days in 2002). Placement of BEN-releasing vials outside of trap tops (for pyramid traps) appeared to preclude the kind of close-range repellency found in previous studies in which BEN-releasing vials had been positioned inside the tops of pyramid, Circle, or cylinder traps.

We conclude that BEN (at 40 mg/day of release) in association with GA (at 1 mg/day of release) constitutes a powerful lure that may greatly improve the effectiveness of monitoring traps for PC.

Acknowledgments

We thank Phillip McGowan for assistance. This study was supported with funds provided by a USDA Northeast Regional IPM grant, a Hatch grant, the New England Tree Fruit Research Committee, and the UMass HRC Trust Fund.

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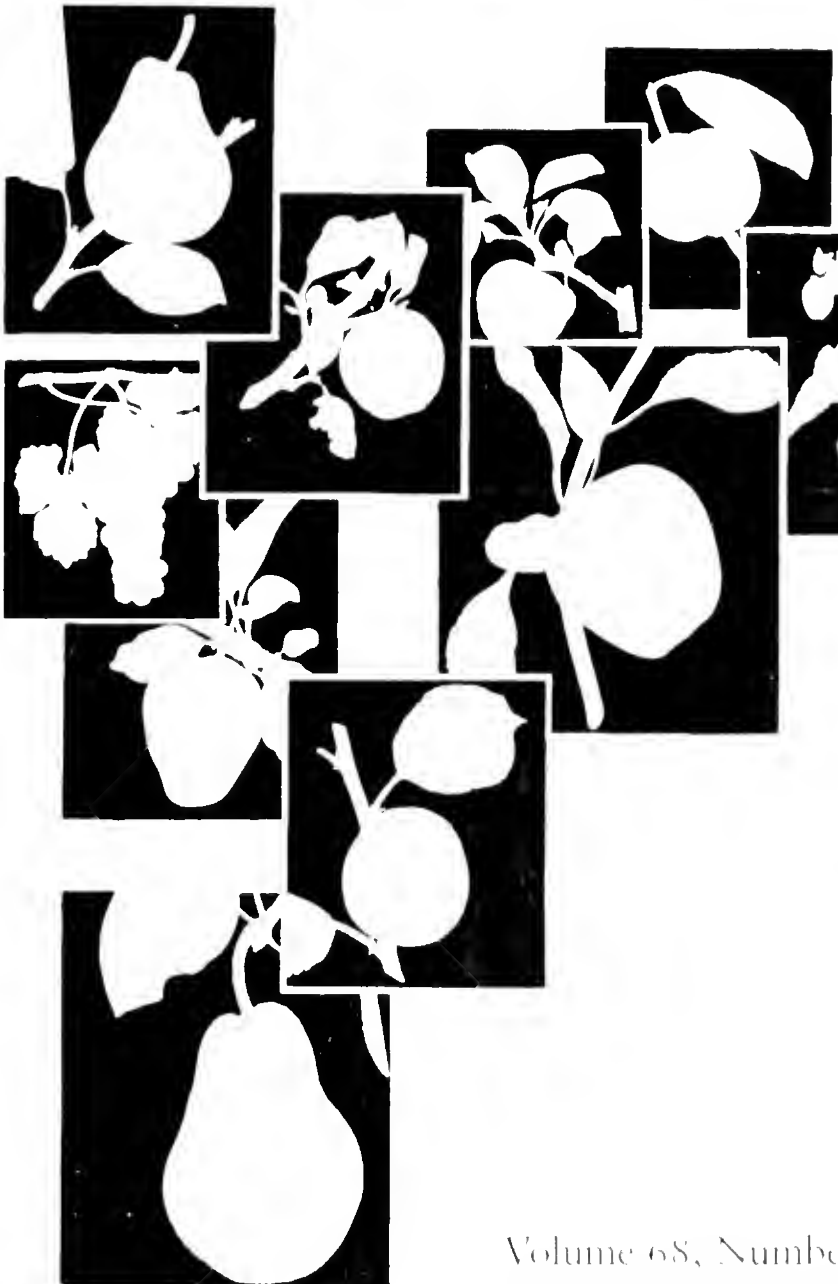

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Comparison of Avaunt versus Guthion in Every-row versus Perimeter-row Sprays Against Key Apple Insect Pests: 2002 Results and Project Summary

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In the 2001 issue of *Fruit Notes*, we presented results from the first year of a planned two-year study comparing the effects of Avaunt versus Guthion in every-row versus perimeter-row sprays against plum curculio (PC), apple maggot (AM), summer leafrollers (LR) and internal Lepidoptera (a combination of codling moth, oriental fruit moth and lesser appleworm). Avaunt is a recently-labelled oxadiazine insecticide for use against these and other orchard pests. Guthion has been our standard organophosphorous material for general-purpose insect control for several decades, but its status for use in orchards beyond 2005 is uncertain. Conceivably, Avaunt might be an effective substitute for Guthion against key orchard insect pests.

Avaunt and most other recently labelled insecticides are substantially more expensive than Guthion and other older insecticides. If the amount of Avaunt needed to achieve effective pest control could be reduced through modification of pattern of spray application (such as limiting application to only peripheral-row trees), then considerable cost savings could be achieved without sacrifice of fruit quality

Here, we present results of our second and final year of research comparing effects of Avaunt versus Guthion in every-row versus perimeter-row sprays against PC, AM, LR, and internal Lepidoptera. We also present combined data from our two years of research on this subject.

Materials & Methods

In April of 2001, four plots were established in each of six commercial apple orchards in Massachussetts (24 plots in all). Rootstocks and cultivars varied among orchards, but all trees in a given orchard were on the same rootstock (either M.7, M.26, or M.9) and of the same cultivar (either McIntosh, Empire, Cortland, Gala, or Delicious). Each plot was about 40 x 40 yards in size and consisted of seven rows of apple trees. The perimeter row bordered woods, hedgerow, or open field and was subjected to pressure from immigrating PCs and AM. In 2002, one of the six orchards was so heavily damaged by frost that it could not be used in our 2002 research.

In 2002, as in 2001, growers themselves sprayed all rows of all plots with azinphosmethyl or phosmet through petal fall. Thereafter, all sprays were applied by Andrew Hamilton using our own tractor-mounted mist blower. Plots in each orchard received four sprays after the petal fall spray: 10 days and again in 20 days after petal fall against PC, and on July 19-21 and again on August 9-11 against AM. Spray was delivered at the equivalent of 150 gallons of water per acre. Guthion (50 WP) was applied at the rate of 30 ounces of formulated material per acre against PC and 24 ounces of formulated material per acre against AM. Avaunt (30% WG) was applied at the rate of 6 ounces of formulated material per acre against both PC and AM. After the petal-fall spray, plots designated as "all row" plots received insecticide applied to both sides of trees on all seven rows, whereas plots designated as "perimeter-row" plots received insecticide sprays applied to both sides of trees of the perimeter (=first) and second rows but no insecticide applied to trees of the third through seventh rows (Figure 1). After the petal-fall spray, Andrew Hamilton applied azinphosmethyl or phosmet to trees in the eighth interior row and to orchard trees bordering plots on either side.

Weekly from petal fall until harvest in September, 100 fruit in each of rows 1, 3, 5, and 7 of each plot were sampled for injury by PC and AM. In addition, two unbaited sticky red sphere traps were hung toward the center of each row of each plot to monitor AM. Finally, at harvest, 100 fruit in each of rows 1,3, 5 and 7 of each plot were sampled for injury by summer LR and internal Lepidoptera.

Results

Incidence of each pest type, as averaged across all samples of fruit or traps in rows 1, 3, 5, and 7 of each plot, is given in Table 1. As in 2001, results for 2002 show no significant differences among any of the four treatments (all-row versus perimeter-row sprays of Guthion versus Avaunt) in incidence of fruit injury by PC, trap captures of AM, fruit injury by AM, fruit injury by summer LR, or fruit injury by internal Lepidoptera.

Injury by PC in 2002 was sufficiently great to justify comparison of PC damage to fruit on perimeter-row trees with damage to fruit on interior trees. Combined date for all-row plus perimeter-row sprays of Guthion revealed that injury to fruit on perimeter-row trees (row 1) averaged about 10 times greater (1.275%) than the mean amount of injury to fruit on trees in row 3, 5, and 7 (0.125%). These data suggest that PCs which immigrate into orchards after a petal fall spray has been applied confine their activity to peripheral-row trees and infrequently penetrate into interior rows of orchards.

Figure 2 displays combined data for each pest for 2001 and 2002. All-row sprays of Avaunt were approximately equal to all-row sprays of Guthion in protecting against PC, AM, summer LR and internal Lepidoptera. For both PC and AM, perimeter-row sprays of Guthion performed as well as all-row sprays of Guthion in providing plot-wide control. For PC and especially for AM, perimeter-row sprays of Avaunt were not as effective as all-row sprays of Avaunt in providing plot-wide control. For both summer LR and internal Lepidoptera, perimeter-row sprays were not as effective as all-row sprays in providing plot-wide control in the case of Guthion as well as Avaunt.

Conclusions

There were no statistical differences among any of the four treatments evaluated here in ability to control target pests in either 2001 or 2002. Indeed, combined data for both years indicate that all-row sprays of Avaunt were approximately as effective as all-rows sprays of Guthion in ability to control PC,

Table 1. Effectiveness of Guthion versus Avaunt against pest insects when applied to all rows versus the two perimeter rows of seven-row plots in five commercial apple orchards in Massachusetts in 2002. Values represent data averaged across all samples taken in rows 1, 3, 5 and 7 of plots.

	Incidence of pest			
	Guthion		Avaunt	
Pest	All rows sprayed	Perimeter rows sprayed	All rows sprayed	Perimeter rows sprayed
Plum curculio (% fruit with injury)*	0.45	0.30	0.45	0.47
Apple maggot (no. captured per sphere)*	6.58	8.78	7.28	10.83
Apple maggot (% fruit with injury)*	0.13	0.08	0.09	0.18
Summer leafrollers (% fruit with injury)*	1.00	1.70	0.90	1.60
Internal Lepidoptera (% fruit with injury)*	0.05	0.15	0.00	0.15

*No statistically significant differences among treatments at odds of 19:1.

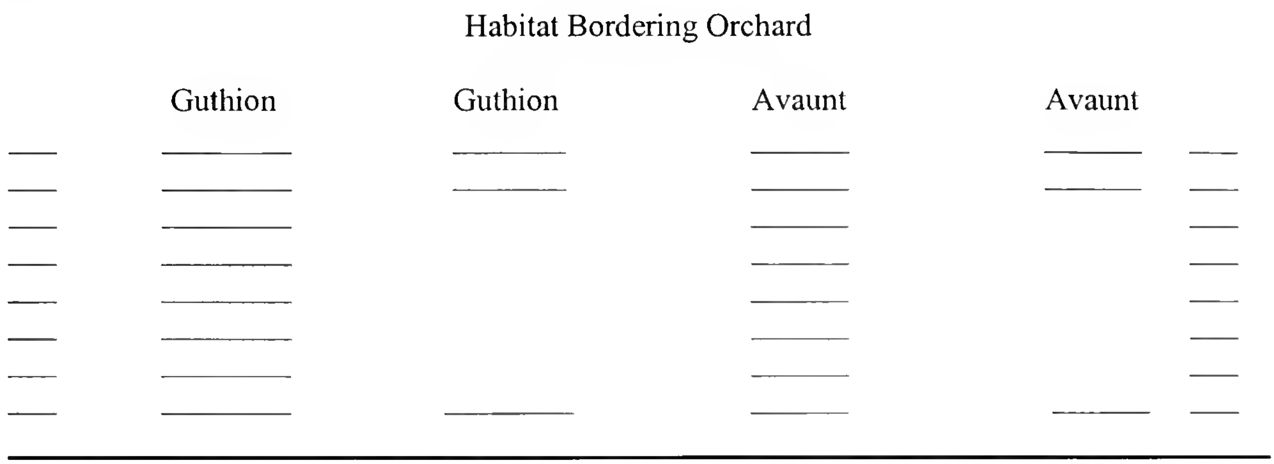

Figure 1. Schematic illustration of pattern of spray application in four experimental plots of a commercial orchard. Plot treatments differed in location within each orchard block.
__________ = Trees sprayed by hired applicator.

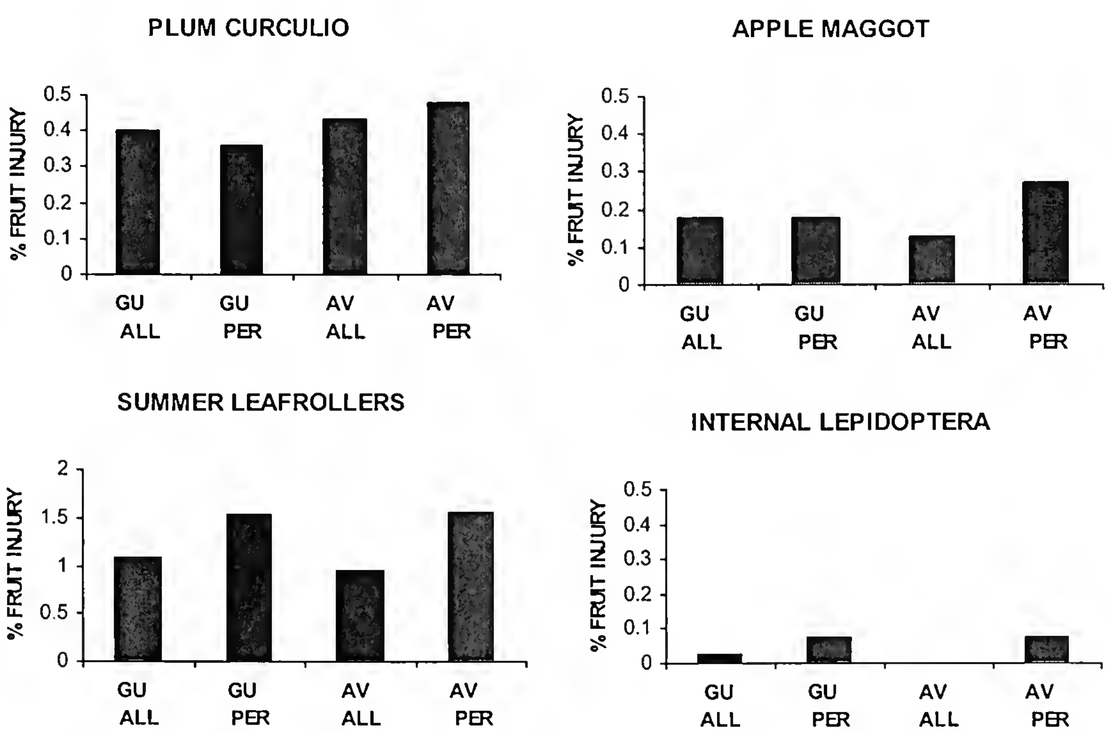

Figure 2. Two-year average (2001 and 2002) of data on effectiveness of Guthion (GU) versus Avaunt (AV) against pest insects when applied to all rows (ALL) versus the two perimeter rows (PER) of seven-row plots in commercial orchards in Massachusetts. Values represent data averaged across all samples taken each year in rows 1, 3, 5 and 7 of plots.

AM, summer LR, and internal Lepidoptera. Further, combined data for both years indicate that applying Guthion only to perimeter-row trees from the first cover spray onward was just as effective in protecting interior rows against injury by PC and AM as applying Guthion to all trees in a block from the first cover spray onward. In the case of Avaunt, however, all-row sprays were numerically (though not statistically) superior to perimeter-row sprays in providing protection against injury by PC and AM on interior rows.

We conclude that Avaunt can be an effective substitute for Guthion against PC, AM, summer LR, and internal Lepidoptera when applied to all trees in an orchard but may be less effective than Guthion in providing orchard-wide control of PC and AM if applied only to perimeter-row trees.

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Comparison of Traps and Trap Trees for Monitoring Plum Curculios: 2002 Results

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Department of Entomology, University of Massachusetts

In the 2002 Winter issue of Fruit Notes, we reported on year 2001 tests in which we compared odor-baited with unbaited traps of three types (pyramid, cylinder and Circle) for monitoring plum curculios (PCs) in several commercial apple orchards. All traps were placed beneath or within canopies of perimeter-row apple trees. Results indicated that Circle traps baited with benzaldehyde (BEN, a component of host plant odor) plus grandisoic acid (GA, male-produced aggregation pheromone) captured numerically more PCs than any other baited or unbaited traps. However, no trap type showed even a moderate positive relationship between the time of occurrence of PC captures by the trap (first, second, third, etc. week after petal fall) and time of occurrence of PC injury to fruit. Even for Circle traps baited with BEN plus GA, captures fell off dramatically soon after petal fall, whereas fruit injury rose steadily. Thus, low trap captures after petal fall could not be taken as indicative of a lack of need to spray against PC.

In the 2002 Fall issue of Fruit Notes, we reported that pyramid traps and sticky-coated Plexiglas panel traps baited with BEN plus GA and placed at orchard border areas were effective in monitoring the seasonal course of immigration of overwintered PC adults into a small unsprayed orchard. This finding suggested that such traps placed in border areas might be useful for monitoring PCs in commercial orchards.

Finally, in the 2002 Winter issue of Fruit Notes, we reported on a preliminary study in a single commercial apple orchard involving the establishment of odor-baited "trap trees" as a potentially new and effective approach to monitoring PCs. This approach involves baiting the branches of a few perimeter-row trees in an orchard with BEN plus GA and examining fruit solely on these few baited trees for signs of fresh PC injury, thereby eliminating the need to examine fruit or a large number of trees to gain an accurate estimate of the degree of current threat of PC injury to fruit. Moreover, a trap tree approach might overcome various shortcomings of odor-baited traps that have afflicted our ability to rely on extent of trap captures as indicative of extent of threat of PC injury to fruit.

Here, we report results of a 2002 study in commercial apple orchards in which we compared the performance of odor-baited-sticky clear Plexiglas panels and black pyramids (both types of traps placed in orchard border areas) with the performance of odor-baited Circle traps (attached to trunks of perimeter-row apple trees) and the performance of odor-baited perimeter-row trap trees for monitoring the seasonal course of PC egglaying damage to developing apples.

Materials & Methods

The three types of traps were: (a) a clean Plexiglas panel (24 x 24 inches) attached vertically at head height to a wooden post, coated with Tangletrap on the side facing the orchard border area, (b) a black pyramid trap (24 inches wide at base x 48 inches tall), and (c) an aluminum-screen "Circle" trap, wrapped tightly around the base of a tree trunk so as to completely encircle the trunk.

Each trap and trap tree were baited with four polyethylene-vial dispensers of BEN (Aldrich Chemical Company) that together released 40 mg of BEN per day plus 1 dispenser of GA (Great Lakes IPM) that released 1 mg of pheromone per day. Each vial of BEN was suspended inside of an inverted colored, plastic drinking cup to minimize the potential negative impact of ultraviolet light on the stability of BEN. Vials of BEN were not renewed during the course of our test but dispensers of GA were renewed once (after 5 weeks). Dispensers of BEN and GA were suspended from the bottom edge of panel traps and from the branches of trap trees. For pyramid and Circle traps, dispensers of BEN were suspended in such a way that the open bottoms of the protective drinking cups were 4 inches above the inverted screen funnel (that capped each trap) to reduce close- range repellency of BEN, and the dispenser of GA was placed inside of the screen funnel. Four plots were established along a continuous 132 yard section of a perimeter row of apple trees in each of 11 commercial orchards. Each plot was 33 yards long by 7 rows of trees deep and contained one of the four trap treatment types. Traps or trap trees were positioned midway along the 33 yard length of the perimeter row of a plot. Panel and pyramid traps were placed in orchard border areas, 7 yards from the near edge of the canopy of the central perimeter-row tree of a plot. Circle traps and trap trees were assigned to the central perimeter-row tree of a plot.

Traps and trap trees were installed at the pink stage of bud development (April 22-24) and remained for 10 weeks (June 24-26). Weekly beginning at petal fall (May 13-15), we counted and removed all PCs from traps and examined 100 fruit per plot on perimeter trees for evidence of fresh PC egglaying scars. In all, 20 fruit were sampled on the central perimeter-row tree (directly opposite a panel or pyramid trap or containing a Circle trap or functioning as a trap tree) and 20 fruit were sampled on each of two evenly-spaced trees to the right and again to the left of the central tree. Fresh scars were those considered to have been made within the past 7 days. It is the appearance of fresh scars (not older scars) that ought to drive a grower's decision to spray against PC.

Each grower applied three sprays of azinphosmethyl or phosmet to control PC in the plots.

Results

Across the entire season, panel traps captured significantly more PCs than either pyramid or Circle traps (Figure 1). Even so, for none of these three trap types was there a significant positive correlation between total captures of PCs per plot (across all weeks from petal fall through June) and mean percent of sampled perimeter-row fruit per plot exhibiting fresh egglaying scars (across all weeks from petal fall through June) (Figure 2).

Furthermore, for none of the three traps types was there a significant positive correlation between sample-week trap captures per plot and sample–week percent of perimeter–row fruit per plot having fresh egglaying scars (Figure 3). A significant positive correlation would indicate that a week during which comparatively many trap captures occurred also was a week in which a comparatively large amount of fruit was injured by PC, whereas a week during which comparatively few

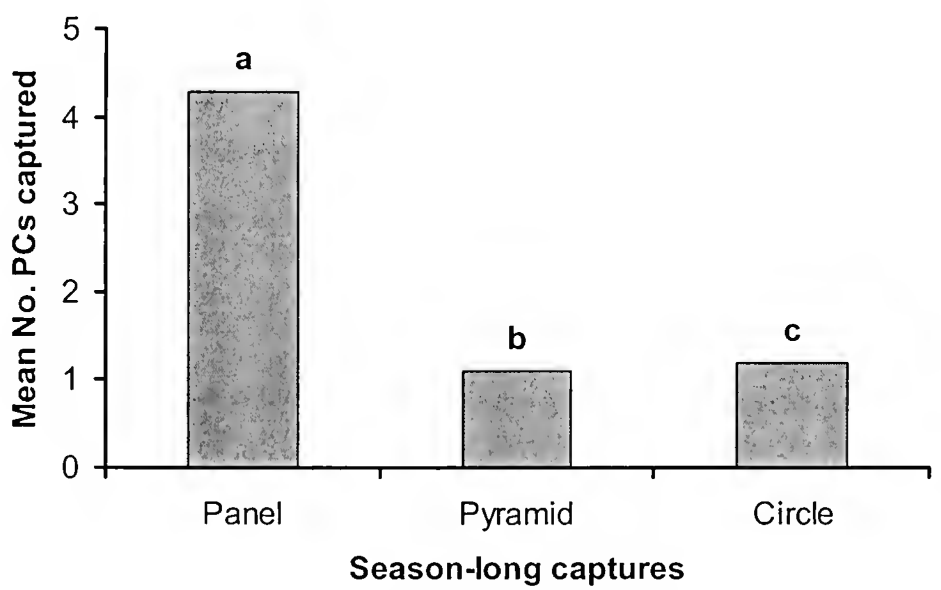

Figure 1. Season-long captures of overwintered plum curculio adults by odor-baited panel, pyramid and Circle traps placed in association with plots of perimeter-row apple trees. Means superscribed by the same letter are not significantly different at odds of 19:1.

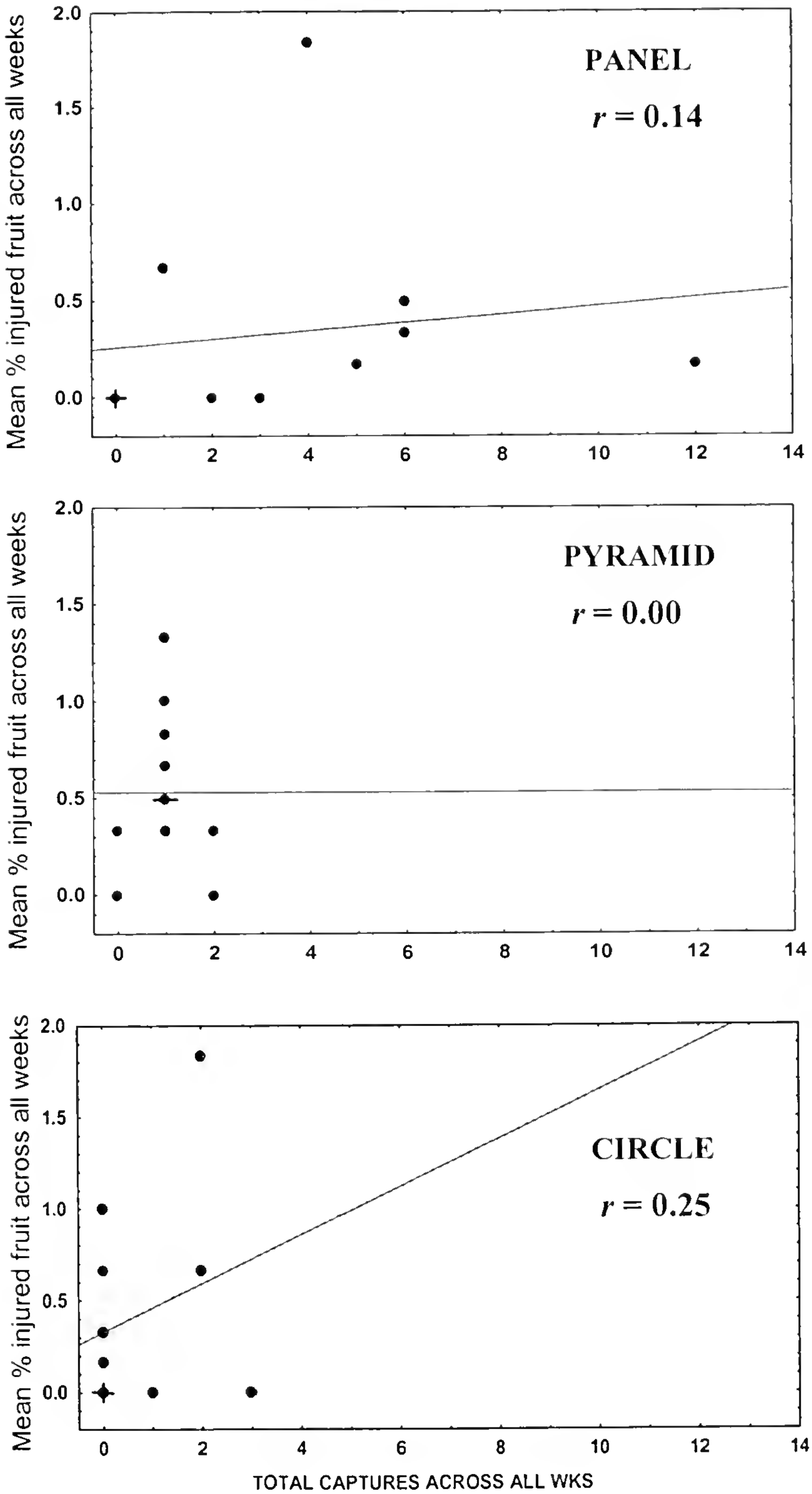

Figure 2. For panel pyramid and Circle traps, relationship between total captures of plum curculio adults per plot (across all weeks from petal fall through June) and mean percent of sampled perimeter-row fruit per plot having fresh ovipositional injury (across all weeks from petal fall through June). N=11 plots (hence 11 data points) per trap type. ? = two overlapping data points.

-●- = three overlapping data points.

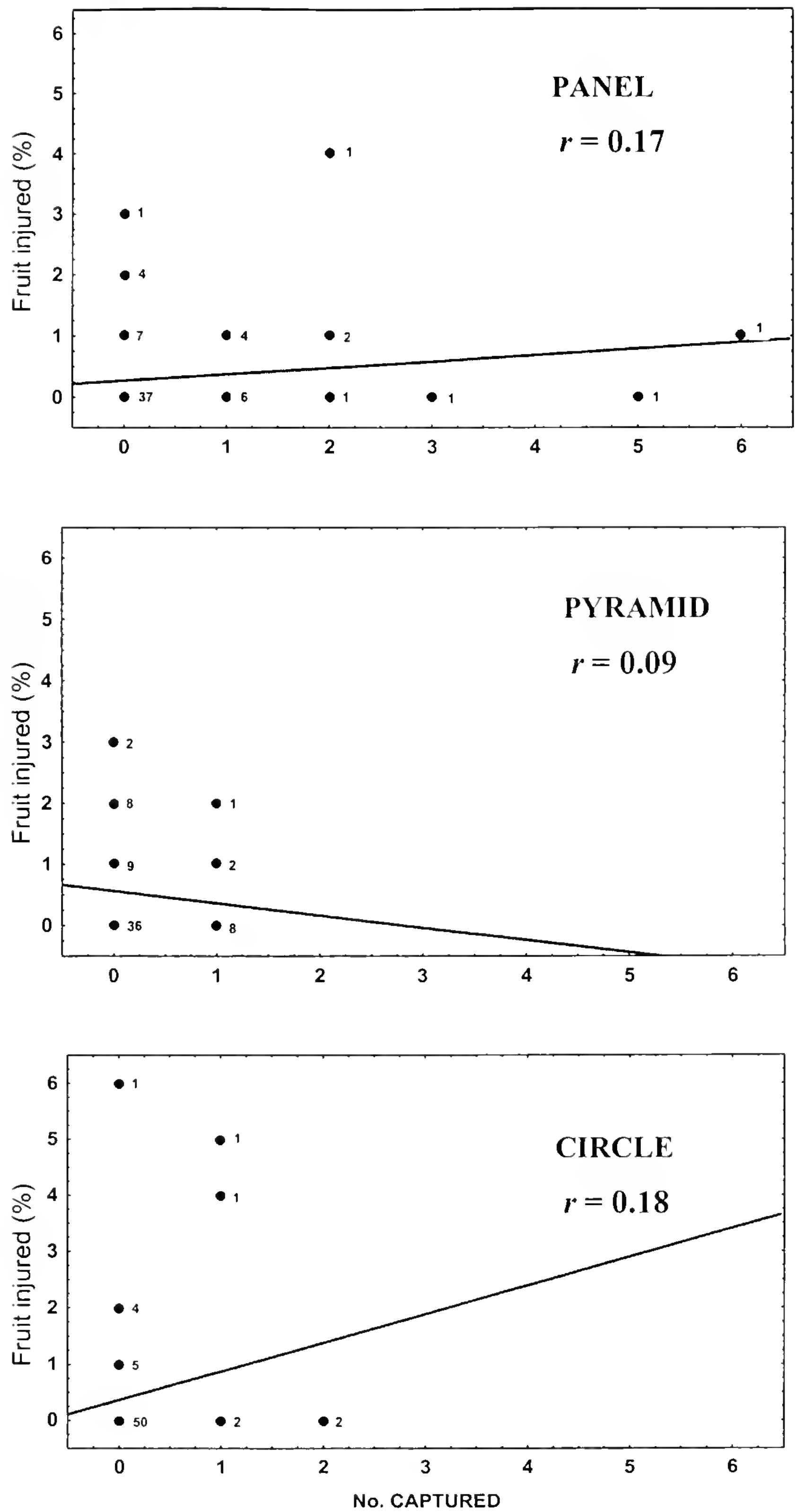

Figure 3. For panel, pyramid and Circle traps, relationship between number of plum curculio adults per plot captured each week (from petal fall through June) and percent of sampled perimeter-row fruit in corresponding plots and weeks having fresh ovipositional injury. N= 66 data points per trap type (11 plots x 6 wk). The number alongside of each ? indicates the number of data points corresponding to that position on the graph.

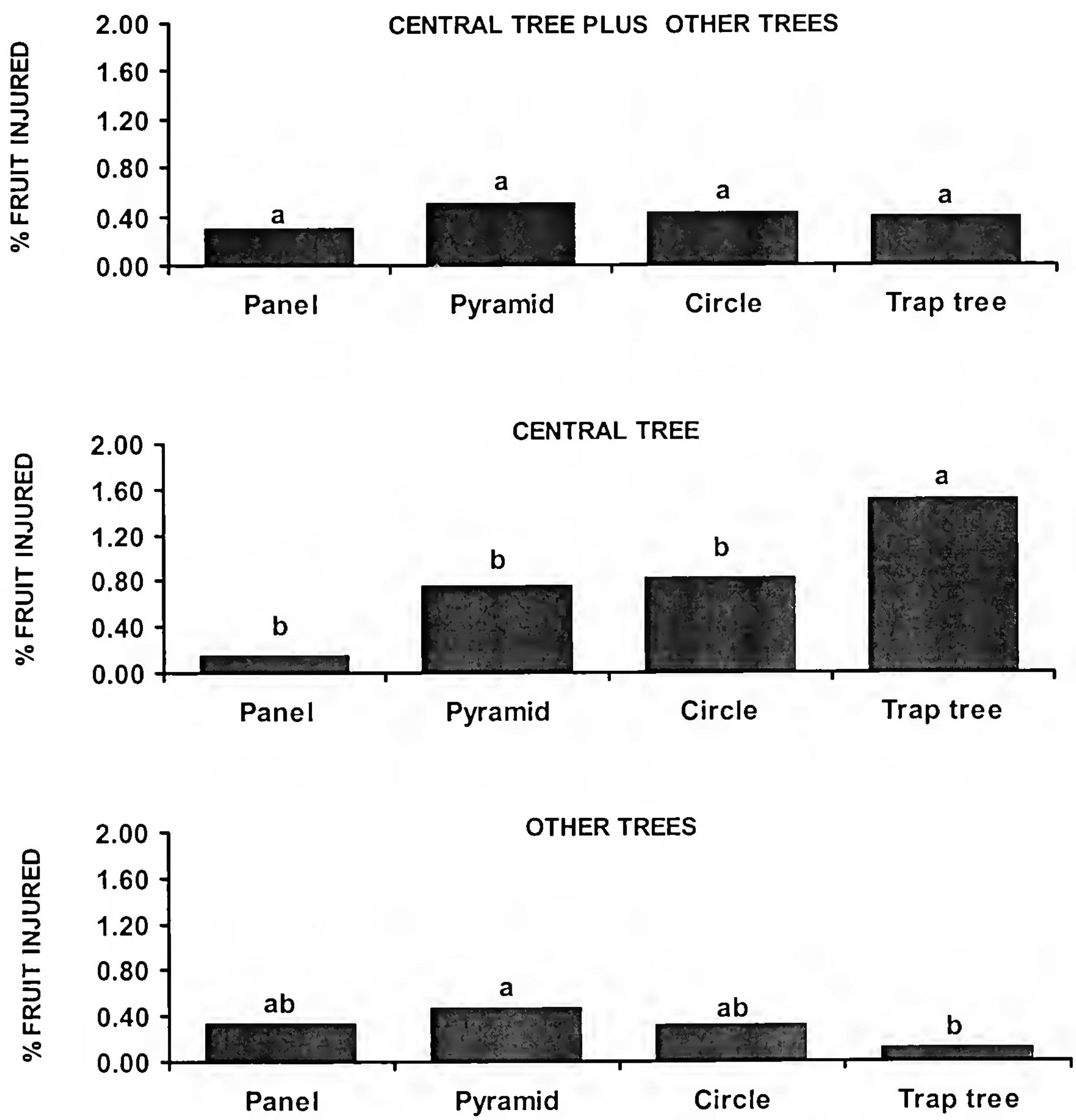

Figure 4. Percentages of freshly-injured fruit (averaged across all six sampling weeks) on central and four other sampled perimeter-row trees of treatment plots. Means superscribed by the same letter are not significantly different at odds of 19:1.

(or no) trap captures occurred was a week in which comparatively little (or no) fruit injury was initiated. Correlation values were only 0.17, 0.09, and 0.18 for panel, pyramid and Circle traps, respectively, indicating weak correspondence in time between rises in levels of fruit injury and rises in levels of trap captures.

Mean percentages of perimeter-row fruit with fresh injury were not significantly different among trap tree plots and plots having panel, pyramid or Circle traps when fruit from all sampled trees (the central tree plus the four other sampled trees per plot) were combined (Figure 4). This finding indicates that presence of a trap tree in a plot did not lead to any greater amount of plot-wide injury to fruit than would have occurred in the absence of a trap tree in a plot.

Importantly, for central trees in a plot, percentages of fruit with fresh injury were significantly greater in trap tree plots than in any other plots (Figure 4). Furthermore, for all other (non-central) sampled trees in a plot, percentages of fruit with fresh injury were less in trap tree plots than in any other plots (Figure 4). These results indicate that freshly injured fruit were significantly concentrated on trap trees and were not significantly concentrated on central trees associated with a panel, pyramid or Circle trap.

Conclusions

Our findings show that even though panel traps placed in border areas adjacent to perimeter rows of apples trees captured significantly more PCs than similarly–placed pyramid traps or Circle traps placed on trunks of perimeter-row trees, none of these trap types (all baited with BEN plus GA) exhibited amounts of captures that correlated significantly and positively with either weekly or season-long amounts of fresh ovipositional injury to fruit. How can the unsatisfactory performance of these traps be explained?

In the case of panel and pyramid traps placed in orchard border areas, immigrant PCs may continue to be captured but fail to cause injury because of sufficient residual effectiveness of a previous insecticide application. Indeed, in 13 (=20%) of the 66 instances (6 weeks x 11 plots) in which weekly captures of PC adults by panel traps were compared with weekly percentages of freshly injured fruit, at least one PC was captured but no fresh injury was detected. Thus, based on captures by these traps, insecticide might have been applied needlessly.

In the case of Circle traps attached to tree trunks, we know from our previous studies that when temperature reaches 70 degrees Fahrenheit or more, progressively more adults tend to enter tree canopies by flight rather than by crawling up tree trunks. The warmer the temperature, the greater the probability of PC injury to fruit. In 12 (=18%) of the 66 instances (6 weeks X 11 plots) in which weekly captures of PCs by Circle traps were compared with weekly percentages of freshly injured fruit, 1 % or more of fruit was found injured but no captures occurred At a failure rate of 18% to detect injury-causing PCs using Circle traps, such traps can not be recommended for grower use.

Our new approach of using trap trees baited with BEN plus GA circumvents the above shortcomings associated with use of captures of PCs by panel, pyramid or Circle traps as a guide for degree of threat of damage by PCs and goes directly to the assessment of damage itself. Our findings here indicate that odor baited trap trees established on perimeter rows act to congregate immigrant PCs, resulting in a 15-fold level of aggregation of egglaying injury. No greater amount of orchard-wide PC injury to fruit occurs as a consequence of establishing trap trees than occurs in the absence of trap trees. The establishment of a few trap trees on perimeter rows in an orchard would appear to be a simple and effective way of aggregating PC injury and allowing growers and consultants to focus exclusively on trap trees to gain an estimate of the current status of PC damage to fruit.

Results of a further 2002 experiment on a trap-tree approach to monitoring PCs are given in the next article in this issue of Fruit Notes.

Acknowledgements

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Evaluation of Odor Combinations for Attracting Plum Curculios to Trap Trees

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In the preceding article, we presented data showing that apple trees whose branches were baited with a combination of benzaldehyde (BEN) plus grandisoic acid (GA) functioned as "trap trees" for plum curculios (PCs). Adult PCs aggregated preferentially on such trap trees, thereby paving the way for growers and consultants to sample only trap trees (rather than additional other trees) for signs of fresh PC injury to fruit.

Here, we report results of a 2002 study in commercial apple orchards in which we evaluated several different odor combinations in association with trap trees to determine if there might be a more attractive combination than BEN plus GA. The rationale underlying this study lay in the proposition that the more attractive the odor bait, the more attractive the trap tree and hence the fewer number of trap trees needed to acquire an accurate assessment of the seasonal course of PC injury to fruit.

Materials & Methods

We established nine treatment types in each of 11 commercial apple orchards. These included BEN plus GA plus one of five other host-derived odor sources known from previous studies (Fruit Notes 2000) to be at least somewhat attractive to PCs: ethyl isovalerate, limonene, hexyl acetate, Z-3 hexenyl acetate and E-2-hexenal. Also included as treatments were BEN plus GA, GA alone, BEN alone, and no odor (control). As described in the preceding article, BEN was released from polyethylene vials at a rate of 40 mg per day per tree and GA at a rate of 1 mg per day per tree. The other five odor sources likewise were deployed in polyethylene vials and likewise released odor at a rate of about 40 mg per day per tree. None of the vials were replaced except ones with limonene, where vials were renewed after 4 weeks. Dispensers of GA were replaced after 5 weeks.

A continuous perimeter row of apple trees about 220 yards long was selected in each orchard. Treatment trees, all on the perimeter row, were about 30 yards apart in order to separate treatments. Odors were deployed on May 6-8 and remained until June 24-26. Weekly beginning at petal fall (May 13-15), 40 fruit were examined per tree for evidence of fresh PC egglaying scars.

Results

Results (Figure 1) show that trees baited with BEN plus GA received significantly more fresh egglaying injury than trees baited with GA alone, BEN alone or trees without odor bait. Addition of ethyl isovalerate, limonene, E-2-hexenal, Z-3-hexenyl acetate or hexyl acetate did not significantly enhance the attractiveness of BEN plus GA as an odor bait guiding PCs to trap trees. Trees baited with BEN plus GA received about 15 times more PC egglaying scars than unbaited trees.

Conclusions

Our findings indicate that BEN plus GA represents a potent combination of attractive odors whose use, in both this study and the study reported in the preceding article, culminates in an aggregation of PC egglaying injury about 15-fold greater than that which occurs on unbaited trees. Findings here further indicate that BEN plus GA represents a synergistic odor combination whose stimulating effects, as a combination,

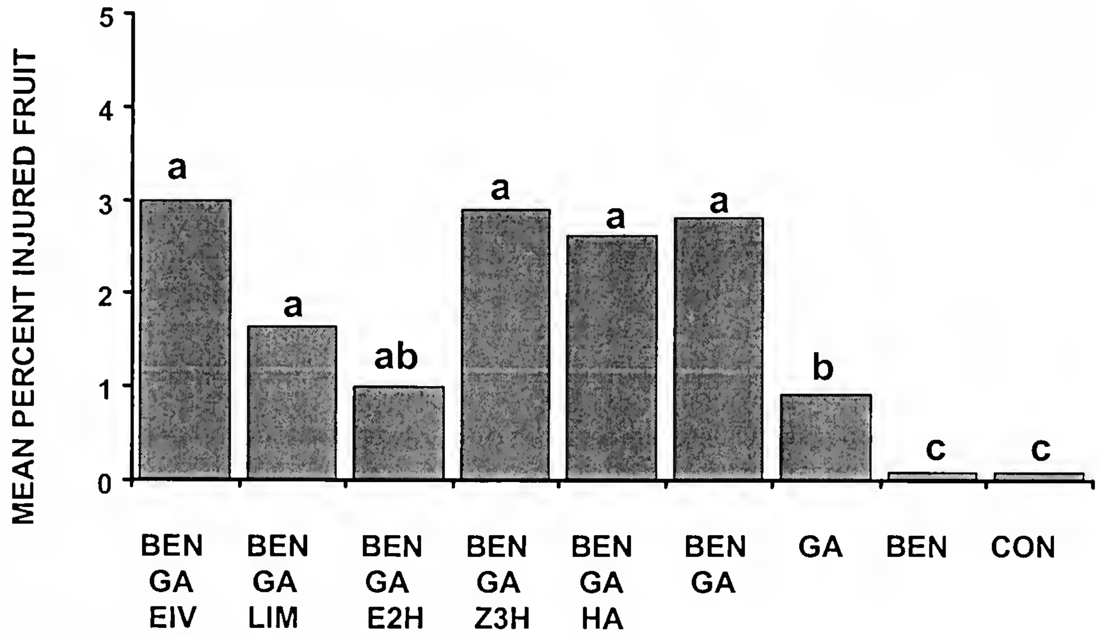

Figure 1. Mean percent of sampled fruit on trap trees baited with different combinations of odor that received fresh ovipositional injury by plum curculio across 6 weeks from petal fall through June. Means superscribed by the same letter are not significantly different at odds of 19:1. BEN= benzaldehyde; GA= grandiosic acid; EIV=ethyl isovalerate; LIM= limonene, E2H=trans-2-hexenal; Z3H=cis-3-hexenyl acetate; HA=hexyl acetate; CON= control (without odor bait).

substantially exceed the effects of adding PC response to BEN alone plus response GA alone. Finally, the findings here indicate that even though each of the other five fruit odor components has been found to be at least somewhat attractive when tested alone, none enhanced the potency of BEN plus GA when used in a blend. Although use of trap trees baited with BEN plus GA appears to be a very promising new approach to monitoring PC, we can not yet recommend it for adoption by commercial growers until the following have been determined: (a) optimum amounts of BEN plus GA to deploy per trap tree, (b) optimum spacing of trap trees along perimeter rows, and (c) percent freshly damaged fruit on trap trees that would justify insecticide application to all peripheral-row trees. Also, a commercial supplier of user-friendly BEN dispensers would have to come forward to complement the current commercial supplier of GA dispensers.

Acknowledgements

We are grateful to the following growers for participating in this study: Gerry Beirne, Carlson Brothers, Dave Chandler, Don Green, Tony Lincoln, Sean McGlaughlin, Mo Tougas, and Steve Ware. This work was supported by a USDA Specialty Crops research grant (via the Massachusetts Department of Food and Agriculture and the New England Tree Fruit Growers Research Committee).

* * * * *

Can a Band of Tangletrap Around a Tree Trunk Suppress Plum Curculio Injury to Fruit?

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Operators of small apple orchards and homeowners have for decades been on the lookout for effective ways of controlling plum curculio (PC) without having to resort to use of insecticidal sprays. Approaches such as daily tapping of tree branches to dislodge PCs followed by removal fallen PCs from a cloth sheet placed beneath the tree canopy have proven ineffective. So also have a variety of non-toxic sprays designed to repel PCs (such as sprays of garlic). We know from studies by colleagues in Quebec that PCs enter and leave apple tree canopies almost on a daily basis as they search for food and egglaying sites and thereafter shelter. We also know from some of our own behavioral observations that during cool weather and also during night hours, PCs tend to enter apple tree canopies by crawling up tree trunks, whereas during warm weather they tend to enter tree canopies by flight.

Here, we asked whether a band of Tangletrap around a tree trunk could prevent PCs from entering the tree canopies to an extent that afforded protection of fruit against injury.

Materials & Methods

The study was carried out in 2002 in a block of unsprayed trees at the UMASS Cold Spring Orchard Research and Educational facility in Belchertown. Half of the trees were McIntosh, and half were Delicious. All were bearing trees on M.26 rootstock. Trees were pruned in such a way that none of the branches of any tree involved in the study touched the branches of any adjacent tree or touched the ground. Herbicide

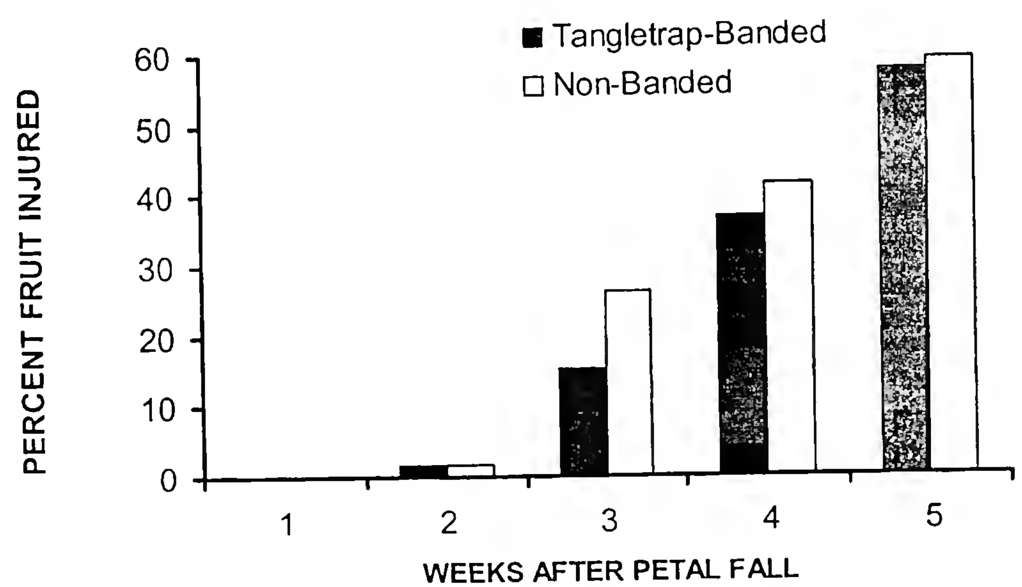

Figure 1. Percent of sampled fruit injured by plum curculio on Tangletrap-banded and non banded apple trees.

treatment beneath the canopy and mowing grass in the alleyway kept understory growth from reaching any branches. These measures insured that PCs could gain entry into the canopy only by crawling up the tree trunk or by flight into the canopy.

On April 18 at the tight cluster stage of bud development, a band of white cloth 3 inches wide was wrapped tightly around the trunk of each of seven McIntosh and seven Red Delicious trees at a height of 12 inches above ground. The cloth was firmly stapled to the trunk, after which the cloth was coated with a thick layer of Tangletrap, 2 inches wide. The Tangletrap was maintained free of debris for the duration of the PC season. Adjacent to each Tangletrap-banded tree was a check tree of like cultivar, devoid of Tangletrap.

Weekly beginning one week after petal fall (May 15) and ending when fruit reached 1 inch diameter (June 10), ten fruit were sampled on each of the 14 Tangletrap-banded and 14 check trees for presence or absence of PC egglaying scars.

Results

Results (Figure 1) show that very little fruit injury occurred on either Tangletrap-banded or non-banded apple trees during the first and second weeks after petal fall. By the third week, when fruit averaged about 1/2-inch diameter, there were slightly fewer injured fruit on banded than non-banded trees. The weather was unusually cool and damp during the first 3 weeks after petal fall. During the fourth and fifth weeks after petal fall, temperatures warmed and injury to fruit by PC increased substantially on both banded and non-banded trees. By the fifth week, there was essentially no difference in percent injured fruit on banded and non-banded trees.

Conclusions

Findings from this experiment are in agreement with findings of our previous studies. In cool weather, PCs tend to enter tree canopies primarily by crawling up tree trunks. Under such conditions, a band of Tangletrap around the tree trunk can aid (at least slightly) in reducing the number of PCs entering the canopy and thereby reduce damage to fruit. In warm weather, PCs tend to enter tree canopies primarily by flight. Under such conditions, which are the most favorable of all for PC egglaying, a band of Tangletrap around the tree trunk is of little or no help in preventing PC entry into the canopy and hence of little or no help in preventing damage to fruit.

* * * * *

Helping Kids Do Farm Jobs Safely: Know Which Tasks Are Appropriate for Your Children

George Cook
Extension Maple Specialist, University of Vermont

Many injuries occur on farms because children are involved in farm work that exceeds their physical and mental abilities. As one father, a fourth generation farmer says, "Our sons help somewhat, when they can. You always have to consider age-appropriate tasks." His other job, as a farm safety and Emergency Medical Services instructor, serves as an acute reminder of the human tragedy behind these statistics:

- About 104 children die each year from agricultural injuries;
- Children younger than 16 years of age are victims of up to 20 percent of all farm fatalities in both the U.S. and Canada;
- Children who do not live on farms are victims of one-third to one-half of nonfatal childhood agricultural injuries.

For farm parents, there is a resource available to help match children's abilities with agricultural job requirements. How much weight can a 10-year-old safely lift? What type of machinery is a child capable of operating? Does your child have good eye-hand coordination? Can an adult supervise as recommended? Suggested parameters for these and other questions are included in the North American Guidelines for Children's Agricultural Tasks (NAGCAT).

"We hope these guidelines will help promote a strong work ethic for young people by giving them safe and appropriate opportunities for work experience under adult supervision," says Barbara Lee, Ph.D. Dr. Lee led the team of parents, specialists in both agricultural safety and child development, and other key partners from the U.S., Canada, and Mexico that developed the guidelines. This task was at the request of farm parents who wanted guidance in assigning appropriate tasks to children.

There were five youth advisors to this planning team. Says one 17-year-old participant, "It's a great start, and I'm very enthused. We need to take a stand on safety. The Guidelines can be another useful tool in preventing injuries on farms and raising awareness."

The guidelines cover 62 agricultural jobs focusing on the most common childhood farm jobs (like "feeding milk to calves"). Categories are Animal Care, Manual Labor, Haying Operations, Implement Operations, Specialty Production, Tractor Fundamentals, and General Activities.

The guidelines are based on a child's physical, mental, and emotional development rather than a child's age. "Kids develop at their own pace and are influenced by their environment," Lee said. "If we said a 10-year-old could do a certain job, we might put half of them at risk."

Each individual guideline includes a section on Adult Responsibilities, Main Hazards, Child's Ability, Supervision Required, Training To Do, and Remember - PPE required. These guidelines are colorful and easy to read with practical diagrams and descriptive pictures.

Being a parent always has been a balancing act. Farm parents, in particular, face unique challenges. These guidelines can help them offer their children a

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chance to develop a safe work ethnic and gain valuable, lifelong experience.

These guidelines, developed for parents, are recommendations, not mandates. Like recommendations on children's toys and games, the guidelines serve as a point of reference that require assessment and decision making by adults. Says Lee; "We help them make informed choices about activities their children do. Our top priority always comes back to children, a child's first 'job' should be to grow up healthy, happy, and strong."

A new, user-friendly Web site, www.nagcat.org, offers complete information about the guidelines. A professional resource manual and parent resources are available for purchase from Gempler's safety supply company, 800-282-8473 or www.gemplers.com/nagcat.htm. While University of Vermont Extension does not recommend one company over another, this is the only source for these guidelines, at this time.

Reference credits given to Cheryl Tevis, *Successful Farming*, May-June 1999.

* * * * *

Visual Exposure: Farm Logos and Signs Tell Your Story

Judith M. Powell
Whitefield, Maine

Deciding what sign and logo best represent you is a challenging and important business decision. Signage and logo make a statement about the farm and the people behind it. The objective is to reach out and hit a target audience of customers you are striving to connect with, while at the same time motivating a positive response by communicating what you are about. These are marketing tools that make a promise of quality, in the mind's eye of what your public perceives.

Perception is a subconscious response computed in the course of a fleeting moment. Webster's Dictionary defines it as intuitiveness, sense of awareness, insight, and understanding – rolled into one. What perception is generated from your logo and signs? If your enterprise does not have a logo already, now is a good time to take this on as a project. It also could be that an existing logo might need an update or face-lift.

Signs: Things to Consider

- Avoid using the shapes and colors the highway department uses, so your sign will stand out.
- Keep the sign well-painted and well-managed. Appearance is very important.
- Place it out in the open, where it will be lighted by the sun not shaded by a tree or building.
- Avoid tall grasses, fences, trees, and houses for readability.
- Know zoning restrictions and state and local regulations, including setback restrictions.

It is easy to keep a daunting task like deciding on a logo on the back burner. An already-too-long list of immediate things-to-do provides good justification. Then, there is not knowing how to begin and not knowing how much it is going to cost to get this done. These seem like reasonable excuses. Priorities should relate to payoff, and your investment in marketing will pay off over and over again. Take it slowly. This is not a project to be completed in an evening or a week, but one that should be slept on so your subconscious can help out.

A good starting point is thinking through where the farm began, and where you are going. Every farm is a unique story. Usually, it is a good story. Your story is about history, family commitment, land stewardship and environment, heritage, lifestyle, and passions. Typically, these represent the same reasons consumers want to support you and will acknowledge their appreciation through their dollars. Make lists of key words that represent what is important in your mind. These key words are your message ingredients. Next, cluster these into groups to identify relationships and characteristics that naturally fall together until a theme emerges or an image formulates in your mind. The logo and signage convey personality and place.

If the exercise seems difficult, a different tact is to define the audience you are targeting – customers who may think like you do and seek the products and services you can supply. All customers are not the same, so your marketing challenge is finding those who need what you have to sell. Your logo and signage

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VISIBILITY

Maximum number of words which can be read by the average motorist traveling at various speeds				Distance from which sign must be visible to be fully read (feet)	Minimum letter height (inches)
30 mph	*40 mph*	*50 mph*	*60 mph*		
4	2	1	0	50	1.75
8	5	4	3	100	3.5
15	11	8	3	200	7
22	16	13	10	300	11
30	22	17	14	400	14
38	28	22	18	500	17.5

will help customers find you and your products.

Thinking through your marketing niche is thinking about your customers. What are the people you hope to reach looking for, and what might drive them to connect with you? Why is your farm or enterprise one that they should want to connect with? The point of this, of course, is that consumers want to find local suppliers who are bringing to the marketplace the products they want, grown or made in a way that fits their philosophy. They are searching and screening to see if what they want are the products you, as seller, have. The consumer, as buyer, wants you to reach out and make a connection. Your image, communicated through your signs and logo, can be the lifeline.

As the farm's image is planted in the minds of neighbors, business associates, and customers, it becomes a familiar identifier and acts as a reminder that the farm is in business and invites patronage. The logo can be put on anything and go anywhere. It should be used on letterhead and invoices, business cards, point-of-sale tags and cards, vehicles, and Web site. It can work hard and extend your message beyond people driving by the farm. The value of familiarity is immeasurable, and exposure is key.

Detail is important. Color, design, size, and materials all make statements. By selecting carefully, a package will evolve into your trademark that expresses your vision. Colors should be chosen to reinforce your intentions. If color is not a forte of someone in the family, your local paint store is a handy resource. Browse the displays of paint shades and tones and consider finish options. Weed out the colors that do not fit, and bring home chips that you think do. Take enough time, remembering that it is OK to change your mind, scrap it, and start over. Ask a local art teacher, relative, or print shop to look at what you have come up with, and ask their opinion. Ask what your image says to them to see if it is in line with your intentions.

Original artwork may be expensive, unless a willing friend or family member has talent. Trying some pencil sketches can help crystallize everyone's thinking. Cost can be managed by using a computer-generated image instead of hiring an artist for an original rendering. A local design company using "desktop-publishing" software may fit the bill, and later modifications, such as sizing, can be handled easily.

The ultimate goal is a picture that reflects the essence of the message you want to send. Now it is time to make a budget. There are options. This expenditure should be thought of as an investment important to the credibility of a business venture, but how much to spend can be hard to decide. Cost considerations can be managed by breaking down the project into steps and by extending the development or the execution over time. Artwork can be purchased one year, leaving the building of the permanent sign until the next. Meanwhile, the logo image can be applied to letterhead and point-of-purchase signage. Once scanned into your computer, it can be placed on invoices and any print fliers, posters, or other disposables tailored to an event, function, or mailing.

Implementing step-by-step is a good way to manage cost. Your list might look like this. Year one, get the artwork for the logo, get it scanned into the computer for application on print materials, and have business cards made. Year two, have farm sign made, buy the hardware and posts, and put it up. Year three, add flood lights and an attractive base around the sign pole and have vehicle decals made and applied. Year four, have sale price tags, price board for retail site, posters, farm brochures, etc. made. Now, your marketing program is well underway and affordable.

One more thought about the stand-alone sign. It is usually the biggest expense item, depending on materials used and who builds it, size and complexity, and how it will be affixed. When planning the sign you really would like to have, do not forget to research and cost-out the style of post and hardware needed to support your theme and design. The post, hinges, and metal hangers can cost as much as the sign itself. They might not be readily available locally and may need to be handcrafted or ordered. Also include costs if someone will need to be hired to put it up. Check out fees for state and local permitting or zoning, and, if the sign will be placed on someone else's property, will there be rent? Research town or highway restrictions to be sure your plans will be in compliance.

When approached in small steps, your sign and logo can be achieved.

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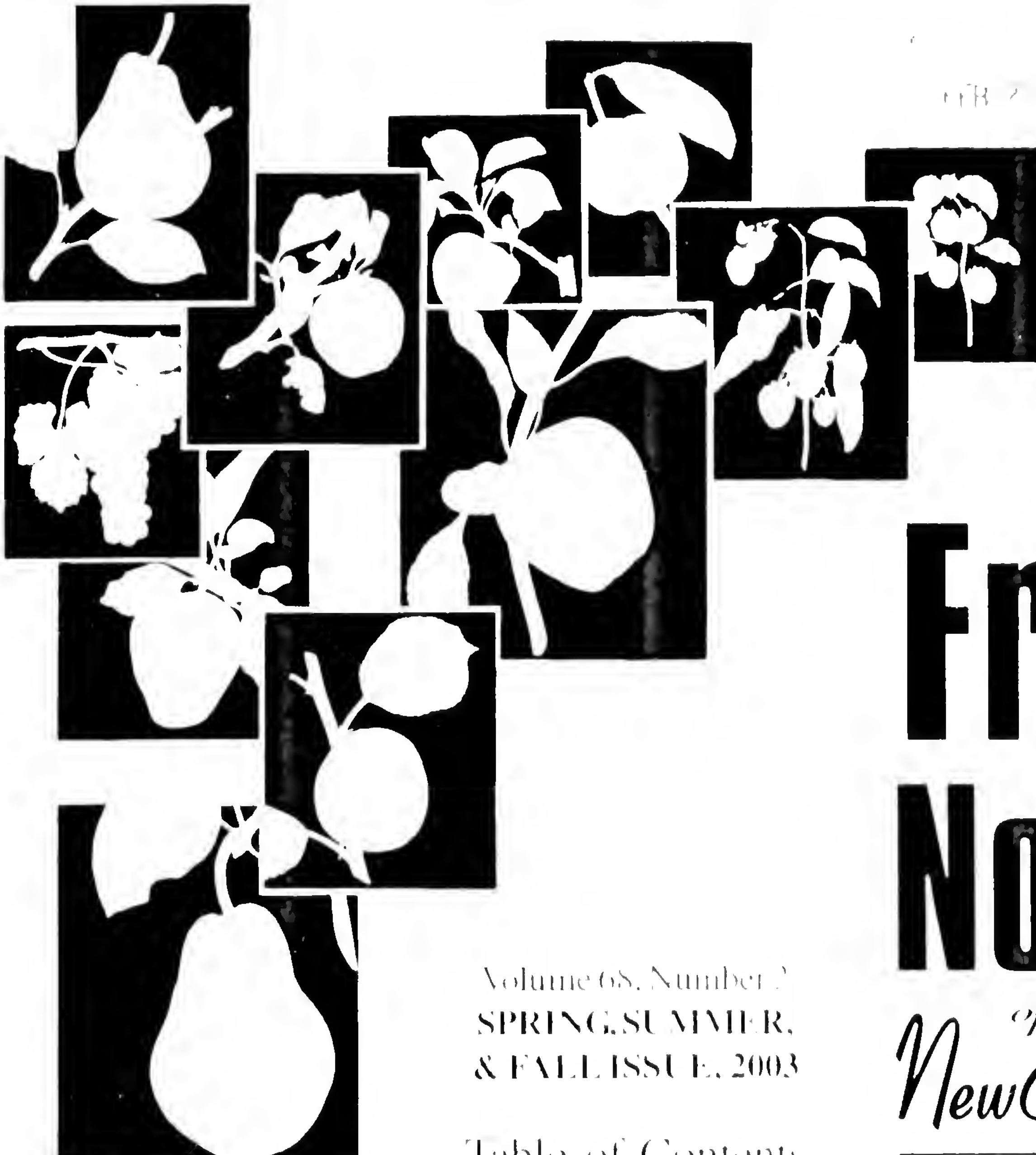

Fruit Notes of New England

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Fruit Notes of New England

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An Appeal for Early Harvest of Honeycrisp

Sarah Weis
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It has been proposed by Dr. Chris Watkins of Cornell University that soft scald in Honeycrisp may be avoided, or at least substantially reduced, by delaying cold storage. Soft scald has been a serious problem on Honeycrisp grown in some areas of the US, one of which being New York. He found that if harvested fruit are kept at room temperature for a period of time (perhaps 1-7 days) before being transferred to cold storage temperatures, development of soft scald can be reduced or eliminated. It has always been recommended that harvested fruit be placed in cold storage as quickly as possible in order to maintain high quality for consumers. If cold storage is delayed in order to avoid soft scald, it is important to consider possible negative effects on other fruit qualities such as firmness and development of disorders such as decay (to which Honeycrisp is quite susceptible), senescent breakdown, and internal browning.

This study looked at the effects of delaying cold storage on these qualities. Honeycrisp fruit were harvested from three orchard blocks at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown, MA on September 16 and 23, 2002. Fruit were divided into three groups. One group was placed in cold storage at 32F immediately following harvest, one group was kept at room temperature for 1 day prior to cold storage, and the third group was kept at room temperature for 4 days before being placed in 32F air storage. Fruit were removed for observation (for about 10 minutes) after approximately 90 days of cold storage and then

Table 1. Effects of delaying cold storage of Honeycrisp harvested September 16 and 23, 2002.

Percent of fruit developing:	Days from harvest (approximate)	Delay to 32F cold storage			
		None	1 Day	4 Days	Signif[z]
Soft scald (%)	90[y]	4	0.5	0.5	*
Decay (%)	90	8	10	14	ns
	150[x]	14	18	23	ns
	157[w]	20	23	27	ns
Internal browning (%)	157	31	19	32	ns
Senescent breakdown (%)	157	7	4	4	ns
Skin greasiness (%)	157	20	20	20	ns
Off taste (%)[v]	157	12	0	25	ns
Average flesh firmness (lbs)	157	13.6	14.1	13.9	ns

[z] ns, * Differences statistically nonsignificant or significant at odds of 19:1, respectively.
[y] Observations made at 90 days were on cold fruit just removed from storage.
[x] Observations made at 150 days were on cold fruit just removed from storage.
[w] Observations made at 157 days were on fruit which had been at room temperature for one week. Note that the same fruit were being repeatedly observed.
[v] Off taste has been described as an aldehyde or fermentation flavor with corresponding odor.

Table 2. Effects of delaying harvest of Honeycrisp, 2002.

Percent of fruit developing:	Days from harvest (approximate)	Date of harvest September 16	September 23	Signif[z]
Soft scald (%)	90[y]	3	0	**
Decay (%)	90	8	13	ns
	150[x]	12	25	ns
	157[w]	21	35	ns
Internal browning (%)	157	13	42	***
Senescent breakdown (%)	157	1	9	ns
Skin greasiness (%)	157	0	40	**
Off taste (%)[v]	157	0	25	*
Average flesh firmness (lbs)	157	14.5	13.3	***

[z] ns, *, **, *** Differences statistically insignificant or significant at odds of 19:1, 99:1, or 999:1, respectively.
[y] Observations made at 90 days were on cold fruit just removed from storage.
[x] Observations made at 150 days were on cold fruit just removed from storage.
[w] Observations made at 157 days were on fruit which had been at room temperature for one week. Note that the same fruit were being repeatedly observed.
[v] Off taste has been described as an aldehyde or fermentation flavor with corresponding odor.

Table 3. Effects of delaying harvest of Honeycrisp, 2002.

Percent of fruit developing:	Days from harvest (approximate)	Date of harvest 9/5	9/10	9/16	9/23	Signif[z]
Soft scald (%)	90[y]	0	0.6	8.0	0	**
Decay (%)	90	6	7	1	15	*
	150[x]	13	13	4	25	ns
	157[w]	10	21	8	35	ns
Internal browning (%)	157	2	2	19	43	***
Senescent breakdown (%)	157	0	0	2	12	**
Skin greasiness (%)	157	0	0	0	40	***
Off taste (%)[v]	157	0	0	0	25	**
Average flesh firmness (lbs)	157	16.0	15.6	14.2	13.1	***

[z] ns, *, **, *** Differences statistically insignificant or significant at odds of 19:1, 99:1, or 999:1, respectively.
[y] Observations made at 90 days were on cold fruit just removed from storage.
[x] Observations made at 150 days were on cold fruit just removed from storage.
[w] Observations made at 157 days were on fruit which had been at room temperature for one week.

Table 4. Averages of some qualities of Honeycrisp at harvest, 2002.

Characteristic	Harvest Date				Signif[z]
	9/5	9/10	9/16	9/23	
Percent Red Color	51	46	58	68	***
Firmness (lbs)	17.0	16.8	15.1	14.0	***
Starch[y]	5.7	6.0	6.7	7.6	***
Internal Browning (%)[x]	-	-	0	12	-

[z] *** Differences statistically significant at odds of 999:1.
[y] Starch index is from Cornell Generic Starch Chart.
[x] Internal browning is percent of fruit which had internal browning. Fruit from the first two harvests were not cut to observe internal disorders.

replaced in cold storage for another 60 days. Following the 150 days, fruit were again removed for observation, kept at room temperature for 7 days to approximate conditions to which they might be subjected prior to consumption, and then pressure tested and tasted.

Table 1 shows the storage disorders observed on the fruit following cold storage, as well as the flesh firmness at the end of the 150 days of cold storage and week at room temperature. The only disorder which was significantly influenced by the delay of cold storage was soft scald. Delaying cold storage essentially eliminated soft scald; however, soft scald was not much of a problem. Only 4% of fruit developed the disorder even when cold storage was not delayed. Delaying storage would be recommended if soft scald were a problem, but it did not appear to be a problem for us (at least in 2002). Decay, internal browning, skin greasiness, and off flavor development were much greater problems, but treatments did not influence these problems differently.

Delaying cold storage did not appear to have a significant negative effect on quality of stored Honeycrisp fruit. The storage problems that were evident were not made worse by delaying storage up to 4 days, so that if soft scald were a problem, this solution would not have a substantial down side, other than that of the inconvenience of moving the fruit an extra time. This is not to suggest that it is not generally important to cool fruit as quickly as possible, but to suggest that in the case of Honeycrisp the benefit of delay may outweigh the risks.

More important to us than soft scald have been decay and internal browning. Internal browning is especially problematic, since it is not visible on the packing line, and therefore seen first by the consumer. The browning tends to show up as a light brown sponginess of a large portion of the cortex of the apple. Overall, 25% of the fruit harvested September 16 and 23, 2002 suffered from internal browning after 5 months of cold storage and 1 week at room temperature.

Time of harvest had a powerful effect on internal browning as well as other qualities of stored fruit (Table 2). Decay was not affected by time of harvest, but internal browning, skin greasiness, and off flavors of fruit were significantly reduced less frequent in fruit harvested on September 16 compared to those harvested on September 23. The earlier harvested fruit were also firmer.

In another experiment including two earlier harvest dates but no storage delay, the effect of time of harvest on post-storage fruit quality was even more dramatic (Table 3). The only storage disorder that developed on fruit harvested on September 5 or 10 was decay, plus a trace of internal browning. It should be noted, too, that while superficial scald can be a post-storage problem on early-harvested fruit, it did not develop on these Honeycrisp.

It is possible to use measurements of fruit ripening to assess a harvest date for Honeycrisp that will result in fewer storage problems (Table 4). A starch index of 5.5 to 6.0 has been recommended for Honeycrisp. In 2002, harvest of Honeycrisp fruit with starch index values in this range would have resulted in little development of storage disorders. Further, fruit were significantly firmer at the earlier harvests. Lack of red color is the only negative aspect of early harvest.

* * * * *

Finding and Keeping the Right Employees: Ideas to Bait the Hook

Judith M. Powell
Whitefield, ME

The right employees bring good fortune. However, finding the right just doesn't happen right out of the blue. Having capable, eager and motivated people come a-knocking on your door, asking to do the kind of work you need done, happens in fairy tales. In real life, managing people is a big challenge that eats up precious time and can cause frustration. Not selecting the best candidate, or losing an enthusiastic worker, can signal that it's time to examine your human resource approach.

Tom Maloney, senior Extension associate in the Department of Applied Economics and Management at Cornell University, has spent the last 15 years of his career focusing on labor issues and policy. He's been visiting with farmers over the past three years at New England dairy seminars. Hiring, managing and succeeding with farm employees are his specialties.

"You need help, and you know the kind of person you wish you could find," Maloney begins his talk at the Maine Dairy Seminar held in Augusta. He asks the audience what counts. "A person who wants to work around animals," someone says. "Reliable—someone who will show up on time," is mentioned. Others say, "mechanical ability, can work independently, someone I can trust." Getting the person you want is within reach, Maloney says.

So, where to begin? Finding the right person starts by getting a handle on the job. The first step is defining what you expect to have done. What exactly will you assign the new person to do? What are the specific tasks, and when must they be done? Must they be done in a certain way or at a certain time? Thinking through details makes it easier to determine what talents and skills are needed for both the employer and employee to succeed.

Farm-owner operators and family manage all kinds of jobs every day. They somehow learn them over time. But expectations must be realistic for a new hire on the farm. A person who is happily mucking out stalls may not efficiently pull reports out of the database or serve customers who drop by the farm stand. Employees who are happy with what they are doing and are satisfied with their work environment are generally more productive.

The first step in a systematic approach to successful human resource management is recruitment, Maloney says. "You want to develop the broadest pool of potential job candidates." He encourages using "traditional" sources like government job services agencies, farm internship programs, community bulletin board postings and advertisement in local and agricultural publications. However, he says, the best source is word-of-mouth. "Some of the best leads come from current employees. They know what the job is and have a vested interest in making sure their coworkers will be good," he explains. "Offer a bonus if the new person stays six months. A $50 or $200 bonus can make the grapevine or e-mail buzz!"

"Don't be afraid to be creative by exploring "non-traditional" sources like homemakers, retirees, teachers with summers off. Don't narrow the field and exclude people who might perform these very well and be happy doing it," Maloney says. Farms offer work variety, flexible hours and the chance to work outside with animals. These are great benefits, which some people prefer over wages. "Not everybody wants to fry hamburgers for McDonald's, even though they might get $7 an hour. Farms should capitalize on their unique setting and mix of opportunities."

The next step in the process is writing a "help wanted" ad that sells the position. There are many positive attributes that may draw people into your prospective applicant pool. Think of everyday "luxuries" your farm offers and draft some help wanted ads:

"Looking or fresh air and exercise? Need variety and a challenge? Family business offers good working conditions, flexible hours, done by 4 p.m."

Choosing the best applicant out of those you interview can be tricky. Be prepared and keep an open mind, Maloney says. He suggests developing a short list of questions and asking all the questions each time, so the interviewer has a consistent means of comparing and evaluating candidates' responses. Asking what people like to do in their free time is one way to get at what tasks the person may excel at. Does the person prefer to work independently or with others? If your crew works as a team, it's important to select for this personality trait.

One of the hardest areas in managing employees is keeping the right ones and getting rid of the others. The U.S. Department of Labor reports that respect—not money, nor benefits, but respect—is the number one thing employees say they want first and foremost. Workers need to know how important the boss thinks their roles are within the total scheme of the operation. An open and friendly atmosphere along with positive acknowledgement for good work will do wonders. What can be easier than thanking people when they make special contributions, like stay late, work lunch, or go the extra mile when they could have gotten by easier? Don't wait; make the acknowledgement immediately. "Positive reinforcement has to be earned. You cannot just give it away. Giving superfluous compliments is not respect," Maloney says. "If the employee does something you did not like, tell him or her as quickly as you can. On the other hand, if he or she performs exceptionally well, tell that employee and everybody else too!"

"Your goal is to build loyalty and an atmosphere of mutual respect," Maloney says, adding that the best way to accomplish this is keeping an open, friendly attitude. "An employee is more apt to ask questions before she he acts on his own, when the boss' attitude encourages it." Maloney advises.

Assigning a title to positions is an easy way to express the importance of the job and regard for how this role fits into the larger farm. The title a person carries tells the employee and others what you think of him. The title should refer to the main job responsibility.

Feedback is critical. Giving feedback becomes easier when performance is rated on a regular basis, such as quarterly or semiannually. Using just three ratings—excellent, okay, unsatisfactory—will communicate your regard for the person's performance. Evaluate the things that matter—such as timeliness, avoiding waste, safety, job skill, care of equipment, willingness, honesty, pride, use of time, reliability. Be candid. Use the time to go over problem issues and give praise, stressing performance rather than personal characteristics. Keeping dated notes provides documentation for future reference.

Finally, protect the investment you have made by developing your good workers who your needs. "No one is in business just to make friends or because they like to work," Maloney says. Employees must feel appreciated and have opportunity to progress. If the family farm cannot increase wages and benefits or offer advancement, the best workers may move on to greener pastures, unless they know that you want them to stay. Instead of a raise, the employer and worker might discuss together what else could be done to replace money. Sometimes, options like flex time, job sharing, assignment of new tasks, supervising or learning something new is reward enough. Keeping good workers satisfied and at peak performance is important. Otherwise, you may be filling vacancies again and starting all over. The goal is to keep good workers who enjoy performing in a friendly and open working environment and who know their roles are important within the whole operation. Feeling an important part of an organization contributes to everyone's success.

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Establishment and Biocontrol Potential of Released *Typhlodromus pyri* Predator Mites in Massachusetts Apple Orchards: 2000-2003

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In the 2000 issue of *Fruit Notes*, we reported the results of a 3-year project (1997-1999) aimed at establishing the predator mite *Typhlodromus pyri* in Massachusetts apple orchard blocks of different tree sizes. Results showed that following release in 1997, *T. pyri* became established in all eight blocks by the following year, spreading fastest from tree to tree among cultivars on M.9 rootstock and slowest from tree to tree among cultivars on M.7 rootstock. Result also showed that even in blocks on M.7 rootstock, by 1999 *T. pyri* had spread to the most distant trees in the 49-tree blocks and provided effective block-wide suppression of European red mites.

Encouraged by results of this 1997-1999 project, in 2000 we launched a 4-year study to further characterize the establishment and spread of released *T. pyri* in commercial apple orchards in Massachusetts. We asked five questions. First, would the addition of pollen to trees in which *T. pyri* were released enhance the buildup of *T. pyri*? This predator is known to feed on pollen when prey mites are low in abundance and previous research has shown that supplementary pollen could elevate predator numbers. Second, in which direction is *T. pyri* likely to spread fastest following release from trees on row 4 of a block: toward row 1 (the perimeter) or toward row 7 (the interior)? Third, would the establishment of American hazel trees opposite plots in which *T. pyri* were released contribute to the buildup of *T. pyri* and/or *Amblyseius fallacis* as predator mites? American hazel trees have been found by others to harbor substantial populations of predatory mites. Fourth, what is the relationship between the abundance of *T. pyri* and the abundance of *Amblyseius fallacis* as predatory mites? Fifth, would the release of *T. pyri* in 2000 guarantee effective biocontrol of European red mites in subsequent years? Here, we present data that address each of these questions.

Materials & Methods

Our experiment was conducted in 12 blocks of apple trees in ten commercial orchards. Each block was about 140 meters long by seven rows deep and was divided into four equal-size plots. The perimeter row of each block was bordered by woods, hedgerow or open field. Trees were on M.9, M.26, or M.7 rootstock and were principally Mc Intosh, Cortland, Gala, Empire, Jonagold or Fuji.

There were four treatments at the outset in May of 2000 (one per plot): (1) *T. pyri* released in the presence of fresh cattail pollen, which was applied to the tree canopy by a commercial pollen applicator (E-Z Power Duster, Firman Pollen Co, Yakima, WA) at the rate of one-seventh ounce of pollen (about 100,000 pollen grains) per tree, (2) *T. pyri* released in the absence of pollen amendment; (3) no release of *T. pyri* but, as with the first and second treatments, no insecticide applied after mid-June (apple maggot flies were controlled by odor-baited red sphere traps), and (4) no release of *T. pyri* and organophosphate insecticide applied during July and August to control apple maggot. For the first and second treatments, *T. pyri* were released at bloom at the rate of about 100-200 individuals per tree on two trees in the fourth row of each plot, one tree to the right and one to the left of the center tree of the plot. Releases were made by wrapping a burlap band that contained *T. pyri* around the trunk of a release tree. In autumn of 1999, such bands had been placed around trunks of apple trees at Geneva, NY to collect *T. pyri* seeking overwintering sites.

In 2000, we sampled 25 leaves per tree on each of two trees in rows 1, 4 and 7 in each plot. We did this twice during July and twice during August. One of the sampled trees was immediately to the right and the other immediately to the left of the center tree of the row (for row 4, these were the same trees in which *T. pyri* were released). For 2001, 2002 and 2003, we no longer segregated samples according to plot and sampled five leaves on each of ten trees (50 in all) on each of rows 1, 4 and 7 in each block. We did this twice in 2001 (once in July and once in August), once in 2002 (in July) and twice in 2003 (once in July and once in August).

In 2000, in four of the blocks we planted 20 seedling trees of American hazel in hedgerows opposite and about 5 meters away from plots in which *T. pyri* were released. Our intent was to sample leaves from these seedlings for abundance of predatory mites as soon as the seedlings achieved reasonable growth (reached 1 meter height). Hence, in 2002 and 2003, we sampled five leaves from each of ten American hazel seedlings (50 leaves in all) once during August in each of the four blocks.

All sampled leaves were sent by overnight mail to Geneva, New York for the identification and counting of pest and predatory mites.

From 2000-2003, none of the sampled plots received pyrethroid or carbamate insecticide (except carbaryl as thinner), none received EBDC fungicide after mid-June, and none received miticide (except prebloom oil). The only exception was orchard F, which received a spot-treatment of Acramite in August of 2003 against European red mite.

Results

With respect to our first question, data for 2000 presented in Figure 1 show that addition of cattail pollen had no detectable effect on the buildup of *T. pyri* in trees in which these predators were released. Peak populations of *T. pyri* in 2000 were just as great in trees not receiving cattail pollen as in those that did receive pollen, and were roughly twice as great (on sampled center trees in row 4) in plots where *T. pyri* were released as in plots where no *T. pyri* were released. Conversely, peak populations of European red mites on sampled trees averaged about twice as great in plots where no *T. pyri* were released and which received insecticide during July and August as in plots where *T. pyri* were released and received no insecticide after mid-June. Peak populations of *A. fallacis* averaged roughly the same in all plots. For each of the four plot types, *A. fallacis* was less abundant than *T. pyri.*

In regard to our second question, there was no statistical evidence that spread of *T. pyri* differed among the rows of trees, although data for 2001 shown in Fig. 2 hint that *T. pyri* released in 2000 on trees in row 4 may have spread faster to trees in row 7 than to trees

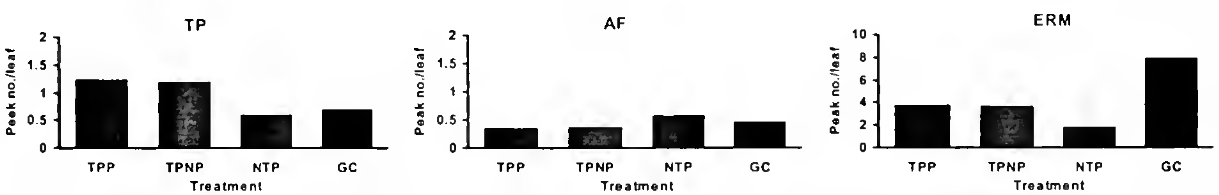

Figure 1. For 2000, peak abundance of *T. pyri* (TP), *A. fallacis* (AF) and European red mites (ERM) in two trees in row 4 of each of four plots in each of 12 orchard blocks: trees in which TP were released and cattail pollen was added (TPP), trees in which TP were released but no pollen was added (TPNP), trees in which no TP were released, no pollen was added and apple maggot was controlled by baited red sphere traps (NTP) and same as preceding except apple maggot was controlled by grower-applied insecticide (GC).

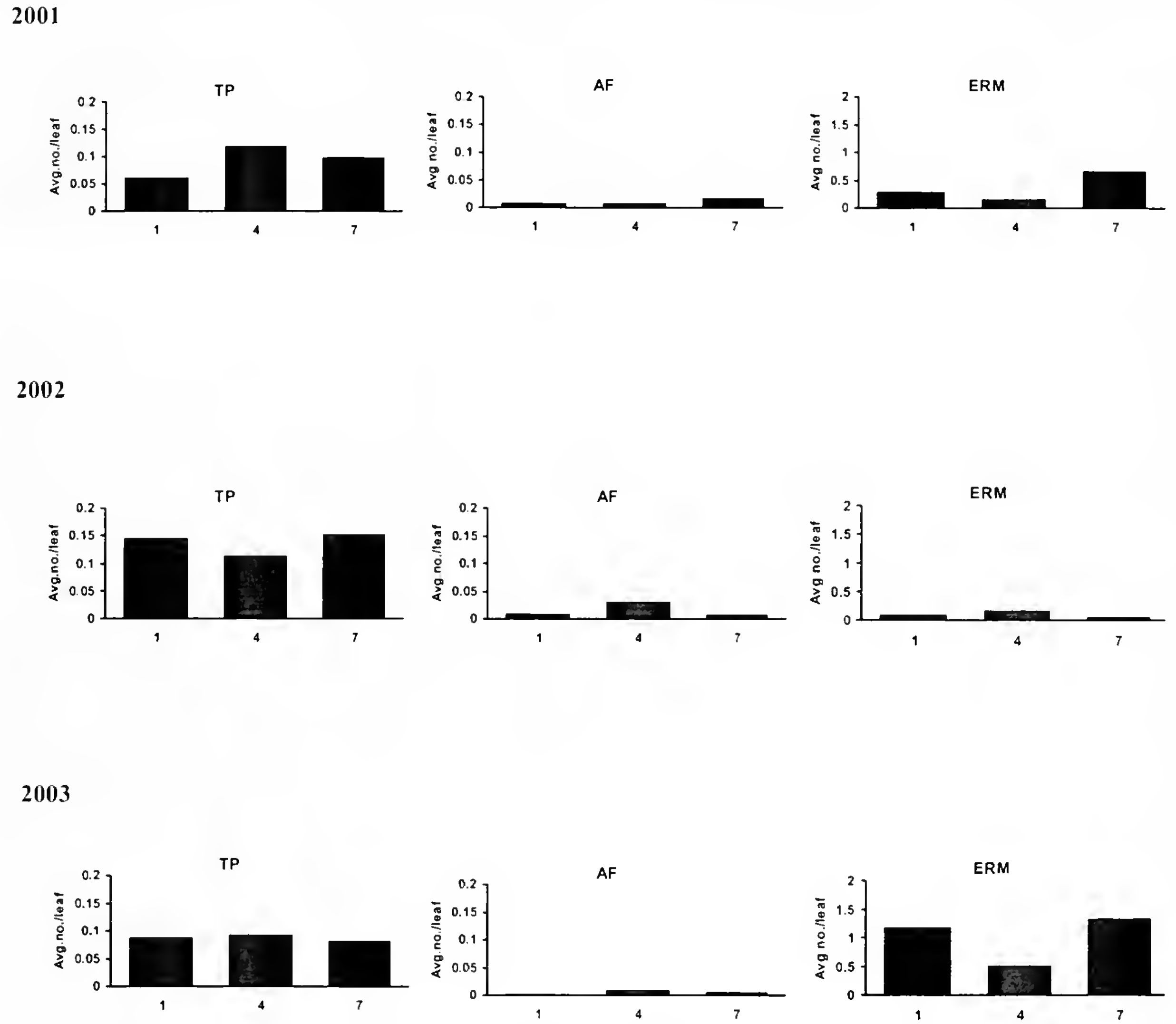

Figure 2. For 2001, 2002 and 2003, average abundance (across all sampling dates) of *T. pyri* (TP), *A. fallacis* (AF) and European red mites (ERM) in rows 1, 4 and 7 of 12 orchard blocks in which TP were released in row 4 in 2000.

in row 1. By 2002 and 2003, however, *T. pyri* were equally abundant in rows 1, 4 and 7. *A. fallacis* showed no clear pattern in abundance according to row across 2001, 2002 and 2003. The same was true for European red mites.

Our third question focused on the potential value of establishing American hazel trees in border areas as a way of promoting buildup of predatory mites and enhancing populations of predators in adjacent blocks of orchard trees. However, as shown in Fig. 3 for the four orchard blocks involved in this evaluation, the abundance of *T. pyri* and especially *A. fallacis* was low on leaves of American hazel trees in border areas. Moreover, neither of these predators was more abundant in row 1 trees than in row 4 or row 7 trees, which could have been expected if substantial numbers of predators were moving from American hazel trees toward orchard blocks.

Our fourth question concerned the relationship between *T. pyri* and *A. fallacis*. Data from our study of

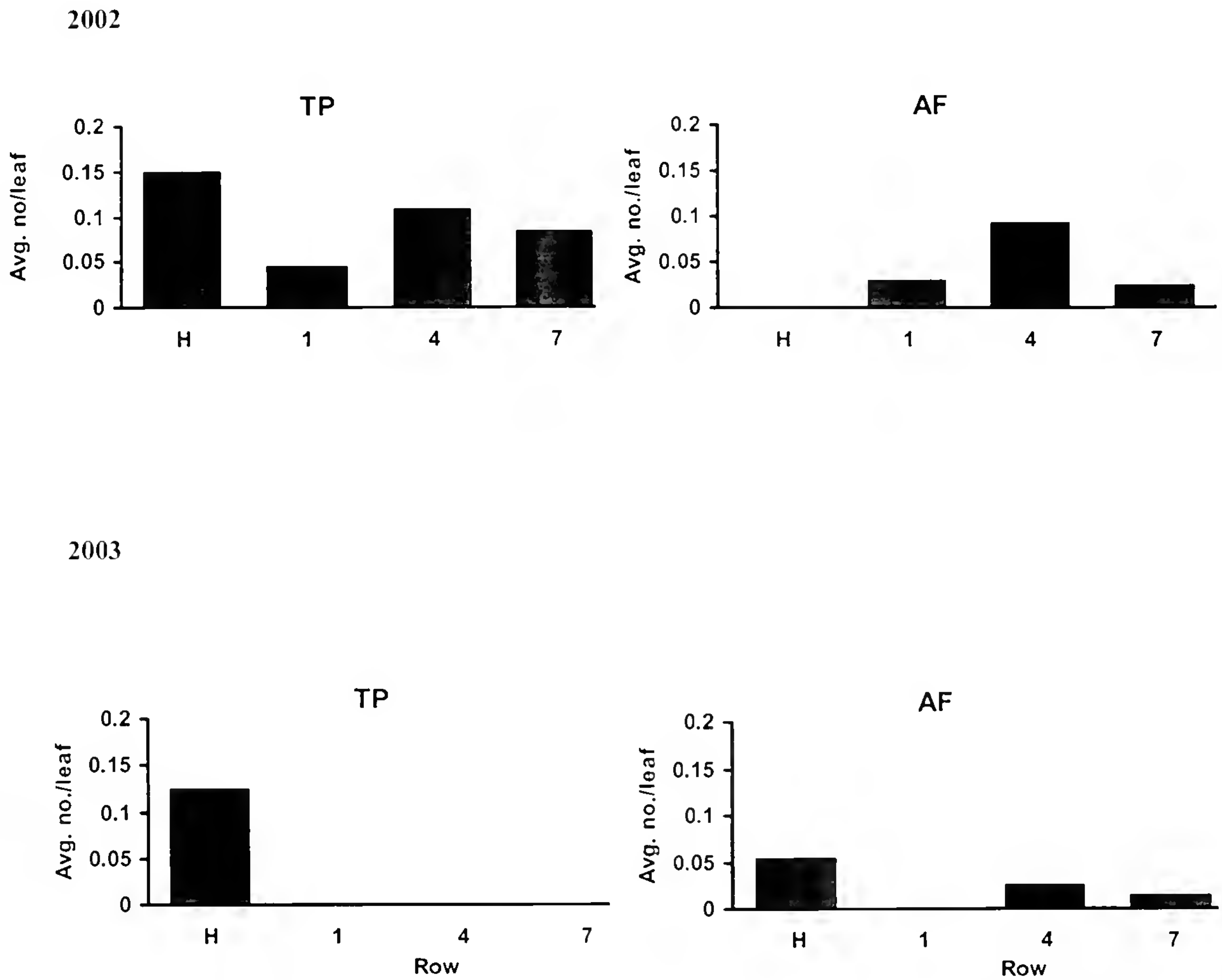

Figure 3. For 2002 and 2003, average abundance (across all sampling dates) of *T. pyri* (TP) and *A. fallacis* (AF) in American hazel trees (H) in border areas adjacent to four orchard blocks and in rows 1, 4, and 7 of these four blocks (in which TP were released in row 4 in 2000).

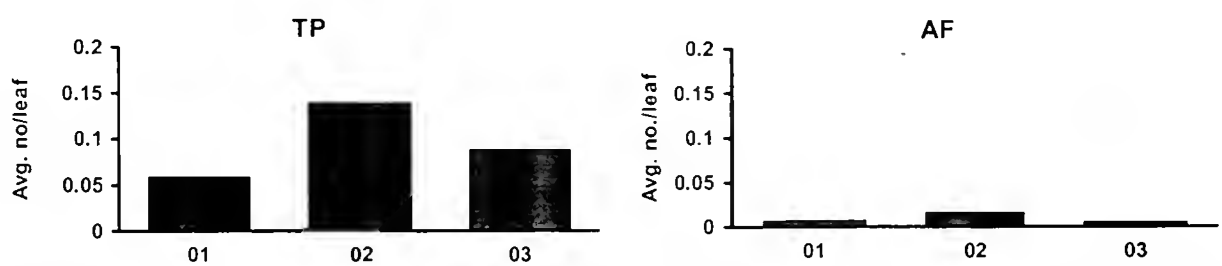

Figure 4. For 2001, 2002 and 2003, average abundance (across rows 1, 4 and 7 and across all sampling dates) of *T. pyri* (TP), and *A. fallacis* (AF) across 12 orchard blocks in which TP were released in 2000.

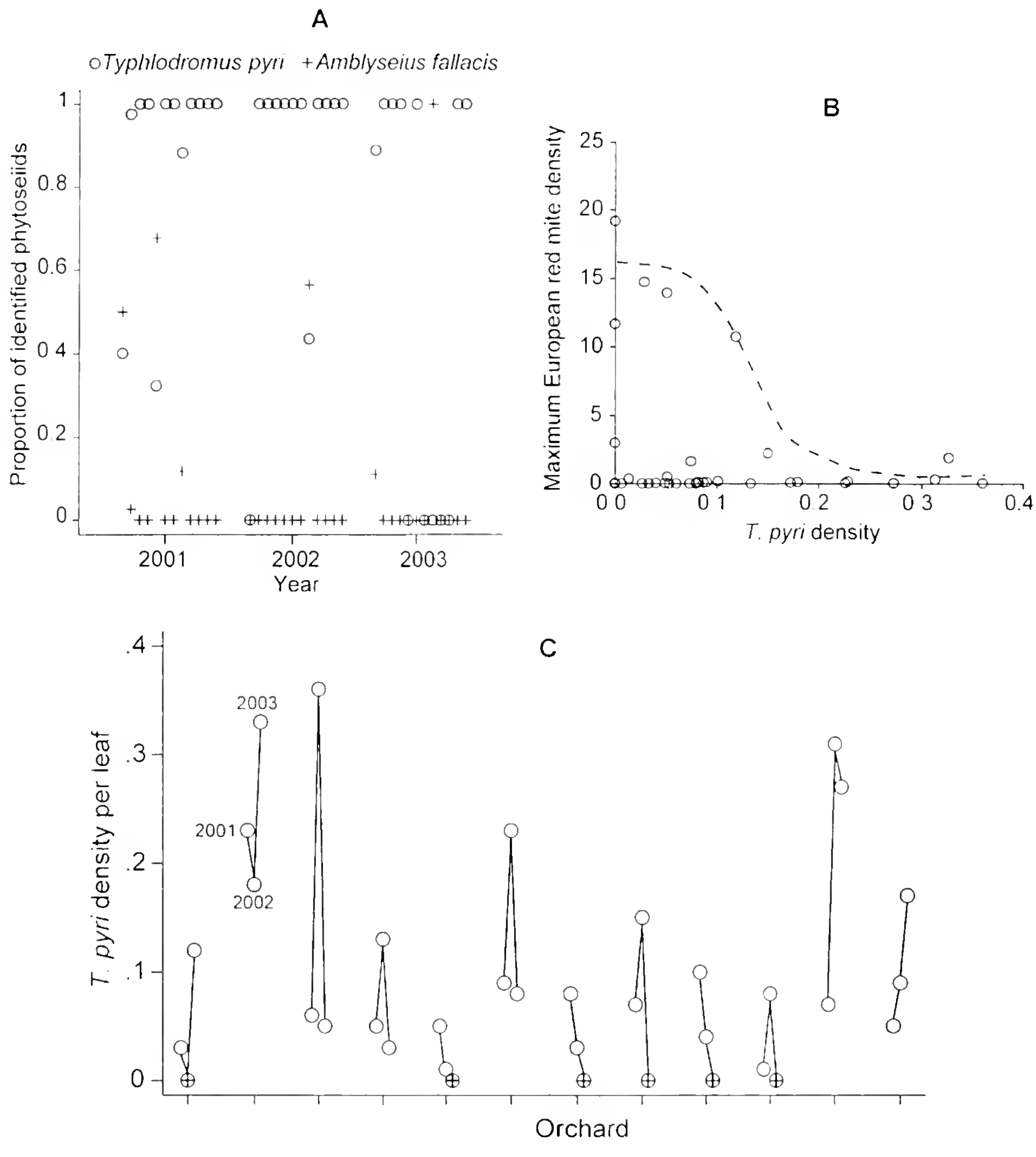

Figure 5. A) Proportions of phytoseiid mites identified as either *T. pyri* or *A. fallacis* in each of 12 orchard blocks over three years. Within a year there are 12 sets of circles denoting the *T. pyri* proportions and 12 + symbols denoting the *A. fallacis* proportions. At some sites, no phytoseiids were collected and these are denoted by a circle enclosing a + symbol. B) Maximum densities of European red mites in relation to the average density of *T. pyri*. Each circle represents data collected from a block in one of the years 2001, 2002 or 2003. The dashed line was fit by eye. C) Average densities of *T. pyri* in orchards over the years 2001, 2002 and 2003. Each set of three connected circles represents three years of data from an orchard block, arranged in sequence (left to right) for 2001, 2002 and 2003. Circles with a + symbol indicate no *T. pyri* were collected in the samples.

1997-1999 reported in the 2000 issue of Fruit Notes suggested that increasing abundance of *T. pyri* was correlated with decreasing abundance of *A. fallacis*. This pattern has been observed elsewhere and occurs because establishment of *T. pyri* usually leads to low levels of European red mites. *A. fallacis* are only abundant in apple trees when there is a ready supply of pest mites for food. In this study, nearly all the orchards had populations of *T. pyri* prior to their release in 2000. Therefore, we would expect low numbers of *A fallacis*. Our resuls are in accord with this expectation. As shown in Fig. 4, data for 2001, 2002 and 2003 averaged across all 12 orchard blocks indicate that overall, *T. pyri* was about ten times more abundant than *A. fallacis* on sampled leaves. Another way of looking at this relationship is to compare the proportions of *T. pyri* and *A. fallacis* found in each orchard (Fig. 5A). In 2001 *A. fallacis* were found in only four orchards and these were sites where some European red mites were also found. In 2002 there was but one orchard where *A. fallacis* was collected and in 2003 this number increased to two. Note that in 2003 there were four orchards where no phytoseiids were collected and five orchards where no *T. pyri* were collected. At present, we have no explanation for this.

Our final question asked whether establishment and conservation of *T. pyri* would assure effective biocontrol of European red mites. Previous research has shown that *T. pyri*, when sufficiently abundant, can keep European red mites at non-damaging densities. Recalll that *T. pyri* were present in most orchards prior to their release and by 2001, *T. pyri* were recoverd in all the orchards (Fig. 5A). Shown in Fig. 5B a is the relationship between the maximum density of European red mites observed and the average density of *T. pyri*. The dashed line was fitted by eye to the data points that reflect the highest European red mite numbers in relation to predator density. This graph shows that when *T. pyri* numbers are low (< 0.15 per leaf), there is a possibility that European red mite will become problematic. Note that even when *T. pyri* densities are low, pest mites do not always reach high densities, but the potential is there. On the other hand, when *T. pyri* were more numerous, European red mites never reached high numbers. It is also helpful to examine changes in the abundance of *T. pyri* over time because our experience has been that once established in an orchard, these predators usually persist in relatively high numbers. As shown in Fig. 5C, this was not the case, as in 2003 we did not collect any *T. pyri* in five of the 12 orchards studied. At present, we can offere no explanation for this decline in predator numbers

Conclusions

Across the four years of our study (2000-2003), we gained much useful information on the ecology and biocontrol potential of *T. pyri* in Massachusetts. Our findings lead us to the following conclusions. First, addition of a substantial amount of cattail pollen (as a food supplement) to trees in which *T. pyri* were released in 2000 had no detectable effect on buildup of *T. pyri*. Thus, there is sufficient alternate food to allow for establishment of *T. pyri* provided no pesticides harmful to this predator are used. Second, by 2002 *T. pyri* were equally abundant in plots where they were released or not released, with the exception of two sites where they were only found in plots where they were released, and they were equally abundant among the sampled rows (1, 4, 7). This likely reflects that *T. pyri* were present in most blocks prior to release. Third, establishment of American hazel trees (known to harbor mite predators) in border areas adjacent to plots of orchard trees did not substantially enhance populations of either *T. pyri* or *A. fallacis* in such plots. Fourth, commencing in 2001, *T. pyri* predominated in the study blocks, with *A. fallacis* absent or at very low levels in most blocks. Only where European red mites were moderately to very abundant were *A. fallacis* found. Finally, in a majority of orchard blocks *T. pyri* were sufficiently abundant by 2001 to provide what appeared to be consistently effective biocontrol of European red mites. In some orchard blocks, however, *T. pyri* did not build to appreciable levels or declined in abundance (for reasons unknown, but apparently not associated with use of offensive pesticides). In some of these blocks in some years, European red mites reached threatening levels.

Overall, as in our 1997-1999 study, *T. pyri* showed much promise as an effective biocontrol agent of European red mites in most of the blocks in which it is established and conserved.

Acknowledgments

We are grateful to the ten growers participating in this study. Each made a special effort to refrain from applying pesticides potentially detrimental to *T. pyri*. They were Keith Arsenault, Gerry Beirne, Bill Broderick, Dave Chandler, Tom Clark, Don Green, Tony Lincoln, Joe Sincuk, Mo Tougas and Steve Ware. This work was supported by a grant from the Northeast Sustainable Agricultural Res. & Education Program.

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Real Buzz Words: Beekeeping Sites for All Levels

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It's no surprise that beekeeping is a traditional farming activity. Bees provide a much-needed service by pollinating crops, and the honey they produce is a great product to offer at farmstands and farmers' markets. Whether you're just thinking about getting into beekeeping, or if you're an experienced apiarist looking for new ideas or suppliers, the Internet is swarming with information on the subject.

The following are several good general reference Web sites, but these will, in turn, lead you to more specific resources on beekeeping and honey sites around the world.

BeeSource.com (*www.beesource.com*) is a nicely designed site that provides new sources of bees, books, supplies, plans for constructing beehives, information on beekeeping laws, equipment and issues; there's also a page of links to other beekeeping Web sites.

If you're looking to share information with other beekeepers, this site provides its own bulletin board for discussion on various beekeeping topics, as well as links to other beekeeping discussion groups, news groups and more.

The Mid-Atlantic Apiculture Research and Extension Consortium Beekeeping Information Index (*http://maarec.cas.psu.edu/Beeinfoindex.html*) is a simple Web site that provides all the basics of apiculture. This site is organized and reads more like a manual. It provides everything you need to know about beekeeping from honeybee biology to beekeeping equipment, and colony management to diseases, pests and parasites and pollination.

The Colony Management section includes information on managing for honey production and managing for pollination. Other management topics are organized by season. There's even advice on contracting with growers for pollination services.

The design of this site is not fancy, but links and information are presented in an easy to navigate format. Only a small amount of the information here is specific to the Mid-Atlantic region. Most of it is applicable to beekeeping anywhere.

There's a page of additional resources, which provides names, addresses and phone numbers of organizations, industry journals and experts. The page is dated 1996 so you have to wonder if some of the information is out of date. The glossary of beekeeping terms is quite extensive.

The Beehive (*www.xensei.com/users/alwine/*), based in Massachusetts, is an electric mix of useful beekeeping information and games. In addition to practical resources such as bee anatomy, how to start beekeeping and how to store and use honey, there is also fun stuff here as well, such as a beehive crossword puzzle, a trivia quiz and a game called "Sting Me." There are articles on how bees were used as weapons of war and city beekeeping, as wells as frequently asked questions about bees.

The programs that you can download from this site also reflect the mix of serious information and fun. Included in the download section are an e-book on Beginning Beekeeping, and a beehive jigsaw puzzle program that is fun and easy to complete.

This light-hearted site would be a good resource for young people just getting into beekeeping.

National Honey Board (*www.nhb.org*) is a broad resource for honey producers including national news, business information, marketing resources, quality control information and statistics on national honey production and consumption. There are also numerous articles here on honey research, legislation, organic standards and the like.

All of these sites are great resources worth bookmarking, but don't stop there. Be sure to follow the many links to more resources that these sites provide to round out your research in apiculture.

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SJP84 Winter Hardy Dwarf Apple Rootstock Series from Agriculture and Agri-Food Canada National High Value Crop Breeding Program

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Apple production potential in Quebec is between 5.5 and 7 million bushels per annum. In 1986 and 1987, there were severe low temperature injuries, and yields were reduced to 2.8 million bushels and 4.0 million bushels, respectively. This loss represents approximately $18 million in 1986 and $12 million in 1987, and a concomitant increase in the volume of apples imported to the province. In 1993-1994, similar damage was reported by Quebec apple growers (Khanizadeh et al., 2000a). Cold winter temperatures is one of the most limiting factor in many apple-growing regions, especially in Northern Central Canada when the winter temperature dropped below –30°C (Granger, 1981; Asnong, 1982; Khanizadeh et al., 2000a).

Cold tolerance of many plant species has been extensively reviewed and studied (Chen and Li, 1980; Gusta et al., 1982; Li, 1987; Sakai and Larcher, 1987; Khanizadeh et al., 1989a; Khanizadeh et al., 1989b; Khanizadeh, 1991; Khanizadeh et al., 1992a; Khanizadeh et al., 1992b; Khanizadeh et al., 1994). Our previous studies have compared the concentration of amino acids, protein, sugars, starch, sorbitol, N, P, and K of cropped and non-cropped trees in relation to cold hardiness (Khanizadeh et al., 1989b; Khanizadeh et al., 1992a; Khanizadeh et al., 1994). It has been shown that cropped trees that progress into the winter with lower nutrient levels in their buds are more vulnerable to low temperatures than those on non-cropped trees (Khanizadeh et al., 1989b; 1992a).

There have been many studies of: 1)cold resistance and metabolic changes in apple woody tissue, (Brown, 1978; Li, 1987; Sakai and Larcher, 1987; Khanizadeh et al., 1989a; 1989b; 1992a; 1994), 2) types of freezing injury (Weiser, 1970; Granger, 1981); 3) breeding hardy varieties or using hardy intermediate framestocks (Stushnoff, 1972; Spangelo et al., 1974; Granger et al., 1991; 1992; 1993); 4) inactivating icenucleating bacteria (Lindow and Connell, 1984; Lindow et al., 1989); 5) use of chemical cryoprotectants (Ketchie and Murren, 1976); 6) cultural manipulation to slow growth and induce wood maturity in early autumn (Collins et al., 1978; Stang et al., 1978); and 7) autumn sprays of growth regulators to delay bud break. The use of winter hardy rootstocks and varieties, however, seems to be the most desirable approach to avoid winter injury and are used in international trials to screen this specific trait (Marini et al., 2001a; 2001b).

Many reports have been published on the winter hardiness and survival of selected rootstocks (Granger et al., 1993; Doroshenko et al., 1995; Skrivele et al., 1995; Fisher & Fisher, 1996; Yang et al., 1995; Witney, 1996; Khanizadeh et al., 2000a; Khanizadeh et al., 2000b; Marini et al., 2001a; Marini et al., 2001b; Webster, 2003). Alnarp 2 (A2) was reported to have the highest survival rate when exposed to low soil temperatures, followed by MM.104, Antonovka, M.26, MM.111, M.4, MM.106, M.9, and M.7, respectively (Zagaza, 1977). O.3 and O.8 were reported to be hardier than M.26 and MM.106 (Heeney, 1981), and Bugadovsky was reported to be as hardy as M.26 (Czynczyk, 1979).

A part of the Agriculture and Agri-Food Canada (AAFC) National High Value Crop (NHVC) breeding program is devoted to development of adapted, dwarf and semidwarf, winter-hardy, and disease-resistant apple rootstocks. The original rootstock-breeding program began in early 1950 in Ottawa. Ottawa 3 (O.3) was the first commercially released clonal rootstock, released in 1974 from this National program, and the rest was send to Quebec for further testing along with others developed in Ottawa and in Manitoba.

The identification of new, well adapted, winter-hardy, disease-resistant apple rootstocks that propagate easily will have a direct impact on the apple industry in the northern U.S. and in Canada by reducing production fluctuation caused by cold-temperature tree damage.

Materials & Methods

Several crosses were made in 1975 including *Malus robusta* R-5 with M.26 or with Budagovsky 579490, and also some seeds was collected from open pollinated O.3. Seeds were germinated under greenhouse conditions and planted in a nursery in 1980. Budding to Spartan was conducted in 1982, and trees with bud failure were cleft-grafted in 1983. All trees were planted in 1984 (5.5 x 3.0m) at the experimental farm of AAFC in Frelighsburg, Quebec. Standard orchard management practices were applied each year (Anon., 1976). Of the 908 trees started in 1984, only 499 were used for evaluation and the rest eliminated from the program due to their lack of winter hardiness, disease susceptibility, or other undesirable characters, like extreme difficulty to propagate in stool bed. Data are shown only for those nine superior rootstocks (Table 1) which have not shown any winter injury since 1984 and were not eliminated for other reasons.

Trunk circumference was measured at 25 cm above the graft union and used to calculate trunk cross-sectional area in 1990. Yield and incidence of root suckers were recorded annually from 1988-1990. Tree height and spread were measured as the maximum vertical extension of the tree and the maximum horizontal extension of the canopy, respectively (Table 1).

Two other sites were also established to examine the ease of propagation and suitability of the rootstocks for commercial grafting compare to M26, M9, and O.3 (data not shown).

'Summerland McIntosh' was used as scion for the nine superior rootstocks (Table 2). They were planted in four selected locations including L'Acadie (AAFC, Experimental site) and also tested under controlled conditions at two commercial grower sites Dunham and Mont St-Grégoire (Verger Dupuis Inc., 587 Hudon,

Table 1. Performance of selected nine superior rootstocks with Spartan as the scion, selected from 908 seedlings planted in 1984 in Frelighsburg, Quebec.

Test Code	Selection	Parentage	TCA[1] (cm^2)	Cumulative Yield (kg)	YE[2] (kg/cm^2)	Canopy size 1990 Height (m)	Canopy size 1990 Spread (m)	Cumulative no of Root suckers
SJP84-5218	75-13-032	R5xM.26	13.2	22.95	1.73	2.6	2.6	5.3
SJP84-5217	75-13-065	R5xB.574900	9.7	10.05	1.04	2.1	2.6	7.3
SJP84-5230	75-13-179	R5xM.26	23.0	28.65	1.25	2.9	2.5	0.0
SJP84-5198	75-13-180	R5xM.26	13.0	17.25	1.32	2.2	3.1	0.6
SJP84-5162	75-13-183	R5xM.26	14.2	25.5	1.81	2.9	2.4	13.0
SJP84-5231	75-13-209	R5xM.26	6.7	6.15	0.91	1.6	0.9	9.0
SJP84-5174	75-13-219	R5xM.26	18.9	20.70	1.10	3.4	3.5	7.0
SJP84-5189	75-13-246	R5xM.26	13.0	22.35	1.71	1.6	2.8	8.3
SJP84-5180	75-13-296	R5xM.26	17.7	19.8	1.12	2.9	2.6	6.3

[1] TCA = trunk cross-sectional area.
[2] YE = yield efficiency (cumulative yield/TCA).

Table 2. Performance of nine superior rootstocks and O.3A with Summerland McIntosh as the scion compared to M.26, M.9, M.27, MM.111 and O.3 planted in 1995 in Mont St-Grégoire, Verger Yvan Duchesne (average of 3 trees per replicate

							Yield (kg)									
Test code	Selection	Vigour[1]	Circ.[2] (mm)	TCA[2] (cm^2)	Height (m)	Spread (m)	1999	2000	2001	2002	1999-2002[3]	Efficiency[4] (kg/cm^2)	No. of fruit 1999-2002	Fruit weight[5] (g)	Burrknot rating[6]	Suckers[7]
SJP84-5218	75-13-032	144	175	24	2.5	3.5	1.2	14.3	29.3	58.1	103.3	4.2	724	116	1.0	1.5
SJP84-5217	75-13-065	176	213	36	3.2	3.5	2.3	12.6	15	46.6	76.4	2.1	544	126	1.5	0.5
SJP84-5230	75-13-179	89	107	9	2.3	2.2	0.5	3.1	13.5	18.8	35.4	3.9	293	106	1.2	0.0
SJP84-5198	75-13-180	128	155	19	2.7	3.0	0.1	2.9	13.5	36.1	52.[illegible]	2.8	403	124	1.8	0.0
SJP84-5162	75-13-183	123	149	18	2.8	2.7	0.6	6.3	12.5	28.8	48.2	2.8	359	119	1.8	3.0
SJP84-5231	75-13-209	99	120	11	1.9	2.3	0.0	3.1	9.0	18.5	30.[illegible]	2.7	249	112	2.5	0.0
SJP84-5174	75-13-219	154	187	28	2.9	3.2	0.1	4.9	15.[illegible]	42.6	63.3	2.3	461	132	2.0	0.0
SJP84-5189	75-13-246	136	165	22	2.9	3.0	0.2	5.8	7.9	35.3	49.3	2.0	368	136	1.5	0.0
SJP84-5180	75-13-296	134	162	21	3.0	3.3	0.0	5.7	18	30.9	54.[illegible]	2.6	323	172	3.5	4.0
	O.3A	116	141	16	2.7	2.8	0.9	8.7	18.[illegible]	30.8	59.1	3.7	420	125	1.3	1.7
	M.26	151	183	27	3.3	3.2	0.6	3.9	12.[illegible]	32.1	48.[illegible]	1.8	292	163	3.0	0.0
	M.9	100	121	12	2.4	2.5	0.5	6.7	10.5	25.5	43.2	3.7	306	133	2.8	2.7
	MM.111	230	280	62	4.1	2.9	0.0	0.9	3.8	19.9	25.[illegible]	0.4	179	133	1.0	0.3
	M.27	79	96	7	1.9	2.1	0.2	3.2	6.8	9.2	19.4	2.6	136	133	1.5	0.0
	O.3	132	160	20	2.7	3.1	0.1	5.1	17.5	32.1	54.7	2.8	398	128	0.3	2.7
	LSD[8]	28	34	10	54	84	1.2	5.4	8.8	19.8	29.[illegible]	1.1	207	30	1.9	3.8

[1] Vigour: Trunk circumference as a percent of M.9.
[2] Trunk circumference and cross-sectional area (TCA) 25 cm above graft union.
[3] 1999-2002 = cumulative yield from 1999-2002.
[4] Efficiency: (cumulative yield/TCA).
[5] Fruit weight (g) was taken using 25 randomly selected fruits
[6] Burrknot rating: 0 = desirable, 10 = undesirable.
[7] Average number of suckers counted during the 2002 season.
[8] If difference between two means exceeds LSD, then it is significant at odds of 1[illegible]

Dunham, Qc., Canada; Verger Ivan Duchesne Inc., 118 ch. Sous-Bois, Mont St-Grégoire, Qc., Canada) in 1997 using three trees per sites/replicates. Several commercially grown cultivars (Gala, Spartan, McIntosh, Lobo) were also grafted onto these rootstocks to assess graft compatibility. During the multiplication and evaluation of the rootstocks, we discovered a clone of O.3 (O.3A) to be different from original O.3 developed earlier by Spangelo et. al. (1974). O.3A appears to produce wider branch angle and have a better rooting efficiency in stool beds compared to the original O.3. This rootstock (O.3A) was also tested along with advanced SJM rootstocks in all sites. M.27 was planted only at one commercial site due to the insufficient number rootstocks.

Results & Discussion

The majority of the superior rootstocks came from R.5 x M.26 crosses, and only one (75-13-065) came from R5 x B57490. The superior rootstocks showed no incompatibility with tested commercial scion cultivars. All rootstocks produced trees that were dwarf or semi-dwarf and were easier to propagate and numerically more efficient than trees on M.26 (Table 2).

Generally the trees were more vigorous in Dunham (Table 3) than in Mont St-Grégoire (Table 2) based on the trunk circumference. SJP84-5230, M.9, and M.27 were the least vigorous rootstocks in Dunham (Table 3) and Mont St-Grégoire (Table 2); however, there was not a significant difference between M.27, SJP84-5230, SJP84-5231, and M.9 in Mont St-Grégoire. MM.111 was the most vigorous at both sites.

SJP84-5218 and SJP84-5217 were the most precocious rootstocks at both sites. MM111 was the least precocious. In Dunham, SJP84-5198, SJP84-5189, SJP84-5162, and SJP84-5217 had higher cumulative yield than did M.26, SJP84-5231, MM.111, M.9, and SJP84-5230 (Table 3). In Mont St-Grégoire, SJP84-5218, SJP84-5217, SJP84-5174, SJP84-5180, O.3, and O.3A had higher cumulative yield than did MM.111

Table 3. Performance of nine superior rootstocks and O..3A with Summerland McIntosh as the scion compared to M.26, M.9, M.26, MM.111 and O.3 planted in 1995 in Dunham, Verger Dupuis Inc. (average of 2-3 trees per /replicate)

Test code	Selection	Vigour[1]	Circ.[2] (mm)	TCA [2](cm²)	Height (m)	Spread (m)	Yield (kg) 1999	2000	2001	2002	1999-2002[3]	Efficiency[4] (kg/cm²)	No. of fruit 1999-2002	Fruit weight[5] (g)	Burrknot rating[6]
SJP84-5218	75-13-032	173	150	18	1.9	2.4	2.3	8.9	5.2	15.2	31.8	1.8	263	118	3.8
SJP84-5217	75-13-065	172	149	18	1.9	2.3	2.7	9.0	4.0	18.1	33.8	1.9	279	114	2.2
SJP84-5230	75-13-179	108	93	7	1.4	1.3	0.8	3.9	0.8	4.0	9.4	1.5	78	126	1.5
SJP84-5198	75-13-180	153	132	14	2.1	2.3	4.0	10.1	5.5	17.1	36.7	2.6	294	114	2.5
SJP84-5162	75-13-183	169	146	17	1.7	2.7	3.3	8.7	7.5	14.4	33.8	2.0	260	118	3.5
SJP84-5231	75-13-209	122	105	9	1.7	1.3	3.2	4.7	2.9	9.2	20.1	2.1	171	126	2.8
SJP84-5174	75-13-219	205	177	25	1.9	2.2	0.5	7.7	9.3	15.4	33.0	1.3	296	96	1.0
SJP84-5189	75-13-246	182	157	20	2.8	2.8	2.1	7.4	6.6	19.9	36.0	1.9	319	100	1.8
SJP84-5180	75-13-296	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	O.3A	160	139	15	1.9	2.2	3.2	8.3	6.7	13.1	31.2	2.0	270	102	0.7
	M.26	173	149	18	1.8	2.7	1.6	5.7	2.4	12.6	22.2	1.3	185	119	3.3
	M.9	100	86	6	1.8	1.6	0.8	2.5	1.7	5.3	10.3	1.8	94	116	3.0
	MM.111	224	194	30	3.2	2.1	0.0	3.2	3.4	9.0	15.6	0.6	119	130	2.2
	O.3	156	135	15	1.9	2.7	1.9	7.5	8.1	11.8	29.2	2.1	242	104	1.7
	LSD[8]	38	33	8	64	56	2.0	4.7	5.6	6.0	10.8	0.9	75	19	1.9

[1] Vigour: Trunk circumference as a percent of M.9.
[2] Trunk circumference and cross-sectional area (TCA) 25 cm above graft union.
[3] 1999-2002 = cumulative yield from 1999-2002.
[4] Efficiency: (cumulative yield /TCA).
[5] Fruit weight (g) was taken using 25 randomly selected fruits
[6] Burrknot rating: 0 = desirable. 10 = undesirable.
[7] Average number of suckers counted during the 2002 season.
[8] If difference between two means exceeds LSD, then it is significant at odds of 19:1.

and M.27 (Table 2).

The most efficient rootstocks were SJP84-5198 in Dunham (Table 3) and SJP84-5218 in Mont St-Grégoire (Table 2). MM.111 resulted in the lowest efficiency at both sites. Few differences existed in burrknot rating (Tables 2 and 3) or root suckering (Table 2).

Based on the observation made since 1984 in six orchards, nine of the SJP84 series are being released for commercial testing and evaluation. All the retained SJP84 series are winter hardy, easier to propagate in stool bed than O.3, and produce a thick and vertical growing sucker in stool bed. No mildew, scab, or woolly aphid was observed on these rootstocks. To date, no graft incompatibility has been observed.

SJP84-5218 and SJP84-5198 stand out from the superior group, based on the visual tree observation (height, spread, branch angle, fruit distribution, tree form, graft union, root suckers, and burr knots) in five locations and also on their performance in stool beds.

A patent is pending for all of the SJP84 series rootstocks. A limited number of rootstocks are available for research purposes from the author (SK). Non-exclusive multiplication licences can be obtained from Agriculture and Agri-Food Canada. European nurseries can obtain a multiplication licence from Meiosis Ltd. (Bradbourne House, Stable Block, East Malling, Kent ME19 6DZ).

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Summertime Heat & Health: Prevention Is the Best Medicine

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Folks boast of their dark tan; many think a dark tan looks healhy, but in reality, skin cancer is the most common of all cancers. The main cause of skin cancer is overexposure to the sun, even here in the Northeast. We may even be more susceptible. Much of our weather is a combination of sun and clouds, so when the sun does shine, we peel off the clothes to take full advantage of it.

Our body's natural defense against damaging ultraviolet radiation from the sun is a pigment called melanin; however, even the darkest skin does not contain enough melanin to prevent damage resulting from exposure to the sun.

Farmers have an increased risk of skin cancer, due to the hours spent working in the sun. Remember, the sun's rays are brightest between 10 AM and 3 PM. There are a few preventive steps you can follow to protect your skin from skin cancer.

A wide-rimmed hat is recommended over the ever-popular "baseball" cap that many of us wear. They provide a sun shield for not only your eyes, but also for your ears, neck, and shoulders. These are all common locations of skin cancer outbreaks.

Fabric provides an excellent source of protection against the sun. Darker colors, though warmer, tend to block more sun. Some clothing manufacturers are beginning to put Sun Protection Factor (SPF) ratings on their clothes. You should look for a rating of 15 or higher. Generally, a tighter weave of fabric gives more protection. For example, denim jeans have an SPF of 1,700. A hat should have a 4-inch rim all around, or a broad bill and flap to cover your ears.

Sunscreen is the best way to protect any exposed skin. It is important that you use the right SPF for you. There are two factors to consider. First, how many minutes can your unprotected skin be in the midday sun before it begins to redden and burn? Second, how many minutes will you be working in the sun? You can then figure the minimum SPF rating suncreen you need to apply (SPF = Minutes to be spent in the sun divided by Minutes before skin reddens).

Always use a sunscreen with a minimum rating of 15. They are available at 30, 45, and higher. If you sweat heavily, use a waterproof or sports sunscreen.

You should apply sunscreen 20 to 30 minutes before going outside to give it time to penetrate your skin and protect your cells. It does not last all day, check the label to see how often you should repeat the application. Also, the sun's rays can reach through thin clouds, so apply sunscreen even on a cloudy day.

Your lips are also at risk, so use an SPF lip balm to provide protection for them.

Finally, when you purchase farm equipment, consider the benefits of features such as enclosed cabs or sun shades. Your skin's health is vitally important to your overall health.

It was 9:30, I had been working for three hours already, the humidity was high, the air hot and close. I had a headache, and I began to pant and feel nauseated. My skin felt hot and dry; I was near collapse. I had only had a small sip of water all morning. My friends called the emergency medical service. The emergency personnel came and immediately administered first aid. Later, they said I nearly died.

Heat stroke is a serious illness caused by overheating. It if life threatening, and must be treated as an emergency. Symptoms include dry, hot, red or spotted skin. The victim becomes extremely weak and may lose consciousness, but with rapid, strong pulse. If not treated immediately, it can lead to convulsions, brain damage, and death.

First Aid

Put the person in a cool or shady area, and fan them to promote cooling. An air conditioned tractor cab may be just what the doctor ordered. Remove the victim's clothing, and sponge the skin with cool water. Call an ambulance immediately.

Prevention Is the Best Medicine

Who is a prime target? Overweight and elderly persons, small children, diabetics, alcoholics and drug users, people with high blood pressure, and people taking certain medications. Precautions should be taken when working in hot, humid environments such as in the field or in hot, confined spaces with poor ventilation.

Heat stroke can be largely avoided by following basic health and safety practices. Get enough sleep every night. Your body needs adequate rest, and this is especially true for farm-workers and others who do manual labor. Eat a good breakfast before going to work. Like a tractor, our bodies need fuel to function properly.

Dress appropriately for the warm weather. A long-sleeved shirt, long pants, and wide brimmed hat give the best protection from the sun. Clothes made of cotton are cool and allow air to circulate on the skin's surface.

Drink plenty of water during the day. Our bodies lose water from sweating, and the water lost must be replaced constantly. Provide an adequate water supply in the field, and take breaks often to get a drink. If you are feeling thirsty, you have waited too long. It is best to carry a water bottle with you. Do not drink beer or other alcoholic beverages; the alcohol actually dehydrates your body.

Take breaks to cool off and rest. This will extend your energy and will actually increase the amount of work done each day. If you feel dizzy, weak, or overheated, stop working and go to a cool place. Sit or lie down, drink water, and wash your face with cool water. If you do not feel better soon, notify your boss or supervisor so you can be treated properly.

We can always find excuses for failing to take all these preventive measures. But remember, it is as much your responsibility to protect yourself, as it is your employer's. Everyone should be aware of the conditions that cause heat stress and do what is necessary to prevent it, and know how to deal with its symptoms.

As farm workers, we need strong, healthy bodies to work. We should strive to keep them in top shape.

* * * * *

A Comparison of Six Strains of M.9 Over 10 Years

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Serious interest in the use of clonal, dwarfing rootstocks for apples developed in the United States only in the latter half of the 1900's. The use of dwarf apple trees, however, dates back more than 2,000 years, and the identification of potentially useful material for rootstocks likely began about 500 years ago. Up through the 1800's, these rootstocks were categorized as either Doucin (semidwarf) or Paradise (full dwarf). The variety of clones within these two categories and the misidentification of clones led the researchers at the East Malling Research Station in Kent, England to collect, name, and properly describe 24 different apple rootstocks. They were given the names East Malling I through East Malling XXIV. One of these rootstocks, EM.IX (later changed to M.9) was originally found in France in 1879. It originated as a chance seedling and was given the name Jaune de Metz. Subsequently, it became known as the fully dwarf rootstock of choice, and now is the most widely planted apple rootstock in the world.

All living organisms are subject to occasional mutation in their genetic code. Apples are no exception. Obvious examples of random mutations (or sports) are seen in some varieties more than others. Delicious, Gala, and Jonagold, for example, are prone to obvious skin-color mutations. Marshall McIntosh is a random mutation of Rogers Red McIntosh found at Marshall Farms in Fitchburg, MA. Rootstocks also express mutations from time to time. Since much of the plant is below ground, however, most mutations are not obvious, and even ones that may be beneficial are lost. Even so, several genetically different strains of M.9 have been characterized over the years. Until relatively recently, U.S. growers have had access only to M.9 and M.9 EMLA. In the last 10 or more years, other strains have entered the U.S. market, most notably M.9 NAKBT337. These strains offer some variation in the grafted tree. Likely, the most obvious difference is in the degree of dwarfing, but other characteristics may change with mutations. It is important for nurseries and growers to understand strain differences, so that the best possible rootstocks and management systems are used.

In 1994, the NC-140 Multistate Research

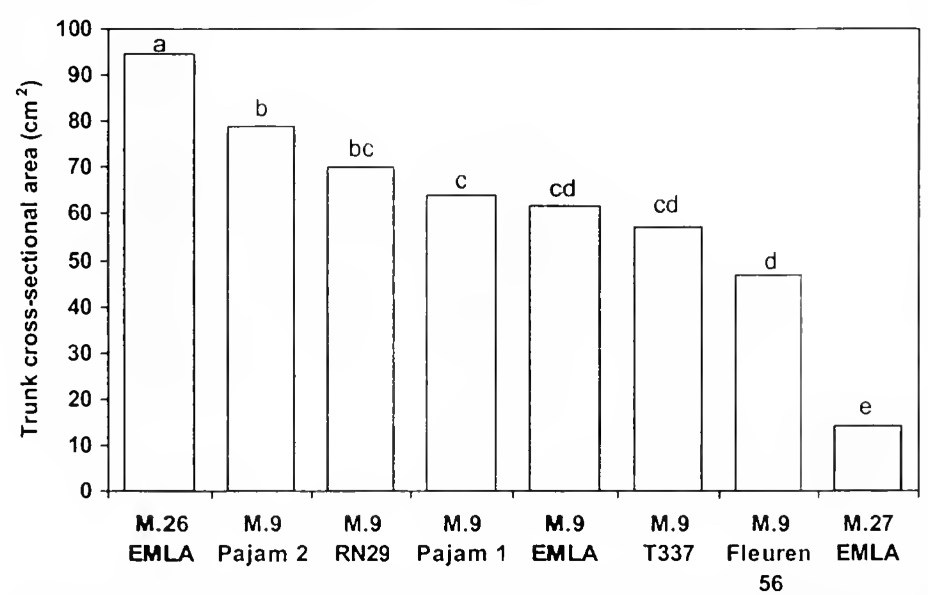

Figure 1. Trunk cross-sectional area of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, after 10 growing seasons. Bars topped by different letters are signficantly different at odds of 19:1.

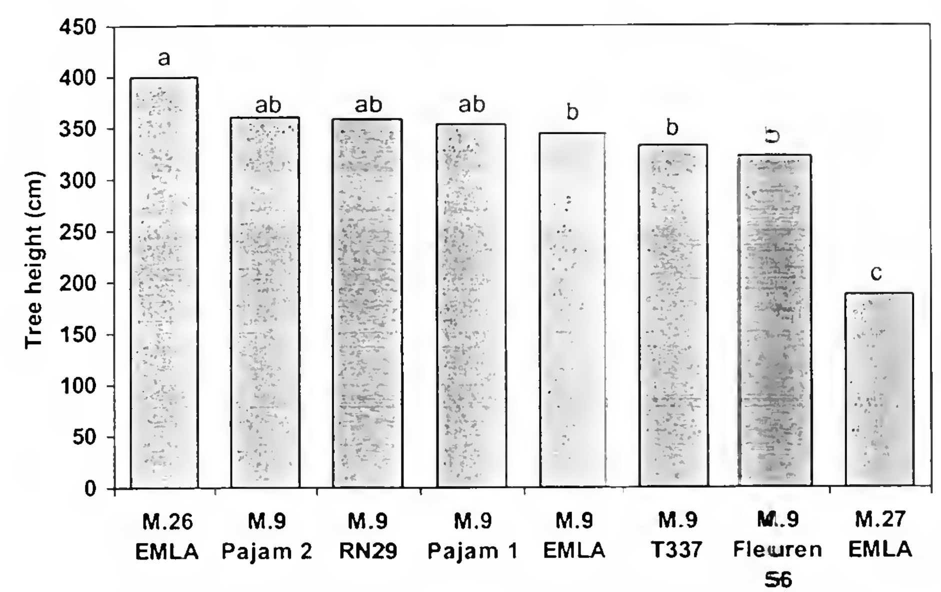

Figure 2. Height of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, after 10 growing seasons. Bars topped by different letters are signficantly different at odds of 19:1.

Committee established a trial including 17 rootstocks with Gala as the scion cultivar at 25 locations. Six of the rootstocks were different strains of M.9. In this article, we report the results gathered from one location after 10 years of trial, concentrating on the M.9 strains.

Materials & Methods

Gala trees were budded on various rootstocks during 1992 growing season and grown in the nursery through the 1993 season. Trees were dug in the fall, stored, and shipped to cooperators in the Spring of 1994. The rootstocks of interest in this article are M.9 EMLA, M.9 Fleuren 56, M.9 Pajam 1, M.9 Pajam 2, M.9 RN29, and M.9 NAKBT337. Data for M.26 EMLA and M.27 EMLA are included in this article for comparison (they also were part of this trial). Trees were planted in April of 1994 at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown, MA in a randomized-complete-block design with 10 replications. All trees were staked and maintained roughly as vertical axes. Pest and fertility management was per local recommendations. Root suckers were counted and cut annually. Yield per tree and fruit size were assessed each year from 1996 to 2003. Trunk cross-sectional area (20" above the graft union), canopy spread, and tree height were measured at the end of the 2003 growing season.

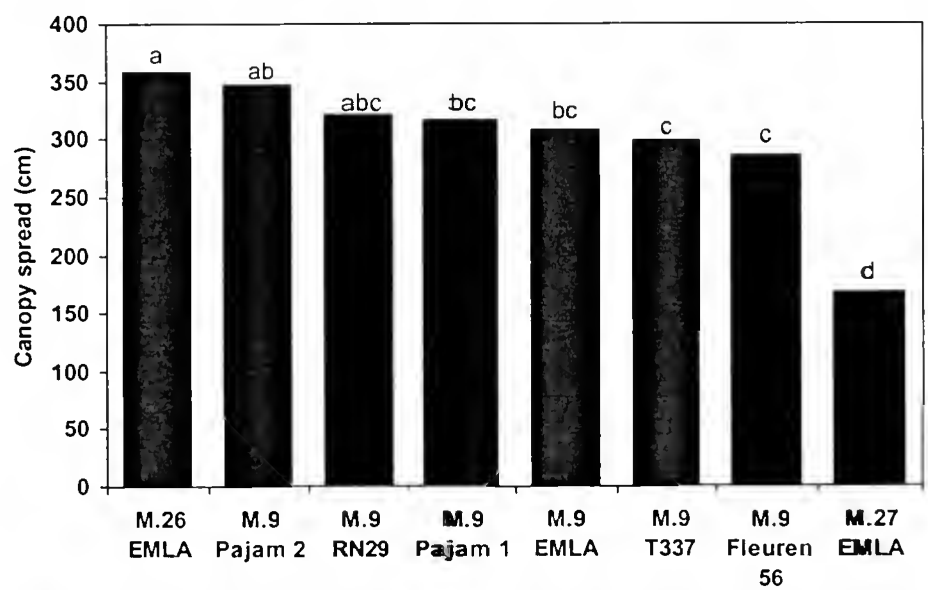

Figure 3. Canopy spread of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, after 10 growing seasons. Bars topped by different letters are signficantly different at odds of 19:1.

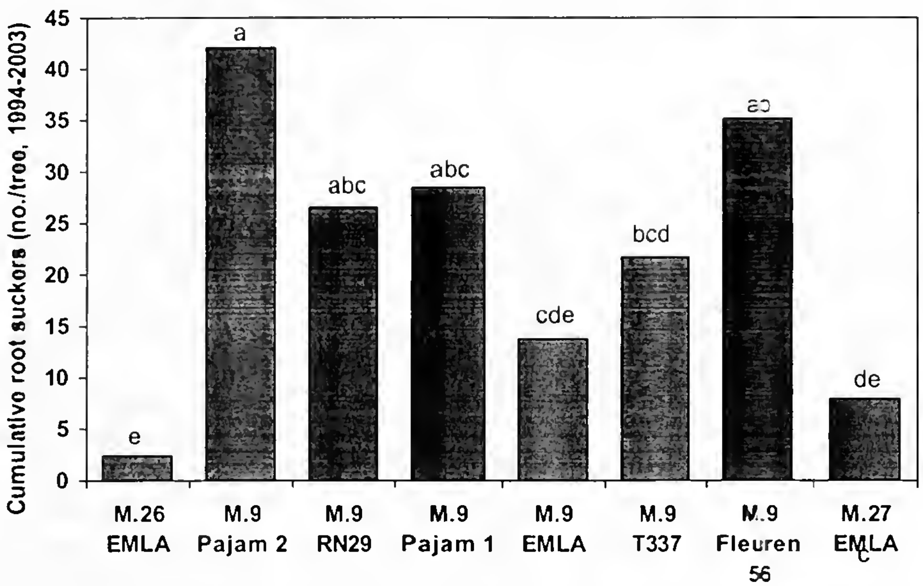

Figure 4. Cumulative root suckering of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, over 10 growing seasons. Bars topped by different letters are signficantly different at odds of 19:1.

Results

After 10 growing seasons, differences among the six M.9 strains were striking, particularly related to tree size. Of the six, the largest trees were on Pajam 2, and the smallest were on Fleuren 56 (Figures 1, 2, and 3). Trees on Pajam 2 were nearly 70% larger than those on Flueren 56. The order of tree size from largest to smallest was Pajam 2, RN29, Pajam 1, EMLA, NAKBT337, and Fleuren 56. Trees on Pajam 2 were somewhat smaller than those on M.26 EMLA, and trees on Fleuren 56 were substantially larger than those on M.27 EMLA.

Root suckering varied greatly over the 10 years of the trial (Figure 4). Cumulatively, trees on Pajam 2 produced 42 suckers on average; whereas, those on EMLA produced only 14. The differences in suckering were not strictly related to tree vigor, since trees on Fleuren 56 were the least vigorous but produced the second most root suckers. As a comparison, trees on M.26 EMLA produced only two suckers on average in the 10 years of this trial.

Cumulative yield per tree (Figure 5) was closely related to tree size. The more vigorous the M.9 strain, the greater the yield. When the yield was adjusted for tree size, that is was assessed as yield efficiency, the strains of M.9 were similar (Figure 6). It is interesting to note that trees on all strains of M.9 were significantly more

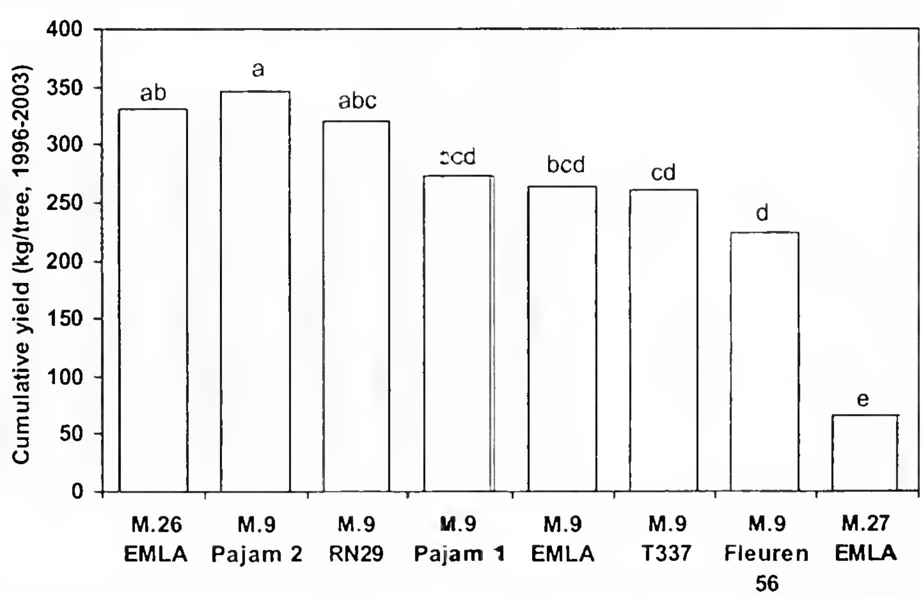

Figure 5. Cumulative yield of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, over eight fruiting seasons. Bars topped by different letters are signficantly different at odds of 19:1.

yield efficient than trees on M.26 EMLA.

Fruit size averaged over the fruiting life of the trial, like yield efficiency, was not affected by M.9 strain (Figure 7). Interestingly, fruit from trees on M.26 EMLA were larger than those from trees on three of the M.9 strains, and fruit from trees on M.27 EMLA were significantly smaller than those from trees on any of the M.9 strains.

Conclusions

Dramatic differences in tree size and relatively similar differences in per-tree yield resulted from the six different M.9 strains. Differences in yield efficiency and fruit size did not result from the different strains. So, the important M.9 qualities of high yield and large fruit did not vary among the strains evaluated here. The degree of dwarfing, however, did vary. Growers must therefore be careful not so much in the choice of M.9 strain but in the planting system and tree spacings utilized with the particular M.9 strain.

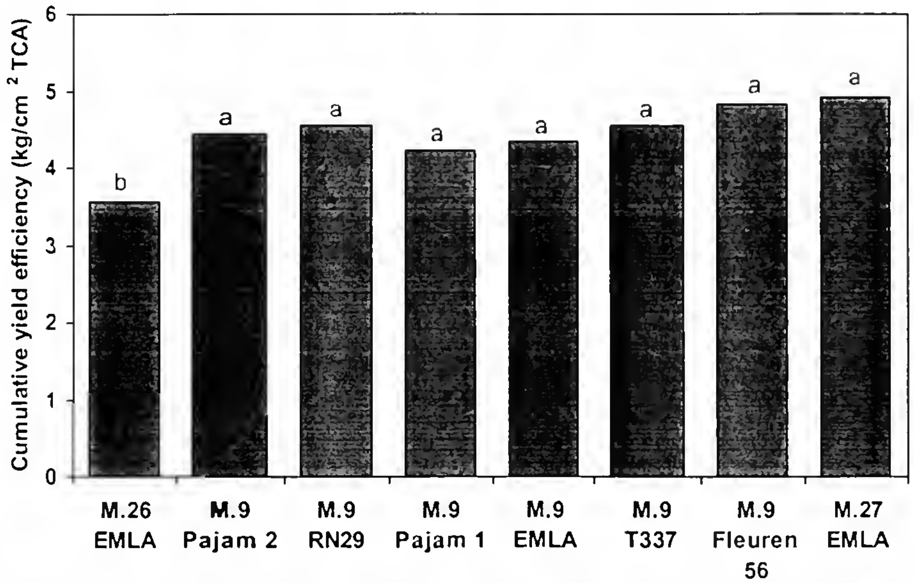

Figure 6. Cumulative yield efficiency of Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, over eight fruiting seasons. Bars topped by different letters are signficantly different at odds of 19:1.

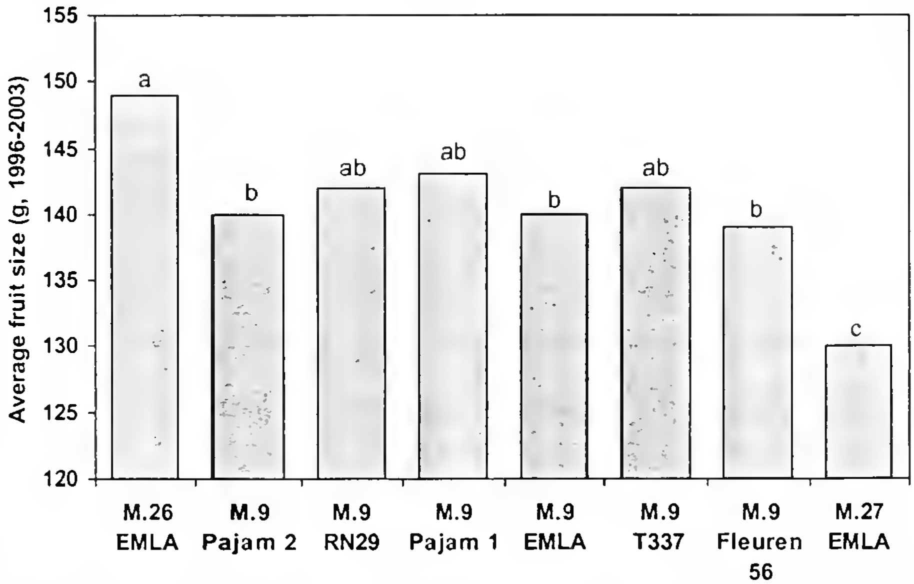

Figure 7. Average size of fruit harvested from Gala apple trees on various strains of M.9 and on M.26 EMLA and M.27 EMLA, over eight fruiting seasons. Bars topped by different letters are signficantly different at odds of 19:1.

* * * * *

Be Aware: Protection During Lightning Storms

George Cook
Extension Maple Specialist, University of Vermont

Lightning is a random and unpredictable event. Lightning strikes may generate electrical current levels that exceed 400 kA, temperatures that reach 50,000°F and hit at speeds approaching one-third the speed of light. Globally, some 2,000 ongoing thunderstorms cause about 100 lightning strikes to earth each second. Lightning causes more than 26,000 fires annually in the United States with damage to property in excess of $5 to 6 billion, according to the National Lightning Safety Institute.

Thunderstorms and lightning are most likely to develop on hot, humid days. Lightning is a frequent weather hazard impacting outdoor recreation and farm-work situations. If lightning is seen or heard, take protective action immediately. Being prepared can reduce the risk of the lightning hazard and raise safety levels.

Lightning Safety for Outdoor Workers

If you can see lightning or hear thunder, activate your safety plan. Resume activities only when lightning and thunder have not been observed for 30 minutes.

Advance planning is the single most important means to lightning safety. The following steps may help avoid injury. Designate a responsible person to monitor weather conditions. An inexpensive portable weather radio will provide regular weather condition updates. An emergency procedure should include: suspending activities, moving people to safety, monitoring conditions, then resuming activities. Identify safe locations beforehand. These include fully enclosed metal vehicles with windows up or substantial and permanent buildings. Unsafe areas include small structures, including huts and rain shelters, and nearby metallic objects like fences, gates, instrumentation, electrical equipment, wires and power poles. Also avoid trees, water, open fields, and using the (hard wired) telephone and headsets.

If outdoors, avoid water, high ground, and open spaces, get off farm machinery, get out of the water if you are swimming or boating, and avoid all metal objects including electric wires, fences, motors, power tools, clotheslines, metal pipes, rails, etc. Unsafe places include underneath canopies, small picnic or rain shelters, or near trees. However, standing under a group of trees, shorter than others in the area, is better than being in the open.

Put down any object that might conduct electricity, such as a rake, hoe, or shovel. Seek low ground, preferably a ditch or gully. If you are outside with no protection, get to a low spot. Make your body low to the ground, but do not lie flat on the earth. Learn the Lightning Safety Crouch. If hopelessly isolated from shelter during close-in lightning, adopt a low crouching position with feet together and hands on ears. If lightning is striking nearby when you are outside, you should assume the Lightning Safety Crouch.

Avoid proximity (minimum of 15 feet) to other people. If there is a group of people, spread out. If someone feels his or her hair stand on end, it may mean lightning is about to strike. Stay calm and keep low. This will help reduce your chances of being struck by lightning.

If indoors, avoid water, stay away from doors and windows, do not use the telephone, and take off

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headsets. Postpone baths, showers, and doing dishes until the storm passes. Turn off, unplug, and stay away from appliances, computers, power tools, and TV sets. Lightning may strike exterior electric and phone lines, inducing shocks to inside equipment. Computers should be surge protected. Suspend activities for 30 minutes after the last observed lightning or thunder.

Lightning-caused Hazards

Do not touch fallen wires. Report them to police or local utility immediately. If an appliance or tool catches fire, try to unplug it or turn off the current at the fuse box. Do not pour water on the fire. Use a Class C fire extinguisher, or throw baking soda on the fire. Before it gets out of control, call the local fire department and get everyone outside.

First Aid for Lightning Victims

People who have been struck by lightning do not carry an electrical charge and are safe to handle. Apply first aid immediately, if you are qualified to do so. Call 911, or send for help immediately.

Besides burns, lightning can also cause nervous system damage, broken bones, and loss of hearing or eyesight. Victims may experience confusion and memory loss. First aid for lightning victims needs to be carried out immediately. After the lightning strikes, get to the victim as quickly as possible. Check breathing and pulse, if the victim is unconscious. If the victim has a pulse, but is not breathing, begin mouth-to-mouth resuscitation. If there is no pulse, begin cardiopulmonary resuscitation (CPR). Check for other injuries, such as possible fractures. Do not move a suspected spinal-injury victim. Cover the electrical burn with a dry, sterile dressing, but do not cool the burn. There may be more than one burn area, one where the current entered the body and another where it left. Keep the victim from getting chilled until help arrives. If a person struck by lightning appears only stunned or otherwise unhurt, medical attention may still be needed. Check for burns, especially at fingers and toes, and areas next to buckles and jewelry. Make sure all lightning victims have a medical examination, even if they do not seem to need it.

Two helpful Web sites are http://lightningsafety.com/nlsi, which is the site for the National Lightning Safety Institute, and www.cdc.gov/nasd/, the National Ag Safety Database.

* * * * *

An Early Look at a Few of the Geneva Series Apple Rootstocks in Massachusetts

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Department of Plant & Soil Sciences, University of Massachusetts

The Cornell-Geneva Rootstock Breeding Program began in earnest in 1968 by Dr. Jim Cummins. Its goal was to produce rootstocks which resulted in a high degree of precocity, high productivity, size control, and resistance to pests. A particular focus of the program was to breed fireblight resistance into dwarfing rootstocks. Recent years have brought the release of a number of rootstocks from this program, but we have had very little experience with them in Massachusetts. The first significant trial including one of the recent releases was planted in 1998, and the next two were planted in 1999. This article will provide early results from these three trials. Please note that the first part of the rootstock name is "G" for those Cornell-Geneva rootstocks that have been commercially released. The names of those under trial but not yet released begin with "CG."

1998 NC-140 Apple Rootstock Trial

As part of the 1998 NC-140 Apple Rootstock Trial, a planting was established at the University of Massachusetts Cold Spring Orchard Research & Education Center, including Gala on M.9, M.9 EMLA, and G.16. Trees were staked and maintained as vertical axes. Trunk cross-sectional area, root suckering, yield, and fruit size were assessed annually.

After six growing seasons, trees on G.16 were larger than those on M.9 or M.9 EMLA (Table 1). Suckering has been low and comparable among the three rootstocks. Trees on G.16 yielded more cumulatively (1999-2003) than either strain of M.9, but yield efficiencies were similar. Average fruit size from 1999 through 2003 was smaller from trees on G.16 than from either M.9 strain.

Table 1. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 of Gala trees on various rootstocks in the Massachusetts planting of the 1998 NC-140 Apple Rootstock Trial.[z]

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (no./tree, 1998-2003)	Yield per tree (kg) 2003	Yield per tree (kg) Cumulative (1999-2003)	Yield efficiency (kg/cm^2 TCA) 2003	Yield efficiency (kg/cm^2 TCA) Cumulative (1999-2003)	Fruit weight (g) 2003	Fruit weight (g) Average (1999-2003)
G.16	17.8 a	0.4 a	15.7 a	40 a	0.97 a	2.26 a	131 a	104 b
M.9	11.7 b	0.3 a	6.5 a	24 b	0.56 a	2.05 a	162 a	132 a
M.9 EMLA	10.6 b	0.3 a	5.3 a	20 b	0.48 a	1.89 a	143 a	125 a

[z] Means within columns not followed by the same letter are significant at odds of 19:1.

Table 2. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 of McIntosh trees on several rootstocks in the Massachusetts planting of the 1999 NC-140 Dwarf Apple Rootstock Trial.

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (no./tree, 1999-2003)	Yield per tree (kg)		Yield efficiency (kg/cm^2 TCA)		Fruit weight (g)	
			2003	Cumulative (2001-03)	2003	Cumulative (2001-03)	2003	Average (2001-03)
CG.3041	16.4 cd	1.2 a	23.4 bcd	35 bcd	1.42 ab	2.14 ab	162 a	155 ab
CG.4013	29.9 a	1.2 a	42.0 a	66 a	1.41 ab	2.19 a	164 a	160 ab
CG.5179	21.9 bc	0.7 a	30.5 ab	49 ab	1.40 ab	2.25 a	165 a	158 ab
CG.5202	25.2 ab	0.0 a	31.3 ab	49 ab	1.29 ab	2.01 ab	161 a	160 ab
G.16N	13.3 d	0.0 a	16.0 bcd	26 bcd	1.12 ab	1.82 ab	154 a	147 ab
G.16T	14.6 cd	0.2 a	17.6 bcd	28 bcd	1.22 ab	1.95 ab	145 a	144 ab
M.26 EMLA	16.5 cd	0.0 a	15.0 cd	20 cd	0.88 b	1.19 b	162 a	158 ab
M.9 NAKBT337	9.2 d	0.0 a	11.4 d	17 d	1.25 ab	1.89 ab	173 a	169 a
Supporter 1	11.8 d	0.0 a	19.5 bcd	30 bcd	1.63 a	2.42 a	145 a	139 ab
Supporter 2	15.3 cd	0.6 a	25.2 bcd	37 bcd	1.66 a	2.50 a	141 a	134 b
Supporter 3	16.3 cd	0.0 a	25.3 bc	41 bc	1.56 a	2.53 a	145 a	146 ab

[z] Means within columns not followed by the same letter are significant at odds of 19:1.

Table 3. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 of McIntosh trees on several rootstocks in the Massachusetts planting of the 1999 NC-140 Semidwarf Apple Rootstock Trial.

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (no./tree, 1999-2003)	Yield per tree (kg)		Yield efficiency (kg/cm^2 TCA)		Fruit weight (g)	
			2003	Cumulative (2001-03)	2003	Cumulative (2001-03)	2003	Average (2001-03)
CG.4814	13.1 c	11.2 ab	24.3 ab	37 ab	1.87 a	2.82 a	175 a	154 a
CG.7707	16.8 c	3.5 bc	20.3 b	29 bc	1.20 ab	1.73 b	175 a	168 a
G.30N	31.5 a	0.5 bc	37.9 a	53 a	1.25 ab	1.71 b	175 a	169 a
M.26 EMLA	15.3 c	0.0 c	13.7 b	19 c	0.88 b	1.23 b	177 a	168 a
M.7 EMLA	30.6 ab	15.2 a	23.2 b	30 bc	0.75 b	0.96 b	153 a	163 a
Supporter 4	29.7 b	1.2 bc	22.6 b	32 bc	0.79 b	1.12 b	164 a	169 a

[z] Means within columns not followed by the same letter are significant at odds of 19:1.

1999 NC-140 Dwarf Apple Rootstock Trial

As part of the 1999 NC-140 Dwarf Apple Rootstock Trial, a planting was established at the University of Massachusetts Cold Spring Orchard Research & Education Center, including McIntosh on CG.3041, CG.4013, CG.5179, CG.5202, G.16 (both tissue cultured and stool bedded), M.26 EMLA, M.9 NAKBT337. Supporter 1. Supporter 2, and Supporter 3. Trees were individually staied and maintained as vertical axes. Trunk cross-sectional area, root suckering, yield, and fruit size were assessed annually.

After five growing seasons, trees on CG.4013 were the largest, followed by those on CG.5202 and CG.5179 (Table 2). The rest had statistically similar trunk cross-sectional areas. Cumulative yield (2001-03) was greatest for trees on CG.4013. Across all rootstocks, however, yield was roughly related to tree size. Cumulative yield efficiency (adjusting yield for tree size) was similar for all but trees on M.26 EMLA. Those trees were significantly less efficient than trees on CG.4013. CG.5179, or any of the Supporter rootstocks. Fruit size was not dramatically affected by rootstock. The only statistically significant difference was that fruit from trees on M.9 NAKBT337 were larger than those from trees on Supporter 2.

1999 NC-140 Semidwarf Apple Rootstock Trial

As part of the 1999 NC-140 Semidwarf Apple Rootstock Trial, a planting was established at the University of Massachusetts Cold Spring Orchard Research & Education Center, including McIntosh on CG.4814, CG.7707, G.30. M.26 EMLA, M.7 EMLA, and Supporter 4. Trees were maintained as free-standing central leaders. Trunk cross-sectional area, root suckering, yield, and fruit size were assessed annually.

After five growing seasons, trees on G.30 were significantly larger than all other except those on M.7 EMLA (Table 3). The smallest tree was on CG.4814, which was obviously misplaced in the semidwarf group. Its trunk cross-sectional area, yield, and yield efficiency were similar to the dwarf trees in the trial reported above. G.30 resulted in many fewer root suckers than did M.7 EMLA, and had significantly greater yield per tree (2001-03). Although the difference was not statistically significant, trees on G.30 were 75% more efficient than those on M.7 EMLA. Fruit size was apparently unaffected by rootstock.

Conclusions

It is much too early to make conclusions based on the data reported here. The variability that exists now will dissipate over the next few years and expose more statistically significant differences. That said, G.16 appears to be producing a tree somewhat larger than does M.9 but one that is comparably yield efficient. Fruit size from trees on G.16, however, bears watching. Trees on G.30 have performed very well for semidwarf trees, similar in size to those on M.7 EMLA, but without many root suckers and with apparently greater yield. The other Cornell-Geneva rootstocks in these trials (CG.3041, CG.4013, CG.4814, CG.5179, CG.5202, and CG.7707) all appear to be performing well but vary considerably in size, from full dwarf to semidwarf.

* * * * *

How Does B.9 Stack Up Compared to M.9?

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Department of Plant & Soil Sciences, University of Massachusetts

In a previous article (pp. 22-25 in this issue), the various M.9 apple rootstock strains were compared. These were part of the 1994 NC-140 Apple Rootstock Trial, with Gala as the scion. Budagovsky 9 (B.9) was also part of that trial, planted in 1994 and maintained for 10 years.

In this brief article, the data for B.9, M.9 Fleuren 56 (the smallest M.9 strain in the trial), and M.9 Pajam 2 (the largest M.9 strain in the trial) are presented (Figure 1). After 10 growing seasons, trees on B.9 were comparable in size to those on M.9 Fleuren 56 but significantly smaller than those on M.9 Pajam 2. Root suckering from B.9 was lower than from M.9 Pajam 2. Yield of trees on B.9 was comparable to trees on M.9 Fleuren 56 and lower than trees on M.9 Pajam 2. B.9 resulted in yield efficiency and fruit size similar to the two M.9 strains.

Over the 10 years of this trial, B.9 performed well, producing a small M.9-sized tree with similar yield characteristics. We now have 20 years experience with B.9 and have no negative aspects of the rootstock to report.

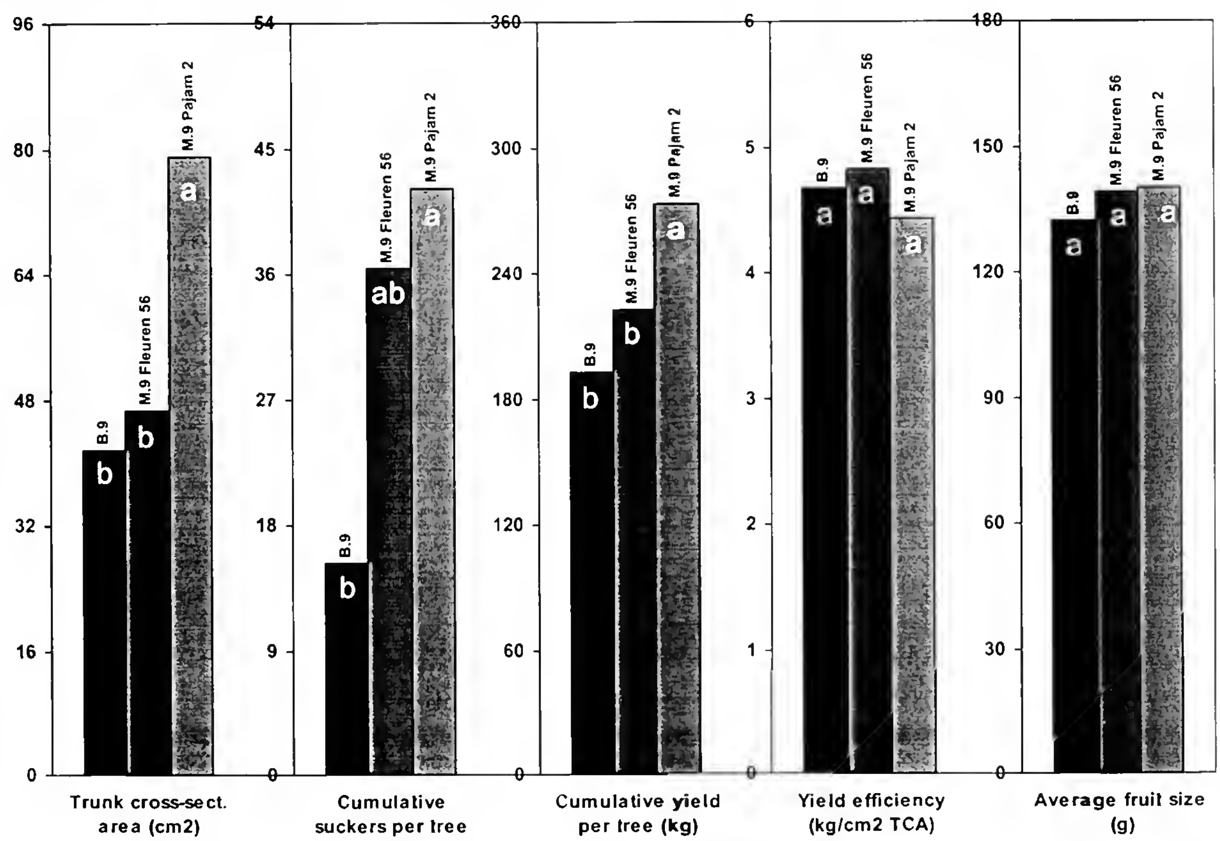

Figure 1. Trunk cross-sectional area, root suckering, yield, yield efficiency, and fruit size of Gala apple trees on B.9, M.9 Fleuren 56, and M.9 Pajam 2, after 10 growing seasons. Bars with different letters are significantly different at odds of 19:1.

Fruit Notes

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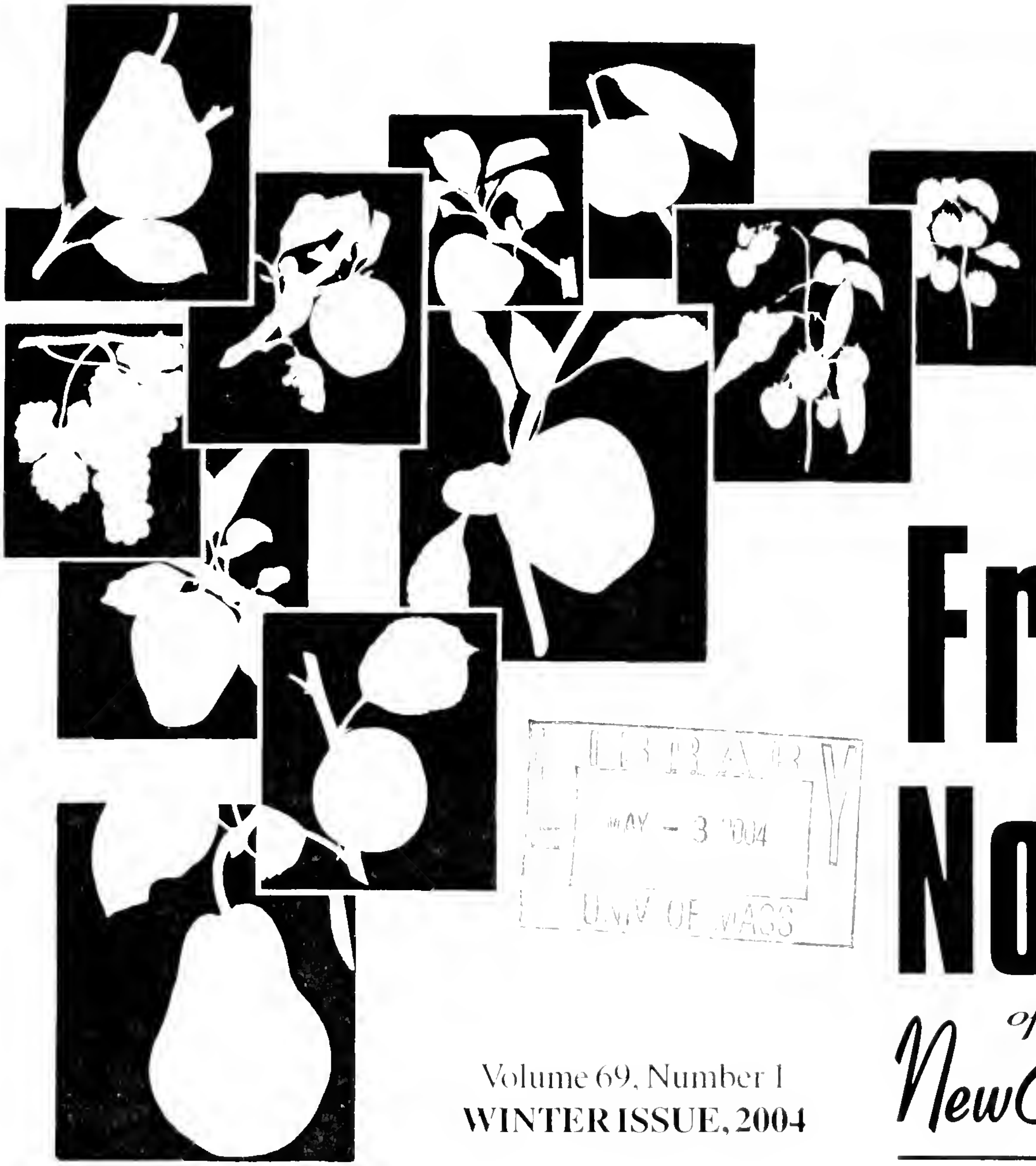

Fruit Notes of New England

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Fruit Notes of New England

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Effectiveness of Peripheral-row vs. All-row Sprays against Plum Curculio

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Studies by Chouinard et al. (1992) and Vincent et al. (1997) suggest that spraying only peripheral rows of trees as opposed to all rows of trees can be an effective approach to plum curculio (PC) control in many Quebec apple orchards. This approach is rooted in the presumption that most PCs overwinter in woods or hedgerows outside of orchards and when entering orchards in spring do not move beyond peripheral rows of apple trees before settling down to feed and lay eggs. The proportion of overwintering PCs that satisfies this presumption under New England conditions is uncertain. Such uncertainty invites evaluation of peripheral-row vs. all-row sprays against PC in New England orchards.

Here, in 2003 in one orchard in Vermont and two orchards in New Hampshire, we compared three different approaches to spraying PC that differed in location of trees (peripheral vs. interior rows) designated to receive sprays.

Materials & Methods

There were three experimental plots in each orchard. Each plot contained seven rows of apple trees. The perimeter row of each plot bordered woods. All rows within a plot were of the same length (80-120 yards). All plots in the same orchard received the same insecticide at each spray event against PC: Avaunt in orchard X and Guthion in orchards Y and Z (each at label-recommended rate).

Treatment protocols in each orchard were as follows:

Plot	Petal fall spray	1st & 2nd cover spray
A	All rows	All rows
B	All rows	Rows 1 and 2
C	Rows 1 and 2	Rows 1 and 2

The petal fall spray was applied within 5 days after 90% petal fall (June 1, June 4, and June 8, respectively, for orchards X, Y, and Z). The first cover spray was applied when fruit on odor-baited trap trees reached a pre-determined threshold of two fresh egglaying scars out of 100 fruit sampled beginning 7 days after the last insecticide spray. A trap tree baited with one dispenser of attractive pheromone (grandisoic acid) plus four dispensers of attractive fruit odor (benzaldehyde) was located at the center of the perimeter row of each plot. In all, 33 or 34 fruit were sampled twice per week on each trap tree, giving a total of 100 fruit per sampling date across all three trap trees in an orchard. In response to sampling information, the first cover spray was applied on June 15 in each orchard. Sampling fruit on trap trees indicated no need to apply a second cover spray in orchards X and Y, whereas orchard Z received a second cover spray on

Table 1. Effectiveness of different spray treatment protocols for controlling plum curculio (PC) in three commercial apple orchards.

	Fruit with PC injury (%)*		
Orchard	Plot A**	Plot B**	Plot C**
X	1.7	1.9	2.0
Y	0.9	0.3	1.1
Z	0.3	1.0	6.5
Average	1.0a	1.1a	3.2a

* Average values followed by the same letter are not significantly different at odds of 19:1.
** Plot A: all rows sprayed at petal fall and first and second cover. Plot B: all rows sprayed at petal fall; only rows 1 and 2 sprayed at first/second cover. Plot C: only rows 1 and 2 sprayed at petal fall and first and second cover.

June 23. For spray applications only to rows 1 and 2, the tractor was driven outside of row 1 and between rows 1 and 2.

On June 26, we sampled 100 fruit in each of the seven rows in each plot for signs of any PC injury.

Results

Data in Table 1 show that across all three orchards, plot-wide injury to fruit by PC averaged 1.0, 1.1, and 3.2% for plots A, B, and C, respectively. Although these values did not differ significantly from one another, injury trends were similar for each orchard, with plot C always showing the greatest injury.

Conclusions

Results from this experiment indicate that applying a petal fall spray against PC only to peripheral rows 1 and 2 (as in plot C) is unlikely to provide effective orchard-wide control. However, applying a petal fall spray to all rows followed by subsequent sprays only to rows 1 an 2 (as in plot B) appears to be just as effective as applying a petal fall spray and subsequent sprays to all rows (as in plot A).

Our data from 2003, therefore, suggest the PC behavior and ecology might be slightly different in New England compared with Quebec, possibly due to the colder climate of Quebec. It seems that either more PCs overwinter within orchards in New England than in Quebec or that, prior to petal fall, more PCs move deeper into orchards in New England than Quebec after emerging from overwintering sites in woods (see the next two articles in this issue of *Fruit Notes* for further information on these two questions). Whichever, based on results here, we tentatively recommend that growers apply insecticide against PC to the entire orchard at or shortly after petal fall and spray only peripheral rows 1 and 2 in subsequent treatments against PC.

We recognize that data from trials in only three orchards provide a somewhat thin foundation for the above recommendation. We therefore plan to repeat this experiment in these same orchards in 2004.

Acknowledgements

Many thanks to Zeke Goodband, Erick Leadbeater, and Steve Wood for participating in this experiment and to Lupita Trujillo and Mareana Ricci for assistance in sampling. This study was supported by a grant from the USDA Crops at Risk Program.

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Are Adult Plum Curculios Capable of Overwintering Within Apple Orchards?

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In the preceding article on the effectiveness of peripheral-row vs. all-row sprays against plum curculio (PC), results indicated that spraying only peripheral rows of apple trees beginning at petal fall was insufficient for adequate orchard-wide control of PC. Two reasons, alone or in combination, were put forward to explain this insufficiency: (1) enough PCs overwintered within the interior of commercial orchards (inside of peripheral rows) to cause excessive fruit injury on interior trees that were left untreated against PC, and (2) excessive fruit injury on interior trees was caused by PCs that overwintered in woods and hedgerows and penetrated into interior rows before a petal fall spray was applied to peripheral rows.

Here, we report results of an experiment conducted in 2003 aimed at addressing the first explanation. We asked whether PCs were able to overwinter successfully inside of two blocks of a commercial orchard in Massachusetts that differed primarily with respect to type of management (weed control).

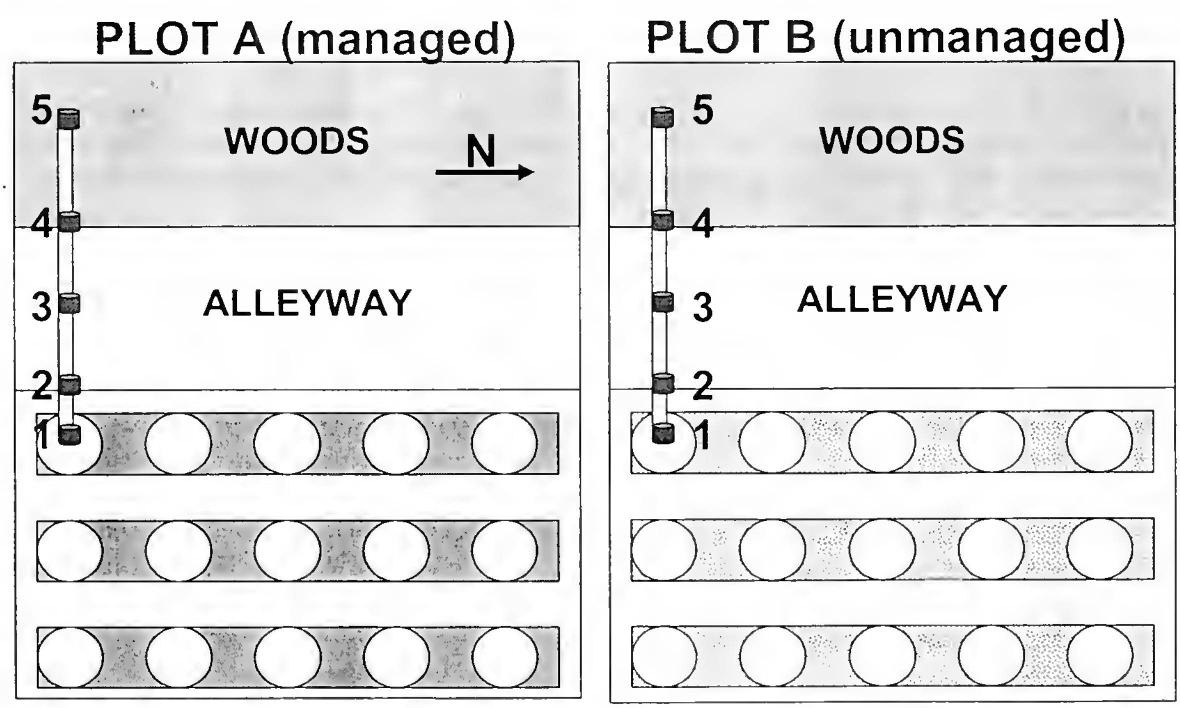

Figure 1. Representation of trap deployment in Plot A (subjected to weed management) and Plot B (not subjected to weed management) to determine distribution of PC overwintering in 2003. For each plot, 60 emergence traps were arranged in 12 transects (only one transect is shown). Each transect consisted of five emergence traps located at different sites (denoted as 1-5) along each transect.

Materials & Methods

Study site. This study was performed during April-June of 2003 in two unsprayed plots of a commercial apple orchard (University of Massachusetts Cold Spring Orchard Research & Education Center, Belchertown, MA) that differed in level of management. For each plot, the perimeter row selected for our experiment had a similar length (about 150 yards) and orientation (west). For each plot there was an alleyway (about 20 yards width) separating perimeter-row trees from woods (which were composed primarily of deciduous trees) (Figure 1). These two alleyways were mowed in August, 2002.

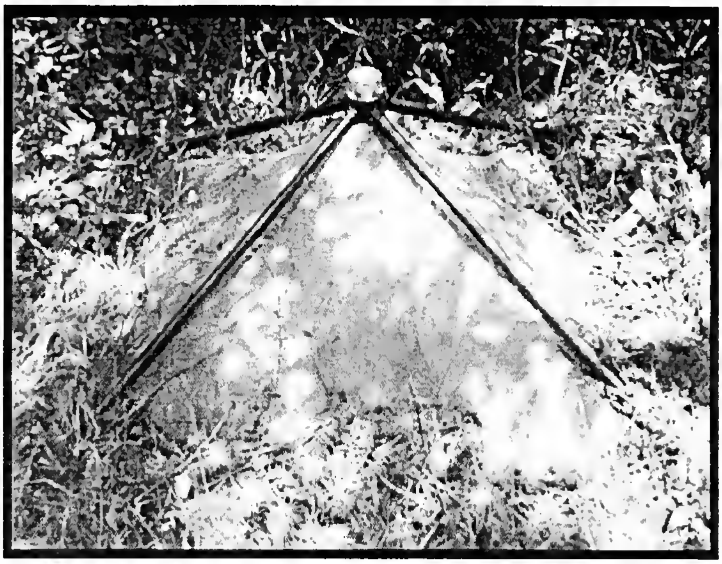

Figure 2. Depiction of a pyramidal emergence trap used for the determination of PC overwintering within two orchard plots in Massachusetts. Trap dimensions: 1.1 x 1.1 yards at base. Traps were purchased from Pest Management Innovations (Harpers Ferry, WV).

In the first plot (Plot A), fungicides, insecticides, and herbicides were applied throughout 2002. Thus, area beneath tree canopies was devoid of vegetation. At the time of trap deployment in plot A (see below), approximately 120 fruit (from the previous year) were present beneath each tree. The second plot (Plot B) was not managed, with no insecticide, herbicide, or fungicide applied for at least 6 years. Thus, there were tall grass and other vegetation growing beneath tree canopies. In this plot, there were fewer fruit present beneath each tree (approximately 30) than in Plot A due to low fruit load the previous year (2002).

Trap deployment. For our study, we used pyramidal emergence traps (depicted in Figure 2) that were 1.1 x 1.1 yards at base and were made of PVC and steel screen. Traps were purchased from Pest Management Innovations (Harpers Ferry, WV). A plastic device topping each trap permitted the capture of PCs that, upon emergence from hibernation, walked upward on the interior surface of the trap.

For each plot, 60 emergence traps were deployed in 12 transects. Each transect consisted of five emergence traps arranged in the following manner: (1) a trap placed next to the trunk of a perimeter-row tree (denoted perimeter-row trap), (2) a trap placed in the alleyway, in close proximity to the edge of the canopy of a perimeter-row tree (denoted canopy-edge trap), (3) a trap placed in the alleyway, midway between perimeter-row trees and woods (denoted alleyway trap), (4) a trap placed at the edge of woods (denoted woods-edge trap), and (5) a trap placed 6-8 yards inside the woods (denoted woods-interior trap) (see Figure 1). Traps were deployed in such a way that no PCs emerging in the area covered by a trap could exit, and no PCs could enter a trap from the outside.

Traps were deployed on April 15 (at the silver tip stage). Each trap was baited with one PC pheromone dispenser (releasing 1 mg of grandisoic acid per day) to draw PCs towards the capturing device. All traps were inspected for PCs two to three times per week until late June.

Results

Figure 3 reveals that for the plot subjected to weed management (plot A), 50% of the total number of PCs was captured by perimeter-row traps, whereas 36% of the total was captured by woods-interior traps. For the unmanaged plot (plot B), 62% of the total number of PCs was captured by perimeter-row traps, whereas 25% of the total was captured by woods-interior traps. For both plots, canopy-edge and woods-edge traps

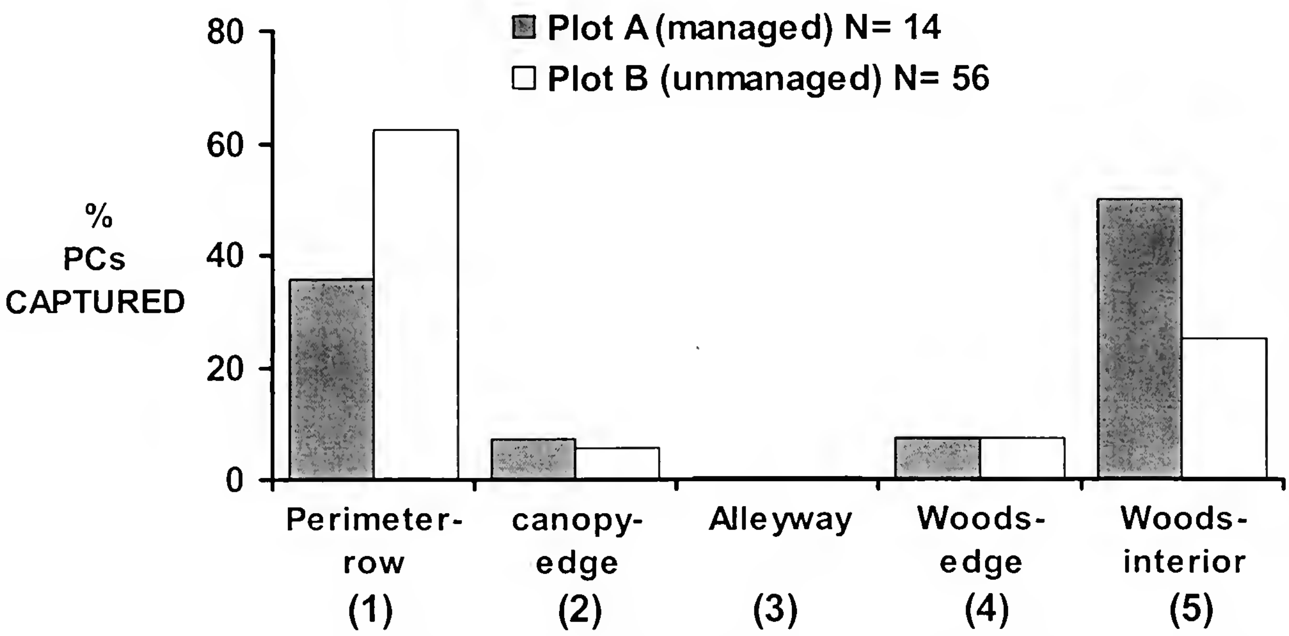

Figure 3. Distribution of PC overwintering that took place within two apple orchard plots in Massachusetts that differed in type of weed management. For each plot, "N" refers to the total number of PCs captured across all (60) emergence traps.

caught low percentages of PCs (5-7%) relative to the total number of PCs captured across all traps. For both plots, no PCs were found in traps located in the alleyways.

Conclusions

Based on our results, we conclude that (1) PCs are able to overwinter inside apple orchards in Massachusetts, and (2) extent of overwintering seems to be influenced by type of weed management. Our findings, when combined with those reported by researchers in Quebec (e.g., LaFleur et al., 1987), suggest that geographical zone along with weather conditions prevalent in a given year, in particular during late summer and early autumn when PCs seek overwintering sites, might also influence the distribution of overwintering PCs. We plan to repeat this study in 2004 to determine if results presented here are consistent over a two-year period.

Acknowledgments

This study was supported with funds provided by a USDA Northeast Regional IPM grant, a Hatch grant, a grant from USDA Crops at Risk program, and the New England Tree Fruit Research Committee.

Literature Cited

Lafleur, G., Hill, S.B., and Vincent, C. 1987. Fall migration, hibernation site selection, and associated winter mortality of plum curculio (Coleoptera: Curculionidae) in a Quebec apple orchard. *Journal of Economic Entomology* 80: 1152-1172.

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Extent of Early-season Plum Curculio Penetration into Commercial Apple Orchards

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In the first article in this issue of *Fruit Notes*, we evaluated the effectiveness of peripheral-row vs. all-row sprays in controlling plum curculios in New England apple orchards. We proposed two possibilities to explain why confining sprays exclusively to peripheral rows led to unacceptable PC control. In the preceding article, we provided information supporting the first possibility: some PCs are able to overwinter inside of orchards, and thereby they may escape sprays applied only to peripheral rows against immigrant adults. We suggested that one of the main factors influencing the amount of overwintering inside orchards might be type of orchard management, such as presence of vegetation beneath orchard trees, particularly during the period of time at which adult PCs seek overwintering sites in the autumn. Here, we report results of a study conducted in 2003 aimed at addressing the second possibility. We asked whether PCs overwintering in woods or hedgerows outside of orchards move into interior rows of orchards before petal fall and thereby escape effects of petal fall and subsequent sprays when they are confined only to peripheral rows.

Materials & Methods

This study was performed during April/May of 2003 in eight commercial apple orchards in Massachusetts. Within each orchard, blocks selected had similar length (about 200 yards of perimeter-row trees) and depth (at least 80 yards). For each block, trees used were of a particular size: either large (M.7 rootstock), medium (M.26 rootstock), or small (M.9 rootstock).

For this study we used Circle traps (originally developed by Edmund Circle, a pecan grower in Oklahoma), which are made of either aluminum or vinyl-coated polyester screen with a PC-capturing device integrated on top. Traps are wrapped around the base of tree trunks so as to completely encircle the trunk, thereby intercepting adults walking upward.

For each selected block, 20 Circle traps were deployed on April 24 (at the green-tip tree stage) on trees located in the central part (about 60-70 yards in length) of each orchard to minimize potential penetration of PCs from the lateral or back sides (Figure 1). For each block, traps were arranged in four transects of five traps each, starting on perimeter-row trees. Because there were different inter-row distances and tree densities due to the different tree sizes, blocks having large trees received traps deployed in consecutive rows (1-5), blocks having medium-sized trees received traps deployed in rows 1, 3, 5, 7, and 9, and blocks having small trees received traps deployed in rows 1, 4, 7, 10, and 13. Under this approach, traps were deployed at similar distances inside a block: on perimeter-row trees (A), and on trees about 12, 22, 32 and 42 yards inside of perimeter-row trees (B-E) (Figure 1).

On May 8 (at mid-pink), traps corresponding to two of the four transects in each block were baited with one dispenser of PC pheromone (grandisoic acid, releasing 1 mg per day) (GA) in association with one dispenser releasing the attractive host plant odor benzaldehyde (BEN) at a very low release rate (2.5 mg/day). Traps for the two remaining transects per block were left unbaited (Figure 1). Results show combined captures (baited + unbaited traps) because no differences in captures by either baited or unbaited traps were found. All traps were inspected for PCs on

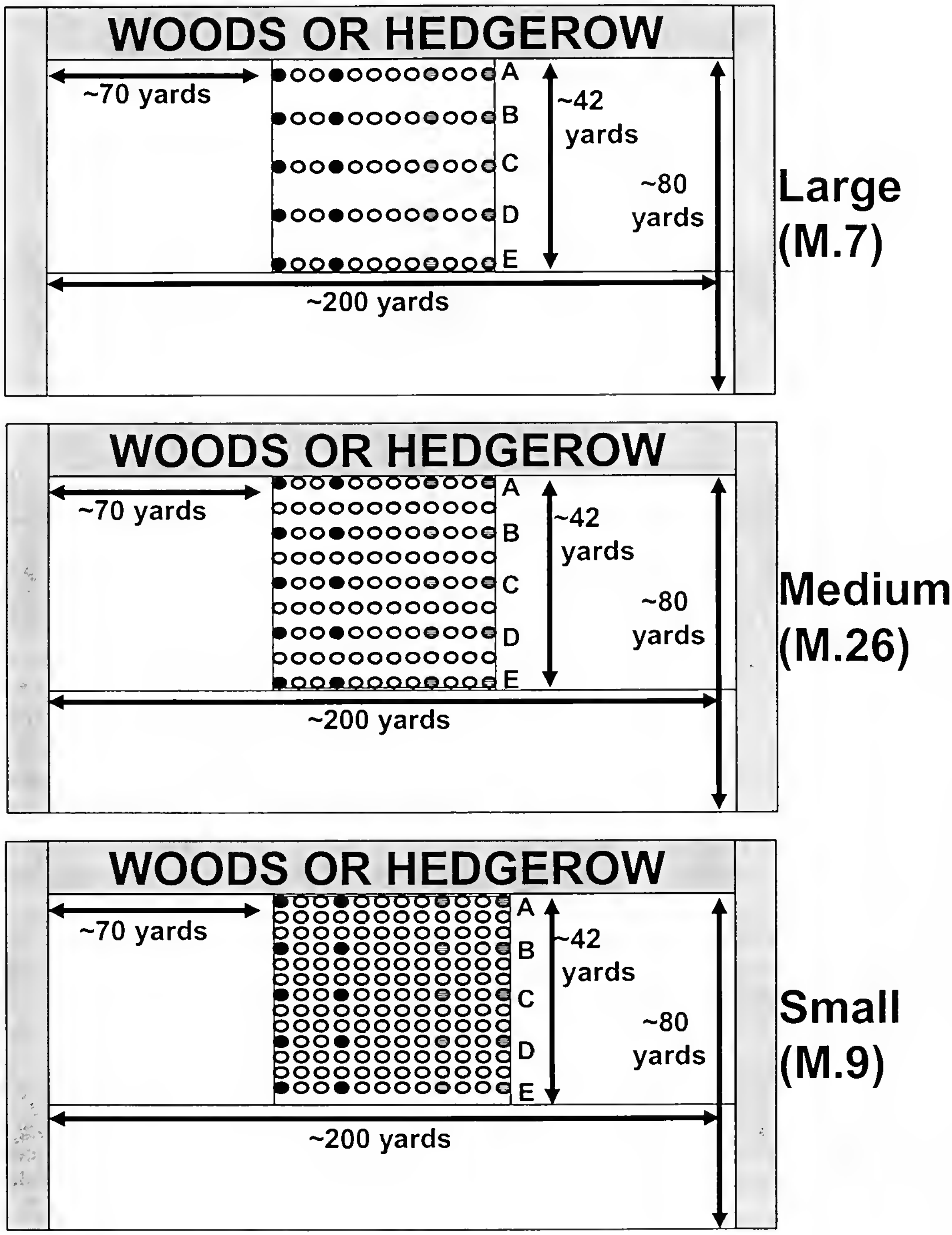

Figure 1. Layout of trap deployment in eight blocks of commercial apple orchard trees in Massachusetts, according to tree size. For each block, 20 Circle traps were deployed, arranged in four transects each having five traps (shown as A-E). Of the 20 traps used per block, ten were baited (denoted as closed circles) and 10 remained unbaited (denoted as hatched circles).

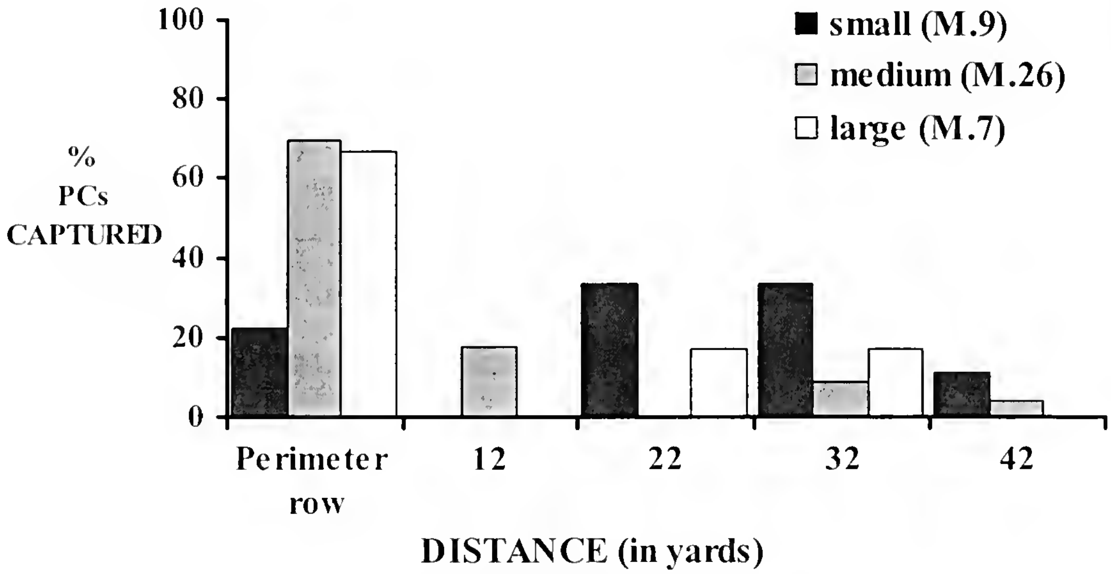

Figure 2. Distribution of overwintered PCs that penetrated into commercial orchard blocks according to tree size and distance (from perimeter-row trees) at which Circle traps were deployed (20 traps per orchard block).

May 23-24, just after the petal fall spray of insecticide against PC. Thus, results show captures that occurred during a two-week period.

Results

Figure 2 reveals that extent of PC penetration into commercial orchard blocks varied considerably according to tree size. For blocks having large and medium trees, most PCs were captured by Circle traps located on perimeter-row trees (about 70 and 67%, respectively). For blocks having small trees, most PCs (about 78%) penetrated into interior rows.

Conclusions

Based on our findings, we conclude that by petal fall: (1) most PCs were congregated on perimeter-row trees in blocks of large or medium-sized trees (M.7 or M.26 rootstock), and (2) a substantial number of PCs was able to penetrate inside blocks (at least up to 42 yards in our study) where trees were small (M.9 rootstock). An alternative explanation is that PCs may have overwintered within rather than penetrated into interiors of some blocks. Our results here, when combined with findings reported in the preceding article, may explain why growers who might limit all insecticide application against PC exclusively to peripheral-row trees would attain unacceptable PC control. We aim to repeat this study in 2004 to corroborate our findings here.

Acknowledgments

We are grateful to Keith Arsenault, Gerry Beirne, Bill Broderick, Aaron Clark, Don Green, Tony Lincoln, Joe Sincuk, and Steve Ware for permitting use of orchards for this study. This work was supported by funds from a USDA Northeast Regional IPM grant, a USDA Northeast Regional SARE grant, a Hatch grant, and a USDA Crops at Risk grant.

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Establishing Characteristics of Odor-baited Trap Trees for Monitoring Plum Curculio

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In the three preceding articles in this issue of *Fruit Notes*, evidence was presented that enough plum curculio (PC) adults are present on interior rows of apple trees at petal fall to justify a petal fall application of insecticide to all rows of an orchard block rather than just peripheral rows. In the first article, evidence was also presented to suggest that following a petal fall application of insecticide, subsequent insecticide applications against PC (first/second cover sprays) can provide effective block-wide control if confined only to perimeter rows 1 and 2. The question now arises as to which blocks in an orchard require cover-sprays for perimeter rows and what is the best timing for such perimeter-row sprays.

In the 2003 Winter issue of *Fruit Notes*, we reported that perimeter-row apple trees baited with a combination of synthetic attractive pheromone (grandisoic acid) plus synthetic attractive fruit odor (benzaldehyde) could function as "trap trees" that aggregated PC injury. We suggested that sampling for PC injury to ascertain where and when to apply perimeter-row sprays could be restricted to trap trees rather than spread out among many different trees in a block.

Here, we present results of 2003 experiments addressing five questions relevant to practical implementation of an odor-baited trap tree approach to monitoring PC: (1) what are optimum amounts of grandisoic acid (GA) and benzaldehyde (BEN) to deploy per trap tree; (2) over what distances do trap trees act to aggregate injury to fruit by PCs; (3) does a trap tree at the intersection of two perimeter rows (i.e., at a corner) outperform one midway along a perimeter row; (4) within a trap tree, is fruit injury likely to be greatest in the vicinity of the odor source; and (5) within a trap tree, where should a grower or consultant examine fruit to gain a representative sample of injury?

Materials & Methods

For all experiments, odor-baited trap trees were located on perimeter rows of blocks of commercial-orchard apple trees in Massachusetts. Tree size, spacing, and cultivar composition were the same for all treatments within a replicate, but these characteristics varied among replicates and experiments. Perimeter-row trees received three or four grower-applied sprays of Guthion or Imidan at label-recommended rate for PC control. Applications commenced in late May, shortly after petal fall and ended in mid or late June.

BEN was introduced into 15 ml capped polyethylene vials in the amount of 8 ml of liquid per vial: 9 parts BEN plus 1 part of 1, 2, 4-trichlorobenzene as stabilizing agent. Each vial was suspended by wire inside of an inverted red plastic drinking cup to minimize potential negative impact of ultraviolet light on the stability of BEN. Both cup and vial were suspended by wire protruding through the bottom of the inverted cup. Vials deployed in this manner were found to release about 10 mg per day of BEN per vial. Each dispenser of pheromone was designed by the manufacturer to release about 1 mg per day of GA. All dispensers of attractive odor were deployed during bloom of apple trees (mid-May) and remained (unrenewed) for 7 weeks (through late June), when all experiments ended. Unless indicated otherwise, each trap tree received four dispensers of BEN plus one dispenser of GA hung at head height near the tree trunk.

In all experiments, PC response to treatments was assessed by examining fruit for signs of ovipositional injury, which comprises 90% or more of all injury to apples by PC. Sampling in each experiment occurred once during each of 4 weeks in June, beginning when fruit averaged 9 mm diameter and ending when fruit averaged 31 mm diameter. Unless indicated otherwise, sampling was accomplished by selecting haphazardly (at approximately head height and in an evenly-spaced manner as possible) 20 fruit from the outer half of the canopy and 20 fruit from the inner half of the canopy of each designated tree. Unless indicated otherwise, a fruit was classified as injured if an ovipositional scar was fresh. Fresh scars were those considered to have been made within the past 7 days (see pictures in the last article in this issue of *Fruit Notes)*. We chose to record only fresh scars because it is the appearance of fresh scars (not older scars) that ought to drive a grower's decision to apply insecticide for PC control.

Experiment 1: Amount of Odor. In 13 blocks of orchard trees, each having a perimeter row at least 225 yards long bordered by continuous woods or hedgerow, we selected nine treatment trees spaced 33 yards apart for evaluation of optimum amount of odor to deploy in a trap tree. Four of the trees received one dispenser of GA plus one, two, four or eight dispensers of BEN. Four other trees received two dispensers of GA plus one, two, four or eight dispensers of BEN. One tree remained unbaited. Within each block, treatments were randomized in position.

Experiment 2: Distance of Response. In 18 blocks of orchard trees, each having a perimeter row at least 90 yards long bordered by continuous woods or hedgerow, we chose one tree at the approximate center of the perimeter row to be the odor-baited trap tree (no other tree received odor bait). The degree to which ovipositional injury on perimeter-row trees was aggregated on the trap tree was determined by comparing the proportion of sampled fruit injured on the trap tree with that injured on each of four perimeter-row trees to the right and each of four perimeter-row trees to the left of the trap tree. Such trees were 7-9, 15-17, 25-27, or 34-36 yards the right or left of the trap tree.

Experiment 3: Trap Tree Location along Perimeter Row. In 10 square blocks of orchard trees, each having three perimeter rows about 90 yards long bordered by continuous woods or hedgerow, we chose as odor-baited trap trees two corner trees and two other perimeter-row trees midway between and about 45 yards from corner trees. We compared incidence of fresh ovipositional injury on corner trees vs. midway trees.

Experiment 4: Nearness of Injury to Odor Source. In eight blocks of large orchard trees (M.7 rootstock), each having a perimeter row bordered by continuous woods or hedgerow, we chose four perimeter-row trees as trap trees. For each of the 32 trees, we randomly assigned one quadrant to receive BEN plus GA and the opposite quadrant to remain

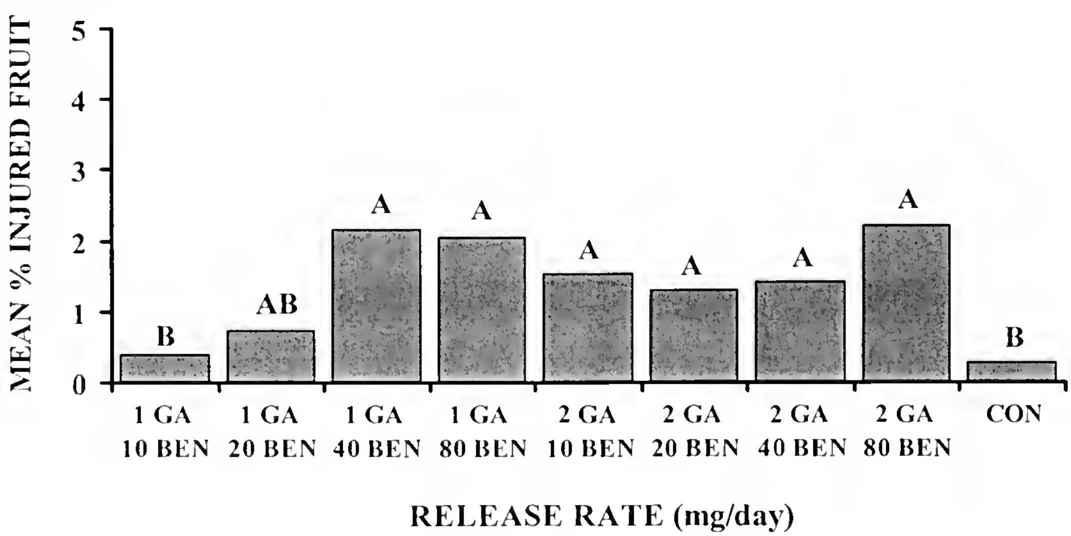

Figure 1. Mean percent of sampled fruit on perimeter-row trap trees baited with different amounts of grandisoic acid (GA) and benzaldehyde (BEN) or unbaited (CON) that received fresh ovipositional injury by plum curculio. Means superscribed by the same letter are not significantly different at odds of 19:1.

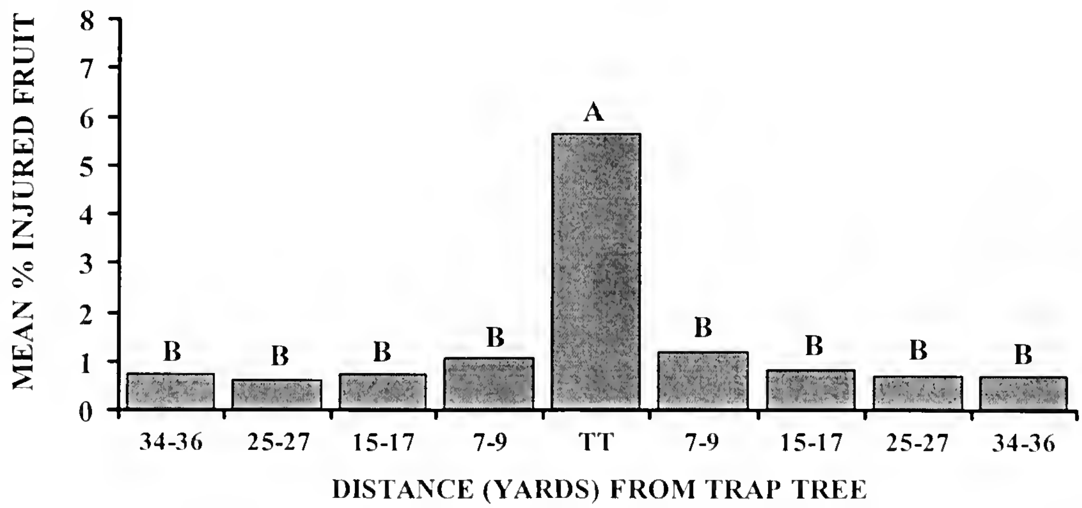

Figure 2. Mean percent of sampled fruit on a perimeter-row trap tree (TT) baited with grandisoic acid (1 mg/day) plus benzaldehyde (40 mg/day) and on perimeter-row unbaited trees at varying distances from the trap tree that received fresh ovipositional injury by plum curculio. Means superscribed by the same letter are not significantly different at odds of 19:1.

unbaited. Within a quadrant, lures were positioned at head height within an imaginary circle about 1 yard from the outermost canopy foliage and 4-5 yards distant from a corresponding imaginary circle on the opposite side of the tree. To assess incidence of ovipositional injury near and far from the source of odor, we examined 20 apples in each of the two imaginary circles.

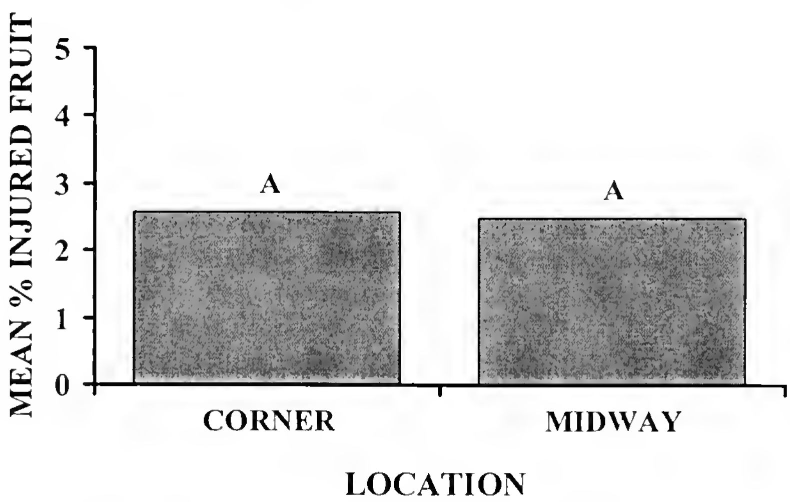

Figure 3. Mean percent of sampled fruit on perimeter-row trap trees baited with grandisoic acid (1 mg/day) plus benzaldehyde (40 mg/day) located at corners of orchard blocks (intersection of two perimeter rows) vs. midway between and at least 45 yards distant from corner trees that received fresh ovipositional injury by plum curculio. Means superscribed by the same letter are not significantly different at odds of 19:1.

Experiment 5: Representative Sample of Injured Fruit within Trap Trees. In each of eight blocks of 18 large-size (M.7 rootstock) apple trees, we chose three perimeter-row trap trees. We examined 20 fruit at head height in the outer half of the canopy, 20 fruit at head height in the inner half of the canopy, and 20 fruit in the upper central part of the canopy in each tree for evidence of ovipositional injury. Sampling was confined to the last week of June. For this experiment, fruit with fresh as well as older damage was counted as injured.

Results

In the first experiment, there were no significant differences in amounts of fresh injury among trap trees baited with one dispenser of GA plus four or eight dispensers of BEN and trap trees baited with two

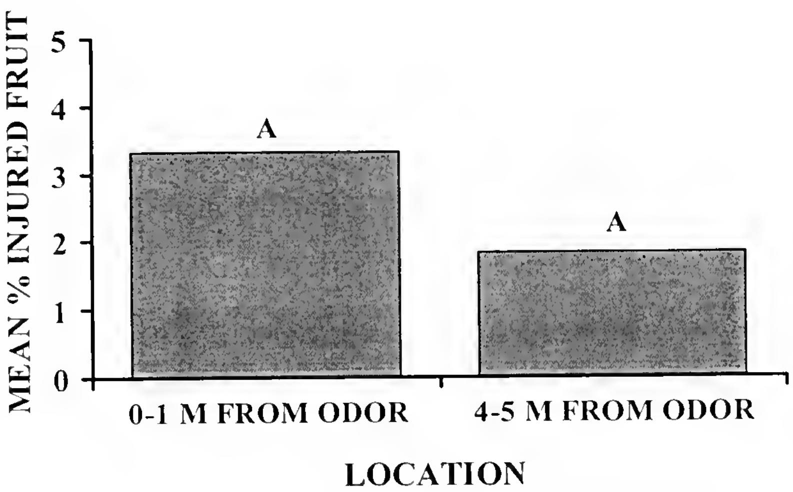

Figure 4. Mean percent of sampled fruit on perimeter-row trap trees that received fresh ovipositional injury by plum curculio when sampled fruit were within an imaginary circle (1 yard diameter) containing grandisoic acid (1 mg/day) plus benzaldehyde (40 mg/day) or within an imaginary circle (1 yard diameter) lacking odor bait on opposite side of the tree (4-5 yards from odor source). Means superscribed by the same letter are not significantly different at odds of 19:1.

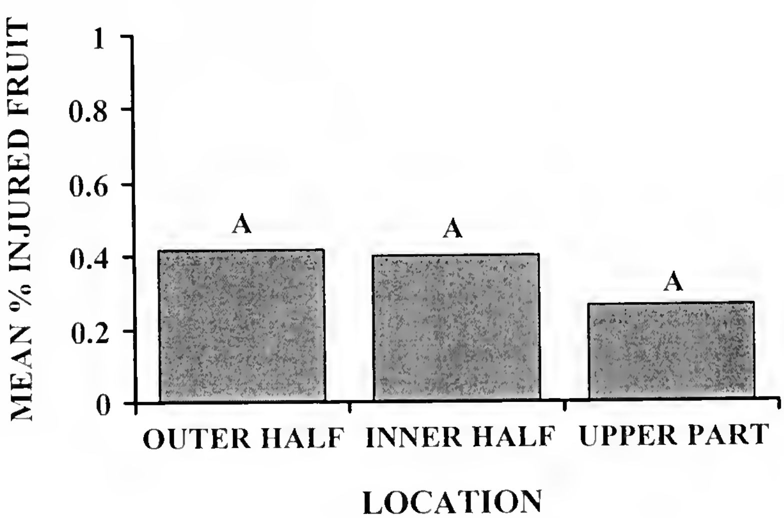

Figure 5. Mean percent of sampled fruit on perimeter-row trap trees baited with grandisoic acid (1 mg/day) plus benzaldehyde (40 mg/day) (both positioned near the center of the tree) that received ovipositional injury (fresh and older injury combined) to fruit at head height in the outer half of the canopy, at head height in the inner half of the canopy and in the upper central part of the canopy in samples taken during the last week of June. Means superscribed by the same letter are not significantly different at odds of 19:1.

dispensers of GA plus one, two, four, or eight dispensers of BEN (Figure 1). All six of these treatments received significantly more fresh injury than trap trees baited with one dispenser of GA plus one dispenser of BEN and than unbaited trees. Numerically, just as much fresh injury occurred on trap trees baited with one dispenser of GA (releasing 1 mg/day) plus four dispensers of BEN (releasing a total of 40 mg/day) as on trees of any other treatment, with injury on trees receiving this treatment about eight-fold greater than on unbaited trees.

In the second experiment, the amount of fresh injury on trap trees was significantly greater (about eight-fold greater) than on unbaited trees 34-36 or 25-27 yards distant from trap trees, and was likewise significantly greater (about seven-fold and five-fold greater, respectively) than on unbaited trees 15-17 or 7-9 yards distant from trap trees (Figure 2).

In the third experiment, perimeter-row trap trees located at corners of orchard blocks received an almost identical amount of injury (no significant difference) as perimeter-row trap trees located midway between corner trees (Figure 3).

In the fourth experiment, there was only a slight (and insignificant) tendency for within-canopy injury on trap trees to be greater in the vicinity (within 1 yard) of the source of attractive odor compared with 4-5 yards distant from the odor source (Figure 4).

In the fifth experiment, a nearly identical amount of injury on trap trees was found among fruit sampled at head height at the outer half of the canopy as among fruit sampled at head height at the inner half of the canopy, with injury among fruit sampled in the upper part of the canopy (above head height) being slightly though not significantly less (Figure 5). In this experiment, odor sources were positioned at head height and near the tree trunk.

Conclusions

Our findings indicate that perimeter-row trap trees baited with one dispenser of GA plus four dispensers of BEN performed as well as or better than trap trees baited with greater or lesser amounts of these attractants. They also indicate that the distance over which a trap tree baited with such an amount of odor is effective in luring PCs extended to at least 34-36 yards along a perimeter row of apple trees and that trap trees at corners of orchard blocks were equally as alluring to PCs as perimeter-row trap trees midway between corner trees. Further, our findings suggest that within the canopy of a trap tree, PC injury to fruit tended only slightly (and not significantly) to be concentrated near the source of attractive odor when such odor was positioned at the periphery of the canopy. When attractive odor was positioned near the center of the canopy, fruit injury tended to be rather evenly distributed among various sectors of the canopy.

Together, these findings set the stage for an experiment to determine a threshold of injury to fruit on a trap tree that would justify spray applied to perimeter rows 1 and 2 to control PC following application of a petal fall spray to all rows.

Acknowledgements

This work was supported by funds from a USDA Northeast Regional IPM grant, a USDA Northeast Regional SARE grant, a USDA Crop at Risk grant, a USDA Specialty Crops Research grant, the Massachusetts Society for Promoting Agriculture, and the New England Tree Fruit Research Committee.

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A Threshold for Spraying Against Plum Curculio Using Odor-baited Trap Trees

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In the preceding article, we established several characteristics that an odor-baited trap tree ought to have in order to qualify as a site for monitoring fruit injury by plum curculio (PC).

Here, we present results of a 2003 experiment aimed at determining a tentative threshold of PC injury to fruit on a trap tree that would justify insecticide application to rows 1 and 2 of an orchard block following a whole-block spray at petal full.

Materials & Methods

We selected 12 blocks of trees in commercial orchards in Massachusetts. Each block was comprised of at least eight rows of trees and was bordered along its entire 200 yard perimeter by continuous woods or hedgerow. Each block was located in a different orchard and was divided into three equal-size plots. A trap tree baited with 1 dispenser of grandisoic acid plus four dispensers of benzaldehyde (see preceding article) was established at the center of the perimeter row of each plot, 33 yards from either edge. Each of the three plots per block was pre-assigned at random a threshold of either 1, 2 or 4 freshly injured fruit out of 50 fruit sampled on the trap tree. Each trap tree was sampled for freshly injured fruit three times per week (Monday, Wednesday, Friday), beginning 7 days after a petal fall spray of insecticide. We presumed that residual activity of insecticide extended at least 7 days after application. Sampling involved examining 50 haphazardly chosen fruit per tree at head height: 25 in the outer half of the canopy, 25 in the inner half. Sampling was terminated on June 30, when no fresh injury was detected in samples on any trap tree for two consecutive sampling periods.

All 36 plots received a grower-applied treatment of Guthion or Imidan across the entire plot within 4 days after petal fall. Thereafter, only the first (= perimeter) and second rows of a plot received insecticide as applied by growers, who sprayed both sides of first-row trees and the perimeter-facing side of second-row trees. In all cases, such treatments were made within 24 hours of our sampling a trap tree and our determination that the proportion of sampled fruit showing injury had reached the pre-established threshold of 1, 2, or 4 freshly injured fruit. Once a plot had received an insecticide treatment to rows 1 and 2, we allowed 6-7 days before resuming examination of fruit on trap trees for injury. Then, for each plot, we waited until fresh injury to sampled fruit on a trap tree again reached the pre-established threshold for that plot before calling for the next insecticide application to rows 1 and 2. To guard against invasion of PCs into plots from an exposed lateral side or from rows deeper than the seventh row, growers applied insecticide at 7-to-10-day intervals to orchard trees abutting trees in test plots.

To evaluate the plot-wide outcome of insecticide application against PC as driven by varying thresholds of allowable injury on trap trees, during the first week of July we examined 20 fruit at head height in the outer half of the canopy on each of five trees in each of rows 1, 2, 3, 5, and 7 of each plot for evidence of any injury caused by PC (total of 100 fruit per row per plot). Fruit on the trap tree were excluded from consideration, because such fruit would normally comprise a very low percentage of all fruit in an orchard block. For example, for a 2.5 acre square block of medium-size trees on M.26 rootstock, fruit from a trap tree at the center of a 110 yard perimeter row would constitute less than 0.2% of the total amount of fruit in the block.

Results

The mean number of insecticide applications made by growers to trees in rows 1 and 2 declined successively (though not significantly) from 1.56 to 1.44 and 0.89 sprays as the pre-assigned threshold calling for spray application increased successively from 1 to 2 and 4 freshly injured fruit out of 50 fruit sampled on trap trees (Table 1). Conversely, the mean proportion of fruit injured by PC in samples taken during the first week of July (i.e., at the conclusion of the injury season) on

Table 1. For apple orchard plots that received insecticide application on rows 1 and 2 whenever a pre-set threshold of 1, ,2 or 4 freshly injured fruit out of 50 fruit sampled on a trap tree was reached 7 days or more after the preceding application, mean number of insecticide applications and mean percent fruit injured by plum curculio in samples of 100 fruit per row taken during the first week of July.

Pre-set injury threshold on trap tree	Mean no. insecticide applications	Mean % fruit injured*		
		Rows 1 + 2	Rows 3-7	Rows 1-7
1	1.56 a	1.61 a	0.43 a	0.77a
2	1.44 a	2.33 a	0.71 a	1.17a
4	0.89 a	2.39 a	0.82 a	1.27a

*Means in each column followed by the same letter are not significantly different at odds of 19:1.

rows 1 and 2 combined increased successively (though not significantly) from 1.61 to 2.33 and 2.39% as the pre-assigned threshold calling for spray application increased successively from 1 to 2 and 4 freshly-injured fruit out of 50 fruit sampled on trap trees (Table 1). The same was true for fruit sampled from rows 3-7 combined (Table 1), where injury increased successively from 0.43 to 0.71 and 0.82% with increasing pre-assigned threshold. Combined injury from all rows in a plot shows that whole-plot injury averaged 0.77, 1.17, and 1.27%, respectively, for plots having pre-assigned thresholds of 1, 2, or 4 injured fruit out of 50 fruit sampled on a trap tree.

Conclusions

Findings from the first article in this issue indicate that a whole-block spray against PC is needed at petal fall to control PCs that many have overwintered within or immigrated into interior rows. Findings from that article also suggest that effective control of PC after a whole-block petal fall spray can be attained by applying insecticide only to perimeter rows 1 and 2.

There appears to be no need to continue spray all rows in a block against PC after an all-row spray shortly after petal fall.

To know where and when to apply post-petal-fall spray to control PC, findings here suggest that a threshold of 1 freshly injured fruit per 50 fruit sampled on an odor-baited perimeter-row trap tree may be used provisionally as an indicator of the need to apply an insecticide spray to all trees on rows 1 and 2 to prevent block-wide damage from exceeding an injury level of 1%. Further, our data suggest that a spray-driven threshold of 2 or more freshly injured fruit per 50 fruit sampled on a trap tree may be too great to prevent block-wide damage from exceeding 1%.

Further studies are needed to confirm the provisional threshold suggested from results here. Special attention should be paid to assessing effects of orchard architecture (size of blocks, spacing of trees, arrangement of cultivars, size, and pruning of trees, etc.) on candidate thresholds.

Acknowledgments

We are sincerely grateful to the growers who allowed use of orchards blocks for this experiment and who responded rapidly when sampling indicated the need for insecticide treatment: Keith Arsenault, Gerry Beirne, Bill Broderick, Dave Chandler, Bob Davis, Don and Chris Green, Tony Lincoln, Mo Tougas, Bob Tuttle, and Steve Ware. This work was supported by funds from a USDA Northeast Regional IPM grant, a USDA Northeast Regional SARE grant, and Massachusetts Society for Promoting Agriculture.

* * * * *

What Size of Apple is the Most Prone to Plum Curculio Attack Early in the Season?

Jaime Piñero, Everardo Bigurra, Sara Hoffmann, and Ronald Prokopy
Department of Entomology, University of Massachusetts

In the 2000 Issue of *Fruit Notes*, we reported on the distribution of fruit injury by plum curculios (PC) within the canopies of large, medium, and small trees that were not baited with attractive odor. Our findings indicated that, for large trees, early-season damage to fruit by PC was greatest at tree tops, which was the area in the canopy that also had the largest fruit. For medium and small trees, however, damage to fruit by PC was distributed similarly among different sectors of tree canopies, a result that coincided with the distribution of fruit size.

Here, we aimed at assessing the relationship between fruit size and early-season damage to fruit by PC in large, medium, and small unbaited trees located in unsprayed blocks of commercial orchards in Massachusetts.

Materials & Methods

This study was performed at Atkins Farm and University of Massachusetts Cold Spring Orchard Research & Education Center (Belchertown, MA) in 2000. In all, 760 fruit were sampled haphazardly (about 30 fruit per tree on each sampling date) from six large (Cortland/M.7), four medium (Priscilla/M.26), and six small (McIntosh/M.9) trees. Sampling began 2 weeks after petal fall, which occurred by May 18 in 2000. Sampling was performed on June 2 for large trees, May

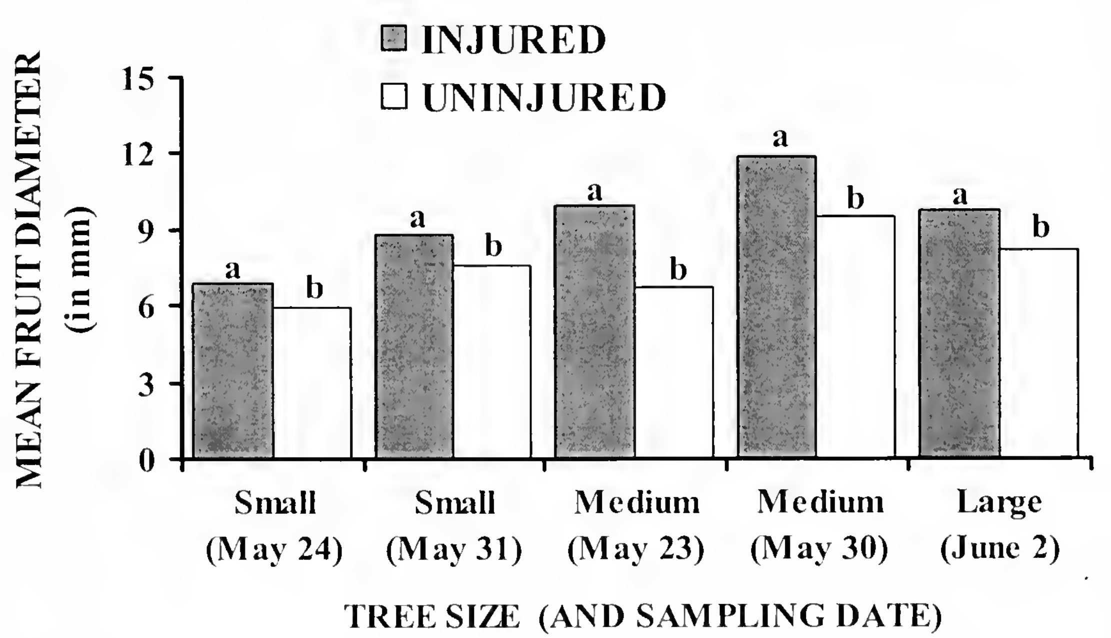

Figure 1. Association between fruit size (expressed as diameter in mm) and early-season injury by PC. Fruit were sampled from small, medium, and large unsprayed apple trees in Massachusetts in 2000. For each doublet of bars, means not superscribed by the same letter are significantly different at odds of 19:1.

23 and May 30 for medium trees, and May 24 and May 31 for small trees. Each individual fruit was categorized as injured or uninjured based on the presence or absence of PC egglaying scars (fresh or old), and its diameter was recorded. To assess the relationship between fruit size and occurrence of injury to fruit by PC, comparisons of the diameter (in mm) of fruit having or lacking PC scars were performed.

Results

Figure 1 clearly shows that, regardless of tree size, fruit sampled early in the season that showed PC injury were significantly larger than uninjured fruit. The smallest size of a fruit having a PC scar was 4.8 mm in diameter, which corresponded to the first sampling date in small McIntosh trees.

Conclusions

Our findings lead us to conclude that, early in the season, larger fruit are much more prone to attack by PC than are smaller fruit, probably because abscission of fruit damaged by PC is more likely to occur when fruit are small. Thus, early-season sampling of unbaited trees should be conducted preferentially in areas of the trees where fruit are larger (e.g., upper part of the canopy of large trees, exterior zone of branches). As the season progresses, however, it is likely that smaller fruit may be more likely to be attacked by PC, possibly because, as suggested by Levine and Hall (1977), late-season mortality of PC larvae is greater in large fruit due to the higher internal pressure of the growing cells. None of the trees in our study was baited with attractive odor. Results on the distribution of PC injury among fruit in various tree sectors could be different for odor-baited trap trees.

Acknowledgments

This study was supported with funds provided by a USDA Northeast Regional IPM grant, a Hatch grant, a grant from USDA Crops at Risk program, and the New England Tree Fruit Research Committee.

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Levine, E., and Hall, F.R. 1977. Effect of feeding and oviposition by the plum curculio on apple and plum fruit abscission. *Journal of Economic Entomology* 70: 603-607.

* * * * *

Photographs of Fresh and Older Egglaying Scars of Plum Curculio on Apples

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Jaime Piñero and Ronald Prokopy
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The use of odor-baited trap trees to aggregate plum curculio (PC) adults should simplify monitoring for PC by confining sampling to just a few odor-baited trees in an entire orchard. Under this approach, sampling would involve examination of about 50 fruit on a trap tree for signs of fresh PC egglaying scars. As discussed in a previous article in this issue, application of a perimeter-row spray would occur when one fruit out of 50 sampled fruit shows fresh injury. The question then becomes: how to tell a fresh injury from an older injury. Here, we present photographs of fresh and older PC injury from a study conducted in 2003.

Materials & Methods

At petal fall, cloth bags were placed over several terminals of unsprayed McIntosh and Delicious trees at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown. Each Monday beginning when king fruit averaged 6 mm diameter, two mated PC females were introduced into each bag and allowed to remain until Tuesday, when they were removed. On Wednesday, Friday, and the following Monday, a digital camera (Nikon CoolPix 990) was used to photograph some of the egglaying scars. Each scar shown here was therefore 1, 3, or 6 days old when photographed.

Results

Figures 1-4 show, respectively, egglaying scars that were photographed over 6-day periods for the weeks of May 28, June 4, June 11 and June 18. For McIntosh, fruit size averaged 6, 8, 14, and 19 mm diameter, respectively, when injury was initiated, whereas for Delicious fruit size averaged 6, 7, 10, and 14 mm diameter, respectively. Regardless of the week when injury was initiated, photographs show that 1-day-old scars appear as narrow crescents (from top to bottom) similar to an eighth moon. Reflecting fruit growth, 3-day-old scars appear as somewhat broader crescents, with 6-day-old scars appearing as crescents that are broader still (much like a half moon) or as scars that have begun to lose their crescent shape.

Scars initiated on 6 mm fruit (week of May 28) show little sign of a stem and have little resemblance to a mushroom (Figure 1). Scars initiated on 10-14 mm fruit (week of June 11) show a distinct stem and strongly resemble a mushroom (or the cloud of an atomic bomb) (Figure 3). By 6 days after egglaying, even the most pronounced mushroom shape of a 1-day-old scar (as in Figure 3) has begun to fade.

It should be noted that the change in appearance from fresh to older PC egg-laying scars as described above is most accurate for McIntosh. With Delicious, the change in appearance is not quite as distinct – some caution is advised when looking at different cultivars as the age of PC egg-laying scars may be more difficult to judge than it is on McIntosh. More observations of other cultivars (such as Gala) are needed.

Conclusions

Once a grower or consultant has firmly in mind the image of a fresh (e.g., 1-day) versus an older (e.g., 6-day) scar, that mental image can be carried to the field to aid in interpretation of the age of PC scars on odor-baited trap trees.

Acknowledgements

This study was supported by USDA Hatch funds.

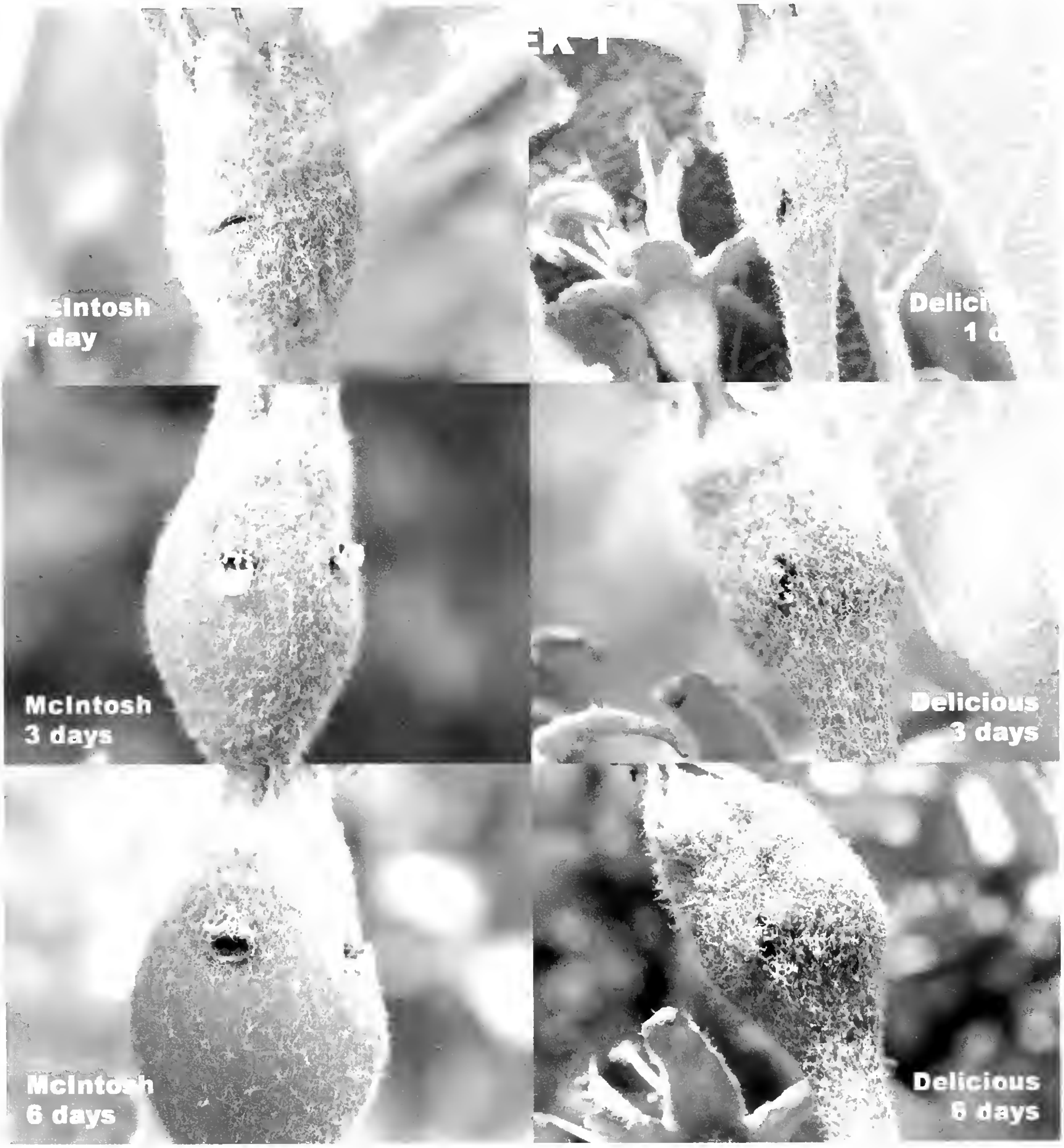

Figure 1. Appearance of PC egglaying scars on McIntosh (6 mm) and Red Delicious (6 mm) apples (left to right) that were initiated on May 27 and photographed when 1, 3 and 6 days old (top to bottom).

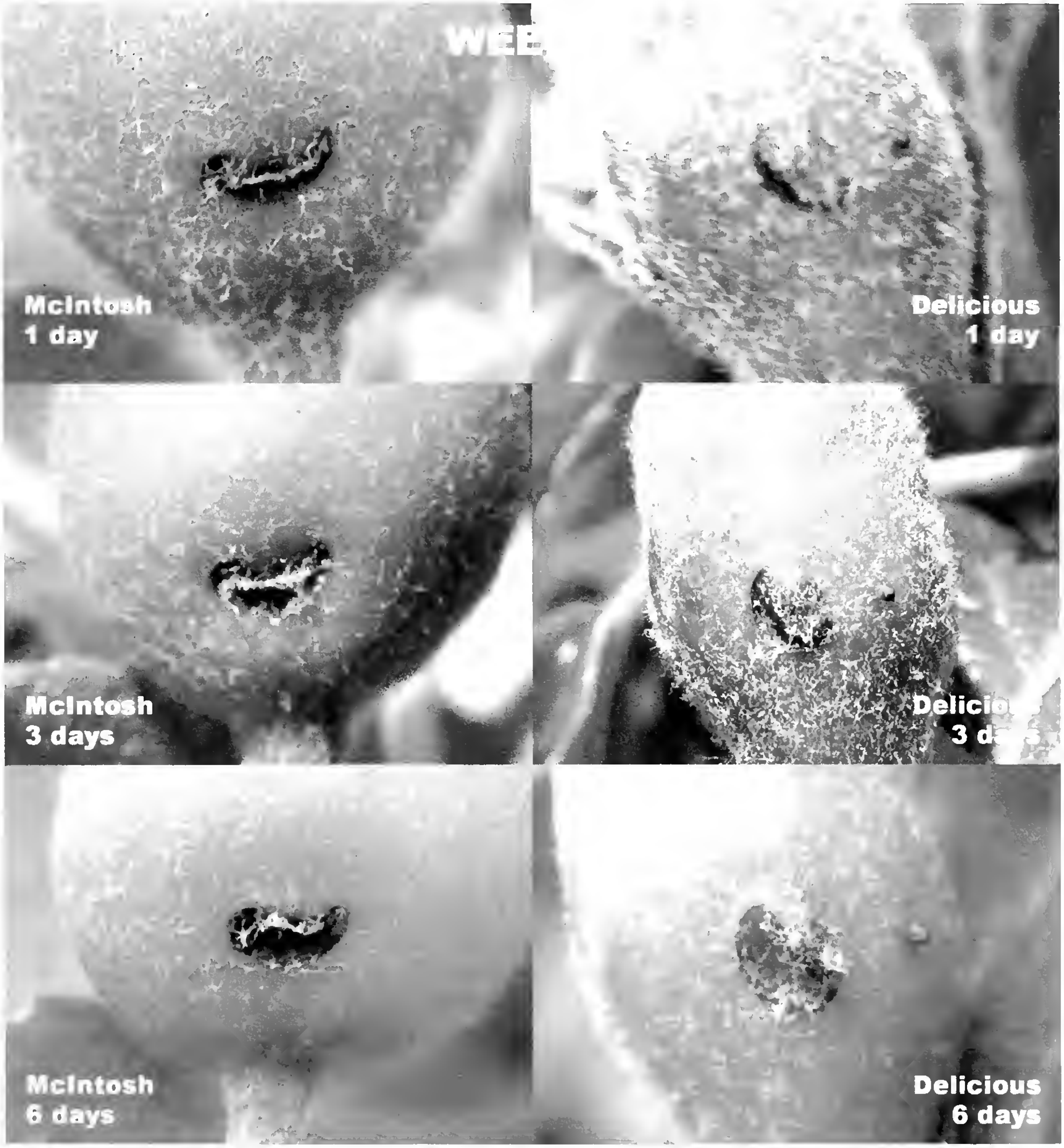

Figure 2. Appearance of PC egglaying scars on McIntosh (8 mm) and Red Delicious (7 mm) apples (left to right) that were initiated on June 3 and photographed when 1, 3 and 6 days old (top to bottom).

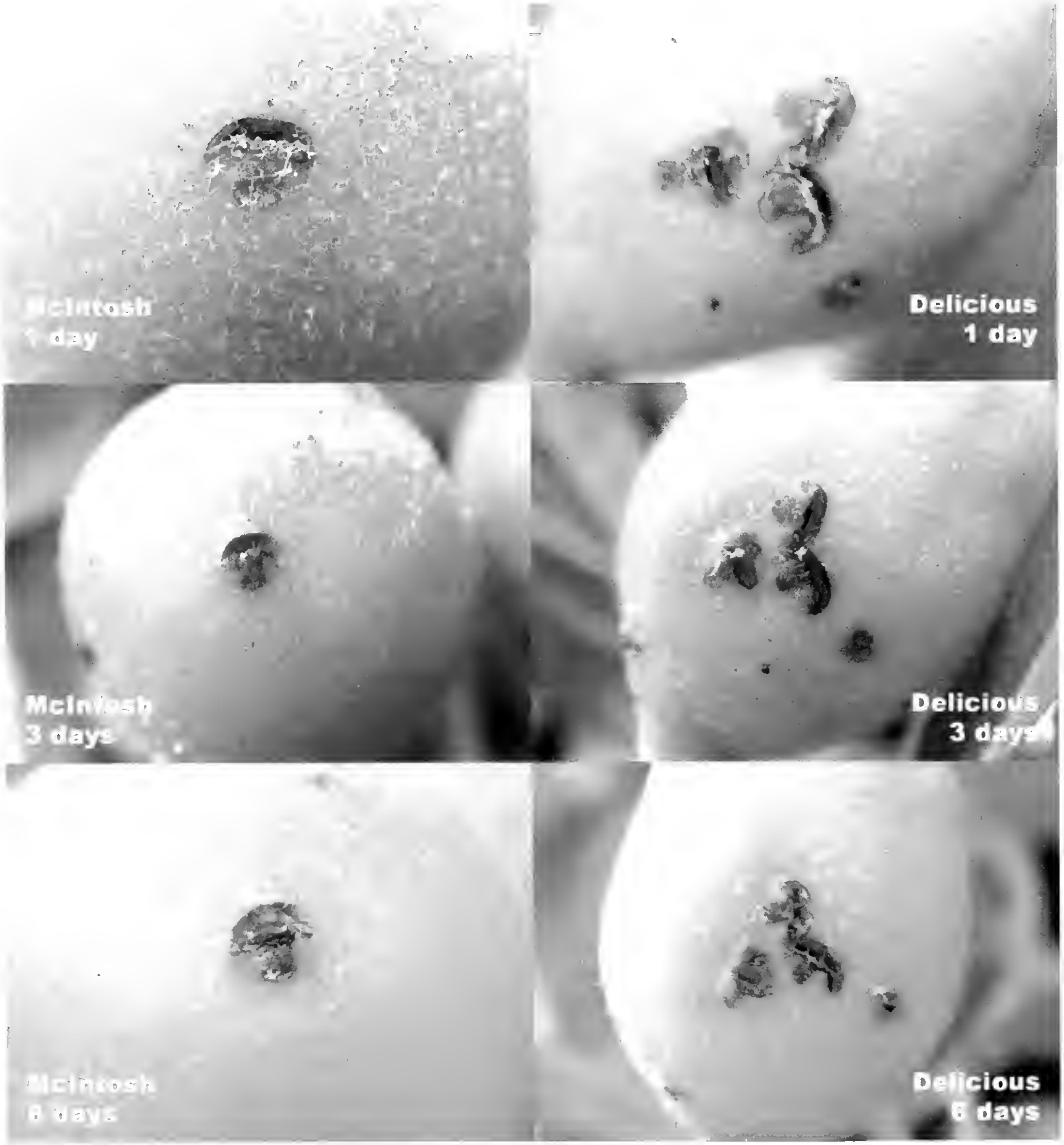

Figure 3. Appearance of PC egglaying scars on McIntosh (14 mm) and Red Delicious (10 mm) apples (left to right) that were initiated on June 10 and photographed when 1, 3 and 6 days old (top to bottom).

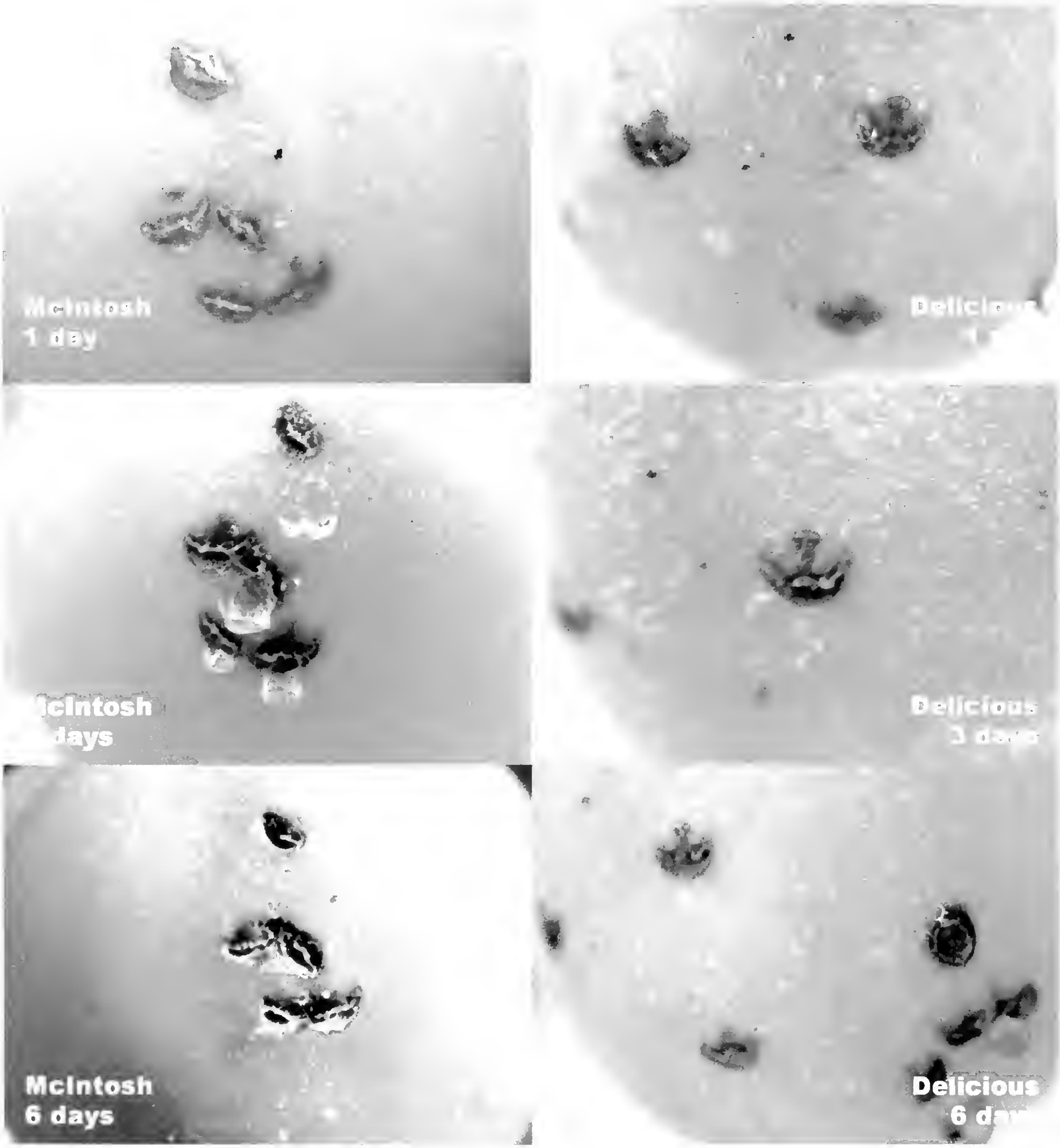

Figure 4. Appearance of PC egglaying scars on McIntosh (19 mm) and Red Delicious (14 mm) apples (left to right) that were initiated on June 17 and photographed when 1, 3 and 6 days old (top to bottom).

Fruit Notes

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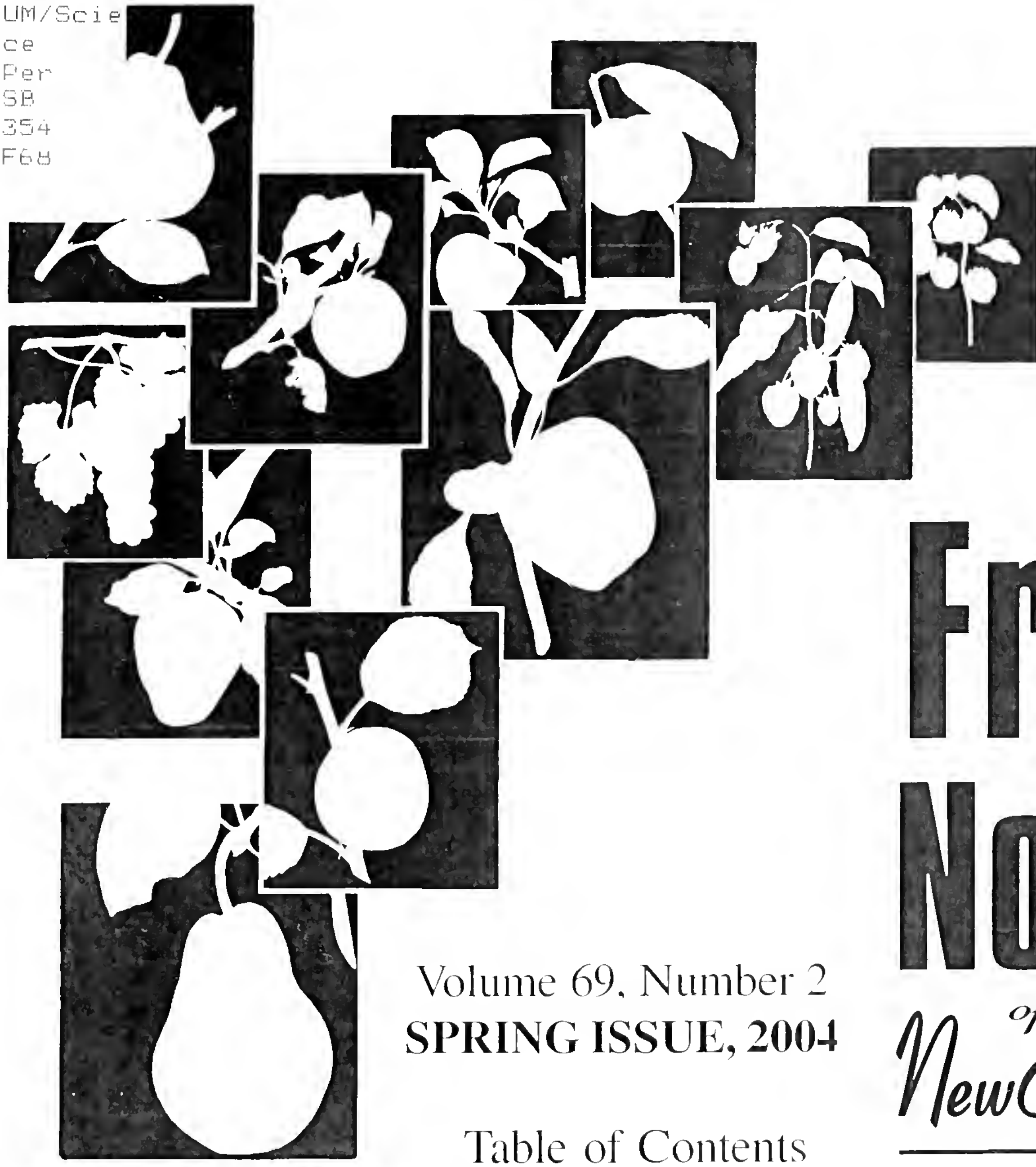

Fruit Notes of New England

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Fruit Notes of New England

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A *Fruit Notes* Issue in Honor of Ronald J. Prokopy

Wesley R. Autio
Department of Plant, Soil, & Insect Sciences, University of Massachusetts

I still have a hard time believing that we have lost our friend and colleague Ron Prokopy in May, 2004. His contribution to the science and practice of apple pest management will never be forgotten.

Ron Prokopy was the entomological side of the UMass Fruit Program. He contributed regularly to *Fruit Notes*, *Healthy Fruit*, and the *New England Apple Pest Management Guide*. He wrote twenty-six *Annual March Messages*, an update on the state of tree-fruit insect control for fruit growers, and he spoke at all but three or four of the nearly 60 Twilight Grower Meetings since I joined the faculty 19 years ago. Further, he was always available to assist growers with their problems. This tally, however, does not adequately capture how Ron extended the research of UMass to the fruit industry. His outreach efforts were borne from a deep-seated concern for the well being of the tree-fruit industry and the growers as individuals and from an unquenchable enthusiasm for the details of insect pest management. He understood the constraints imposed on farmers both by the natural world and by society. This understanding helped Ron mold

his outreach to guide our tree-fruit industry to a level which put them among the most progressive pest managers in the World.

This extremely effective outreach effort was supported by one of the most productive research programs in the University. With hundreds of research articles to his credit, Ron Prokopy was one of the most respected entomological scientists in the World. He helped mold the concepts which are the foundation of current and future integrated pest management (IPM). It was both remarkable and inspirational how his research spanned the spectrum from basic to applied. All his research, even the most fundamental, was clearly focused on solving a practical problem.

There are many examples of how Ron brought his research and outreach together, but I particularly enjoyed his talk at one of our twilight meetings a few years ago. Plum curculio is one of the most difficult pests for orchardists and scientists alike. Ron focused much of the last 10 years on this troublesome insect. He spent much time watching and recording curculio movement into and around apple trees. At a mid-June twilight meeting, Ron spent a good portion of his 20 minutes (which usually lasted at least 40 minutes) describing how curculios found an apple tree. This talk was given mostly from the orchard floor, that is Ron was lying down and crawling along the ground (and speaking) showing the growers how the curculio saw the world. This enthusiasm for the actions of plum curculio, and also for apple maggot flies, gave Ron the ability make great strides in research, interpret those results, and develop and transfer the knowledge necessary to help growers.

Members of the Fruit Program cooperate on a number of fronts, from research to educational programs, but we are always together at nine twilight grower meetings per year (three series of three meetings each). For at least one of each of these series over the last several years, three or four of us would travel together. This trip usually was to Plymouth County, Bristol County, or Rhode Island and was as much as a two-hour ride from Amherst. We always had to study the weather forecast before heading that way with Ron. If it was going to be hot (and Ron loved hot, humid weather), we tried to get the largest vehicle available, usually a van. Most of us enjoy the benefits of automotive air conditioning in hot weather, but not Ron. The large vehicle allowed us to make him ride in the far back, away from the air conditioning and near his own open window. Some of Ron's other eccentricities included power naps, eating a head of lettuce for supper, reviewing papers while driving, and his numerous pillows, sweaters, and bags that always traveled with him. These "quirks" punctuated his honest and unwavering concern for people. He cared about all of us, growers, students, colleagues, and friends.

This issue of *Fruit Notes* is dedicated to Ron's memory. It begins with a few memories of Ron and ends with the last three articles that he wrote for Fruit Notes (in the few weeks before his death, thanks to Isabel Jácome for typing these articles).

Ron Prokopy was an amazing individual. He was among the best scientists, the best extension educators, and the best people that we will ever know.

* * * * *

Remembering Ron

William M. Coli
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By now, orcharding and University communities all over the world have learned that we have all lost a rare and unique individual: Dr. Ron Prokopy. As Wes Autio put it so well in a recent email, "Ron's boundless support of the apple industry will be sorely missed, and his extensive research contributions will never be forgotten."

As Ron would have wanted, and in spite of the depth of our feelings of loss, I hope we can all focus on how he lived his life rather than on this untimely loss. I'm sure there will be a lot of sharing of stories at the memorial service planned for May 22 at his beloved farm in Conway. For those who can not attend, I'd like to offer just a few recollections about the 29 years I have known Ron.

The first time I ever met him, I knew right away that Ron was not your typical University faculty member. I don't know if it was the longer than normal hair style, the South American knit bag that he always carried with him (and which inevitably contained bags of neatly sliced, home grown carrots), or his propensity to take his little "rests" (cat naps that he would always take while we were on route to some place or another).

When he first arrived at UMass Amherst in 1975, he was already well known in Entomology circles for his ground-breaking and innovative work developing effective, multi-colored, sticky sphere traps for monitoring fruit flies. The story goes that when another faculty member (Dr. John Stoffolano) was introducing Ron to the clerical staff in Fernald Hall, he was obviously excited to have this new high-powered behavioral ecologist in the department. John, assuming perhaps that the clerical staff was familiar with Ron's earlier research said: "This is Ron Prokopy, our new faculty Extension Entomologist. You know, he's the guy with the red and yellow sticky balls!!" Once all present stopped laughing, John told them what he really meant to say.

While working on a special research project on traps for the blueberry maggot fly with Ron, I continued to gain a better perspective on this unique guy. I learned that he was about the hardest working person I'd ever known. There was never a single field day that Ron wouldn't be out there counting flies with me. When the data were finally analyzed, he was insistent that we write the results up for a paper to submit to an Entomological journal. Those researchers who know him well are probably saying "What? Only one paper?" since Ron, in addition to arguably knowing more than anyone else in the world about the Family Tephritidae (fruit flies), was also incredibly productive in his publication record.

In spite of his brilliant intellect, Ron was very down to earth, very easy to talk with, and incredibly committed to extension work: once again not typical of University Faculty in general. He loved his days in the field. There was literally nothing he preferred more than sitting in the orchard observing his beloved insect subjects. Ron always joked that when he died, he wanted to be reincarnated as an apple maggot fly. I hope for all our sakes that he does not get his wish, because I envision apple maggot becoming A LOT BIGGER problem if the species has Ron's incredible knowledge and energies to draw upon.

Ron Prokopy was truly deserving of the 'one-of-a-kind' label. While it is comforting to know that Ron was following his passions right to the last, and that his passing was peaceful, the fruit industry, the science of Entomology, the University of Massachusetts, his many graduate students, and all his many friends and colleagues will miss him dearly.

* * * * *

Ron's Papers

Daniel R. Cooley
Department of Plant, Soil, & Insect Sciences, University of Massachusetts

There was no doubt in my mind that Ron Prokopy would live until he was at least 90. I also knew he wouldn't stop his life's work, ever. And now that only one of those certainties has proven true, I can't yet see how our world of New England apple growers and researchers, the world of insect ecologists, our university, or my own world will function in quite the same way. Half the time I forget that he isn't home in Conway, isn't at his Fernald Hall office, and isn't checking curculio traps.

Maybe as a way to make my mind adjust, I've been focusing on just one facet of his life. I've been wondering how Ron Prokopy ever managed to write all those papers, over 450 publications, an almost incomprehensible number. As the main form of academic research currency, the number of publications a person writes gives other academics a quick read on the stature and impact a scientist carries. It's a career batting average, and Ron was a Ted Williams when it comes to writing. Very good scientists would be happy to write one or two hundred articles, chapters and other pieces over a career. And just as every hit Williams got represented hundreds of swings and hours of practice, every article a scientist writes represents hours of grant writing, lab and field experiments, data analysis and finally, the actual writing.

Naturally, some scientists cook the books a bit, accepting partial credit for papers to which they may have made little or no real contribution. It's like Enron reporting millions in imaginary earnings so that the company will look much more substantial. In science, this sort of "pub padding" can make author lists that read like an Old Testament genealogy. Ron never indulged in this sort of publication inflation, and he contributed a meaningful part in any research that carried his name, making his accomplishment all the more remarkable.

So I wonder, how did he do it? Perhaps it was because he frequently had trouble sleeping, and would not so much complain as comment on the fact that he had gotten only 4 hours of sleep the previous night. Getting along on a sleep regimen that could crack hardened spies certainly could explain some of Ron's productivity.

He did need an occasional recharge. When we were out on the road, between orchards he might say that he really needed a little rest, if I didn't mind, and he would doze off for 10 or 15 minutes. He revived, dragging his palm from forehead to chin as if it would wipe away the last vestiges of his nap, and emerging from his pupae-like slumber he'd launch full flight into an intense discussion concerning how we might arrange tests in the next orchard to serve multiple research tasks. Couldn't we use Broderick's old Mac block for the curculio work, and the maggot work, and the flyspeck work, making data collection visits even more productive? Ron lived with a New England farmer's kind of efficiency, carrying lettuce and carrot lunches in washed and re-used plastic bags, sporting an eclectic wardrobe of Goodwill clothes, and always trying to squeeze every bit of data possible from an experiment.

While Ron always got the most from a dollar, I'm not sure his Yankee frugality always contributed to research efficiency. He grew up on a Connecticut farm, and eeking a living from rocky New England soils means a lot of getting by and making do. For better or worse, he carried those habits into his research projects. And since the sort of research and teaching he did extended beyond brick and ivy to the orchards of New England, Ron and his lab group drove hours to and from research sites every day. The several vehicles needed for this were much like his clothes, a sort of Goodwill collection, including such classics as a vintage Korean War surplus MASH ambulance, a banana yellow Ford Torino with vestigial brakes, and cabin-cruiser like station wagons with rotted floors, all vehicles that had been rescued from the scrap-heap. They had far outlived their usefulness in polite society but could still carry people, tools and various objects covered with sticky goop around the state. I don't think Ron could fully conceive of buying a new car, or even a late-model used car, not when the same money could be used for an extra summer assistant. In fact, I think the rusty roof of a 10 year old LTD appealed to Ron not only because it was cheap, but because it said to growers

that Ron didn't care what things looked like, that we were not some well-funded, effete research institute, but rather people who got by and could be trusted. On the other hand, whether these crates would start reliably or keep chugging through sparsely populated parts of the state was another issue. Some days, I think Ron's powerful will to understand the orchard ecosystem was the only thing that kept those cars going.

Ron used time much the way he used research dollars, squeezing the minutes. When he drove one of the old heaps himself, he wasn't content to just think or listen to the radio. He had to read, review and, some say, even write papers while navigating the notoriously narrow, rock- and tree-lined roads between New England orchards. His approach to driving pretty much insured that if someone else was joining him, they volunteered to get behind the wheel. Ron could then retreat to the back seat to fully devote attention to his papers without the distraction of an on-coming cement truck. For longer trips, every plane ride, every hotel room served as an office and study for the constant, nearly undecipherable pencil scribbling on page after page of yellow lined paper. That single-minded attention to filling in what might otherwise be downtime with writing undoubtedly helped Ron's publication record.

Technology didn't. Ron never allowed computers to make his writing and research more efficient. He tried a laptop computer once, thinking it might save everybody time if they didn't have to download his email, then read and type his responses, not to mention typing up the pages of pencil scrawled manuscripts. And with a laptop, Ron could still write as he traveled, or when he sat in an orchard. It was a good theory, but Ron's mind never adapted to the keys and electronic screen. Within a few weeks, his son Josh had inherited the unused computer for his own use. Ron stayed with the yellow lined paper.

Naturally, rather than a PDA, Ron had a unique paper organizational system. For day-to-day operations, he would periodically pull a small pile of recycled scraps from his pocket, consult 2 or 3 of them, and then make a phone call, ask a student to copy a research paper, or do whatever else the notes reminded him needed to be done. To my knowledge, Ron never had a date book or notebook; he had stacks of recycled paper scraps filled with his cryptic scrawl.

He did have a relatively inflexible organization to his year that probably contributed to efficiency; he could more easily plan ahead. His field experiments would be, for the most part, planned by the time we started the twilight grower meetings in the spring. Ron looked forward to those drafty barn sessions, talking with growers about the latest way to deal with tarnished plant bug or leaf miner. He remembered going to them as a kid with his uncle and seeing scientists from the Connecticut Experiment Station. Then, after getting his Ph. D. in entomology at Cornell, he went back to the Connecticut Agricultural Experiment Station to take on the position working with insects and mites in apples. The happy homecoming only lasted a little while, and the stories are vague. Evidently, Ron got involved in late 60's radical politics in New Haven. Ron left the station, traveling Europe with Linda, his wife, in a VW microbus. Being Ron, traveling Europe meant going behind the Iron Curtain rather than to the Riviera. On his return, he tried starting his own research station in Wisconsin and spent time in Texas working with seminal figures in the IPM movement just as it was starting. Then in 1975, he landed in Massachusetts.

But I'm digressing. As I said, Ron's year began with twilight meetings and grower visits, and it continued with 16 hour or longer days filled with field experiments, circus-like tents over apple trees, and all manner of contraptions designed to figure out why apple insects behaved the way they did. Ron digested data as it came in, on a daily basis, but by the end of the summer, he would already be putting it together into a bigger picture. The fall meetings would start in late October with a gathering of apple IPM researchers and advisors in Vermont, where the very latest results from that year would be presented and shared. A little later, more polished presentations would be made at the national entomology meetings and as the New Year began to growers at the New England Fruit Meetings. At Amherst, Ron would teach his IPM course each fall. In January, he would disappear to the library each day, reading articles that would be assimilated into grants or papers, as well as the March Message. The March Message included all the latest apple pest management information a grower could want, and Ron created it because the standard pest management material couldn't or wouldn't keep up with the pace he wanted to set. Delivered just before the growing season started, Ron would joke that it was good bathroom material. Wherever they read it, growers would make sure that they had. By the time the March Message was ready for press, Ron would be leaving for his annual trip to Hawaii. Of course his New England heritage wouldn't let him just go and enjoy Hawaii though he loved the place, so Ron had a long-running grant to study fruit flies there. Anyone he took with him soon discovered that the research agenda was just as 24-7 in Hawaii as it was in Amherst. As soon as he got back to Amherst, the twilight meetings and grower visits would start again. Woven into this annual fabric were daily meetings with grad students, lab assistants and technicians, post-docs, other faculty and visiting scientists. And all this was punctuated by special meetings and talks in which any successful scientist engages, talks in China or Washington, or meetings in Europe and Australia. Around this schedule Ron wrote the huge number of grant proposals and publications that mystifies me.

I know that it made a few people feel better to write-off Ron's publication record as the results of a monomaniacal workaholic. It wasn't that, and Ron, while he worked hard, didn't eliminate family, friends, recreation or the arts from his life. Some of the other parts of Ron's life seem totally at odds with his image as hard-working, salt-of–the-earth academic. For example, Ron played golf. When I went a round with him, he showed up carrying a battered, ancient set of clubs, wearing his Larry Bird short shorts and a T-shirt. It occurred to me that golf must be some concession Ron had reluctantly made to recreation, that someone had told him he needed a hobby, so he'd looked around a thrift store, seen golf clubs and determined that he would go play a round every week for Recreation. About the 6h hole, I began to see a pattern that suggested a different story. Short, but straight drives on the fairway, uncannily accurate approaches to the best part of the green, and consistent putting had Ron at par or better, while everyone else in the group was at least 5 strokes over. Ron was playing winning golf, and thoroughly enjoying it.

In fact, he had several athletic hobbies, done in less-than-conventional ways that fit his schedule. He probably swam in every orchard pond in the state, following a day counting insects in apple trees, and maybe a short jog. On his own farm, he kept a muddy pond that doubled as a hockey rink. I remember one game when Ron had magnanimously taken a few of the weaker skaters, among them my wife, on his team. Because we had a shortage of real hockey sticks, Ron volunteered to use a broom. Not surprisingly, Ron's team quickly slipped behind. Ron's frustration grew more visible as the debacle played out, and as one of his sons threatened to score against Ron's group yet again, Ron swooped over to my wife, grabbed her stick, stole the puck from his 10-year-old, and skated the length of the ice to score himself. He followed that with enough goals to satisfy himself that he would not be humiliated. I suspect Ron's competitive nature also had a significant effect on his research record as well.

I can't fit his love of opera into an explanation of his publishing record, except that it was probably one of those releases any intense person needs to keep from imploding. Not being an opera aficionado, I failed, on several levels, to understand Ron's trips to New York to see Carmen or some lesser-known production. I do like non-musical theater, and music without theater, and Ron, knowing this, would be the one who organized evenings to see a summer play at Smith or a jazz performance in Northampton. Releases though these may have been, I still wonder how a man doing the grant writing, experiments, analysis and publication work necessary for 15 or so publications a year could have time for any of this? Or the baseball trips to Fenway Park. Or the hikes. Or the dinners with students, colleagues and friends. Or singing with the local chorus.

Teaching a course sets limits on research, and many successful scientists consider teaching a burden. Most have no idea what it means to work with people outside the university, people like New England apple growers. For many of the most successful scientists, their exclusive priority is the production of research papers. In contrast, Ron reveled in his role as advisor and colleague to the apple growers of New England, and devoted himself to teaching IPM to university students. He never considered ignoring the growers or students so that he might focus on more on research. Ron loved apples, the people that grow them, the places they grow, the insects that feed on them, all of it. Just as important, and less obvious, he knew that his work in the orchards led to better research and teaching. He knew that teaching growers how to manage apple pests taught him how to develop ecological theories that worked in the real world. It made his classroom more relevant and real to his university-based students. The time it takes to do all this, of course, makes those 450 papers even more astounding.

Ron uniquely bridged the space between academics and apple growers. I think it's difficult for purists in either group to appreciate how well he did it. For example, he and a colleague discovered that Rhagoletis pominella (the apple maggot fly) had moved from its native American host, the hawthorn (Crataegus sp.), to an imported host, the domestic apple (Malus domestica). They held this up as an exciting example of sympatric speciation (one species diverges into two separate species in a single geographic location) by publishing in the world's best scientific journals and speaking at major academic meetings. It's still a classic example in ecology. At the same time Ron showed that the apple maggot's predilection for round, red objects could be useful to growers, telling them when the damaging flies were present in their orchards, and just as importantly, when they were not. For a few years, I'm sure Ron totally disrupted the market for croquet and bocce balls, buying them up, painting them red, covering them in sticky goo, and hanging them in apple trees to determine whether growers needed to apply an insecticide.

I'm still not sure how Ron sold IPM to apple growers. He came into the job with some pressure, as the previous two apple entomologists at UMass had been fired. When he started his Extension work, Ron still had most of his long hair from the 60's and carried his ever-present paperwork and field equipment in a woven Guatemalan shoulder bag. It's hard to remember now, but at that time IPM ran counter to standard pest management dogma. For years, Extension and pesticide salesmen had been telling orchardists that they needed to spray chemicals weekly, sometimes more, to eliminate any possibility of pests and disease in apples. Along came Ron, asking them to hang colored sheets of sticky cardboard and bocce balls in their trees, count bugs, and above all, not to spray pesticides until the pests actually started their invasion. I know many growers, looking at Ron and the colored bocce balls, were worried that this ivory tower hippie from the University was trying to lead them into disaster.

But Ron, having grown up on a fruit farm, was not an ivory tower scientist. He may have been an idealist but he understood growing apples. And after talking with him, a few influential growers recognized that. Perhaps more importantly, Bill Pearse, probably the most influential quality control man working for the largest apple wholesaler in Massachusetts, saw the promise of better pest management with fewer pesticides. Ron was a little different and intense, but I know Bill liked and respected him, and the feelings were mutual. I'm sure Bill quietly suggested that growers give some of this IPM stuff a try, and at the same time, set Ron straight as to how far growers might actually be willing to go. In the next decades, even after Bill's death, New England apple growers would be leaders in using IPM, because Ron wanted to do more than just hide in the University and write papers.

But of course he did write all those papers too. I probably never will really understand how, but I'm glad that he did it, that he managed to get down on paper so much of the knowledge he gained. Ron collected knowledge, from growers and other scientists, from everyone he met, from his experiments, he gathered it in, processed it in his own inimitable way, and wrote so much of it down. What a tremendous legacy. While no one will ever touch each of us the way Ron did, I remain hopeful that some of his students, or perhaps his students' students, will be able to bridge that widening gap between academics and our agricultural resources, and carry on Ron's dream of a truly ecological, sustainable orchard.

* * * * *

Optimizing Distances Between Odor-baited Spheres on Perimeter Apple Trees for Control of Apple Maggot Flies

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For several decades, spraying apple trees with insecticide in July and August has been the standard approach to apple maggot fly (AMF) control. While this approach is likely to continue to be the standard in most orchards for decades to come, some growers would like an alternative approach that eliminates the need for insecticide application during summer months. One alternative that we have been studying for more than a decade is the surrounding of orchard blocks with odor-baited spheres on perimeter apple trees to intercept immigrating AMF before they can penetrate into interior rows.

In the Spring 2002 issue of *Fruit Notes*, we reported that the most effective odor bait to use in conjunction with perimeter spheres for maximizing AMF control under a broad range of orchard conditions is a five-component blend of synthetic attractive apple volatiles developed at Cornell University. In other issues of *Fruit Notes* preceding 2002, we presented data suggesting that odor-baited spheres deployed on perimeter trees may be more effective (a) in orchards comprised of small or medium trees than in orchards of large trees, (b) in orchards having particular arrangements of susceptible versus tolerant cultivars, and (c) in orchards bordered by open space than by hedgerow or woods. In addition, we suspected that sphere effectiveness might be greater in well-pruned than poorly-pruned perimeter trees.

To qualify as a viable alternative to spraying an orchard for AMF control, use of odor-baited spheres on perimeter trees must be cost-competitive; the fewer the number of spheres needed, the less the cost. Until now, distances between perimeter spheres in apple orchards have been assigned largely on an arbitrary basis (devoid of established guiding principles), varying from 2 to 45 yards apart.

Here, we developed an approach to assigning distances between odor-baited spheres or perimeter trees of apple orchards. It employs an index incorporating characteristics of four environmental variables: size of orchard trees, quality of pruning, cultivar composition and nature of bordering habitat.

Materials & Methods

Block layout. Our experiment was conducted in 12 blocks of apple trees in ten commercial orchards in Massachusetts. Each block consisted of seven rows of apple trees, was about 120 yards long, and averaged 35 yards deep in extension from a perimeter row that bordered open field, hedgerow, or woods to the seventh interior row. Each block was divided into two plots: one plot about 90 yards long, the other about 30 yards long. Blocks consisted of either small (M.9 rooted), medium (M.26 rooted), or large (M.7 rooted) trees that were either well, moderately, or poorly pruned in 2003. Each row of a block was comprised of the same cultivar, which was considered as being of relatively low susceptibility to AMF if McIntosh or Empire, moderate susceptibility if Cortland or Delicious, and high susceptibility if Fuji, Gala, or Jonagold. Each of the four sides of a block was bordered by grower-sprayed orchard trees, open field, hedgerow, or woods.

Pesticide sprays. Each plot in each block was sprayed by cooperating growers with insecticide and fungicide in April, May, and June to control a variety of insects and diseases. Thereafter, the smaller (30 x 35 yards) plot received two or three grower-applied sprays of insecticide in July and August to control AMF; whereas, the larger (90 x 35 yards) plot received no insecticide after June but received odor-baited spheres to control AMF.

Spheres. Each sphere trap was 3.5 inches in diameter, red in color, and coated with Tangletrap to

Table 1. Values ascribed to characteristics of four environmental variables as components of an index for assigning distances between odor-baited spheres on perimeter apple trees.

Value	Tree size	Quality of pruning	Cultivar susceptibility	Bordering habitat
1	Large	Poor	High	Woods
2	Medium	Fair	Moderate	Hedgerow
3	Small	Good	Low	Open*

*Also applies to bordering habitat consisting of grower-sprayed orchard trees.

capture alighting AMF. Spheres placed on perimeter trees to intercept immigrating adults were accompanied by a blend of five synthetic attractive fruit volatiles contained in a polyethylene vial. Spheres placed on interior trees to monitor adults that penetrated into plots were not baited. All spheres were deployed during the last week of June (before arrival of adults) and remained through harvest (in September). Deployment was at mid-canopy height in a way that maximized visual conspicuousness and attractiveness.

Index for assigning distances between spheres. The index used for assigning distances between odor-baited spheres on each side of each targeted plot was created by first prescribing a value of 1, 2, or 3 for each of tree size, quality of pruning, cultivar susceptibility, and bordering habitat for that side (Table 1) and then using the sum of the four values to determine distance between spheres (Table 2). Based on previous studies conducted in Massachusetts and Quebec, we chose 6 yards as a minimum distance between spheres and 18 yards as maximum distance. Given that this was the first year of using such an index and given that all test blocks were in commercial orchards where valuable fruit was at risk, we were reluctant to deploy spheres at distances greater than 18 yards apart. In some cases, the structure of a block (spacing of trees within and among rows) did not allow us to position spheres precisely according to assigned distances. In such cases, we compromised in favor of an assigned distance closest to the original.

Assessment of treatment performance. We used two methods of assessing treatment performance. First, every other week from trap deployment until harvest we counted and removed all AMF captured by eight unbaited spheres placed on interior trees of row 4 of baited-sphere plots and by four similarly-positioned unbaited spheres in grower-sprayed plots. Captures by such spheres were used as an indicator of relative numbers of adults that penetrated into interiors of plots. At the same time, we counted and removed all AMF captured by odor-baited spheres on perimeter trees and cleaned all baited and unbaited spheres of insects and debris, re-coating spheres with Tangletrap if necessary. Second, at harvest we sampled 20 fruit on each of five trees on each of the four sides of each baited-sphere and each grower-sprayed plot plus ten fruit on each of

Table 2. Index for assigning distances between odor-baited spheres on perimeter apple trees. Sum of values is derived from qualities of four environmental variables as given in Table 1.

Sum of values	Distance between spheres (yards)
4	6
5	7.5
6	9
7	10.5
8	12
9	13.5
10	15
11	16.5
12	18

five interior trees in each of rows 3 and 5 of each plot (total of 500 fruit per plot). All sampled fruit were picked and kept in a greenhouse for one month before examination for ovipositional punctures, confirmed by dissection of punctured fruit for signs of larval growth.

Treatment comparisons and data analysis. In both 2001 and 2002, the same 12 baited-sphere plots used here received odor-baited spheres on each side of each plot at arbitrarily prescribed distances of 6 or 11 yards apart. Also, in both 2001 and 2002, the same 12 grower-sprayed plots used here received similar pesticide treatments as here. Use of unbaited spheres on interior trees to monitor penetration of adults into plots and sampling of fruit for AMF damage in 2001 and 2002 were equivalent to procedures used here. To compare outcomes of the index-based approach of 2003 with the arbitrary approach of 2001 and 2002 for assigning distances between spheres, we subjected each year's data on number of baited spheres used on perimeter trees, number of AMF captured per unbaited monitoring sphere, and percent sampled fruit injured by AMF to analysis of variance.

For 2003 data, we used correlation analysis to determine the relationship between percent injured fruit on each of the four sides of each of the 12 baited-sphere plots and the value (1, 2, or 3) ascribed to that side for each of the following: tree size, quality of pruning, cultivar susceptibility, and bordering habitat. In addition, we used correlation analysis to determine relationships between mean numbers of AMF captured by interior unbaited monitoring traps in baited-sphere plots or percent fruit injured on interior trees of baited-sphere plots (100 fruit per plot) and tree size or quality of pruning for that plot. Whereas, in every case, tree size and quality of pruning were the same for all perimeter trees in a plot, thus permitting such analysis, cultivar susceptibility and border habitat differed among perimeter trees of the same plot and thus were excluded.

Results

Compared with the mean number of odor-baited spheres deployed on perimeter trees per plot in 2001 and 2002, the mean number deployed in 2003 was significantly fewer (33-39% fewer) (Figure 1). Even so, mean values in Figure 2 show that captures of AMF on unbaited monitoring traps at interiors of plots

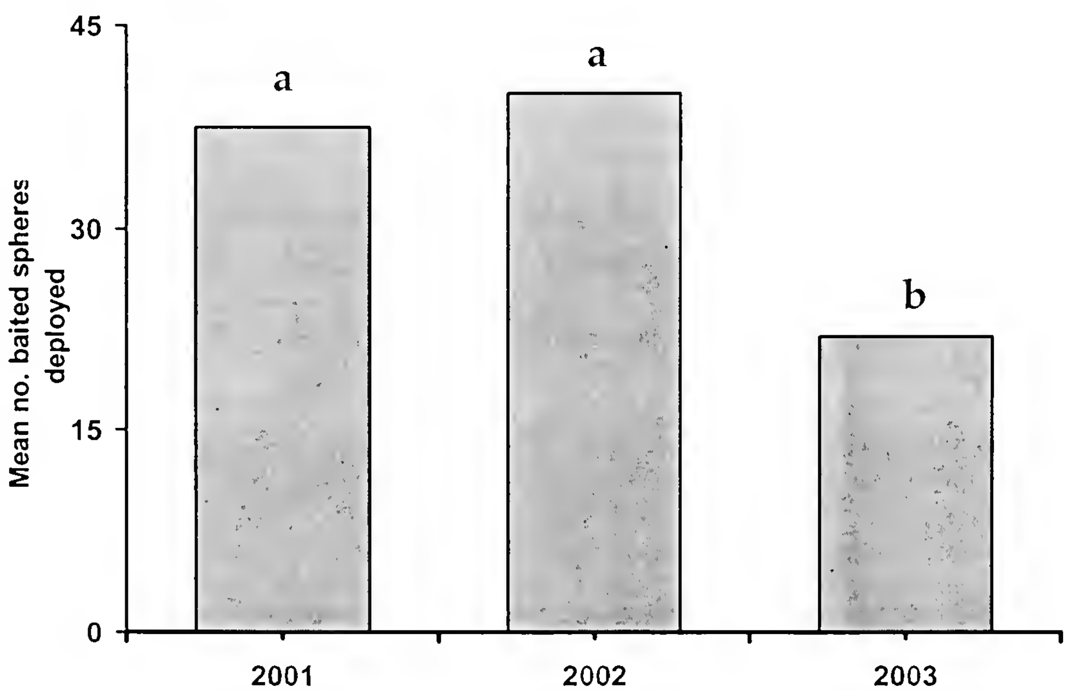

Figure 1. Mean number of odor-baited spheres deployed on perimeter apple trees in the same 12 plots in commercial orchards in 2001, 2002 and 2003. Means superscribed by the same letter are not significantly different at odds of 19:1.

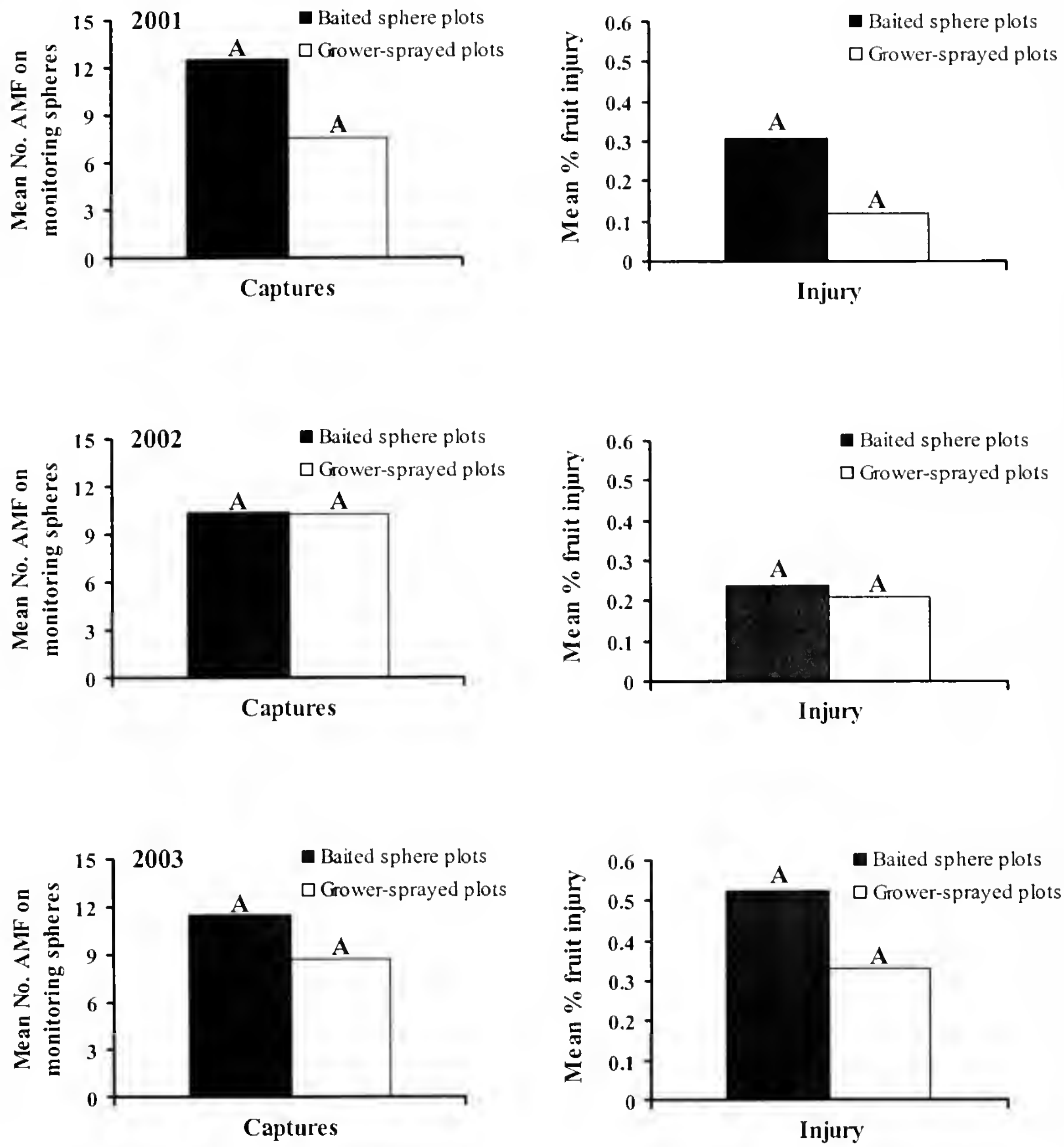

Figure 2. Mean number of AMF captured on interior unbaited monitoring spheres and mean percent injured fruit in baited sphere and grower-sprayed plots in 2001, 2002, and 2003. For each comparison, means superscribed by the same letter are not significantly different at odds of 19:1.

and plot-wide percent fruit injury were not significantly greater in baited-sphere plots (relative to sprayed plots) in any of the three years (2001, 2002, or 2003).

For 2003, percent fruit injured on perimeter trees comprising the four sides of baited spheres plots was significantly negatively correlated (at odds of 15 to 1) with values prescribed for quality of pruning but not significantly correlated with values prescribed for tree size, cultivar susceptibility or border habitat. For 2003, captures of adults by unbaited monitoring traps on interiors of baited sphere plots were significantly negatively correlated (at odds of 10 to 1) with values prescribed for tree size and quality of pruning but not with values prescribed for cultivar susceptibility or border habitat. Percent fruit injured on interior trees of baited-sphere plots was not correlated with values prescribed for tree size or quality of pruning.

Conclusions

Our findings for 2003 indicate that assigning distances between odor-baited spheres (on perimeter trees of plots in commercial apple orchards) according to an index incorporating characteristics of four environmental variables (tree size, quality of pruning, cultivar susceptibility, and border habitat) resulted in a level of AMF control no different from that achieved by sprays of insecticide in 2003 and no different from that of arbitrary assignment of distances between odor-baited perimeter spheres in the same plots in 2001 and 2002. Only 61-67% as many spheres were used under our new index system for determining distances between spheres in 2003 as under the arbitrary system used in 2001 and 2002.

Correlation analyses suggested that the index used here for assigning distances between odor-baited spheres on perimeter trees was reliable with respect to values prescribed for cultivar susceptibility and border habitat, but for future use it may require adjustment with respect to tree size and quality of pruning. Some of the analyses showed a significant negative correlation between tree size or quality of pruning and fruit injury by AMF or captures of AMF by interior monitoring traps, suggesting that distances between spheres prescribed by the index used here may have been too great to ensure high performance in plots of large and/or poorly pruned trees. One potential solution to this possible shortcoming would be to prescribe a value of less than 1 (rather than the value of 1 used here) for perimeter trees of large size and poor pruning. Doing so could, in some cases, require that spheres be placed closer than 6 yards apart. Conversely, for small-size perimeter trees that are pruned well, it may prove possible to assign a value 4 or more (rather than the value of 3 used here) and achieve acceptable control of AMF using odor-baited spheres positioned greater than 18 yards apart (the maximum distance apart allowed here).

On average, each of the 12 plots in this study received 24 odor-baited sticky spheres 12 yards apart on perimeter trees that encompassed about 1 acre of orchard. We estimate that it cost about $10 per sticky sphere for all materials and labor ($1.50 for sphere, Tangletrap, and odor plus $8.50 for labor to apply sticky, deploy spheres, periodically clean spheres of insects and debris, and replenish sticky). The estimated cost per plot of controlling AMF using odor-baited sticky spheres was therefore $240, compared with an estimated cost of about $45 per plot for control using insecticide (materials, spray equipment, and labor). If odor-baited sticky spheres were used to encompass a block of 10 acres rather than a 1 acre plot of apple trees, then 72 spheres (at 12 yards apart) would have been needed, costing a total of $720, or $72 per acre. This still is substantially greater than the cost of applying insecticide to control AMF ($45 per acre) and calls into question the economic wisdom of using sticky spheres for this purpose.

Ultimately, a replacement for sticky spheres is needed that is both less expensive and less messy to deploy and maintain. Such a replacement is on the horizon in the form of a red sphere topped by a disc comprised of spinosad (as insecticide), sugar (as feeding stimulant) and paraffin wax (as binder) (see a following article in this issue). Under high humidity, morning dew, or rainfall, spinosad and sugar seep from the disc onto the sphere surface, where they are ingested by alighting AMF, which then die. The total annual cost per odor-baited sphere of this type, amortized over a 10-year period, is estimated by its manufacturer (Pest Management Innovations, Harpers Ferry, West Virginia) to be about $3. Following initial deployment, such disc-capped spheres would require no further attention through harvest. Deploying odor-baited, disc-capped spheres on perimeter apple trees at distances prescribed by an index such as that put forward here could render behavioral control of AMF as effective and affordable as insecticide sprays, especially for large blocks of apple trees that are on dwarfing rootstock and well pruned.

Acknowledgements

We thank Eliza Gray, Guadalupe Trujillo and Mareanna Ricci for technical assistance and Jaime Piñero for statistical analyses. This study was supported by a USDA Northeast region SARE grant, a USDA Northeast Region IPM grant, a USDA Crops at Risk grant, and the Massachusetts Society for Promoting Agriculture.

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Ideal Within-canopy Positioning of Odor-baited Red Spheres for Monitoring or Control of Apple Maggot Flies

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About 20 years ago, we conducted tests aimed at establishing favorable positions within canopies of apple trees for deploying unbaited sticky red spheres to capture apple maggot flies (AMF). We found that removal of all foliage and fruit within 10 to 20 inches of a red sphere resulted in greater AMF captures than allowing foliage and fruit to encroach within 3 inches of a sphere or removing all foliage and fruit within 40 inches of a sphere. Since the time of this initial study, researchers at the New York Agricultural Experiment Station in Geneva have developed a blend of synthetic, attractive apple volatiles that draws AMF toward blend-baited trees and enhances captures of AMF by red spheres deployed in blend-baited trees.

Here, we report on experiments conducted in 2002 and 2003 aimed at defining favorable positions within apple trees for deployment of blend-baited red spheres for capturing AMF. We asked three questions. First, we asked which distance between a baited red sphere trap and the nearest foliage and fruit gave rise to the greatest AMF captures. Second, we asked which part of the tree canopy (outer half or inner half) was the more favorable for positioning a baited red sphere trap to maximize captures. Finally, we asked whether the distance to which foliage and fruit were cleared away from a red sphere trap was of greater consequence to trap performance when traps were baited or when traps were not baited. For each question, we examined effects of season on the pattern of AMF response to traps.

Materials & Methods

All experiments were conducted in a city-owned apple orchard in Leominster, Massachusetts dedicated to honor Johnny Appleseed (a.k.a. John Chapman, who was born in Leominster). We used Jersey Mac trees on M.26 rootstock, which had a moderate amount of fruit each year. We also used Golden Delicious trees on M.7 rootstock, which also had a moderate amount of fruit each year. All trees involved in our trials were moderately well pruned and received periodic season-long treatments of fungicide to protect against apple diseases. They received insecticide treatments through May to protect fruit against early-season insect pests but none thereafter.

Each year, we conducted two experiments: one using Golden Delicious trees, the other using Jersey Mac trees. There were not enough trees of either cultivar to conduct both experiments each year using the same cultivar.

Spheres used as traps were wooden, 3.5 inches in diameter, and coated with Tangletrap to capture alighting AMF. When baited, a sphere received a single polyethylene vial containing a five-component blend of synthetic attractive apple volatiles positioned about 6 inches to the side of the sphere. Each year, spheres were deployed in mid-July and remained in place until mid-September. Each tree received a single sphere hung at head height.

Our first question was addressed in 2002 using Golden Delicious trees. Foliage and fruit were cleared to one of five distances (in a radius) around spheres: 0, 10, 20, 30, or 40 inches. For the 0-inch treatment, clearance was just enough to prevent foliage and fruit from touching the sphere. All spheres were odor-baited and hung in the outer half of the tree canopy. There were six replicates of each treatment.

Our second question was addressed in 2002 using Jersey Mac trees. Odor-baited spheres were deployed either in the outer or inner half of the tree canopy, with foliage and fruit cleared to a distance of either 10 or 20 inches. There were six replicates of each treatment.

Our third question was addressed in 2003 using both Jersey Mac and Golden Delicious trees. Spheres were either odor-baited or not baited. Spheres in Jersey Mac trees were deployed either in the outer half of the canopy with foliage and fruit cleared to a distance of 20 inches or in the inner half of the canopy with foliage and fruit cleared to a distance of 10 inches. Spheres in Golden Delicious trees were deployed in the outer half of the canopy with foliage and fruit cleared to a distance of either 20 or 40 inches.

Once per week, captured AMF, other insects of similar or larger size and debris were removed from spheres. If necessary, Tangletrap was renewed, new growth of foliage was pared back, and enlarging fruit that encroached upon prescribed clearance distances were removed. The sex of captured AMF was not recorded in 2002 but was recorded in 2003.

For each experiment, captured adults were separated into three groups according to season of capture. For captures in Jersey Mac trees, groups were mid-season (mid July to early August), late-season (early to late August), and post-harvest (late August to mid September). For captures in Golden Delicious trees, groups were early-season (mid July to early August), mid-season (early to late August) and late season (late August to mid-September).

Results

For our first question, data reveal that over the entire season in Golden Delicious trees, baited spheres with foliage and fruit cleared to 10 or 20 inches captured significantly more AMF than equivalent spheres having foliage and fruit cleared to 0 or 40 inches (Figure 1). Captures on spheres having foliage and fruit cleared to 30 inches were not significantly different from either group. This pattern characterized adult response to sphere treatments during early, mid and late season (Figure 1).

For our second question, results show that across the entire season in Jersey Mac trees, baited spheres

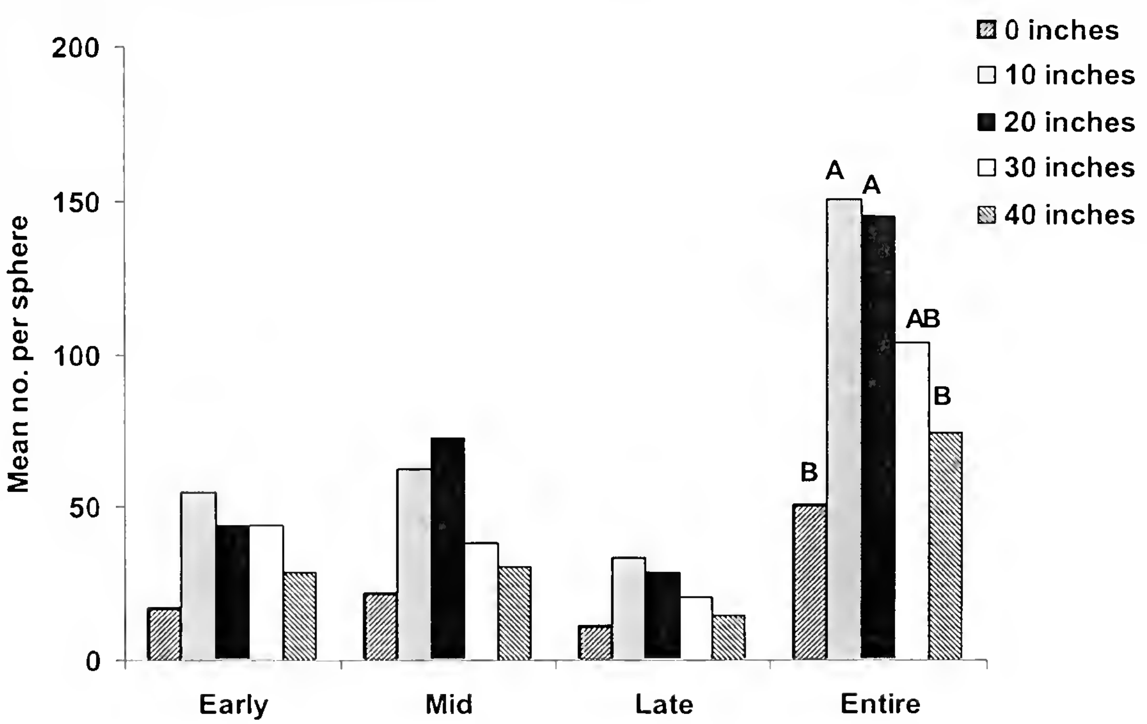

Figure 1. Mean number apple maggot flies captured per odor-baited sphere in Golden Delicious trees with foliage and fruit cleared to a radius of either, 0, 10, 20, 30, or 40 inches around a sphere. Captures were evaluated for early, mid, and late season and across the entire season. For the entire season, mean values superscribed by the same letter are not significantly different at odds of 19:1.

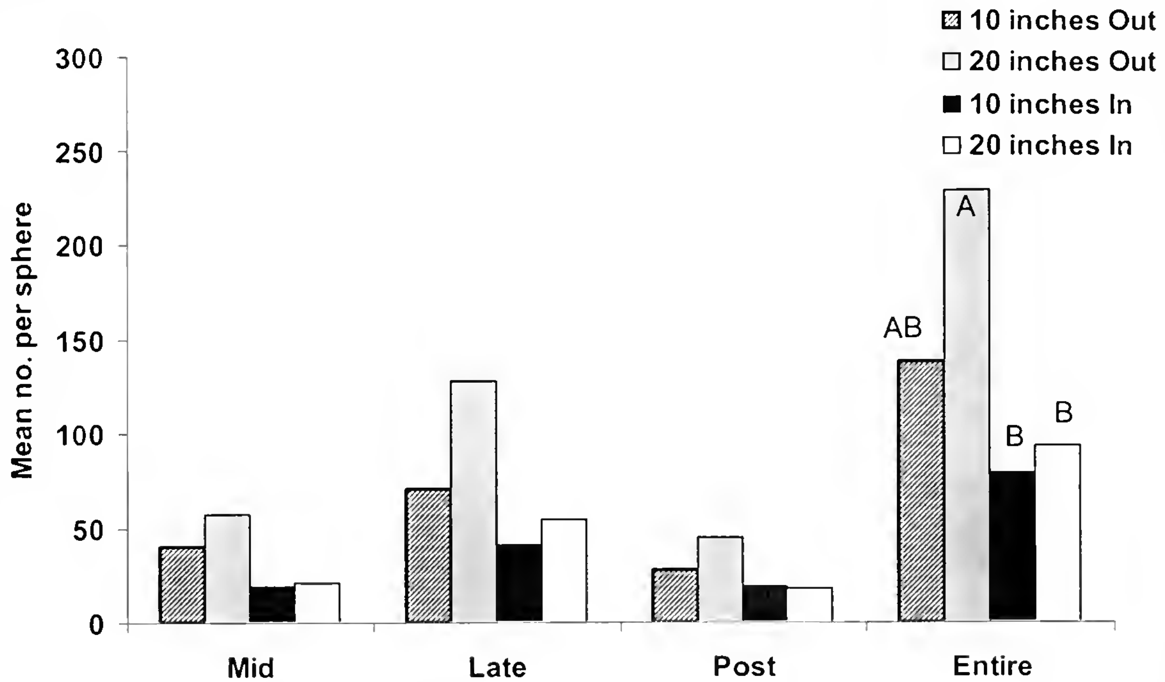

Figure 2. Mean number AMF captured per odor-baited sphere in Jersey Mac trees when spheres were either in the outer or inner half of the canopy and foliage and fruit were cleared to either 10 or 20 inches in a radius around the sphere. Captures were evaluated for mid, late, and post season and across the entire season. For the entire season, mean values superscribed by the same letter are not significantly different at odds of 19:1.

in the outer half of the canopy with foliage and fruit cleared to 20 inches captured significantly more AMF than equivalent spheres in the inner half of the canopy with foliage and fruit cleared to 10 or 20 inches (Figure 2). Captures on spheres placed in the outer half of the canopy with foliage and fruit cleared to 10 inches were not significantly different from the other treatments. This pattern characterized adult response to sphere treatments during mid, late and post season (Figure 2).

For our third question, data show that across the entire season in Jersey Mac trees, baited spheres placed in the outer half of the canopy with foliage and fruit cleared to 20 inches caught significantly more female AMF than baited spheres in the inner half of the canopy with foliage and fruit cleared to 10 inches (Figure 3). The same was true for males. On the other hand, there was no significant difference in response of either female or male adults to these two position treatments when spheres were unbaited. For each sex and each position, baited spheres captured significantly more adults than unbaited spheres. These patterns characterized the response of each sex to each position treatment during mid, late, and post season (Figure 3).

For our third question, data also reveal that across the entire season in Golden Delicious trees, baited spheres placed in the outer half of the canopy with foliage and fruit cleared to 20 inches caught significantly more female AMF than baited spheres in outer half of the canopy with foliage and fruit cleared to 40 inches (Figuire 4). Again, the same was true for males, again there was no significant difference in response of either sex to position treatments when spheres were unbaited, and again baited spheres in each position captured significantly more adults of each sex than unbaited spheres. These patterns held during early, mid and late season (Figure 4).

Conclusions

Combined findings show that AMF responded maximally to odor-baited red sphere traps when traps were hung in the outer half of the tree canopy and all

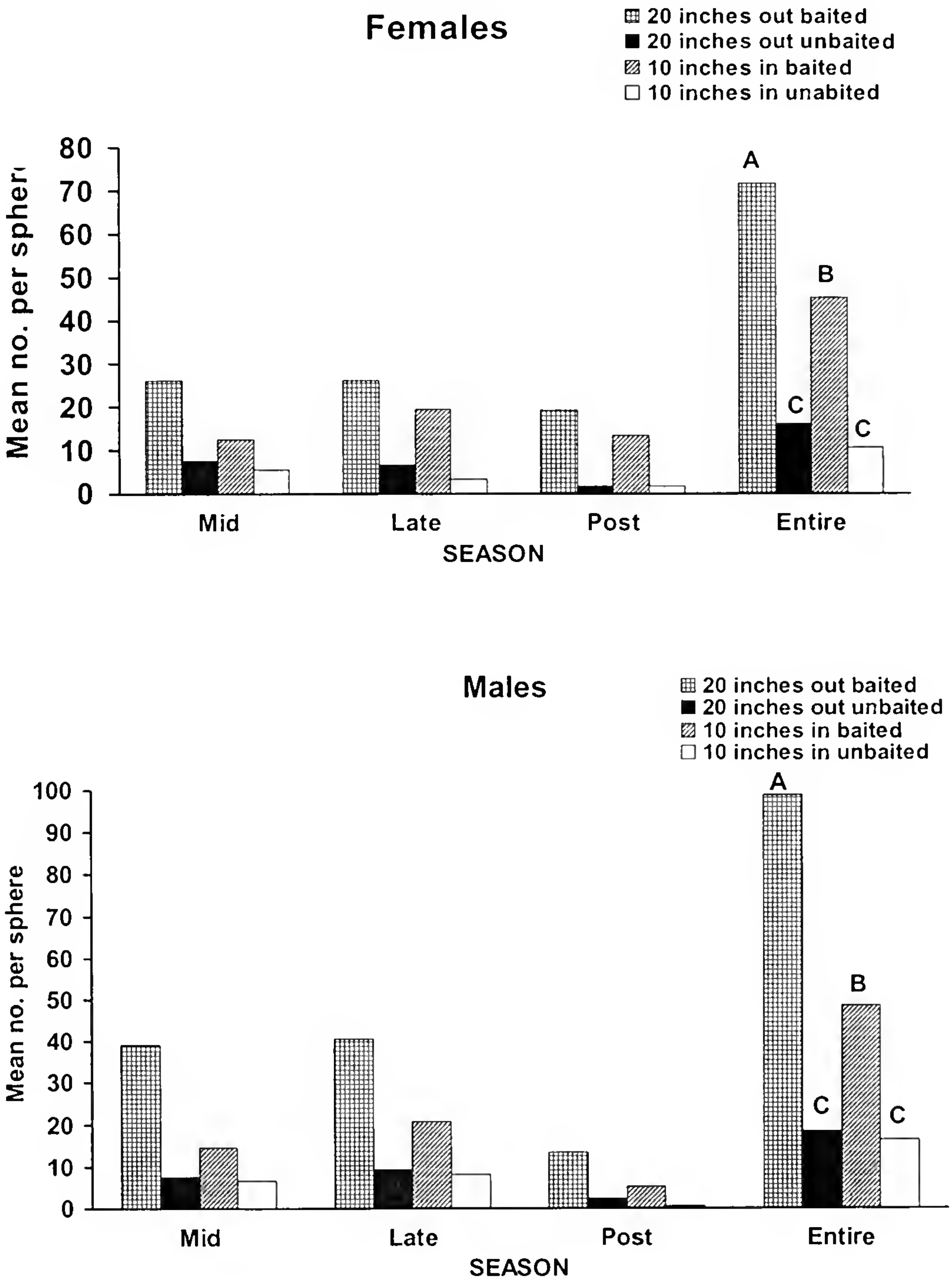

Figure 3. Mean number female and male AMF captured per odor-baited and unbaited sphere in Jersey Mac trees when spheres were either in the outer or inner half of the canopy and foliage and fruit were cleared to either 20 or 10 inches in a radius around the sphere. Captures were evaluated for mid, late, and post season and across the entire season. For the entire season, mean values superscribed by the same letter are not significantly different at odds of 19:1.

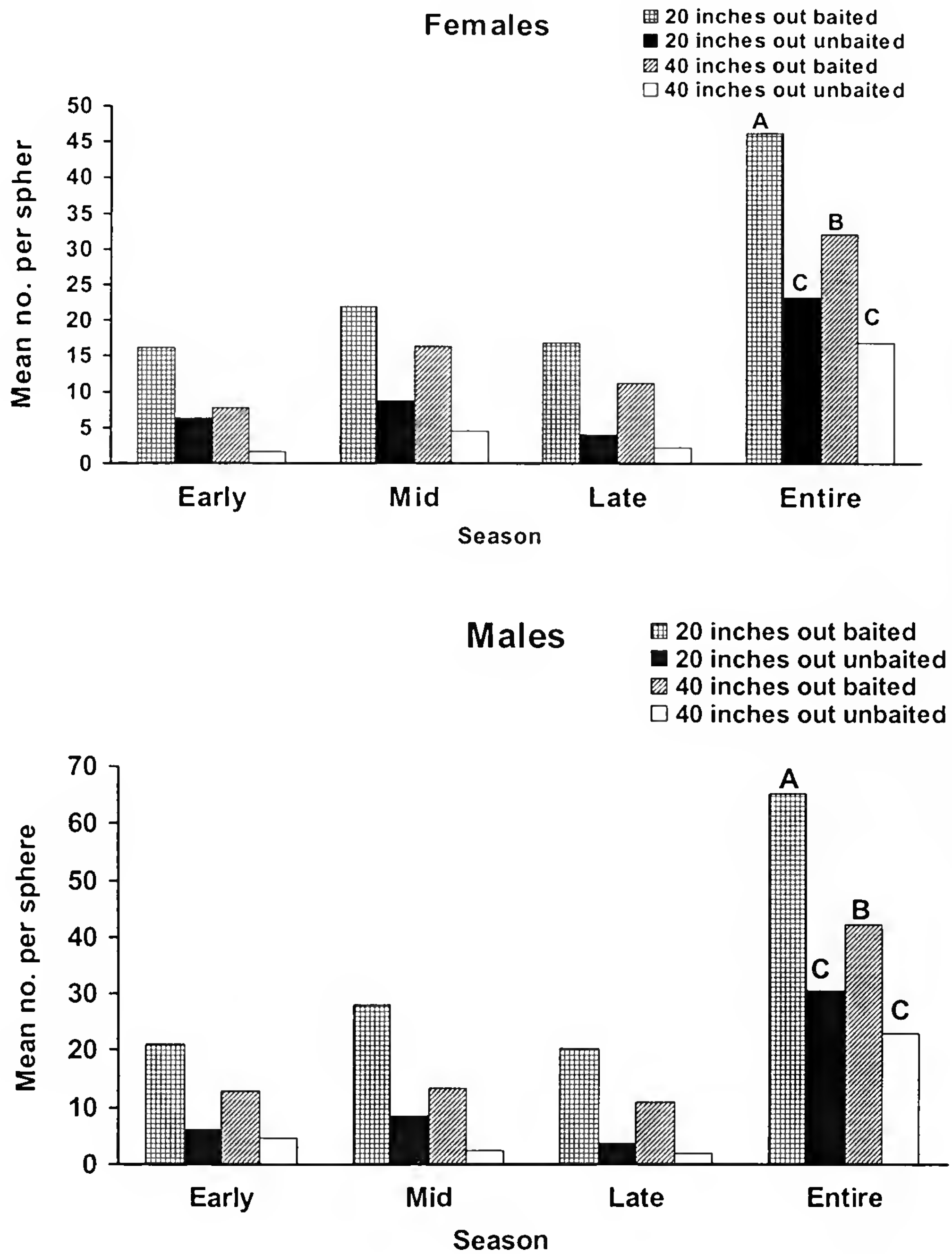

Figure 4. Mean number female and male AMF captured per odor-baited and unbaited sphere in Golden Delicious trees when spheres were in the outer half of the canopy and foliage and fruit were cleared to either 20 or 40 inches in a radius around the sphere. Captures were evaluated for early, mid, and late season and across the entire season. For the entire season, mean values superscribed by the same letter are not significantly different at odds of 19:1.

foliage and fruit within 10 to 20 inches of a trap was removed. Response was significantly or numerically less to baited spheres when spheres were hung in the inner half of the canopy (foliage and fruit cleared to 10 or 20 inches) or when spheres in the outer half of the canopy had foliage and fruit cleared to distances of 0, 30, or 40 inches. In contrast to baited spheres, unbaited spheres performed about as well when hung in sub-optimal position (either in the inner half of the canopy with foliage and fruit cleared to 10 inches or in the outer half of the canopy with foliage and fruit cleared to 40 inches) as when in optimal position (in outer half of the canopy with foliage and fruit cleared to 20 inches). Patterns of adult response to sphere treatments were essentially the same during each phase of the fruit development season.

In our experiments, use of a five-component blend of synthetic apple volatiles in association with red spheres not only significantly enhanced attractiveness of spheres but also significantly accentuated degree of differential response to varying within-tree sphere positions compared with response to unbaited spheres. For example, adults responded equally to outer-canopy spheres with foliage and fruit cleared to 20 inches and inner-canopy spheres with foliage and fruit cleared to 10 inches when spheres were unbaited but significantly favored the former over the latter when spheres were baited. Causes underlying this and similar differential response patterns found here are unknown but could involve an interaction between presence of synthetic fruit odor and visual apparency of spheres that favors discovery of baited spheres in positions where the integrity of a synthetic odor plume and the conspicuousness of a sphere are not compromised by an overabundance of nearby foliage and fruit (e.g., as at a distance of 0 or even 10 inches) or an insufficient amount of light (e.g., as at interior of canopy). Too little nearby foliage and fruit, however, as for odor-baited spheres having foliage and fruit cleared to 40 inches, is just as unfavorable as too much nearby foliage and fruit, possibly in part because AMF are less able to visually detect 3.5-inch red spheres at a distance of 40 inches compared with closer distances.

In summary, our results suggest that maximal success in using a red sphere for monitoring or controlling AMF can be achieved by baiting a sphere with a five component blend of attractive odor, positioning the sphere in the outer half of an apple tree canopy, clearing away all foliage and fruit within 20 inches of the sphere, and allowing foliage and fruit beyond that distance to remain.

Acknowledgments

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* * * * *

Evaluation of Pesticide-Treated Spheres for Control of Apple Maggot Flies in 2003

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In the two preceding articles in this issue of *Fruit Notes*, we described results of recent research aimed at optimizing (1) distances between odor-baited spheres on perimeter trees for control of apple maggot flies (AMF) and (2) placement of spheres within the tree canopy. These results were obtained using spheres coated with Tangletrap as the agent for capturing and killing arriving AMF. If odor-baited spheres are to be used extensively for AMF control in commercial orchards, a substitute for Tangletrap as fly killing agent must be found. One potential substitute that we began to develop in 1990 and have been refining ever since is a sphere whose surface has pesticide as fly killing agent and sugar as feeding stimulant to induce arriving AMF to ingest the pesticide.

In the 2001 issue of *Fruit Notes* and in a 2003 issue of the *Canadian Entomologist*, we described results of commercial-orchard tests of pesticide-treated spheres (PTS) for control of AMF. The tests were conducted in 2001 and 2002, respectively. Combined findings led us to conclude that sugar as feeding stimulant can best be maintained on the sphere surface via periodic seepage from a disc atop the sphere that contains a mixture of highly compressed sugar and paraffin wax.

Here, we describe results of tests conducted in 2003 that compare the version of PTS evaluated in 2002 with a new version of PTS developed in 2003 for AMF control. The 2002 version involved a plastic sphere coated with red latex paint containing a small amount of imidacloprid as fly killing agent, topped by a sugar-paraffin disc. The 2003 version involved an unpainted red plastic sphere topped by a sugar-paraffin disc that contained a small amount of spinosad as fly killing agent. This version relied on seepage of both spinosad and sugar from the disc onto the sphere surface under high humidity, dew, or rainfall.

Material & Methods

For the 2002 PTS version, the sphere was 3.5 inches in diameter and received a coat of latex paint containing 2% (a. i.) of imidacloprid (Provado). The disc atop the sphere was composed of 80% table sugar. (sucrose) and 20% paraffin wax (200 grams total mass). It measured 3 inches in diameter x 1.5 inches tall. It was white in color, compressed under 20 tons of hydraulic pressure and embedded in a wire guard to protect it from consumption by rodents.

For the 2003 PTS version, the 3.5-inche sphere received no paint or pesticide on the surface. It was topped by a disc (similar to the 2002 version) that contained one of several different concentrations (ranging from 0.001 to 4.0% a.i.) of spinosad (Entrust) thoroughly mixed with the sugar.

In our first experiment, spheres were evaluated in six commercial orchards in MA, each of which contained four 1/2-acre plots of apple trees. Three of the plots received no insecticide after mid-June and were surrounded by either 2002-version PTS, 2003-version PTS (containing 4.0% spinosad), or sticky spheres placed 6-8 yards apart on perimeter trees. Spheres were deployed during the first week of July and remained for 12 weeks. Discs atop PTS were not

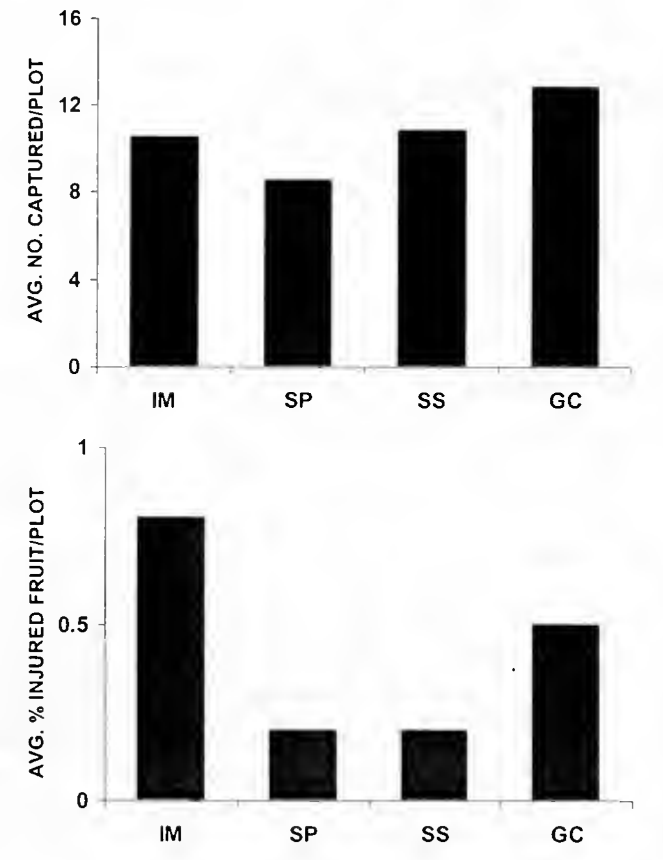

Figure 1. Captures of feral AMF on unbaited monitoring traps and percent fruit injured by AMF in 24 plots of apple trees in 6 commercial orchards in 2003. Plots with IM=imidacloprid-treated PTS, SP=spinosad-treated PTS, and SS=sticky spheres. GC= grower-sprayed plots.

replaced. Each sphere was baited with a vial containing a synthetic 5-component blend of attractive fruit volatiles. The fourth plot received two or three grower-applied sprays of organophosphate insecticide to control AMF. Treatment effectiveness was judged by comparing numbers of feral AMF captured on interior unbaited monitoring traps (four traps on central trees of each plot) and percent injury to fruit in samples taken at harvest (100 fruit per plot).

After 6, 9, and 12 weeks of sphere exposure, we retrieved two randomly-chosen PTS of each type from each of the six orchards and returned them to the laboratory for testing. We assessed the fly killing power of each retrieved PTS by exposing 10 walnut husk flies to each sphere (our supply of AMF was depleted, so we substituted adults of this other very closely related species). A single fly (deprived of food for 12-15 hours) was transferred gently to the sphere just below mid-height and allowed to remain up to 10 minutes, after which it was transferred to a small clear-plastic cup supplied with sugar and water. After 72 hours, we recorded whether the fly was dead or alive.

In our second experiment, we hung one sphere of each of six different types in each of six apple trees that received no insecticide in 2003. Sphere types per tree were as follows: one 2002-version PTS, four 2003-version PTS (topped by discs containing either 0.5%, 1.0%, 2.0%, or 4% spinosad), and one untreated (control) sphere. Spheres were deployed in early July and remained for 12 weeks. At 6, 9, and 12 weeks after deployment, two spheres of each type were brought to the laboratory and assessed for fly killing power using above procedures.

In our third experiment, we subjected 2003-version PTS to different amounts of artificial rainfall (1, 4, 7, or 10 inches) in a laboratory chamber. The chamber was designed to deliver

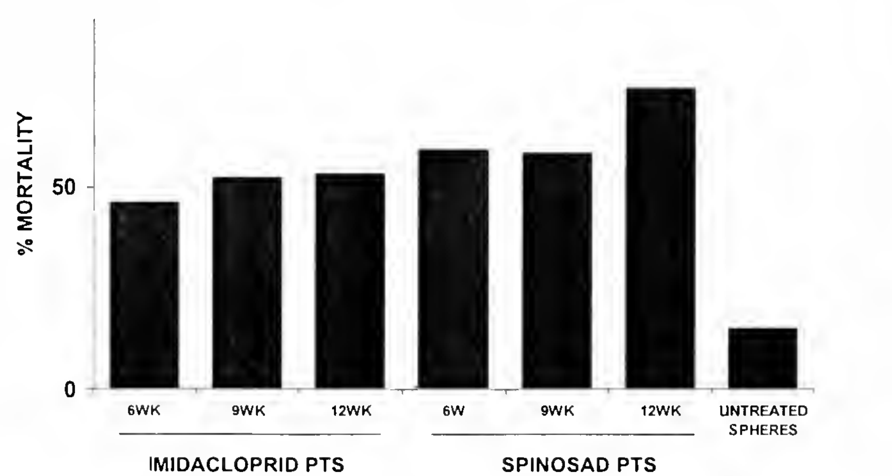

Figure 2. Percent mortality of flies 72 hours after exposure for 10 minutes in laboratory cages to PTS retrieved 6, 9, or 12 weeks after deployment in commercial orchards in early July. Each value is based on sphere exposure to 120 flies (10 per sphere x 2 spheres per orchard x 6 orchards).

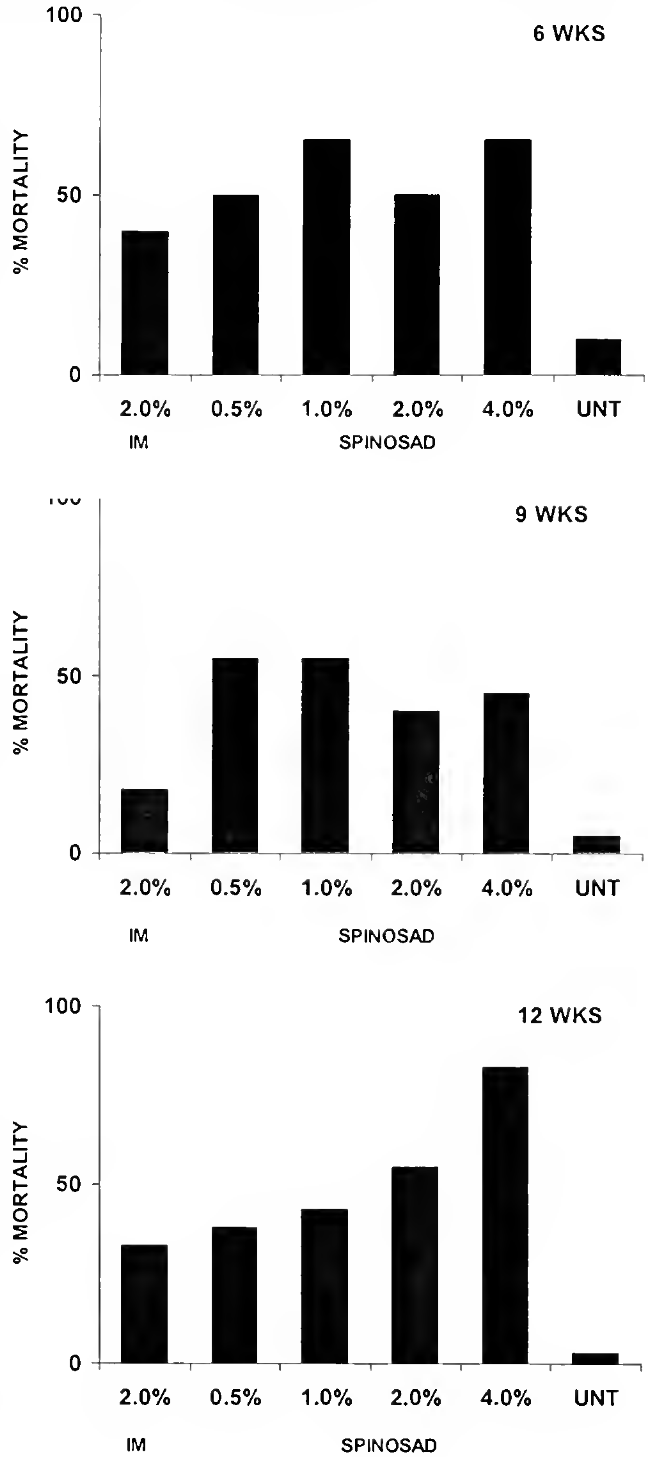

Figure 3. Percent mortality of flies 72 hours after exposure for 10 minutes in laboratory cages to PTS retrieved 6, 9, or 12 weeks after deployment in an unsprayed orchard in early July. Each value is based on sphere exposure to 20 flies (10 per sphere x 2 spheres per treatment). Treatments were: 2% imidacloprid (IM) in paint on sphere; 0.5, 1.0, 2.0, or 4.0% spinosad in discs atop spheres; or untreated spheres (UNT).

water at an intensity and droplet size approximating medium rainfall. Discs atop spheres contained either, 0, 0.001, 0.01, 0.1, or 1.0% spinosad. After each inch of artificial rain, a sphere was allowed to dry for 24 hours before the next inch was applied. Spheres were assessed for fly killing power using above procedures, accompanied by careful observation of fly feeding behavior during each 10-minute trial. A fly was considered to have fed if it remained still with proboscis fully extended for at least 10 seconds.

Results

Results of Experiment 1 (Figure 1) for commercial orchard plots show that, on average, the fewest AMF captured on interior monitoring traps and the fewest injured fruit in samples taken at harvest were in plots surrounded by 2003-version PTS topped by discs containing 4.0% spinosad. By each of these measures, 2003-version PTS outperformed both 2002-version PTS (whose surface was treated with imidacloprid) and insecticide spray for AMF control. When assayed in the laboratory (after retrieval from orchard plots) to AMF placed directly on the PTS, again 2003-version PTS containing 4.0% spinosad in the disc outperformed 2002-version PTS whose surface was treated with imidacloprid (Figure 2). Especially impressive was the finding (Figure 2) that 74% of adults died after placement on 2003-version PTS exposed for 12 weeks in commercial- orchard trees. During these 12 weeks, 18-22 inches of rain fell on the PTS.

Results of Experiment 2 (Figure 3) show that after 6 weeks of exposure in unsprayed orchard trees, 2003-version PTS topped by discs containing 0.5, 1.0, 2.0, or 4.0% spinosad were about equally effective in killing adults placed directly on the spheres (50-65% mortality). Results were nearly the same after 9 weeks of field exposure (40-55% mortality). After 12 weeks of field exposure, however, there was a consistent trend toward greater toxicity (from 38 to 83%) with increasing dose (from 0.5% to 4.0%) of spinosad in the disc. Imidacloprid-treated, 2002-version PTS were inferior to all

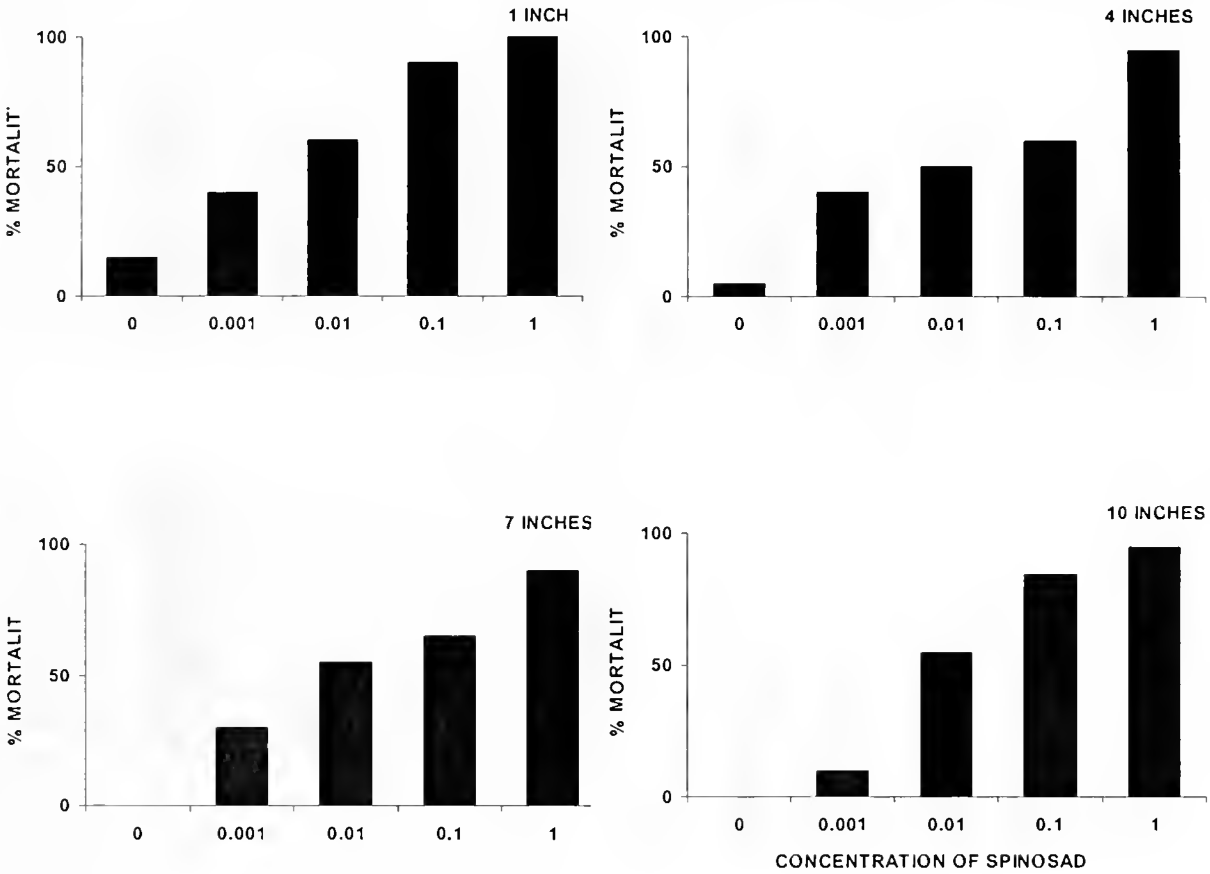

Figure 4. Percent mortality of flies 72 hours after exposure for 10 minutes in laboratory cages to spheres topped by discs that contained different concentrations of spinosad (0 to 1.0%) and received 1, 4, 7, or 10 inches of artificial rainfall before testing. Each value is based on sphere exposure to 20 flies (10 flies per sphere x 2 spheres per treatment).

2003-version PTS (regardless of dose of spinosad) at 6, 9, and 12 weeks of field exposure (Figure 3), during which cumulative totals of about 11, 13, and 21 inches of rain fell on the PTS.

Results of Experiment 3 (Figure 4) show that among adults placed on 2003-version PTS exposed to artificial rainfall of 1, 4, 7, or 10 inches, mortality of adults after 10 inches of rainfall was 0, 10, 55, 85, and 95% for spheres having discs containing 0, 0.001, 0.01, 0.1, and 1.0% spinosad, respectively. Additional results for spheres exposed to 10 inches of rainfall revealed that about 25% of adults placed on spheres moved onto the disc, irrespective of amount of toxicant in the disc (data not shown). Data in Figure 5 show that regardless of the dose of spinosad in the disc, 71-93% of flies that remained on the sphere surface (after placement there) fed for at least 10 seconds and 67-100% of flies that moved onto the disc (after placement on the sphere surface) fed on the disc. Mortality of flies that remained on the sphere surface (79-91%) or moved onto the disc (100%) was high for discs having 0.1 or 1.0% spinosad but was lower (50-56%) for discs having a 0.01% spinosad and very low (0-7%) for discs having 0.001% spinosad. Combined results from Experiment 3 suggest that after receiving 10 inches of artificial rainfall, disc-topped PTS receive enough sugar to stimulate a high proportion of adults to feed on the sphere surface but an insufficient amount of toxicant to kill a high proportion of adults at doses of spinosad of 0.01% or less.

Conclusions

Results of all three experiments conducted in 2003 pave the way for a new type of pesticide-treated sphere for control of apple maggot. The new type (our 2003-

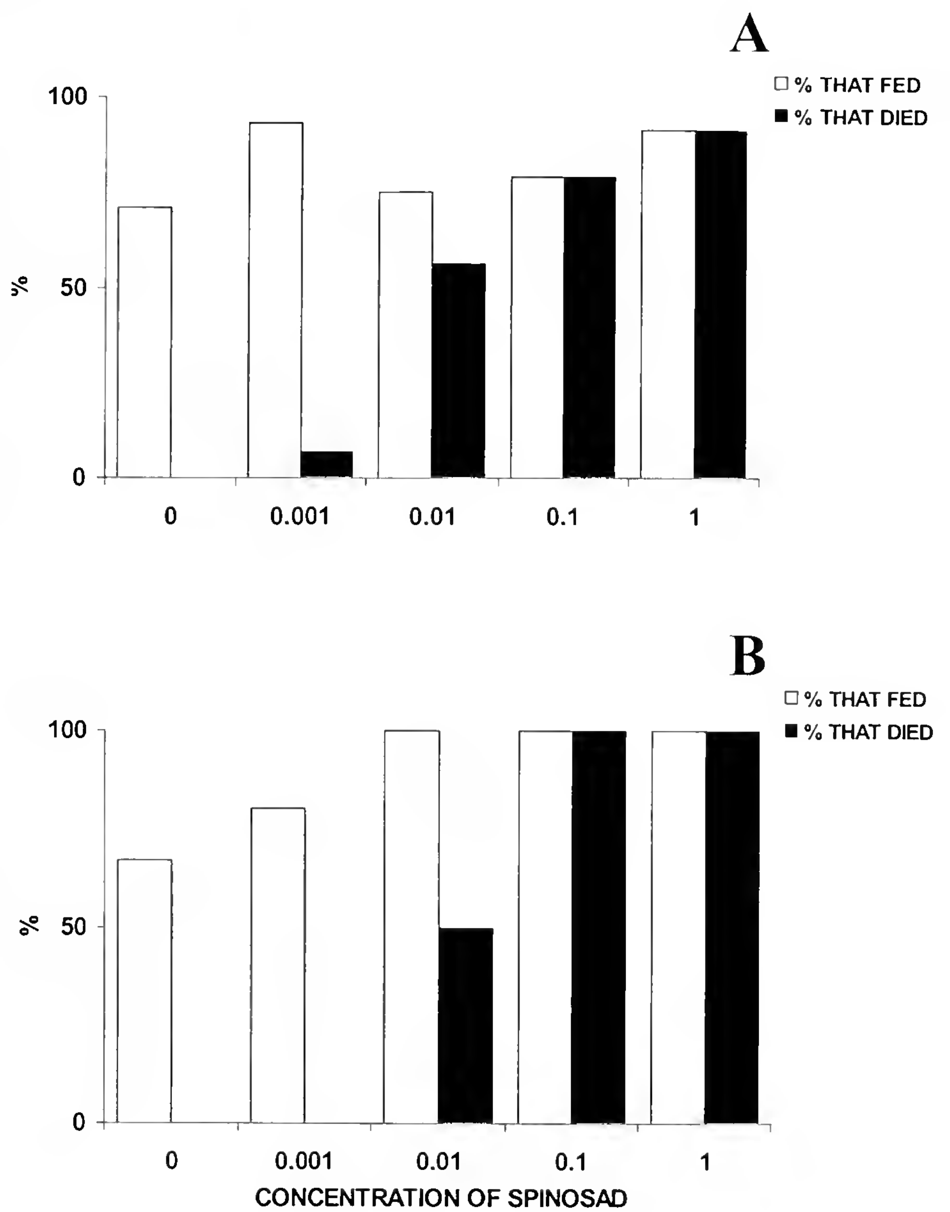

Figure 5. Among flies (from Figure 4) placed on spheres topped by discs that contained different concentrations of spinosad (0 to 1.0%) and received 10 inches of artificial rainfall before testing (A) percentage of those which remained on spheres that fed and died within 72 hours, and (B) percentage of those which moved onto discs that fed and died within 72 hours.

version) contains spinosad (Entrust) in the disc atop the sphere. Results of laboratory trials (Experiment 3) suggest that the concentration of spinosad in the disc needs to be at least 0.1% to be effective after 10 inches of artificial rainfall, whereas results of field trials (Experiments 1 and 2) suggest that a dose of spinosad higher than 0.1% may be needed to withstand amounts of natural rainfall that exceed 10 inches.

It is encouraging to know the University of Massachusetts (the financial supporter of a pending patent for this new type of PTS), Dow Chemical Company (manufacturer of Entrust), the EPA (which supervises registration of new products for orchard used), and Pest Management Innovations Incorporated (manufacturer of discs atop PTS) are jointly enthusiastic about this new technology of incorporating spinosad into sugar/paraffin discs atop spheres for managing AMF.

Acknowledgments

Thanks to Eliza Gray, Mareanna Ricci, and Guadalupe Trujillo for technical assistance in the field test. These studies were supported by grants from the USDA Pest Management Alternatives Program and the USDA Crops at Risk Program.

* * * * *

Fruit Notes

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SERIAL SECTION
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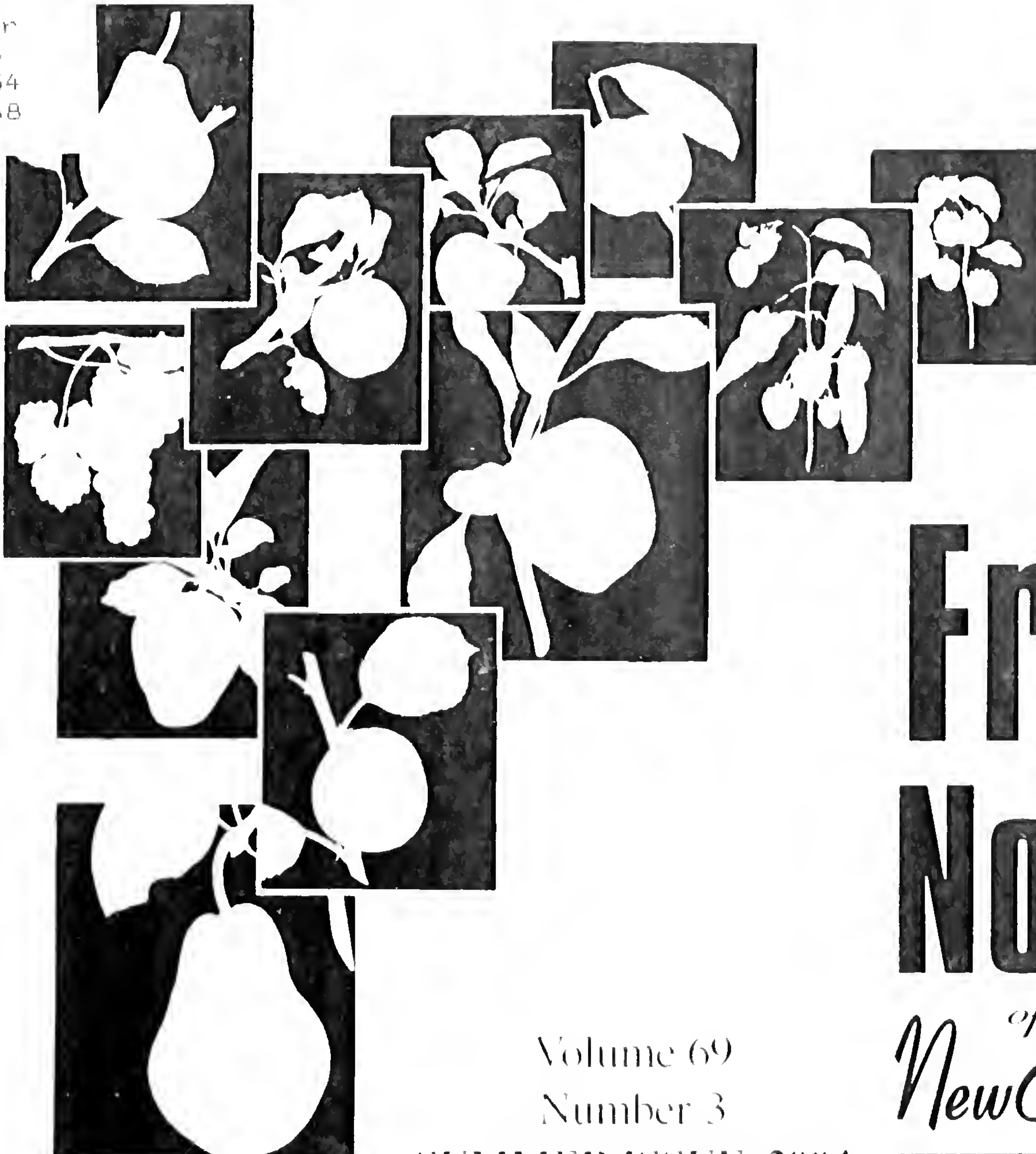

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An Orchard System for Monitoring and Modeling Apple Scab, Disseminating Apple Scab Model Data Regionally, and Managing Orchard Fungicide Use

Jon M. Clements

Department of Plant & Soil Sciences, University of Massachusetts

In 2003, James O'Brien (Brooksby Orchard), Steve Ware (Bolton Orchard), Richard Bartlett (Bartlett Orchard), Tom Clark (Clarkdale Fruit Farm), Maurice and Phyllis Tougas (Tougas Family Farm), William Broderick (Sunnycrest Orchard), and I received an Agro-Environmental Technology grant from the Massachusetts Department of Agricultural Resources (DAR) to purchase and install Spectrum Technologies (23839 West Andrews Rd., Plainfield, Illinois) weather stations in their orchards. What follows is the narrative of the Final Report I submitted to DAR in December, 2003. The complete report is available on the UMass Fruit Advisor, www.umass.edu/fruitadvisor/clements/ and from the DAR Agro-Technology web site, www.state.ma.us/dfa/programs/agroenviro/.

A simple system for apple growers to monitor environmental weather data (temperature and leaf wetness particularly) to be used in models for predicting apple scab infection periods would make their fungicide applications more timely and accurate, thereby potentially reducing pesticide use, improving disease control, and saving money. Additionally, raw weather data and model output can now be shared regionally via the Internet to be used by neighboring growers. Such a system has recently become feasible with the availability of inexpensive electronic weather data monitors, personal-computer (PC)-based models, e-mail delivered weather data, and models by commercial services, and grower familiarity with PC's and the Internet.

Objectives

1. Establish a series of onsite weather stations that collect data, which can be used in models to predict apple scab infection periods. Such models will help growers determine the need (or lack of) for fungicide sprays to control apple scab based on accurate environmental information previously unavailable to them.
2. Post weather and apple scab infection period information from these orchards on the Massachusetts Fruit Growers' Association web site (http://www.massfruitgrowers.org) for neighboring growers access and use in helping *them* make fungicide application decisions.
3. Compare weather data collected by onsite weather stations in trial orchards to SkyBit E-Weather information, particularly when used in models to predict apple scab infection periods. Survey trial growers to ascertain their preference, and be able to make recommendations to other growers based on their preference.

Procedures

In late April 2003, Spectrum Technologies weather stations (either 3610TWD 'Watchdog' Leaf Wetness/ Temperature Logger or 3684PDSR 'Watchdog' Plant Disease Station) were installed in the cooperating grower orchards. Spectrum Technologies PC software (3656 SpecWare 6.0) for collecting and displaying weather data and analyzing apple scab infection periods (3656AS Apple Scab IPM) were installed on cooperating growers computers, and they were given coaching in its use. Growers were instructed to collect weather data, run the apple scab model, and post the results to the Massachusetts Fruit Growers' Association (MFGA) web site at weekly intervals via FTP (File Transfer Protocol) (Figure 1).

Specware 6.02 CLARK Apple-Scab From 04/25/2003 To 07/01/2003

Date	Temperature High	Low	Wet Hrs	Degree Days	%Spore Mature	Infection Degree Mills	Wash St	Cornell
04/25	71.6	48.8	0.0	16	0	None	None	None
04/26	50.3	44.5	19.3	32	1	Light	Light	Infected
04/27	70.4	45.2	0.0	55	1	None	None	None
04/28	83.0	37.7	0.0	85	2	None	None	None
04/29	77.4	46.7	0.0	116	3	None	None	None
04/30	67.7	40.8	0.3	138	4	None	None	None
05/01	66.3	46.7	3.0	161	6	None	None	None
05/02	78.8	48.1	8.5	187	8	None	None	None
05/03	67.7	42.3	0.0	209	9	None	None	None
05/04	67.7	32.2	0.0	228	11	None	None	None
05/05	70.4	35.4	0.0	250	14	None	None	None
05/06	50.3	41.5	2.8	265	18	None	None	None
05/07	75.3	48.1	3.5	294	22	None	None	None
05/08	59.4	48.8	15.5	313	26	Medium	Light	Infected
05/09	70.4	45.9	8.3	338	30	Medium	Medium	Infected
05/10	76.0	38.5	0.0	362	34	None	None	None

Figure 1. Sample 'Specware' apple scab model output.

For the months of April, May, and June, 2003, SkyBit Inc. E-Weather Combo (Forecast & Summary) and IPM Apple Disease products were received by cooperating growers via daily e-mails (Figure 2). Growers were instructed in interpreting the SkyBit E-Weather information and comparing it to the weather data collected on-site. It was assumed and suggested that growers would use the environmental information from both sources to help determine the need for and the timing of orchard fungicide sprays for apple scab.

During the growing season, contact was maintained with grower cooperators to make sure the weather stations were functioning properly and accurately and that apple scab model data were being posted to the MFGA web site. In late September 2003, an on-line survey was developed for cooperating growers to give feedback on their experience with the weather equipment, SkyBit E-Weather, and using the information to make spray decisions.

In general, installation and use of the Spectrum Technologies weather data loggers/stations went smoothly. On occasion, growers had trouble downloading and saving data to their personal computers; in one instance data was lost and unrecoverable. In addition, growers found it easy to upload model data to the website; however, timeliness and frequency of uploading could be improved.

As a rule, cooperating growers used the Spectrum weather stations to collect orchard weather data successfully, and then used the information in models to predict if apple scab infection periods occurred. They also monitored daily SkyBit E-Weather information to evaluate predicted spray conditions and the disease/insect models. Survey results suggest growers preferred the on-site weather stations to SkyBit E-Weather.

Survey results suggested, however, that growers may not have used the models to predict apple scab infection periods and help them make spray decisions as often as one would hope. One concern expressed by growers was the time it takes to evaluate the information ('information overload'), particularly during the 2003 wet spring and early-summer scab spray season. In fact, it was so wet during this season, that sprays to control apple scab had to be applied on a weekly basis. At least one grower, however, said he should have paid better attention to the model output, which predicted he should have applied fungicides more often than he did.

Based on survey results, the model data uploaded to the MFGA web site was used minimally (if at all) by neighboring growers. Web site page requests to the web server weather directory, however, totaled

E-WEATHER SERVICE — AGWEATHER IPM APPLE DISEASE PRODUCT

For: MA-BELCHERTOWN-HORTRESCENTER — Date: SUN Jul 13, 2003

	WEATHER					APPLE SCAB 030415				FIRE BLIGHT 030506				SOOTY BLOTCH 030521	
	TMX	TMN	PREC	ARH	LW	ASM	AW	TW	PW	ADH	AW	TW	PW	ALW	PW
Date	F	F	in	%	hr	%	hr	F		65F	hr	F		hr	
BASED ON OBSERVATIONS															
0701	80	57	0.00	64	0	100	0	-	+	225	0	-	-	346	+
0702	83	57	0.00	63	0	100	0	-	+	225	0	-	-	346	+
0703	79	64	0.00	75	0	100	5	65	+	225	5	65	++	351	++
0704	89	64	0.00	71	9	100	9	69	++	225	9	69	++	355	++
0705	86	70	0.08	73	8	100	14	75	++	225	14	75	++	369	++
0706	87	70	0.00	66	10	100	18	75	++	225	18	75	++	373	++
0707	84	64	0.00	70	0	100	5	70	+	225	5	70	++	378	++
0708	85	70	0.00	75	10	100	10	72	++	225	10	72	++	383	++
0709	72	59	0.25	80	14	100	20	63	++	225	20	63	++	403	++
0710	75	57	0.00	71	9	100	23	64	++	225	23	64	++	412	++
0711	65	60	0.94	96	24	100	30	63	++	225	30	63	++	436	++
0712	80	61	0.00	73	10	100	34	63	++	225	34	63	++	440	++
BASED ON FORECASTS															
0713	77	61	0.00	65	0	100	0	-	+	225	0	-	-	440	++
0714	78	56	0.00	68	0	100	0	-	+	225	0	-	-	440	++
0715	82	62	----	69	0	100	3	64	+	225	3	64	++	443	++

Figure 2. Sample 'SkyBit E-weather.

approximately 2,800 for the three-month period April through June.

A press release on June 04, 2003 resulted in articles appearing in at least two newspapers about this project. They included: 'Grant application bears fruit: New Weather station will provide data for area growers,' *The Berkshire Eagle*, June 26, 2003; 'The fruit of his labors: Brooksby Farms teams up with UMass to improve apple growing,' *Gloucester Daily Times*, August 27, 2003.

All six cooperating growers now have functioning orchard weather monitoring stations installed that can be used in upcoming growing seasons. They also have personal computer software to download and store the weather data collected by the stations, as well as disease and insect models. All growers expressed an interest in continuing to collect and use orchard environmental data from the weather instruments in upcoming growing seasons.

Conclusion

The objectives of this project were met. To summarize:

1. Six on-site weather stations were easily established in grower orchards. Growers used models minimally to help assess scab infection periods and time fungicide sprays. The Limitations encountered were occasional weather station/computer software interface problems and lack of time during a busy period for orchard activities to analyze fully all the information available for decision-making.
2. Weather and apple scab infection period information from these orchards were posted on the Massachusetts Fruit Growers' Association web site for neighboring growers access and use in helping them make fungicide application decisions. It is unclear, however, how much this information was used by neighboring growers. A better approach would be to encourage growers to purchase their own weather stations.
3. SkyBit E-Weather information was used by cooperating growers in decision-making, although the consensus appears to favor the use of on-site weather stations for this purpose. A thorough comparison of SkyBit E-Weather model output vs. on-site weather stations still needs to be done; however, it may be irrelevant, as grower preference

clearly favors the on-site weather stations and model output derived from them.

Unfortunately, it is difficult to quantify the real impact, both monetary and environmental, of deployment of these weather stations, and was perhaps beyond the scope of this project. Clearly, however, a basic tenet of IPM is monitoring, and there is no doubt grower use of the technologies explored here has given cooperating growers information to make spray decisions that they would otherwise not have, and therefore, ought to have both favorable economic and environmental impacts.

Finally, although a start was made here, more education and effort needs to be made giving growers IPM tools that are both accurate and friendly, hence enhancing their adoption. Clearly there is room for improvement in gathering and analyzing weather data to make orchard spray decisions.

Acknowledgements

We are grateful to the Massachusetts Department of Agricultural Resources Agro-Environmental Technology Grant Program for funding this project. Also, thanks to the cooperating growers for learning the technology to make this project possible.

* * * * *

Flyspeck Epidemics I: Measuring Ascospore Maturation of the Causal Fungus

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If flyspeck of apple were like apple scab and had both a primary stage and a secondary phase, it might be useful to understand how the primary stage works, so that management tactics could focus on it, the same way scab management is focused on primary scab. Theoretically, if the epidemic could be stopped early, then summer fungicides might be greatly reduced. Interestingly, the fungus that causes flyspeck, *Schizothyrium pomi* and its asexual form, *Zygophiala jamaicensis*, are ascomycetes that are similar to the apple scab pathogen *Venturia inaequalis*. That is, *S. pomi* produces ascospores and conidia; however, not much more is known about how the fungus overwinters and then ends up producing the damaging black specks on apple fruit. Of course, it grows on the waxy cuticle of fruit forming colonies of circular, black, specks called thyriothecia. These thyriothecia group in colonies of several to 50 or more, and it is these structures that eventually produce ascospores. There are a few key questions to ask. Do thyriothecia produce ascospores throughout the year, or just during a single period? Secondly, if there is just one period of ascospore production, when is it? Finally, where do the ascospores land and infect? Nearly 8 years ago, we suggested that ascospores matured only once a year, during the spring and early summer and that they might be the spores that start flyspeck epidemics each year (7). Now we have more definitive information on how ascospores of the flyspeck fungus function.

When evaluating the risk of apple scab infections in the spring, it is useful to look at the fungal structures that contain ascospores, to see how mature the spores are. The more mature spores get, the higher the risk goes. Such an approach might prove useful in both the study and, eventually, management of FS. As part of this study, we modified a technique for the preparation and interpretation of thyriothecial squash mounts of *S. pomi*.

Flyspeck can live on the waxy cuticles of many kinds of plants. We identified *S. pomi* on 26 woody plant species that commonly grow in orchard borders in Massachusetts including trees, shrubs, and vines. For these studies, we have focused on a common blackberry (*Rubus allegheniensis* Porter), which supports easily identifiable infections with abundant thyriothecia. Blackberry is an excellent indicator of the presence of *S. pomi* near orchards and is one of the most common hosts of the fungus in Massachusetts.

Thyriothecia can be picked from blackberry, using a dissecting microscope, and then squashed using a method similar to the one used for apple scab. They are examined under a high-powered microscope, and rated according to the following maturity classes: undeveloped, no asci present (0); immature asci present without ascospores (1); mature asci present containing ascospores (2); majority of asci ruptured or empty with or without released ascospores (3).

The blackberry canes can also be cut and brought into the laboratory, where they can be put into controlled environments to see how the thyriothecia develop. So, over several years, canes have been incubated in different humidity levels and at different temperatures.

Both temperature and humidity significantly affect the maturation of *S. pomi* ascospores. Thyriothecia do not produce ascospores when the air is not extremely humid, 99% relative humidity or more. It also needs to be relatively warm for ascospores to mature. At 70°F, if the air stays nearly saturated with humidity, *S. pomi* ascospores will mature in about 48 hrs. At 57°F, it takes 5 days, and at 50°F it takes 6 to 9 days. Below 48°, thyriothecia never really develop in the lab, even after 18 days of incubation (Table 1).

We followed maturation of thyriothecia on canes

Table 1. Development of *Schizothyrium pomi* thyriothecia collected in the field and grown in controlled temperatures and high humidity chambers in each of three years.

Year	RH[a]	Temp°C	Days elapsed to mature spores	DD_0[b] to mature spores
1995	high	7	-[c]	-
		14	5	126
		21	2	76
1996	high	4	-	-
		6	-	-
		10	10	180
1997	99	7	-	-
		9	8	130
		21	3	113
Mean				125±33

[a]Relative humidity. In 1995 and 1996, thyriothecia were incubated in sealed glass Petri dishes containing filter paper saturated with distilled water; in 1997 incubation was in a sealed glass Petri dish containing salt-amended agar that maintained relative humidity at pre-determined levels.
[b]DD_0 are degree-days base 0°C accumulated over the incubation period.
[c]A dash indicates failure to develop at that treatment.

in borders near commercial orchards over 3 years. They developed in a consistent pattern over the 3 observation years and over the five orchard sites (Figure 1). Mature ascospores were first observed when McIntosh was in pink or bloom. In 1997 and 1999, all thyriothecia had matured 4 weeks after McIntosh petal fall, while in 1998, maturation ended 6 weeks after petal fall. When thyriothecium maturation stopped, McIntosh fruit were from 1 to 3 in diameter. Over all orchards and dates, the earliest date at which thyriothecia reached 95% maturation was June 8, while the latest was June 19.

If *S. pomi* spore development follows apple development, then like apples, the fungus maturation process may be

Table 2. Days from green tip to bloom, degree days base 0°C, and degree days base 0°C for periods at or above 95% relative humidity for orchard sites in Massachusetts, 1997, 1998 and 1999.

Year Location	Date of gt[a]	First mature thyriothecia observed	Days gt[a] to first mature thrytiothecia	DD_0[b] gt[a] to first mature	$DD_{0;rh?95\%}$[c] gt to first mature	First Symptoms on apples
1999 Ashfield	9-Apr	26-May	47	882	-[d]	21-Sep
Belchertown	8-Apr	24-May	46	991	82	15-Sep
Brimfield	6-Apr	24-May	48	962	-	3-Sep
Shelburne	8-Apr	18-May	40	757	127	16-Sep
1998 Ashfield	1-Apr	5-May	34	605	-	28-Jul
Belchertown	28-Mar	13-May	46	956	128	27-Jul
Brimfield	28-Mar	1-May	34	611	-	16-Jul
1997 Shelburne	23-Apr	26-May	33	638	135	11-Aug
Sterling	16-Apr	20-May	34	655	102	7-Aug
Mean			40	763	115	

[a]Green tip, the phenological stage where 50% of 'McIntosh' fruit buds have opened and show green tissue.
[b]DD_0 are degree-days base 0°C accumulated over the specified period.
[c] $DD_{0;rh?95\%}$ are degree-days base 0°C that accumulate over the specified period when relative humidity is at or above 95%.
[d]A dash indicates that there was insufficient relative humidity data to calculate $DD_{0;rh?95\%}$.

largely driven by temperature. To evaluate this possibility, we calculated degree-days from green tip using various base temperatures from 32° to 60°. We found that 90% of the maturation could be explained by degree-days calculated from a 32° base (Figure 2). We developed a model that predicts that 5% of the thyriothecia will mature at 540 degree days, and 95% will mature by 1630 degree days. The first mature spores were actually observed at 550 degree days, and no spores were observed beyond 2100 degree days.

We needed to compare this to the degree days in the laboratory experiments. Obviously, it was taking only 2 to 9 days to go from no spores to mature spores in the lab, while it was taking weeks to see similar development in natural setting. In terms of degree days, the laboratory thyriothecia matured after a mean of 125 degree days (Table 1). The average degree days from green tip to the first mature thyriothecia in the field was 763, over six times greater than in the laboratory experiments (Table 2).

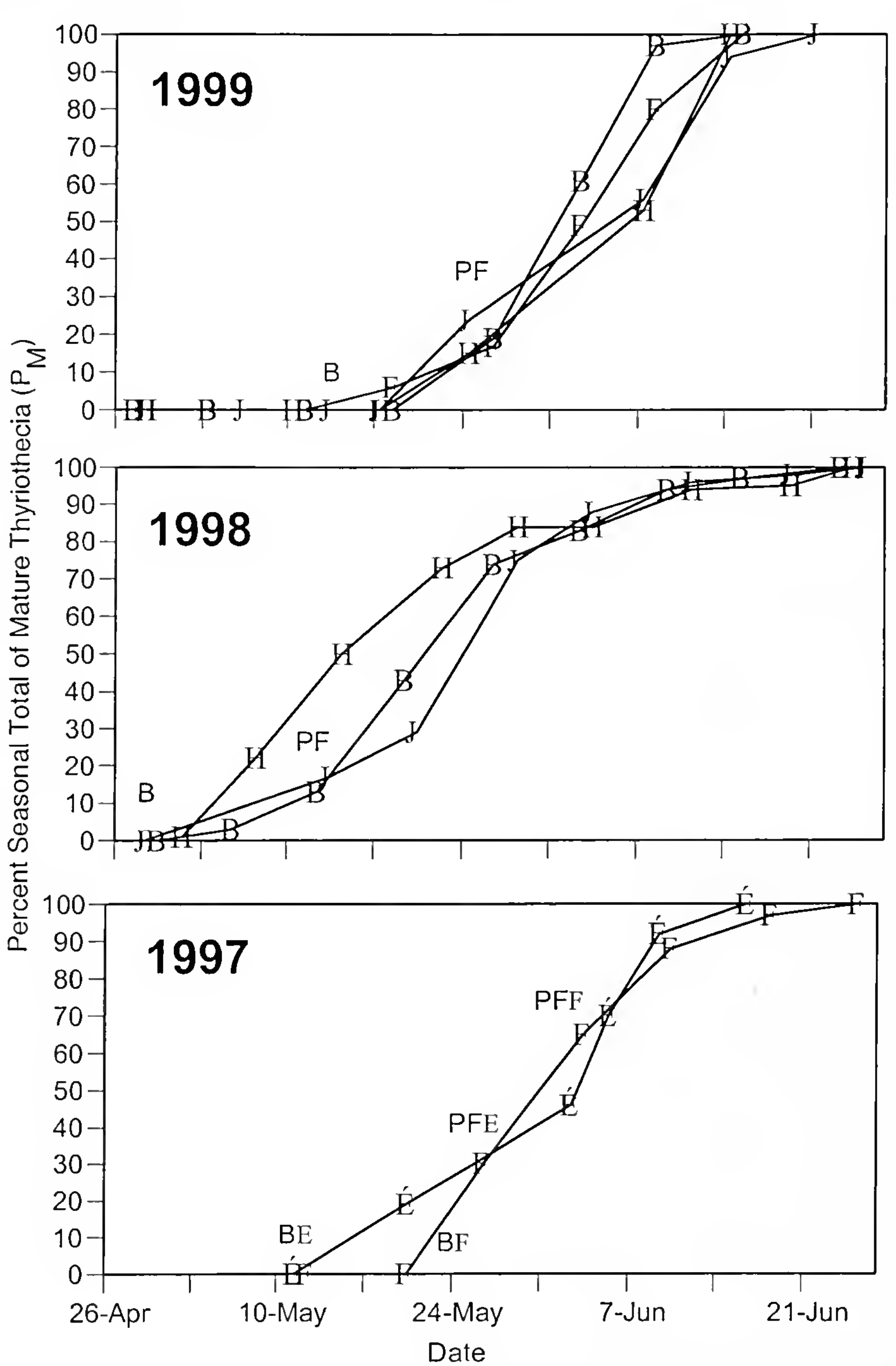

Figure 1. Percent thyriothecia on blackberry canes that matured during each year, 1997, 1998, and 1999, in five Massachusetts orchards: Ashfield (B), Belchertown (J), Brimfield (H), Shelburne (F), and Sterling (É). Times of bloom (B) and petal fall (PF) of McIntosh in 1998 and 1999 are shown, ±3 days depending on the orchard, while in 1997 the phenological stages are indicated for each site.

It is possible that the results differed because the thyriothecia in the laboratory were always exposed to high relative humidity, while those in nature have only short periods where relative humidity meets or exceeds 95%. We calculated degree-day values at the orchard sites for those periods when relative humidity was 95% or greater. Five of the nine data sets had hourly humidity data sufficient to calculate

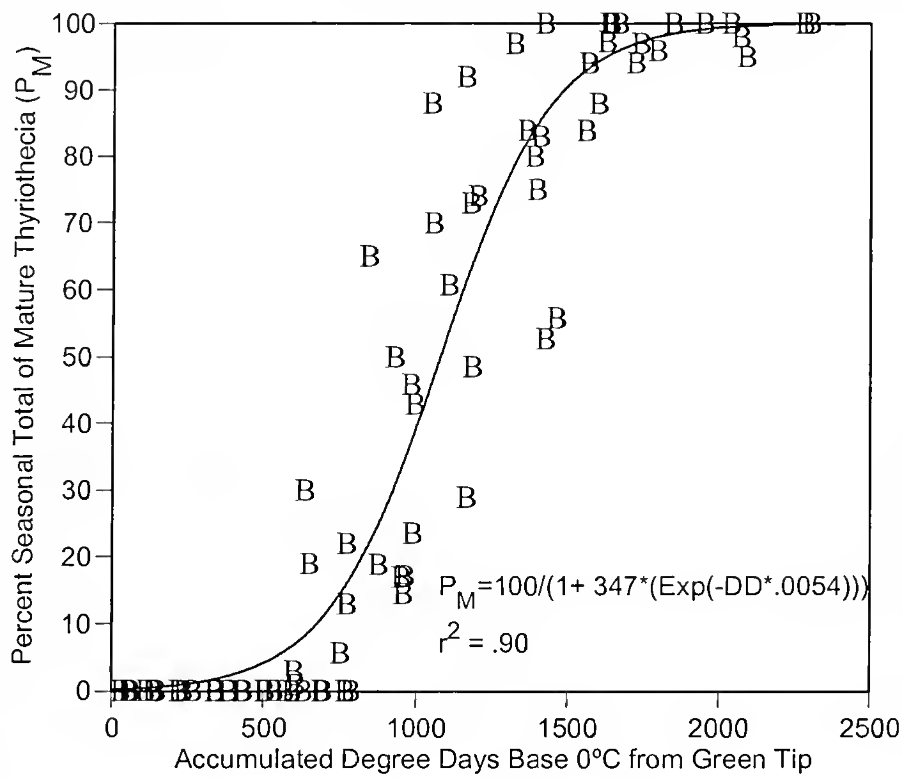

Figure 2. Percent of the season's thyriothecia matured in five Massachusetts orchard sites during 1997, 1998, and 1999 as a function of the degree days (base 0°C) accumulated from green tip for the apple cultivar McIntosh.

in the number of thyriothecia in the southwest was more rapid than that in the northwest. Examinations of these thyriothecia from July through November never found any that matured and produced new ascospores.

We feel that is because thyriothecia need to go through a winter, some sort of chilling dormancy perhaps, before they can produce ascospores. When we collected thyriothecia over the winter, they differed in their potential to mature, depending on the date they were collected and on the site where they grew. Thyriothecia collected from three sites in Massachusetts during December 1996 failed to develop after one week of incubation in high humidity at 70° (Figure 3). Of thyriothecia collected in January 1997, 4 to 13% developed mature asci after incubation, and the percent that matured in subsequent months generally increased through April, when sampling ended. In other words, with more exposure to winter temperatures, the fungus is increasingly ready to produce spores when it gets warm.

Therefore, it appears *S. pomi* has a disease cycle similar to that of *V. inaequalis*, in that ascospores get ready to grow during the winter and early spring, and then are matured and released when environmental conditions are favorable in the growing season. There is little evidence that conidia or mycelia serve as primary inoculum. While thyriothecia have been found on apple twigs and fallen fruit in orchards, it is unlikely that these serve as important sources of primary inoculum in commercial orchards where fungicides are commonly used.

Like *V. inaequalis, S. pomi* produces the season's generation of ascospores over a discrete period generally corresponding to phenological development

degree days. The mean of these observations was 106 degree days, not significantly different from the 125 degree days observed in the laboratory. So, it appears that both high humidity and accumulation heat are required to get the maturation process started.

Surprisingly, humidity did n0t seem to play a role in spore development once it started. When we looked at high humidity degree days throughout the whole maturation process, from green tip to the end of spore development, then they were poorer predictors of what percentage of thyriothecia would mature than using total degree days.

Would a second generation of thyriothecia develop ascospores in the same growing season? Thyriothecia start to form on blackberry in mid to late summer and continue to form until late fall. The rate at which the number of thyriothecia increased depended on location (Figure 4). At two locations in the eastern Berkshires, thyriothecia counts dropped slightly in September and October, while counts increased linearly at two locations in south-central Massachusetts. The increase

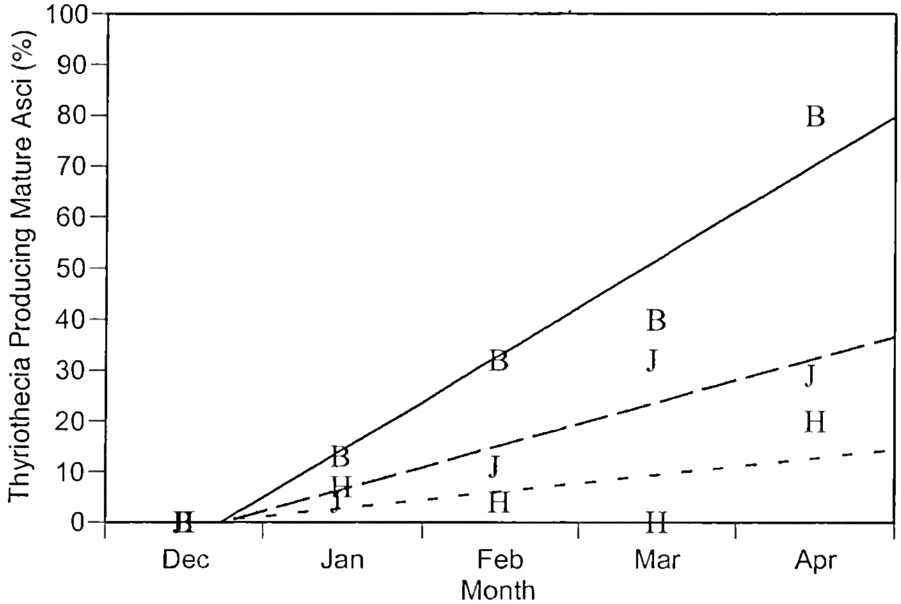

Figure 3. Percent of thyriothecia that had produced mature asci after one week incubation at 21°C. Collections from blackberry canes at three sites in Massachusetts, Amherst (B), Wilbraham (J), and Shelburne (H), during 1996-1997. Lines indicate linear regressions for each site.

temperature.

In our study orchards, the first flyspeck infections on fruit occurred at the earliest on July 16, nearly 30 days after the production of ascospores had stopped, and as late as September 21, 90 days after the end of ascospore production. While fruit infections first appeared by mid-July at the earliest in Massachusetts, they appear earlier in warmer climates: near the end of June in West Virginia (5), by late May or early June in North Carolina (3), and by the beginning of May in Alabama (6). Again, this is not surprising given that both tree development and fungal development are

in apples. In New England, the period when *S pomi* produces mature asci generally starts at late pink to bloom, and continues for 4 to 6 wks, when fruit are 0.75 to 1.75 inches in diameter. While the beginning and end of ascospore production coincided with apple growth stage, dates varied from year to year just as a growth stage such as bloom varies. For example, depending on the orchard and year, flyspeck ascospores began to mature as early as May 5 and as late as May 25, as would be expected when a process is highly dependent on

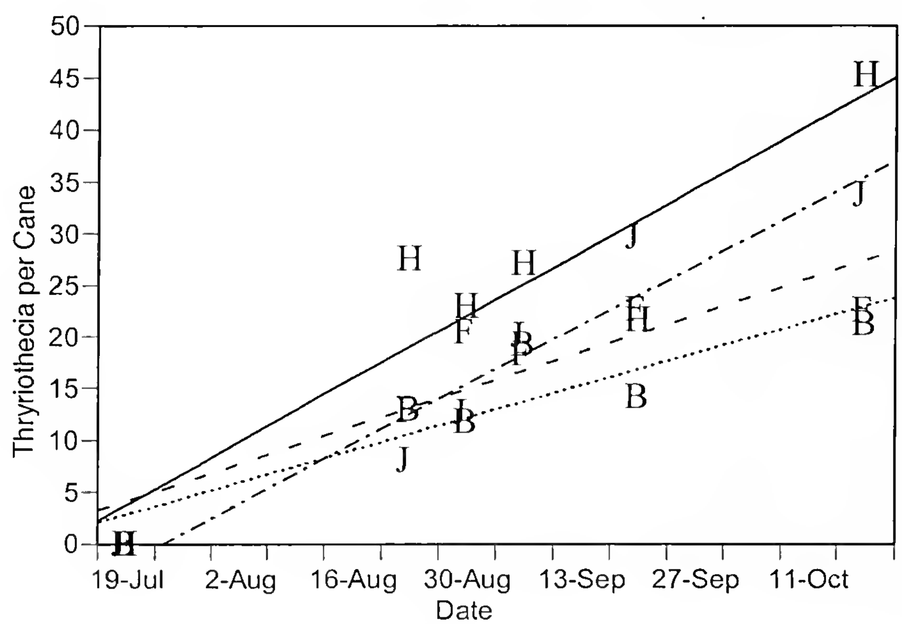

Figure 4. Thyriothecia counts per cane from blackberry canes growing in border areas of four apple orchards during 1999 in Massachusetts, Brimfield (H), Belchertown (J), Shelburne (F), and Ashfield (B). Ten canes located in a flagged area of the orchard border were counted on each date. Lines represent the linear regressions for each location.

largely temperature driven.

In our study during 1999, while apple infections first appeared between September 15 and 21, the first new thyriothecia (infections) appeared on blackberry canes in the borders of four orchards by August 17-24, about 4 weeks earlier. This may indicate that the environment in orchard hedgerows is more conducive to *S. pomi* growth, or that the infections on these canes occurred before those on adjacent apple trees. The latter possibility would support the hypothesis that epidemics originate on alternate hosts in orchard borders and spread to the orchard from there via conidia.

A significant number of thyriothecia never mature. Over the three years, from 33% to 69% of thyriothecia did not contain any signs of spores at the end of the maturation cycle. Such thyriothecia might have actually been fertile, but when examined, they had released their spores and the spore tissue had disintegrated. Possibly some thyriothecia are damaged over the winter by cold temperatures or desiccation. It takes two different mating types of the *S. pomi* fungus to produce ascospores, and perhaps some thyriothecia never come in contact with a different mating type of the fungus, so no spores can develop.

We have answered a couple of the key questions. *S. pomi* does not produce ascospores throughout the year, but only at one time, and that time is between pink and early fruit set. Unfortunately, we still have not answered the question of where these ascospores cause their infections. We do have some suggestions. A 30-day period between the appearance of inoculum and the first flyspeck symptoms in the field is typical of flyspeck (9). In one of three years in this study (1998) the end of ascospore production was 30 to 40 days before first infections were detected. Apples inoculated with ascospores from several wild hosts can cause flyspeck symptoms (1; 2). However, conidia of *Z. jamaicensis* commonly infect apple and cause flyspeck (1; 4; 8). Spore trapping and the timing of symptom development also indicated that conidia are a significant portion of the inoculum that causes flyspeck on apple (10). Conidia are common during the period of most rapid symptom development. In 2 of 3 years the latency period between the end of ascospore release and the first appearance of flyspeck on apple was 60 to 90 days, and it is unlikely that ascospores do any more than start the epidemic.

As we said at the beginning of this paper, if the initial inoculum of flyspeck epidemics is primarily ascospores, it might be possible to manage the disease by preventing these primary infections, much as apple scab is managed by targeting primary ascosporic infections. However, if most or all of the infections that blemish apples are secondary infections caused by conidia that arise on reservoir hosts in orchard borders, primary infections would have to be stopped in those borders. Given legal constraints on fungicide use off site, and the expense involved in owning and clearing border areas, such an approach is problematic. Before such treatments could be recommended, it would be necessary to know that the registration changes and expense of these approaches would be justified in terms of SBFS disease reductions. At present we have a better understanding of when primary infections occur.

Acknowledgements

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SmartFresh™ Maintains Firmness and Delays the Onset of Senescent Breakdown in Macoun Apples

Renae E. Moran and Patricia McManus
Highmoor Farm Agricultural Experiment Station, University of Maine

Macoun, a high-value apple cultivar in New England, has high consumer appeal because of its flavor, but loses its appeal within a few months of harvest because of rapid softening. In addition to softening, Macoun is prone to senescent breakdown, typically succumbing after two to three months in regular air storage. As a result, production remains less than 10% of the total in New England. We tested SmartFresh effectiveness in maintaining firmness of Macoun harvested at different maturities and stored in regular air.

Materials & Methods

Macoun apples were harvested at two different dates in three years: September 24 and October 4 in 2001, October 7 and 15 in 2002, and October 1 and 8 in 2003. Fruit were harvested from trees on various dwarf rootstocks. Flesh firmness and starch index were measured on ten fruit at each date. The Cornell Starch Chart was used where 1 = all starch remaining and 8 = no starch. Internal ethylene concentration at harvest was measured in ten fruit in 2002 and 2003.

Apples were exposed to 1 ppm of SmartFresh within 24 hours of harvest. Fruit were stored at 37°F in regular air for 100 days in 2001. In 2002 and 2003, fruit were stored at 34°F in regular air for 50 and 90 days. Following storage, fruit were kept at 68°F for one and seven days when firmness and disorders were measured.

Results

In 2001, starch index was 3.0 at the first harvest and 5.6 at the second. Following four months storage and seven days at 68°F, SmartFresh maintained firmness in fruit from the first harvest (12 lbs.) above the firmness of untreated fruit (11 lbs.). This did not occur with the second harvest when firmness was 10 lbs. in both treated and untreated fruit. Fruit from the second harvest were too mature for SmartFresh to be effective for as long as 100 days in regular air. The effect of SmartFresh is temporary, becoming undetectable after several months in regular air storage. In this study, the effect on firmness did not last 100 days in overmature fruit.

In 2002, starch index was 3.1 at the first harvest and 4.9 at the second. Internal ethylene was undetectable at the first harvest and 29 ppm at the second. An apple is considered too mature for long-term storage when the internal ethylene rises above 1 ppm. In 2002, SmartFresh maintained firmness above that of untreated fruit after 50 and 90 days, but was more effective in fruit from the first harvest (Figure 1). After 50 days, firmness was greater by 4 lbs. in first-harvest fruit, but only by 2 lbs in second-harvest fruit. After 90 days, firmness of first harvest fruit was greater by 3 lbs., but only by 1 lbs. in second harvest fruit.

In 2003, starch index was 2.7 at the first harvest and 3.5 at the second. Ethylene was 4 ppm at the first harvest and 1 ppm at the second. Firmness in 2003 followed a similar pattern as in 2002. Firmness was maintained 4-5 lbs. above untreated fruit with the first harvest and 2-3 lbs. with the second.

Minimum acceptable firmness by consumers is considered to be about 12 lbs. and optimum firmness about 15 lbs. SmartFresh maintained firmness near

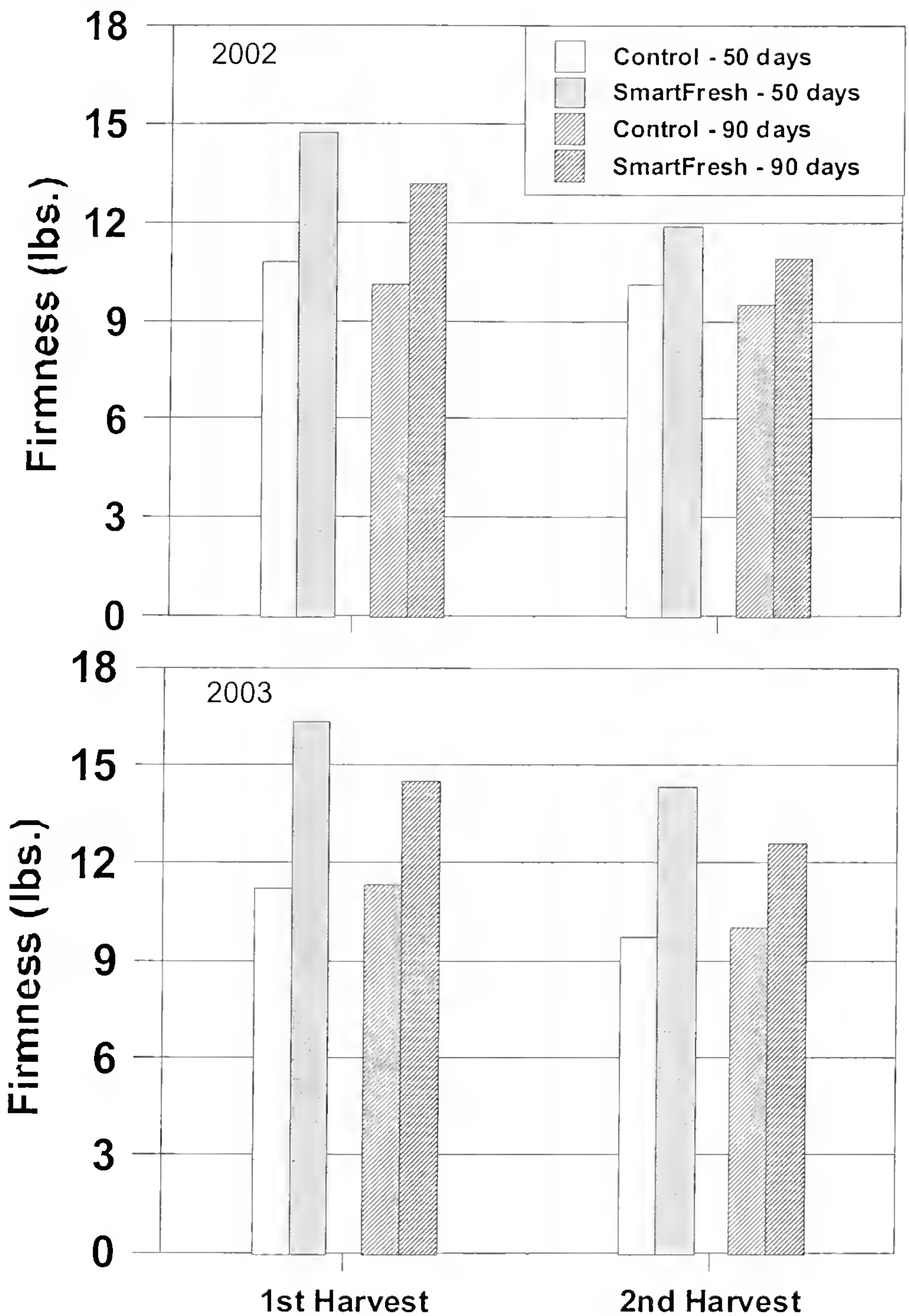

Figure 1. Macoun apple firmness was maintained by SmartFresh after 50 and 90 days regular air storage and seven days at room temperature.

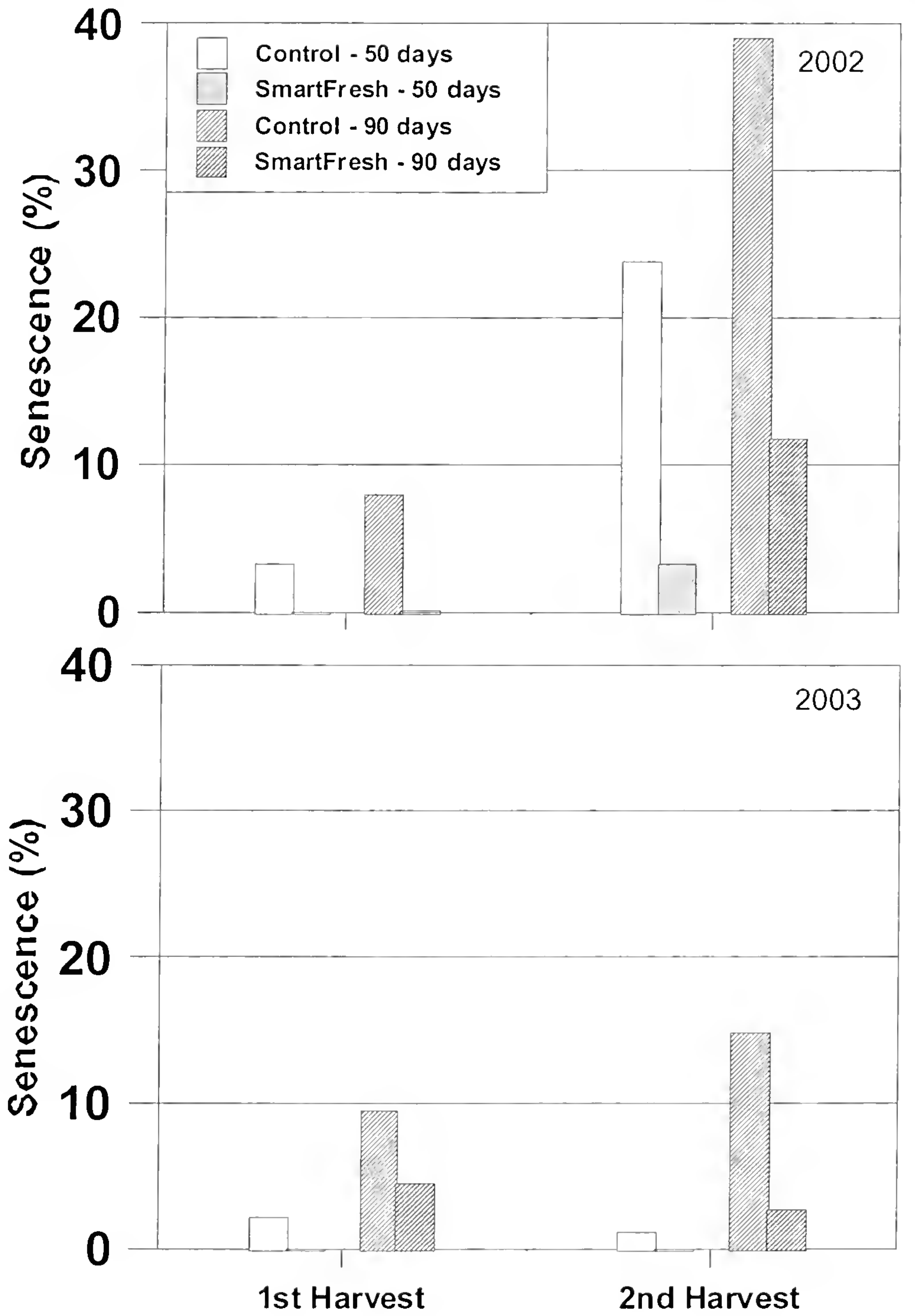

Figure 2. SmartFresh delayed the development of senescent breakdown after 90 days regular air storage and seven days at room temperature.

optimum for 50 days and near the minimum acceptability for 90 days when fruit were picked before starch index reached 4.0. When fruit were picked after a starch index of 4.0, SmartFresh maintained firmness near minimum acceptability for 50 days. In untreated fruit, firmness fell below 12 lbs. by 50 days with little difference between the two harvest dates.

Senescent breakdown was not affected by SmartFresh in 2001 when incidence was approximately 10%. Occurrence of senescent breakdown in 2002 was slight in fruit from the first harvest, so SmartFresh had no effect on its occurrence (Figure 2). In fruit from the second harvest, senescent breakdown was more prevalent, and was reduced by SmartFresh after both 50 and 90 days storage. In 2003, there was almost no senescent breakdown in either treatment after 50 days, so SmartFresh had no effect on its occurrence. After 90 days, senescent breakdown was more prevalent, and SmartFresh reduced its occurrence. Macoun is very prone to senescent breakdown, which occurred in each year of the study, but was most severe in 2002. It began to develop in untreated fruit as early as 50 days in storage. SmartFresh reduced the occurrence of senescent breakdown, but did not completely prevent it, since SmartFresh-treated fruit eventually developed it, as well.

SmartFresh increased the occurrence of coreline browning in 2001, but this was slight and insignificant in fruit from the first harvest (Figure 3). In fruit that were very mature at harvest, SmartFresh increased the incidence of coreline browning. Incidence of coreline browning was highly variable from year to year, being very prevalent in 2002 and almost nonexistent in 2003. In these two years, SmartFresh reduced the incidence of coreline browning. It is not clear why

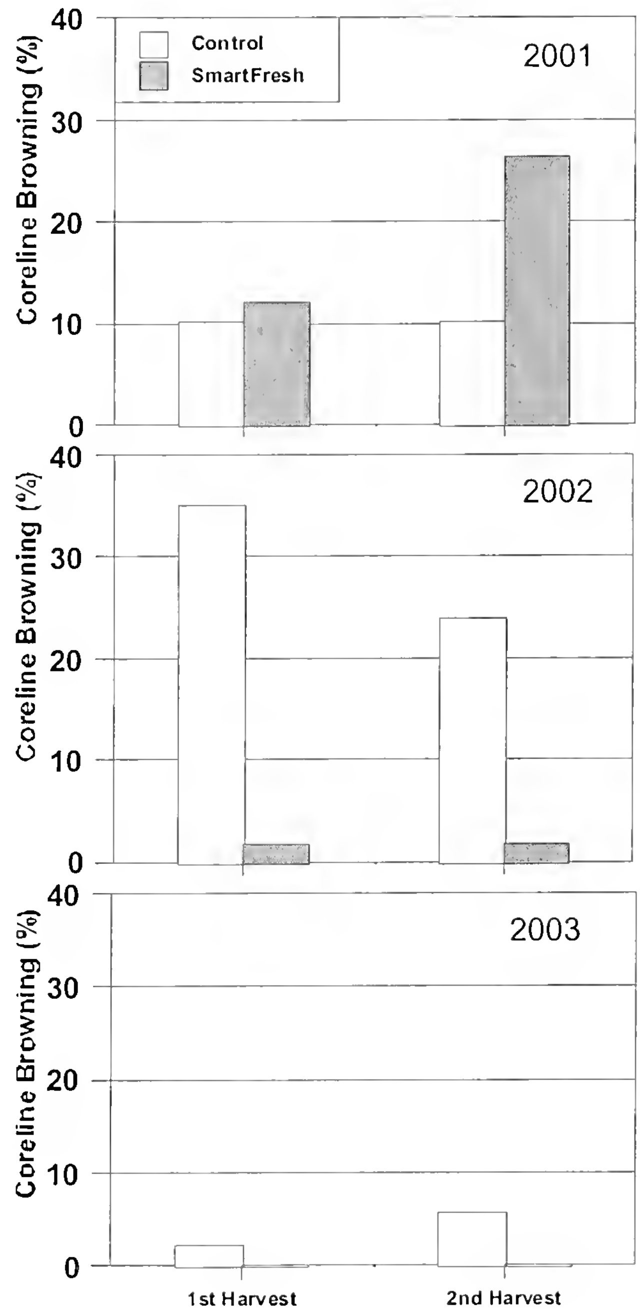

Figure 3. Coreline browning in Macoun after 100 days regular air storage in 2001, and 50 days in 2002 and 2003.

coreline browning was increased by SmartFresh in 2001, but could have been due to the advanced maturity with the second harvest since these fruit were harvested more mature than in later years.

In 2002, stem-end browning did not occur until 90 days when SmartFresh reduced its occurrence from 7% to less than 1% with the first harvest, and from 4% to 2% with the second harvest. In 2003, stem-end browning did not occur.

Conclusions

For Macoun, SmartFresh has the potential to maintain optimum firmness during the normal two-month marketing window. SmartFresh did not completely prevent senescent breakdown or coreline browning, but in most instances these disorders were reduced to a very low level.

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The James Underwood Crockett Agricultural Technology Growth Fund

James E. Mulcahy
Clerk and 1960 Stockbridge School of Agriculture Graduate

James Underwood Crockett was a student at the Stockbridge School of Agriculture in the class of 1935. The James Underwood Crockett Agricultural Technology Growth Fund (aka the Jim Crockett ATG Fund) was established in his honor and memory after his untimely 1979 death. The non-profit public-charity status as an IRS 501(c)(3) tax-exempt entity was achieved in 1982. The IRS account number is 04-2754324. The first contributions arrived promptly, and the first grant was made in 1983. The fund continues to solicit annual donations as well as asking for bequest in the wills of supporters.

The donations have been received and invested by the Personal Trust Department of the State Street Bank & Trust Co. in Boston. In December 2003, the Personal Trust Department became a part of the U.S. Trust Co., with the same trust officers, headed by Francis M. Barrett Assistant Vice President, and with the same mailing address at 225 Franklin Street, Boston, Massachusetts 02110. The trust account number is 52-010157. All donations become the principal or corpus of the trust for perpetual investment to generate principal growth as well as producing earnings of interest and dividends for distribution.

The trustees meet twice a year and vote to grant about 5% of the value of the fund from the earnings to non-profit organizations, schools, etc. that are in the northeast U.S. and that are involved in some phase of agriculture. See the web site at www.jimcrockett.org.

Since 1983, $120,600.00 has been distributed by the trustees in mini-grants to 34 grantees in 96 grants, usually in the $500 to $2,000 range. Over half have been given to various parts of the UMass College of Natural Resources & the Environment, both on the Amherst campus as well as to UMass research sites in Belchertown, Waltham, and Wareham.

Editors' Note: The Jim Crockett ATG Fund has been a generous contributor to fruit activities at the University of Massachusetts, including contributions to purchase equipment for teaching, to establish new plantings for educational purposes, to erect a new I-181 sign, and to help build the Massachusetts Fruit Growers' Association endowment in support of the UMass Cold Spring Orchard Research & Education Center. We are very grateful for this long-term support.

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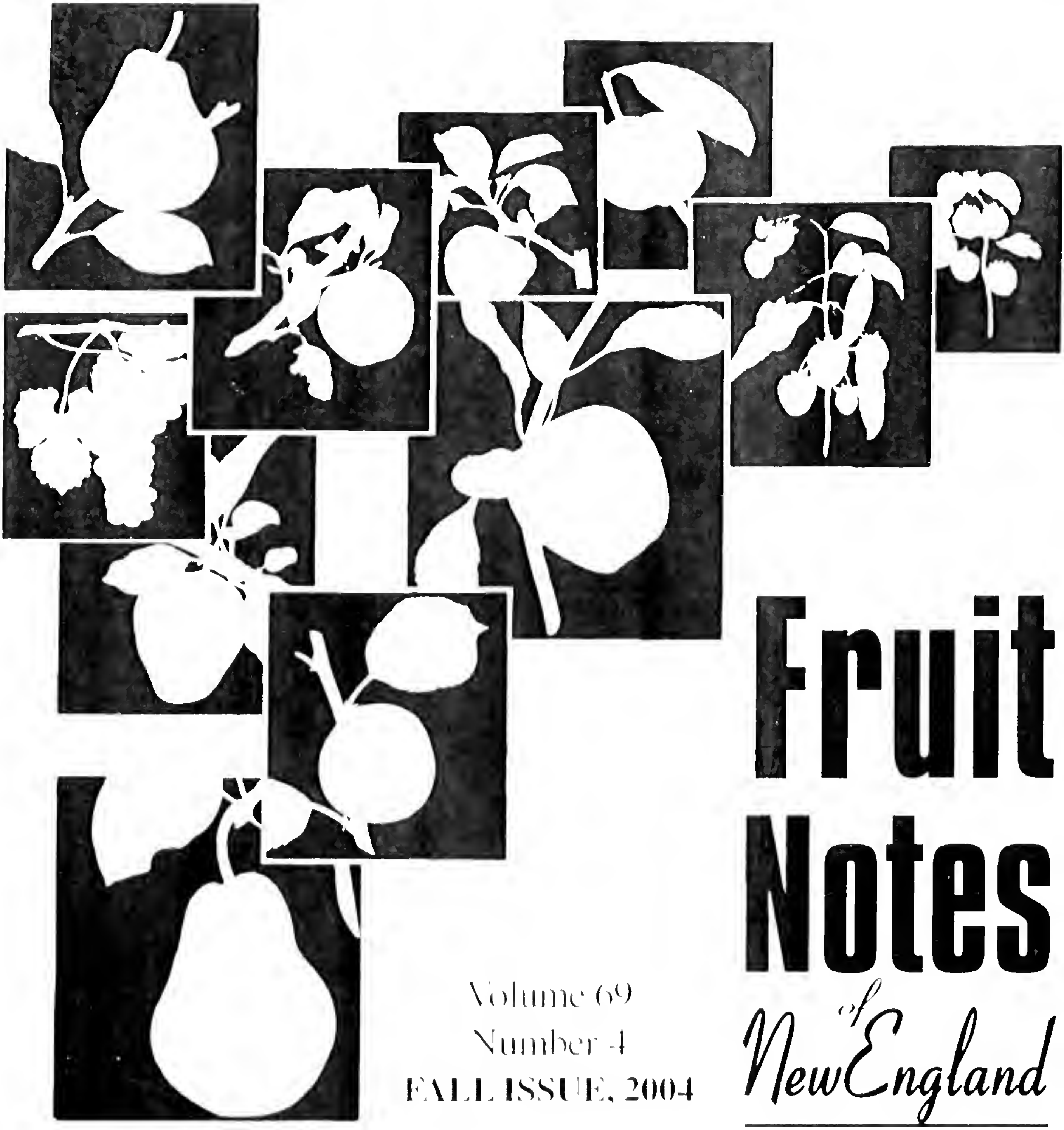

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Predicting Plum Curculio Immigration into Apple Orchards in Massachusetts: Degree Days versus Tree Phenology

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Determining need for and timing of insecticide applications that will protect fruit from injury by plum curculio (PC) based on presence of adults on host trees has been a critical aspect for managing populations. In concept, a reduction in amount of insecticide used against PC, from the current norm in Massachusetts of three spray applications during May and June to an amount that is precise according to need should be accompanied with an effective approach to monitoring the course of PC immigration into apple orchards. Limb jarring, an approach that involves tapping tree limbs using a pole to dislodge PCs onto an underlying ground cloth is one of the methods traditionally used to determine the time of first appearance, location, and relative abundance of PCs within an orchard. However, limb jarring has several shortcomings: (1) it is labor intensive; (2) it is not very accurate (its effectiveness is highly dependent upon tree size, weather, and other factors); (3) it cannot be used to study immigration, because PCs that are able to overwinter beneath perimeter-row trees will be confounded with true immigrants that overwintered in the woods; and (4) it cannot be performed at night, the time of day when PCs are most active on trees.

In the 2000 combined issue of *Fruit Notes* we reported that panel and pyramid traps baited with attractive odor and deployed in close proximity to the forested areas that are the main overwintering sites of adult PCs offered great potential for monitoring the onset and extent of PC immigration into apple orchards. Here, we investigated, over a five-year period, temporal dynamics of PC immigration into an unsprayed section of a commercial apple orchard using odor-baited traps. In particular, our objectives were: (1) characterizing the overall pattern of PC immigration; (2) determining the relationships among trap captures, tree phenology, and weather; (3) estimating thermal constants, expressed in Degree Days, for different stages (onset, 50th and 80th percentiles of cumulative captures) of PC immigration; and (4) determining the relative predictability of different stages of PC immigration by comparing tree phenology versus thermal constants.

Materials & Methods

Study site and trap deployment. We conducted this study over a period of five years (2000-2004) at the University of Massachusetts Cold Spring Orchard Research & Education Center (Belchertown, MA) utilizing a 1.4-acre unsprayed block comprised of a section having 216 small (M.9 rootstock) McIntosh and Delicious trees located on the eastern side, and two smaller sections having 145 medium-sized (M.26 rootstock) trees of various disease-resistant varieties located on the western side (Figure 1). The perimeter of the entire block, bordered almost entirely by mixed deciduous forest, was about 500 yards.

Traps utilized for the study were of two different types: (a) clear sticky Plexiglas panels (2 x 2 feet), which capture PCs in flight, and (b) a trunk-mimicking black pyramid traps, which capture PCs approaching host trees primarily by crawling. The woods-facing side of each panel was coated with Tangletrap glue to capture PCs that were presumably immigrating from the woods into the orchard block.

For each of the five years, traps were deployed in pairs along the periphery of the orchard, in close proximity to the woods. Each pair of traps was spaced 10 yards from other trap pairs on either side except in 2004, when the distance between each trap pair was 35 yards. For each of the five years, trap captures were pooled across all traps of the same type deployed in

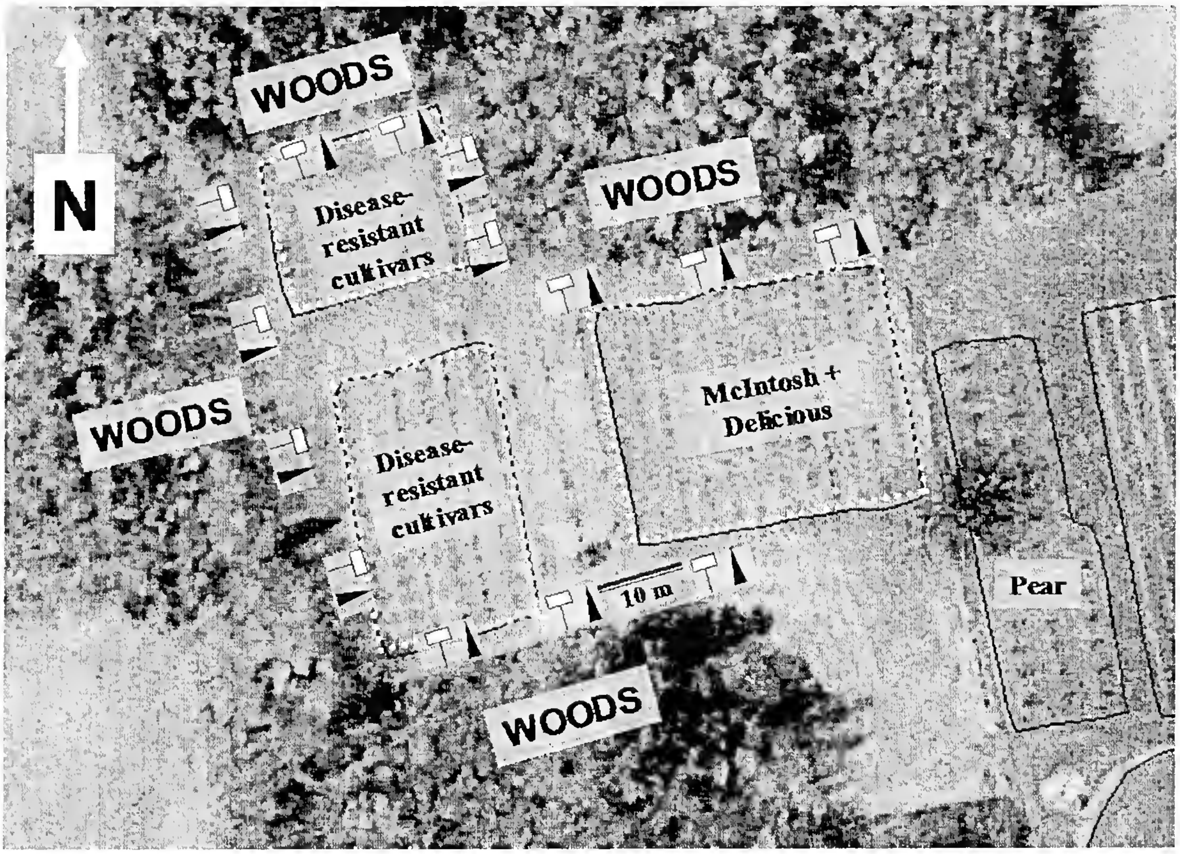

Figure 1. Unsprayed section of the apple orchard used for this study (UMass Cold Spring Orchard; Belchertown, MA). Panel and pyramid traps were deployed in pairs along the periphery of the orchard block, in close proximity to woods, the main overwintering sites of adult PCs. The perimeter of the block was about 500 yards. Picture: courtesy of Jon Clements (UMass Extension).

the orchard. The predominant bait used for luring PCs to traps was composed of benzaldehyde (attractive, synthetic, host-plant odor) in association with and grandisoic acid (PC aggregation pheromone). For each trapping year, trap deployment and baiting took place approximately during the silver-tip stage of bud development. Traps were inspected for PC captures on a daily basis (7:30-10:00 AM) from the moment of trap deployment until fruit reached 1.2 inches in diameter (by late June/early July). All adult PCs captured were brought to the laboratory, where they were sexed. All females captured were dissected under a stereomicroscope to determine the sexual maturity stage (presence of mature eggs) and mating status (presence of sperm in the spermatheca).

Characterizing PC immigration. The process of PC immigration into the apple orchard was characterized beginning with the day of first captures by traps. The next important stages of PC immigration were the 50th and 80th percentiles of cumulative captures. The latter occurred around petal fall, the stage of tree phenology at which PCs have shown the highest activity and dispersal and the time at which the first insecticide is commonly applied against PC. We ended the studies by late June/early July, when no captures occurred for 3-4 consecutive days with relatively high temperatures.

Classification of tree phenology. We monitored and characterized, on a daily basis, the different stages of bud and fruit development on the McIntosh trees using the following numerical code: (1) silver tip, (2) green tip, (3) half-inch tip, (4) tight cluster, (5) first pink, (6) full pink, (7) first bloom, (8) full bloom, (9) petal fall, (10) within a week after petal fall, and (11)

2-6 wks after petal fall (depending on the year). Stages 1-9 were considered as pre-petal fall, whereas stages 10-11 were post-petal fall.

Calculating Thermal Constants. Thermal constants for the initiation of PC immigration (START), and the 50th and 80th percentiles of cumulative captures were estimated using a temperature threshold of 43°F for the resumption of adult PC activity after overwintering. On each trapping year, Degree Days started to accumulate on January 1.

Relative Predictability of PC Immigration: Tree Phenology versus Thermal Constants. To determine whether the onset of immigration was better explained by accumulation of Degree Days or by tree phenology, two coefficients of variation (CV) were constructed. A coefficient of variation is a relative measure of variability (it uses the standard deviation [SD]) around a mean value, therefore a low CV (relative to the other CV estimated) suggested greater reliability of the particular method used to predict onset of PC immigration. Our first CV involved mean thermal constants (using the mean DD and SD obtained across the five trapping years), whereas the second CV involved the particular phenological tree stage at which PCs started immigrating into the orchard block (using the mean and SD of the numerical codes used on each year).

Results

Overall pattern of PC immigration. In all, 4,279 PCs were captured by traps across all five trapping years (Table 1). On average, the entire period of PC immigration lasted 63 days, with the shortest and longest periods encompassing 51 days in 2000 and 85 days in 2002, respectively. The earliest start of PC immigration occurred in 2002 (on 14 April), whereas the latest start of immigration took place in 2001 (on 2 May). PCs started immigrating when trees were either at the silver tip stage (stage 1) (in 2004), at the tight cluster tree stage (stage 4) (in 2000, 2002, and 2003) or at the first pink tree stage (stage 5) (in 2001). Fifty percent cumulative captures occurred when trees were either in full bloom (stage 8) in 2000 and 2001, by petal fall (stage 9) in 2003 and 2004, or during the first week of fruit development (stage 10) in 2002. Eighty percent cumulative captures took place during stage 10 (i.e., first week of fruit development) in four of the five years (2000-2003) or during stage 11 (i.e. after one week of fruit development) in 2004.

Table 1 shows that of the total number of PC immigrants captured by traps (potentially colonizing host trees), on average, 59% have already done so by petal fall, with the remaining 41% being captured by traps after petal fall. A statistical test revealed that numbers of PCs being captured by traps before and after petal fall differed significantly across years. The period of time required from the last day of petal fall to achieve 80% cumulative PC captures was one week in 2000 and 2004, two weeks in 2003, and three weeks in 2001 and 2002.

Relationships among trap captures, tree

Table 1. For each of the five trapping years, PC captures (by panel and pyramid traps combined) occurring before petal fall (PF) (phenological tree stages 1-9) and after petal fall (phenological tree stages 10-11).

EVENT	2000	2001	2002	2003	2004	Average
Total PCs captured	430	544	1,354	485	1,366	
Last day PF	05/24	05/16	05/17	05/22	05/14	
Cum. captures last day PF	307	303	575	289	877	
Percent of total	71.4	55.7	42.5	59.6	64.2	58.7 ± 4.8

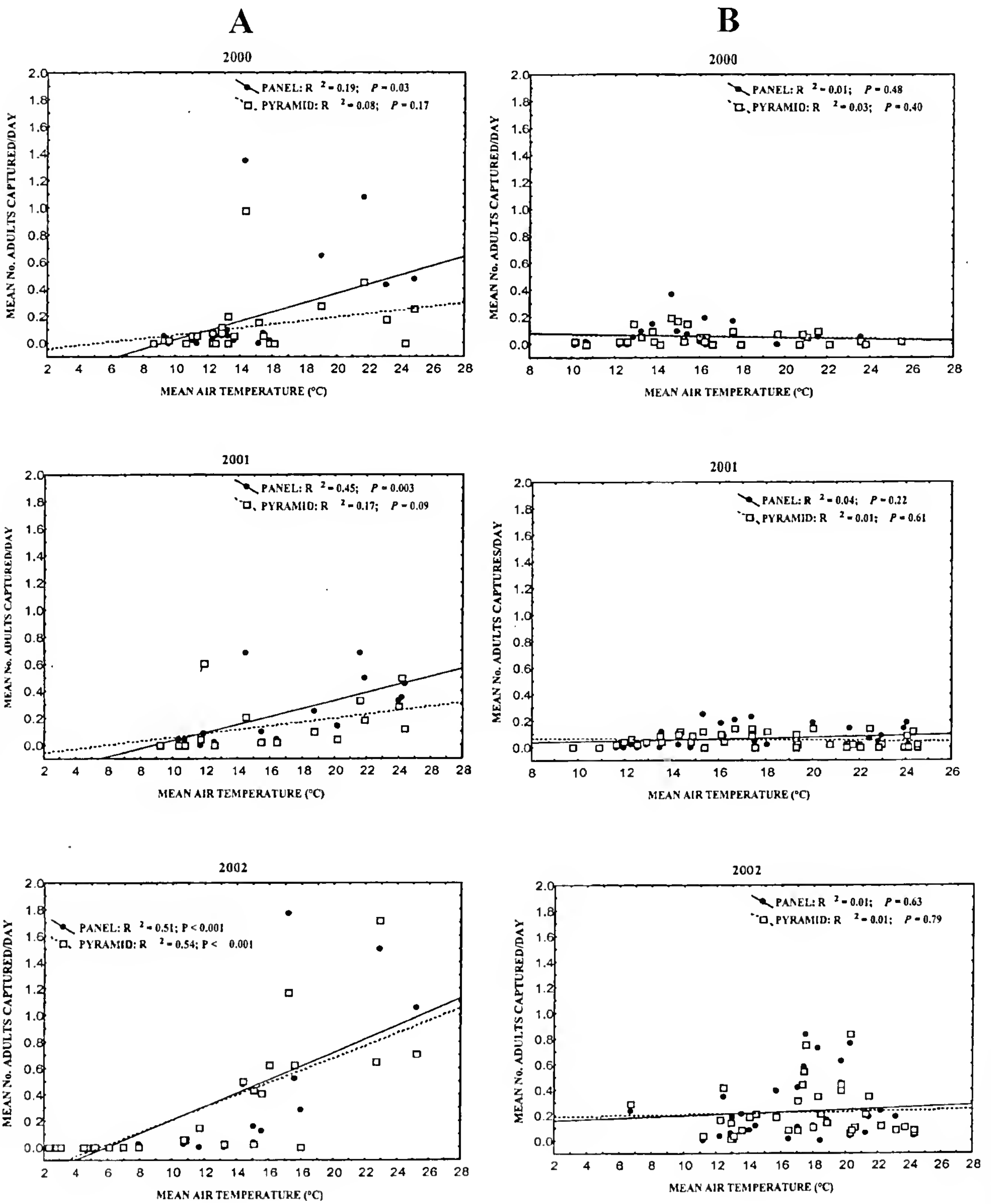

Figure 2. For each of the five trapping years, relationships between daily PC captures by panel and pyramid traps and mean air temperature either (A) before or (B) after petal fall. The number of days before/after petal fall was 23/52 in 2000, 17/43 in 2001, 33/51 in 2002, 24/30 in 2003, and 29/37 in 2004, respectively. R^2 values denote, on a scale of 0 to 1, the amount of common variation between the two variables. An R^2= 1 indicates a perfect correlation.

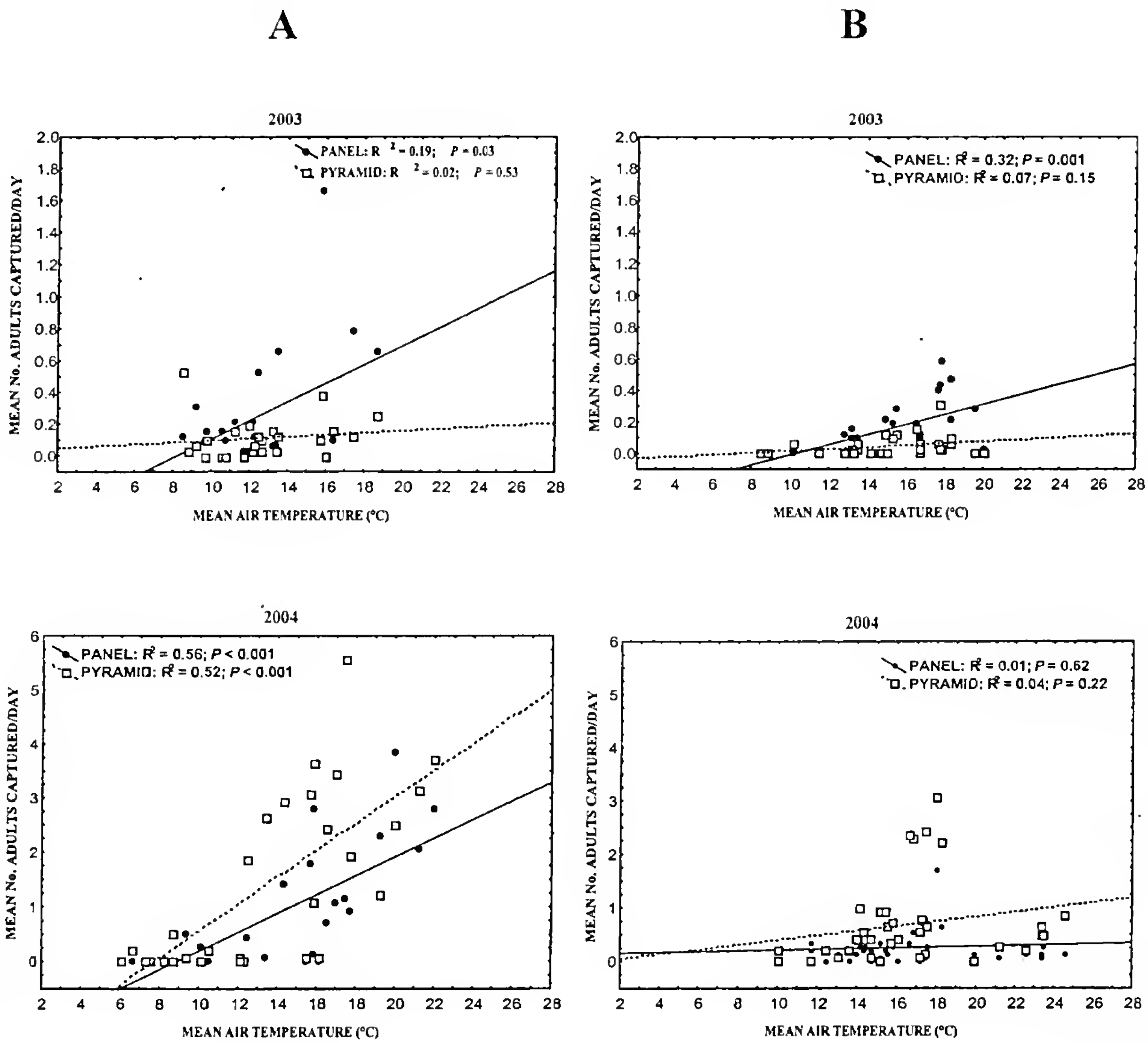

Figure 2. Continued.

phenology, and weather. Correlation analyses revealed a strong positive influence of mean daily air temperature on PC captures by panel traps before petal fall for each of the five trapping years. Captures by pyramid traps were less influenced by temperature than panel traps (Figure 2A). In contrast, the relationship between mean air temperature and captures by either panel or pyramid traps after petal fall was rather weak, except in 2003 for panel traps (Figure 2B). The proclivity of adults to either fly or crawl was independent of sex.

Thermal constants for different stages of PC immigration. Table 2 shows the thermal constants (base 43°F) for different stages of PC immigration. On average, PC immigration started when 235 DD had accumulated since January 1. The number of DD accumulated since January 1 to attain 50% and 80% cumulative captures was 480 and 775, respectively.

Relative predictability of PC immigration: Tree phenology versus thermal constants. Using CV's, we determined that initiation of PC immigration was better explained by accumulation of Degree Days (CV= 13.2) than by tree phenology (CV= 42.2).

Female sexual maturity stage and mating status.

Table 2. For each of the five trapping years, date and stage of tree phenology for the first captures, and thermal constants (expressed in Degree Days [DD]) estimated for different stages of PC immigration (START, 50^{th} and 80^{th} percentiles of cumulative captures). See Materials and Methods for a description of numerical ranks used to characterize phenological tree stage.

EVENT	2000	2001	2002	2003	2004	Mean ± SE
START (date)	05/02	04/30	04/15	04/29	04/17	
START (rank of tree phenology)	(4)	(5)	(4)	(4)	(1)	3.6 ± 0.7
START ($DD_{43°F}$)	283	212	209	248	222	235 ± 14
50^{th} percentile (date)	05/07	05/11	05/24	05/19	05/12	
50^{th} percentile ($DD_{43°F}$)	404	450	556	462	526	480 ± 27
80^{th} percentile (date)	06/01	06/08	06/05	06/08	05/21	
80^{th} percentile ($DD_{43°F}$)	785	853	789	732	713	775 ± 25

Figure 3 (A-E) reveals that, except for 2003, all females captured by traps were already sexually mature and/or had been mated by the end of the petal-fall period. These findings will be discussed in the next article of *Fruit Notes*.

Conclusions

In this study we focused on the relative importance of weather factors and tree phenology on the timing of PC immigration into an apple orchard as determined by trap captures. Because odor-baited traps were deployed along the periphery of the orchard block and inspected on a daily basis for the entire period of PC immigration, we believe this study examined timing and extent of PC immigration from overwintering sites (which primarily are woods) more accurately than previous studies that have relied on branch-tapping.

Based on our combined data, we propose the occurrence of a pre- and a post-petal-fall period of PC immigration, each of which is influenced to a different extent by temperatures prevailing in spring. The relative influence of temperature on patterns of PC immigration was very strong during the pre-petal-fall period of immigration, whereas immigration taking place during the post-petal-fall period depended to a lesser extent on temperature. In almost all cases, captures by panel traps were more strongly influenced by air temperature than captures by pyramid traps.

Historically, the timing of PC immigration was related to either soil and air temperatures or to host-plant phenology, but the relative influence of these two environmental factors had not been quantified in detail before. Here, we determined that the onset of immigration was better explained by accumulation of DD (base 43°C) than by tree phenology. This finding means that examination of the stages of bud development in spring is a poor tool for forecasting onset of PC immigration.

Our trap-capture patterns obtained over a five-year period allow us to characterize PC immigration as follows. First, stretches of hot weather occurring during the pre-petal-fall period (as in our 2000 season) are conducive to concentrated PC emergence and immigration. Under these conditions, most adults may be present within orchards before the end of the pre-petal-fall period and thus a petal-fall spray covering the entire orchard block is recommended and should yield excellent control of the majority of the population. Second, during the post-petal-fall period, PC immigration continues but with a lesser influence of weather, unless cool temperatures (such as in our 2002 season) have prevailed during the pre-petal-fall period, which would lead to an extended period of PC emergence and immigration.

We recommend that, depending on the type of weather (primarily temperature) prevalent during the pre-petal-fall period of PC immigration, the first spray

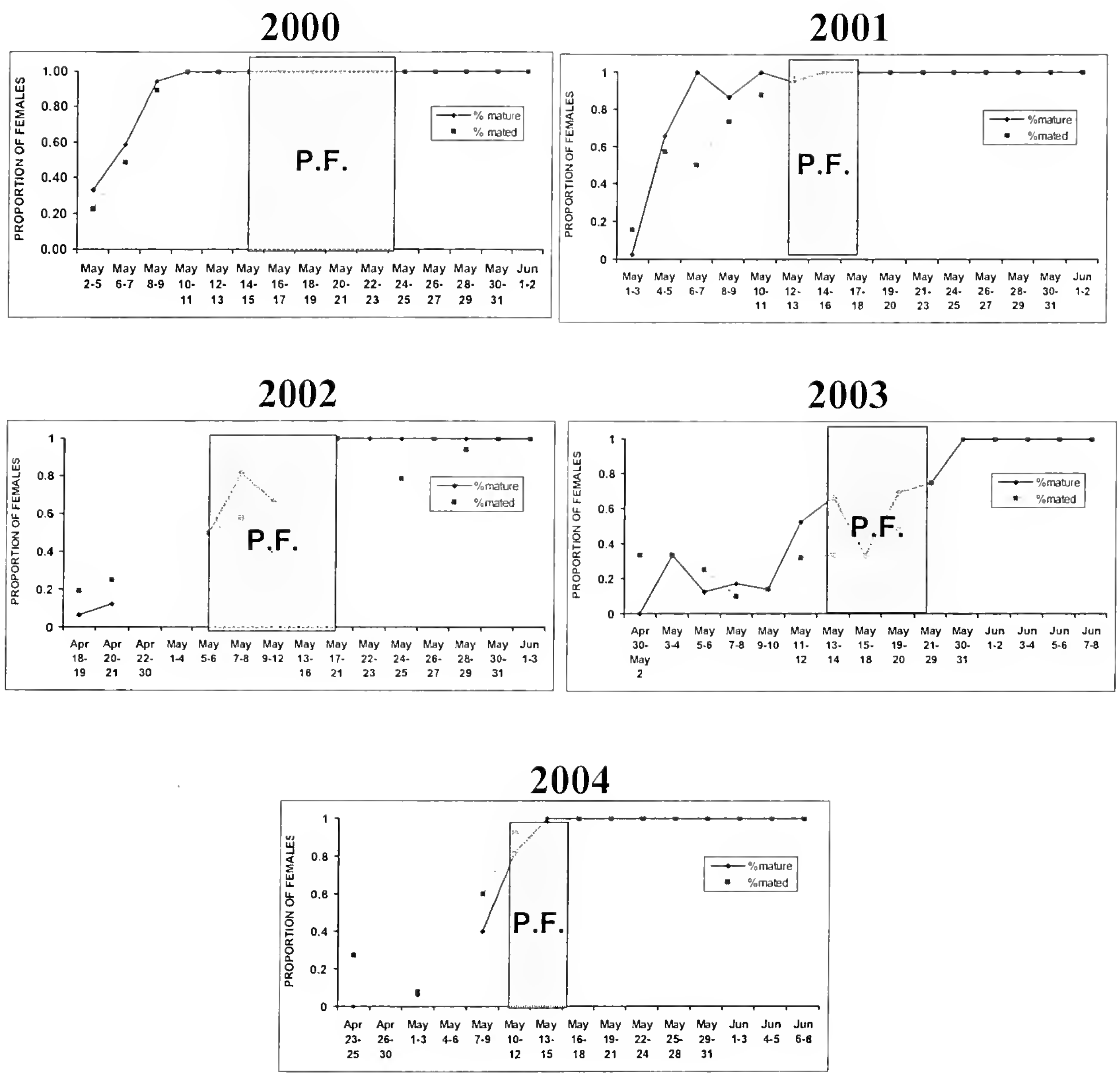

Figure 3. For each of the five trapping years, proportions of PC females captured by traps that were either sexually mature or mated, according to date. For each year, a box with diagonal lines indicates the petal-fall period.

of insecticide (commonly applied by the time of petal fall) be delayed either (1) by one week if the pre-petal-fall period is characterized by high temperatures (as in our 2002 season), or (2) by 10-14 days if cool, rainy weather prevails during the pre-petal-fall period. By doing this, a grower can maximize PC control as a higher proportion of immigrants may be killed, while costs and exposure to insecticide would be minimized given the fewer applications that might be needed. This is analogous to the temperature model developed at Cornell University by Reissig et al. (1998) to control PC, which involves use of cumulative heat unit models to predict, in particular, termination of PC oviposition activity.

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Immigrants or Re-colonizers? Studying Plum Curculio Movement Using Odor-baited Traps

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In the preceding article of *Fruit Notes,* we presented results of a 5-year study aimed at establishing the relationships between timing of plum curculio (PC) immigration, weather factors, and phenological tree stage. One of our findings was that most PCs (59% on average) were captured by traps by the end of the petal-fall period, with the remaining 41% being captured after petal fall. Therefore, an important aspect to consider because of its implications for management is whether those PCs captured after petal fall are either immigrants or re-colonizers. One way of addressing this and other questions concerning PC immigration and movement

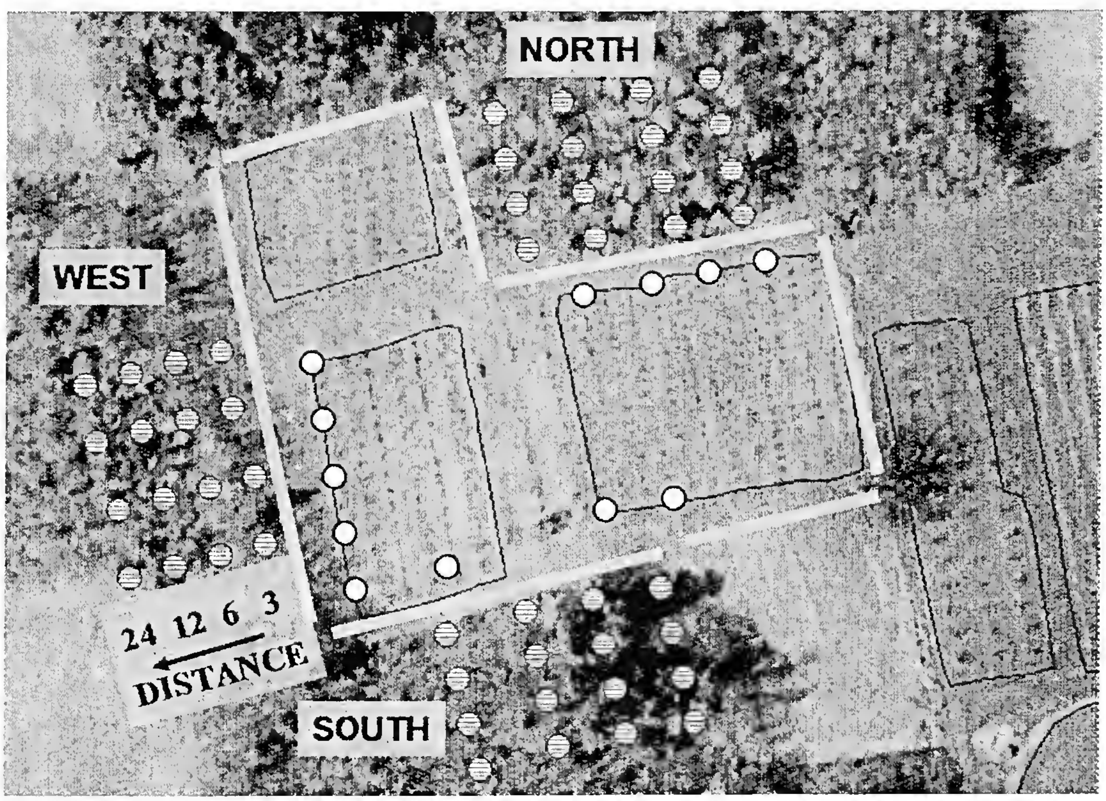

Figure 1. Unsprayed section of the commercial orchard used for this study (UMass Cold Spring Orchard Research & Education Center, Belchertown, MA). Hollow circles represent the 12 release points of color-marked PCs beneath perimeter-row trees. Dashed circles represent the 48 points at which color-marked PCs were released (at 3, 6, 13, and 24 yards inside the woods) in 2002. Picture courtesy of Jon Clements (UMass Extension).

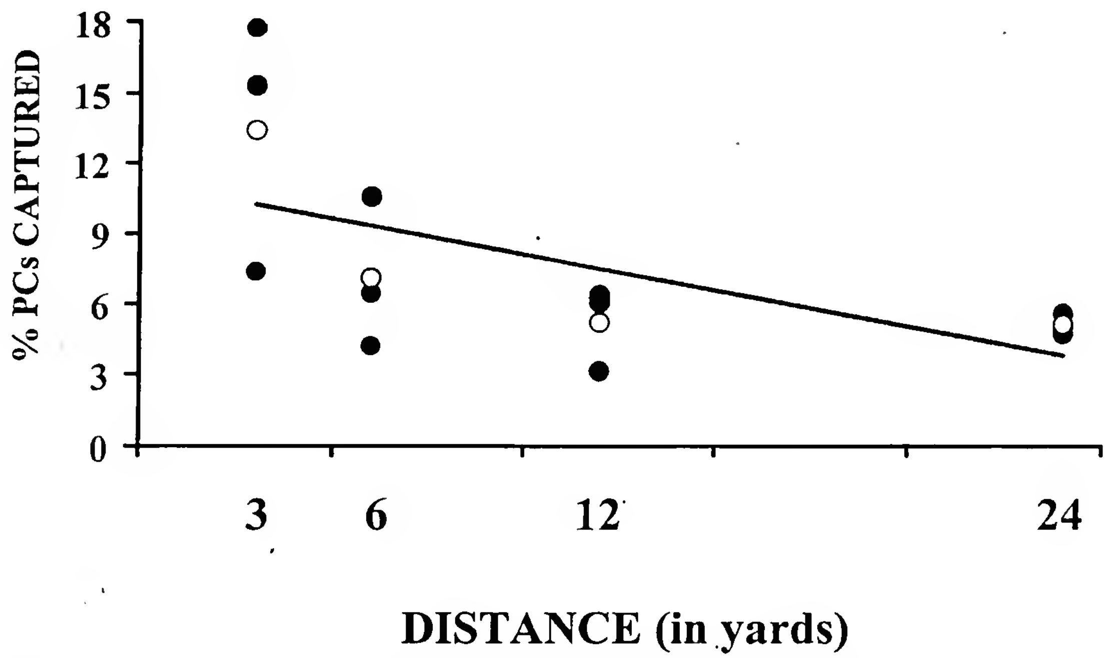

Figure 2. For the 2002 study, percentages of color-marked adult PCs captured by panel and pyramid traps at different distances (3, 6, 12, and 24 yards) from the woods edge. For each distance, solid circles denote PC captures occurring at each of the three release areas (N, W, and S). Hollow circles represent the mean percent value.

is by means of mark-capture studies using odor-baited traps.

Here, our objectives were to determine (1) the distance from which odor-baited traps are attractive to overwintered PCs immigrating into an apple orchard block from forested areas; (2) the relative attractiveness of odor-baited traps to PCs immigrating from woods versus PCs already present on orchard trees; and (3) the extent of back-and-forth PC movement between orchard trees and woods as determined by trap captures. In this article, we also discuss the findings presented in the preceding *Fruit Notes* article, in relation to the female maturity stage and mating status of the PC females captured by odor-baited traps over a 5-year period.

Materials & Methods

This study was conducted during 2002 and 2004 at the University of Massachusetts Cold Spring Orchard Research & Education Center located in Belchertown, MA.

The first two questions were addressed in 2002. For the 2002 study we used adult PCs that were raised from infested fruit collected in Amherst area in the summer of 2001 and kept over the winter in plastic containers with a layer of soil (5 inches), overlaid by 5 inches of maple leaves. Containers were then buried into the ground outdoors and protected from rainfall. Before being overwintered, adult PCs were separated by sex and marked on the elytra with different color combinations using acrylic paint.

Of the 938 color-marked PCs that were recovered in the spring of 2002 after overwintering, 168 were released beneath 12 perimeter-row trees (14 PCs per tree) next to the tree trunks, and 770 PCs were released in the woods, at 3, 6, 12, and 24 yards from the woods edge (Figure 1). Color-marked PCs were released in the woods in the northern, southern, and western areas of the orchard block. Within each release area, 16 different release points of about 48 color-marked PCs each were established (Figure 1). Overwintered PCs were not fed prior to release. For the releases, each group of PCs was placed on the ground after removing some leaves and then were covered with a boll weevil trap top that was slightly buried into the ground. This protected PCs from potential predators and at the same time allowed them to exit from the open end of the funnel whenever they chose to do so. To assess the extent of response of wood-released versus orchard-released PCs to synthetic odors, 48 panel and 48 pyramid traps were baited with benzaldehyde (attractive synthetic host plant odor) in association with grandisoic acid (attractive PC pheromone). Traps were deployed at the periphery of the orchard block and were inspected for PC captures on a ~daily basis for a 8-week period starting on May 16 (at bloom).

Our third question, concerning the extent to which PCs exhibit some sort of back-and-forth movement between orchard trees and woods, was addressed in 2004 in a straightforward way by putting sticky on both sides of 14 panel traps deployed along the periphery of the orchard block. We then contrasted numbers of wild PCs captured on a daily basis in the wood-facing side or in the orchard-facing side of the panels.

Results

For the first question, Figure 2 shows that the greater capture rates (13.4%) of color-marked PCs occurred for PCs released 3 yards from the traps (which also correspond to the wood's edge). Fewer PCs were captured as the distance from traps (i.e., woods edge) progressed. A capture rate of 5.1% was achieved for PCs released 24 yards inside the woods.

For the second question, Figure 3 reveals that, without taking into account the distance at which color-marked PCs were released inside the woods, substantially more PCs (almost seven times more) were captured by panel and pyramid traps when they were released from the woods (7.9% on average) than from orchard trees (1.2%).

For the third question, Figure 4 shows that before petal fall, most wild PCs were captured by the woods-facing side of panel traps and very few PCs were captured in the back of panels. However, during and about 2 weeks after petal fall, PC captures in the back of panels increased substantially, suggesting that during this period there were high rates of back-and-forth movement between woods and orchard trees. PC captures beyond the 2-week period after petal fall period were in general low.

Figure 3. For the 2002 study, overall capture rates (in %, shown inside the arrows) of color-marked PCs released in the woods (n= 770) and beneath perimeter-row trees (n= 168).

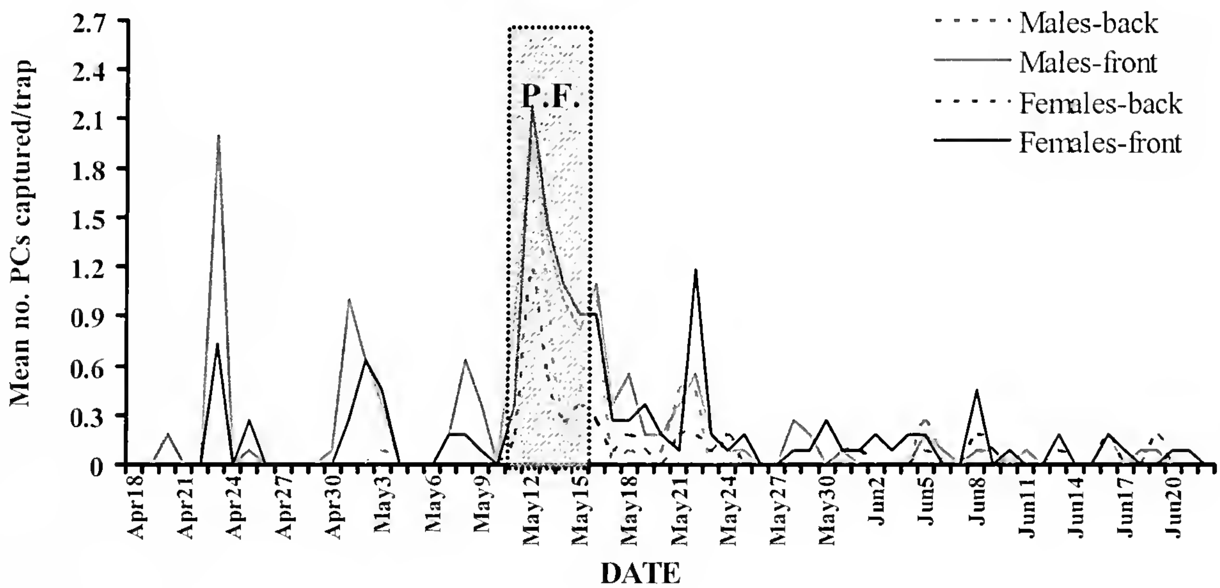

Figure 4. For the 2004 study, mean number of male and female PCs captured per trap (only panel traps) according to date. Panel traps were coated with Tangletrap in the woods-facing side (i.e., front) as well as in the orchard-facing side (i.e., back). The area delimited by a dashed line and filled with diagonal lines represents the duration of the petal-fall period in 2004.

Conclusions

From the 2002 study, we learned that adult PCs are attracted to the odor emitted by traps baited with benzaldehyde and grandisoic acid from at least 24 yards inside the woods. The maximum distance considered for this study represents the area more likely to be serving as overwintering sites for PCs (Lafleur and Hill 1987). From the 2002 study, we also determined that, once PCs are present on orchard trees, their degree of responsiveness to odor-baited traps decreases substantially, compared to PCs released in the woods that had not been exposed to stimuli provided by a host tree. Similarly, Leskey and Wright (2004) also determined that the responsiveness of southern-race PCs to traps baited with benzaldehyde and grandisoic acid decreased significantly in the presence of apple trees.

From the 2004 study we determined that, before petal fall, nearly all overwintered PCs trapped were captured in the woods-facing side of panel traps. This supports the notion that, early in the season, overwintered PCs moving into the orchard by means of flight are, most likely, immigrants. We also determined that, during and about two weeks after petal fall, there seem to be high rates of movement by PCs from host trees to woods and vice versa. This finding suggests that some PCs may be moving from orchard trees to woods (and vice versa) by the time of petal fall onwards. However, the exact proportion of PCs that may exhibit this behavior has yet to be determined.

In the preceding *Fruit Notes* article we reported that nearly all females captured by traps by the end of petal fall were already mated and ready to lay eggs. If PCs captured by traps after petal fall were actually immigrants that had just emerged from overwintering sites and were moving into the orchard block, then we would expect some of those trapped females to be sexually immature or unmated. Results from another study that involved use of pyramidal emergence traps in the same orchard block showed no emergence of PCs beyond two weeks after petal fall.

Altogether, the evidence presented above, gathered under unsprayed conditions, lead us to the conclusion that some of the PCs potentially found inside orchard blocks immediately after petal fall may be re-colonizers rather than true immigrants, although the exact proportion is still unknown. Under this scenario, some of the damage by PC to fruit sampled at harvest may be as a consequence of re-infestations that occurred after the petal-fall spray of insecticide. It would be very important to determine, under sprayed conditions, the extent to which PCs show this type of back-and-forth movement after the petal-fall application of insecticide. More research is also needed to determine what type of factors (e.g., weatherand tree size) influence this behavior.

Acknowledgments

We thank Paul Appleton, Everardo Bigurra, Sara Hoffmann, and Isabel Jácome for assistance. This study was supported with funds provided by a Hatch grant, a grant from USDA Crops at Risk program, and the New England Tree Fruit Research Committee.

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Is More Than One Trap Tree Required on Perimeter Rows to Monitor the Course of Plum Curculio Injury to Fruit?

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The concept of a trap tree as a practical approach to determine need and timing of insecticide applications against overwintered plum curculios (PCs), based on the occurrence of fresh egglaying injury, was put forward by Ron Prokopy in the 2002 Winter Issue of *Fruit Notes*. Based on research conducted during 2003, the following guidelines were proposed: (1) use of four vials dispensing benzaldehyde (BEN), the attractive host plant odor at a rate of ~40 mg/day (= 4 BEN), in association with one dispenser releasing the attractive PC pheromone grandisoic acid (GA) at a rate of ~1 mg/day (= 1 GA); (2) use of a threshold of one fruit showing fresh PC injury out of 25 fruit sampled on a trap tree; and (3) use of a single perimeter-row odor-baited tree located mid-way of a perimeter row encompassing 60-70 yards.

Because in our 2003 evaluations the greatest distance tested on a perimeter row was 30 yards to either side of a trap tree, it was not possible to determine whether trap trees would be attractive to PCs over distances longer than 30 yards. Whether or not the amount of attractive odor being emitted by a trap tree could draw PCs into an orchard from a distance greater than they would normally travel to find an orchard, which could potentially result in a greater-than-normal amount of PC injury to fruit on perimeter-row trees having trap trees, was another question that came out from the 2003 evaluations.

Here, our objectives were to determine (1) the maximum distance over which the combination of 4 BEN + 1 GA is able to congregate PCs and (2) whether an increase in the number of odor-baited trees on a perimeter row is associated with increasing amount of damage to perimeter-row fruit.

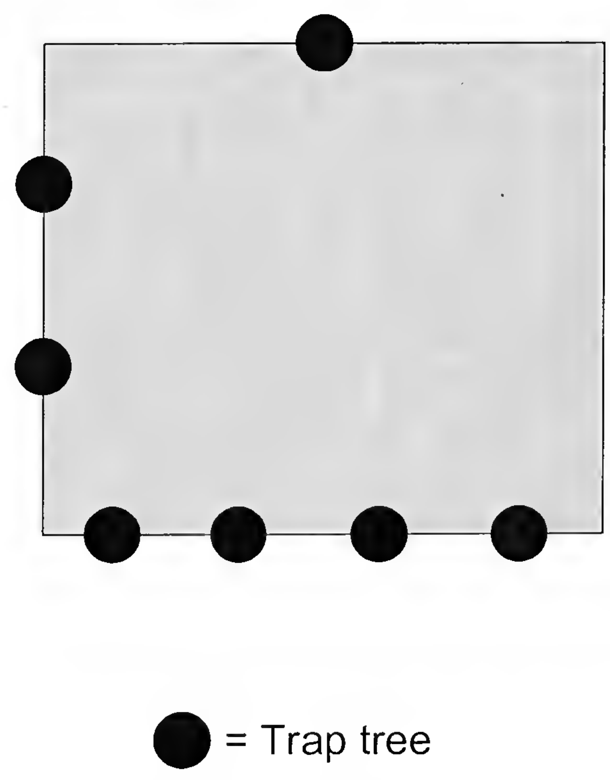

Figure 1. Representation of an apple orchard block having on each of its four sides either 0, 1, 2, or 4 trap trees spaced equidistantly. Each trap tree was baited with 4 BEN and 1 GA. Each of the four sides of the blocks used for this study comprised at least 120 yards.

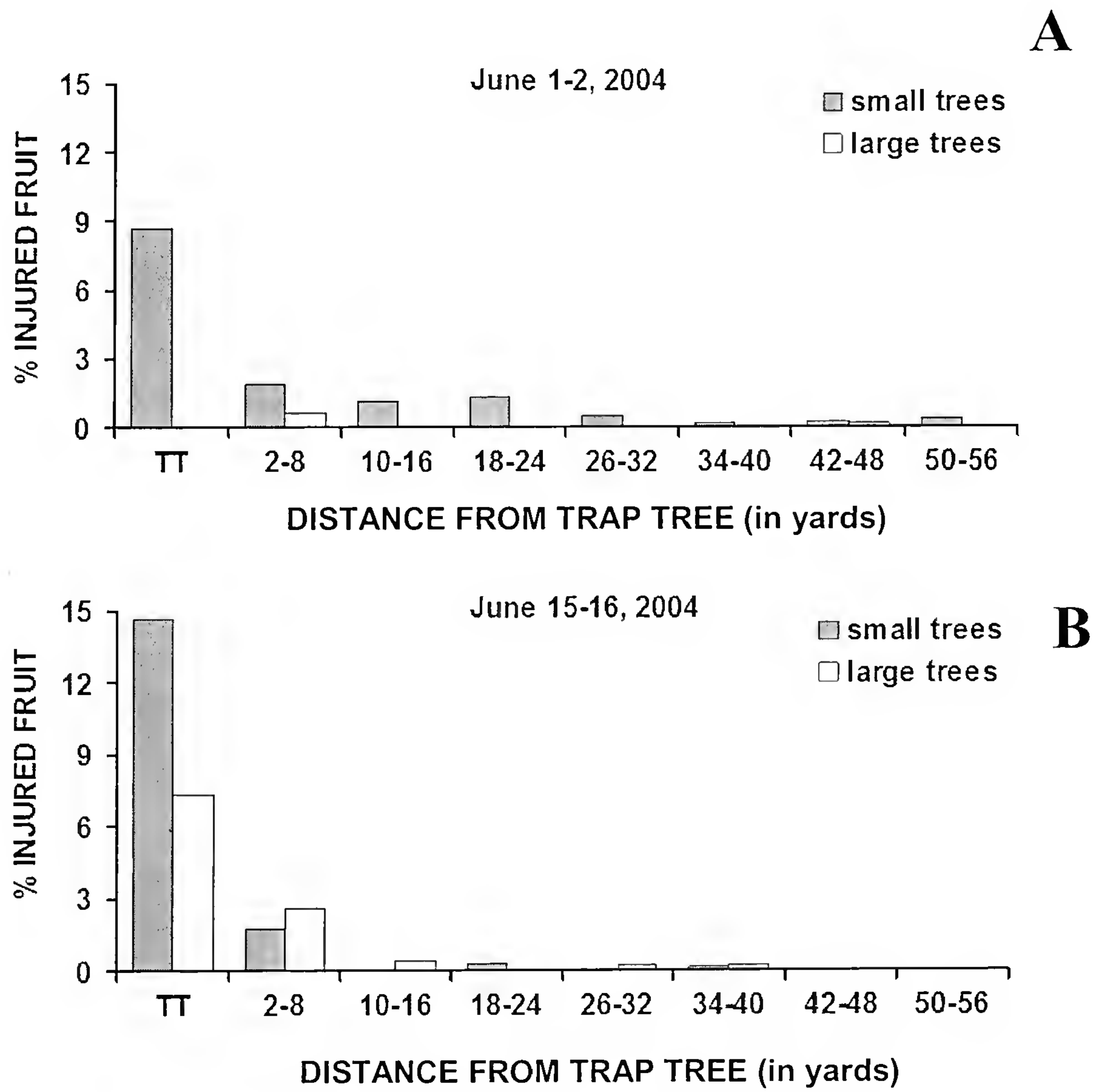

Figure 2. For the side of orchard blocks having only one trap tree located at the center of the perimeter row, amount of injury to perimeter-row fruit by PC on either (A) the first sampling date or (B) the second sampling date, as a function of distance from a trap tree. Trap trees were baited with 4 BEN and 1 GA on May 25-26, 2004.

Materials & Methods

This evaluation was conducted during May and June, 2004, in 12 sprayed sections of eight commercial orchards located in Massachusetts. Six of the orchard blocks used had small (M.9 rootstock) trees, whereas the remaining six blocks had large (M.7 rootstock) trees. Each block was composed of one or more of the cultivars McIntosh, Gala, Delicious, Cortland, and Empire, among others. Each of the four sides of the blocks used for this study was at least 120 yards long. All trees within a block were sprayed with insecticide against PC in a similar fashion.

On May 25-26 (i.e., about 10 days after petal fall), either, 1, 2, or 4 perimeter-row trap trees, each baited with 4 BEN and 1 GA, were set up on each side of a block; the remaining side of a each block had no trap trees (Figure 1). The sides of the blocks to which a

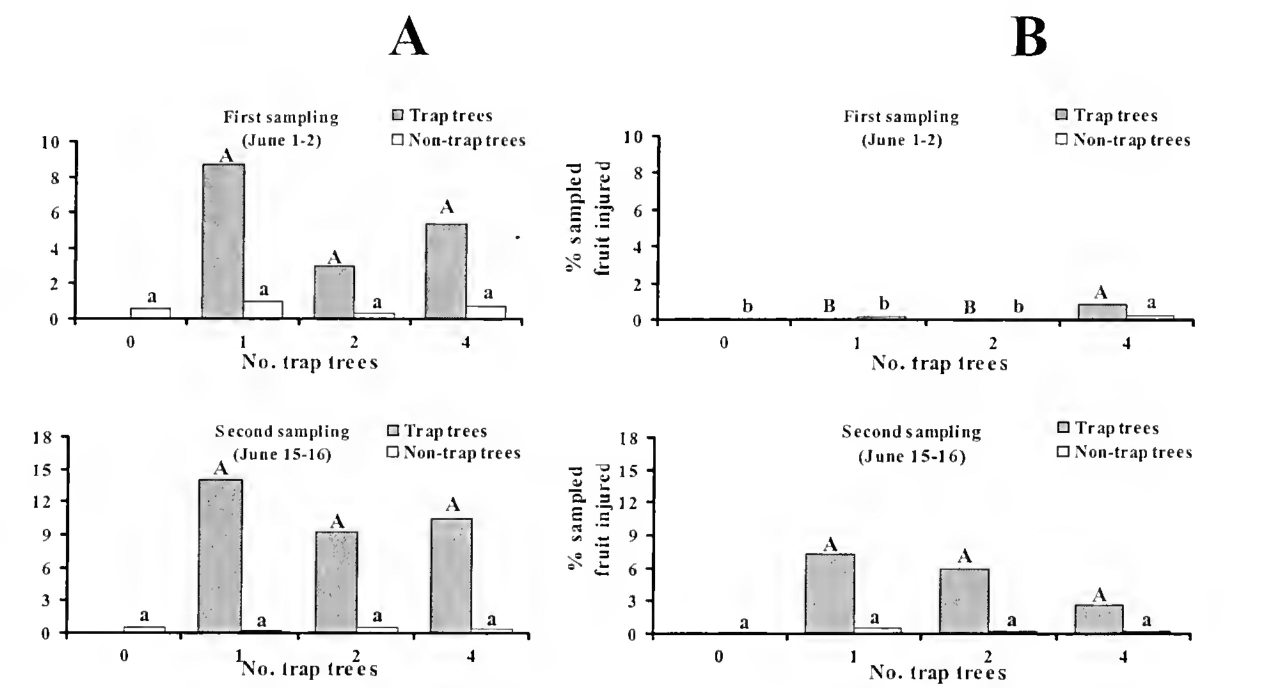

Figure 3. For each of the four sides of orchard blocks composed of either (A) small or (B) large trees, amount of injury by PC that occurred on trap trees or on other perimeter-row trees (= non-trap trees), according to the number of trap trees deployed.

particular treatment were assigned (i.e., 0, 1, 2, or 4 trap trees) were randomized to minimize variation in results due to the nature of habitat (woods, hedgerow, orchard trees) bordering the different sides of a block.

We addressed the first question by sampling 25 fruit per tree on the side of blocks having only one trap tree. This showed incidence of PC injury on perimeter-row trees located up to 60 yards on either side of the trap tree. The second question was addressed by comparing PC injury occurring on trap trees, as well as on perimeter-row non-trap trees, on each of the four sides of each block. This showed what effect trap trees exerted on total amount of injury by PC to fruit in perimeter-row trees. Amount of injury by PC to fruit was quantified twice: on June 1-2 (i.e., one week after odor-baiting) and on June 15-16 (i.e., three weeks after odor-baiting). For blocks having large trees, all perimeter-row trees were sampled for PC injury (25 fruit per tree). For blocks having small trees, either every other tree or every-two trees were sampled for PC injury (including all trap trees) because of the tree density in these blocks was much higher than in blocks having large trees.

Results

Combining both sampling dates, almost 63,000 fruit were sampled on the 12 orchard blocks used for this study.

For the first objective, Figure 2 reveals that one week after deploying 4 BEN and 1 GA (i.e., on June 1-2), the maximum distance over which PCs were congregated to a trap tree was 50-56 yards for blocks having small trees, and 42-48 yards for blocks having large trees. Three weeks after deploying the synthetic lures (June 15-16), the maximum distance over which PCs were congregated to a trap tree was 34-40 yards, regardless of tree size.

For the second objective, Figure 3A shows that, for both sampling dates and for blocks having small trees, amount of injury to fruit by PC on the trap trees was similar in the sides of blocks having either 1, 2, or 4 trap trees. Importantly, for both sampling dates, an almost identical amount of injury to fruit by PC occurred on non-trap trees in each of the four sides regardless of the number of trap trees deployed. Figure 3B reveals that, for large trees, initial amount of injury to fruit by PC (i.e., first sampling) was greater in the sides of blocks having 4 trap trees than either 1 or 2 trap trees. The same result was found for amount of injury by PC in non-trap trees. For the second sampling, the amount of injury produced by PC to fruit on the trap trees was similar on the different sides of blocks, regardless of the number of trap trees deployed. The amount of injury by PC in non-trap trees was very low in general and was not associated with the number of trap trees deployed on the different sides of a block.

Overall, three weeks after deploying 4 BEN and 1 GA (i.e., by June 15-16) trap trees were, on average, 28 times more likely to reflect injury by PC than all perimeter-row non-trap trees sampled in blocks having small trees, and were 15 times more likely to reflect injury by PC than all perimeter-row non-trap trees sampled in blocks having large trees.

Conclusions

From the first study, we learned that the effective distance over which trap trees seemed to aggregate PC injury was at least 50-56 yards for the first sampling date and 34-40 yards for the second sampling date. We also determined that trap trees were less able to concentrate injury by PC by the first sampling than by the second sampling, in particular if blocks had large trees. We believe this result is largely due to the cool and rainy weather that prevailed from the moment in which we baited the trap trees (on May 25-26) until the first sampling (on June 1-2). Because during that period of time the release rates of the synthetic lures were presumably low, it is conceivable that PCs may have not been strongly attracted to trap trees and, as a consequence, injury to fruit by PC was more spread from the trap tree for the first sampling date than for the second sampling date. After three weeks, most injury by PC occurred on the trap trees and on the most adjacent trees.

Our results from the second study show that, except for blocks having large trees in the first sampling date, the amount of injury by PC to trap trees was similar on perimeter rows having 1, 2, or 4 trap trees, regardless of the size of trees in a block. This finding indicates that a single trap tree deployed mid-way of a perimeter row of about 120 yards will be sufficient to monitor accurately the seasonal course of injury by PC to fruit. Remarkably, the amount of injury by PC to perimeter-row fruit located in the side of blocks having no trap trees was as low as the amount of injury that occurred in all perimeter-row fruit when we excluded injury on the trap trees. Thus, we should not expect greater-than-normal amounts of injury by PC to perimeter-row fruit by having odor-baited trap trees (regardless of the number).

Whether the attractiveness of a trap tree could be enhanced by adding other types of stimuli so as to increase its ability to congregate PCs is a question that remains to be investigated. Finding a way of enhancing the attractiveness of trap trees could be very valuable, for instance, in the context of potential direct control of PC by confining insecticide sprays to trap trees only (after a whole-block spray). In the context of monitoring of PC injury, an enhanced trap tree might decrease the extent to which PCs penetrate into orchard blocks (especially in blocks having small trees) by holding PCs on perimeter-row trees, thereby making perimeter-row sprays more efficient.

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