Fruit Notes

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Volume 52, No.1
WINTER ISSUE, 1987

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APPLE ROOTSTOCK EVALUATION IN MASSACHUSETTS: 1986

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With the increasing costs of land, labor, and all inputs of orchard production, there is a need to intensify management. The use of dwarfing rootstocks is one way to accomplish this while reducing some costs and increasing returns. However, rootstocks must be evaluated thoroughly prior to wide scale planting. In this paper I would like to present the results of two rootstock plantings at the Horticulture Research Center in Belchertown, Massachusetts.

The University of Massachusetts has been involved with the NC-140 Regional Research Committee for a number of years, and in 1980 and 1984 plantings were established at about 30 locations across the country and Canada. The 1980 planting consists of Starkspur Supreme Delicious on Ottawa 3, M.7 (EMLA), M.9A (EMLA), M.26 (EMLA), M.27 (EMLA), M.9, MAC 9 (Mark), MAC 24, and OAR 1. The EMLA designation means that the source of the rootstock was a clone which has had the viruses removed. A similar planting of these rootstocks with Summerland Red McIntosh as the scion cultivar was established in 1985.

The 1984 planting includes Starkspur Supreme Delicious on Bud.491, Bud.9, MAC 1, MAC 39, P.1, P.22, seedling, CG 10, CG 24, M.4, M.7 (EMLA), M.26 (EMLA), Bud.490, P.2, P.16, P.18, C.6, and Ant.313. Descriptions of the origins of the rootstocks in both the 1980 and 1984 plantings can be found in Fruit Notes 51(4):22-24.

1980 Planting

Tables 1, 2, and 3 show the sizes, yields, and amounts of suckering of the trees in the 1980 planting after seven growing seasons. Based on trunk diameter and height (Table 1), the largest trees were on MAC 24 roots, and they were significantly larger than those on M.7 (EMLA). Trees on MAC 9 were similar in size to those on M.26 (EMLA). Trees on M.27 (EMLA) and M.9 were the smallest. Interestingly, those on M.9A (EMLA) were significantly larger than those on M.9.

The hypothetical number of trees per acre (Table 1) was calculated from tree spread. It was assumed that spacing between trees should be 40% greater than the present spread, and the distance between rows should be approximately 8 feet larger than the spacing between trees. These data suggest that the optimal density of MAC 9 is similar to that of M.26 (EMLA). MAC 24 requires a very wide spacing, approximately 20 x 28 feet.

Yield for these trees is reported in Table 2 as yield per tree and per acre (calculated from hypothetical tree density) for 1986 and on a cumulative basis. Generally, the largest trees were the most productive per tree, but the potential yield per acre was highest for trees on MAC 9 and M.9A (EMLA). In 1986, on a per acre basis, trees on OAR 1, MAC 24, and M.27 (EMLA) were the poorest yielders.

Table 1. Tree size and hypothetical density in the 1980 planting as measured on October 15, 1986

Rootstock	Trunk diameter (in)	Tree height (ft)	Tree spread (ft)	Hypothhtical number of trees per acre (+ approx. spacing in ft.)
Ottawa 3	2.2 d*	8.4 d	7.4 b	214 (11 x 19)
M.7 (EMLA)	3.2 b	11.2 b	9.0 b	165 (13 x 21)
M.9A (EMLA)	1.8 e	7.4 de	5.4 c	342 (8 x 16)
M.26 (EMLA)	2.5 cd	9.8 c	7.4 b	214 (11 x 19)
M.27 (EMLA)	1.0 f	5.2 f	2.8 d	952 (4 x 12)
M.9	1.3 f	6.2 ef	3.4 d	760 (5 x 13)
MAC 9	2.5 cd	7.8 d	7.6 b	218 (11 x 19)
MAC 24	5.0 a	14.4 a	13.0 a	83 (20 x 28)
OAR 1	2.6 c	10.4 bc	5.2 c	377 (8 x 16)

*Means in a column not followed by the same letter are significantly different.

Table 2. Cumulative and 1986 yields per tree and per acre for the 1980 planting.

Rootstock	Yield per tree (1986) (bu)	Cumulative yield per tree (1983-86) (bu)	Potential yield per acre (1986) (bu)	Potential cumulative yield per acre (1983-86) (bu)
Ottawa 3	1.29 c*	3.82 cd	276 abcd	817 ab
M.7 (EMLA)	2.03 b	5.06 bc	335 abc	835 ab
M.9A (EMLA)	1.11 c	3.12 d	380 ab	1067 a
M.26 (EMLA)	1.57 bc	4.41 bc	336 abcd	944 ab
M.27 (EMLA)	0.27 d	0.80 e	257 cd	762 ab
M.9	0.43 d	1.46 e	327 bcd	1110 a
MAC 9	2.02 b	5.19 b	440 a	1131 a
MAC 24	2.72 a	7.51 a	226 cd	623 ab
OAR 1	0.48 d	1.43 e	181 d	539 b

*Means in a column not followed by the same letters are significantly different.

The number of suckers per tree and per acre are reported for each rootstock in Table 3. On a per tree basis MAC 24 resulted in many more suckers than any other rootstock. When the number of trees per acre were considered MAC 24 and M.9 produced the most suckers per acre.

Table 3. The number of suckers per tree and potential number per acre for trees in the 1980 planting.

Rootstock	Cumulative suckers per tree (1980-86)	Potential suckers per acre (1980-86)
Ottawa 3	0.8 b*	171 b
M.7 (EMLA)	4.2 b	693 b
M.9A (EMLA)	1.6 b	547 b
M.26 (EMLA)	5.0 b	1070 b
M.27 (EMLA)	0.2 b	190 b
M.9	7.8 b	5928 a
MAC 9	1.4 b	305 b
MAC 24	118.4 a	9837 a
OAR 1	2.6 b	980 b

*Means in a column not followed by the same letter are significantly different.

In 1986 evaluation of fruit quality and ripening of fruit from these trees began. Results will be reported in later issues.

1984 Planting

The trees in the 1984 planting are not old enough for a full evaluation of tree characteristics, but tree size after 3 growing seasons and bloom are reported in Table 4. Trees on Ant.313, Bud.491, and seedling roots were the largest, and those on P.2, P.16, and P.22 were the smallest. The number of flower clusters were counted in 1986 and the bloom is presented as the number of blossom clusters per unit of trunk cross-sectional area. Because of the significantly higher amount of bloom, trees on B.9, MAC 39, P.22, M.26 (EMLA), P.2, P.16, and C.6 likely would fruit earlier than trees on the other rootstocks. Further observation of these trees will give us insight into new rootstocks which may perform well in Massachusetts.

Table 4. Tree size and bloom of trees in the 1984 planting.

Rootstock	Trunk diameter (in)	Height (ft)	Spread (ft)	Blossom clusters per cm^2 trunk cross-sectional area
Bud.491	1.59 ab*	7.1 ab	4.4 ab	0.03 f
Bud.9	1.23 def	7.1 fg	3.1 bcdef	8.87 c
MAC 1	1.29 cde	7.3 defg	3.3 abcde	0.45 f
MAC 39	1.04 fg	6.9 gh	3.1 bcdef	5.01 de
P.1	1.47 abc	8.1 bcde	3.2 bcdef	3.98 e
P.22	0.78 h	4.7 j	1.8 e	8.24 c
Seedling	1.55 ab	8.1 bcde	4.0 abcd	1.24 f
CG 10	1.49 abc	7.9 cdefg	3.9 abcd	0.99 f
CG 24	1.38 bcde	8.2 abcd	3.6 abcde	0.65 f
M.4	1.23 def	7.6 cdefg	3.3 abcde	0.80 f
EMLA 7	1.32 cde	7.9 cdefg	3.6 abcde	1.06 f
EMLA 26	1.19 ef	7.1 efg	2.9 cdef	4.51 e
Bud.490	1.43 abcd	7.8 cdefg	3.4 abcde	0.91 f
P.2	1.00 fgh	5.7 ij	2.7 def	4.54 e
P.16	0.85 gh	5.9 hi	2.3 ef	8.33 c
P.18	1.43 abcd	8.2 abcd	4.0 abcd	0.65 f
C.6	1.18 ef	6.9 gh	3.3 abcde	6.18 d
Ant.313	1.64 a	8.7 abc	4.8 a	0.50 f

*Means in a column not followed by the same letter are significantly different.

Conclusions

MAC 9 (sold as Mark) continues to perform extremely well under our conditions. Trees are similar in size to M.26. They are more stable than M.26, not requiring support at this point, and they are very productive. The other rootstock which shows a lot of promise is M.9A (EMLA). The source of this stock is derived from M.9A (a clone of M.9) after the viruses were removed. It is considerably more vigorous and much more productive than standard M.9. It could be particularly useful for plantings on posts. The additional vigor keeps lateral branches more upright and productive longer.

In coming years we will be able to observe Mark with McIntosh and several other cultivars in different plantings around Massachusetts. It would be advisable for growers to begin experimenting with Mark in small plantings but, it is too early in testing to recommend it for large-scale plantings.

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POMOLOGICAL PARAGRAPH

Revision of Storage Handbook

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The U.S. Department of Agriculture recently published a revision of its Agriculture Handbook Number 66, "The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stock."

The handbook discusses factors that can significantly affect quality maintenance during storage, and is a wealth of specific information about the postharvest needs and problems of many horticultural crops. Anyone working with storage of horticultural crops should have this publication for quick reference to needs for storing these crops.

Agriculture Handbook Number 66 can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. The stock number is 001-000-04478-8, and the price is $6.00.

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POMOLOGICAL PARAGRAPH

Public Opinion About Alar

International Apple Institute

Are consumers concerned about apples? Not really, according to a national study conducted by Opinion Research Corporation, a San Francisco based market research firm. The study, conducted in July 1986, reports that only an estimated nine percent of the population is even aware of any publicity or news stories of health concerns about apples.

A surprising number of respondents to the study replied that the news they heard about apples was good. In addition, many other respondents who remember recently hearing something about apples in the news could not even recall whether it was positive or negative.

Consequently, the overwhelming majority of consumers are not concerned with apples and therefore, we hope retailers are not worried.

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MAUGET MICROINJECTION OF OXYTETRACYCLINE FOR THERAPY AND PREVENTION OF EASTERN X-DISEASE OF PEACHES

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Introduction

Peach X-disease has been considered one of the factors that limits profitability of commercial peach production in the Northeast. This mycoplasma disease has been brought into remission by trunk injection of oxytetracycline antibiotics (2). However, the injection methods used were very labor intensive and difficult for peach growers to use in commercial orchards (1). There also is some evidence that these methods have led to significant trunk damage over time (Pierson, personal communication). Mauget (J.J. Mauget Co., 2810 No. Figueroa St., Los Angeles, CA 90065) microinjection has been used widely for trunk injection of shade trees by arborists to deliver fertilizers, fungicides, antibiotics, insecticides, and micronutrients. Recently, a Mauget capsule with 4% oxytetracycline (OTC) became available for experimental use in controlling mycoplasma diseases of trees. If a simple system of trunk injection like the Mauget microinjection system could deliver oxytetracycline to peach trees effectively, control of X-disease in peach orchards by trunk injection could be performed by peach growers. The object of this study was to determine if Mauget capsules containing 4% oxytetracycline could be used to control X-disease in a commercial peach orchard.

Materials and Methods

Green Acres Orchard in Wilbraham, Massachusetts was the test site for this study. In late summer, 1985 it was noted that a number of trees in the northeast corner of a 5- to 6-year-old peach block (a late variety mixture) were exhibiting symptoms (reduced apical and radial growth, greatly reduced fruit yield, chlorotic and red-spotted foliage, premature defoliation of inner leaves, and premature bud break) of eastern X-disease. At this time several trees in this corner of the block had already died and replacement trees had been planted. A number of other trees had one-third to one-half of their crowns removed by pruning.

Antibiotic therapy was performed in an attempt to save the living trees exhibiting X-disease symptoms, and to protect a number of trees growing adjacent to the affected ones. The method chosen for therapy was trunk injection with Mauget capsules, which contain 4 ml of 4% oxytetra-cycline (OTC) antibiotic and are disposable after use. On October 7, 1985 twenty-seven trees were trunk injected using a dose rate of one capsule per two inches of trunk diameter, measured at approximately one foot above ground. Since most trees were approximately 5 to 7 inches in diameter, three capsules per tree was the most common dose. To place the Mauget capsule in the tree, a drill hole (3/16" in diameter and 1/2" deep) was made in the trunk approximately 2 to 4" aboveground. The delivery tube and capsule were inserted immediately into the hole. Most of the capsules were empty within two hours and all were empty by the next day when the capsules were removed.

Results

In the spring of 1986 all treated trees appeared free of X-disease symptoms. However, in late July and August, nine of the 27 injected trees began to display X-disease symptoms. Most of these trees were the most severely affected trees in the fall of 1985. One of these trees died by the end of the growing season. The remaining 18 trees stayed in remission through fruit harvest and fall coloration. Fruit yields on these trees were normal. The wounds from the injection completely closed by the end of the 1986 growing season.

Discussion

The effect of OTC therapy on this block was a partial success, with most trees remaining free of X-disease symptoms in 1986. Since most of the trees that went out of remission were in poor condition before injection, there may be limited effectiveness of OTC therapy on trees in advanced stages of the X-disease. The Mauget capsule delivery system for the OTC antibiotic appeared to be an effective and simple technique for injection therapy in this experiment. Additional research is needed to evaluate further this preliminary study. We are particularly interested in establishing levels of injury at which treatment is effective, and levels where treatment is not effective.

Outlook

The effect of Mauget injection of OTC for X-disease control currently is being evaluated in 5 commercial orchards in central and western Massachusetts. Trees in these orchards were injected after harvest in September and October, 1986. An update of this research project will be made in the fall of 1987.

Literature Cited

1. Lacy, G.H. 1982. Peach X-disease: Treatment site damage and yield response following antibiotic infusion. Plant Disease Reptr. 66:1129 - 1133.

2. Sands, D.C. and G.S. Walton. 1975. Tetracycline injections for control of eastern X-disease and bacterial spot of peach. Plant Disease Rept. 59:573-576.

Acknowledgements

The authors wish to thank Dorence Green, Steven Smedberg, and George Swain of Green Acres Orchards for their assistance and cooperation during this study. We also thank the J.J. Mauget Company for supplying us with the Mauget OTC capsules for these experiments.

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STRAWBERRY ARTHROPOD PESTS: AN INTRODUCTION TO STRAWBERRY INSECT PEST MANAGEMENT

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Compared with other fruit crops grown in the Northeast strawberries have relatively few insect or other arthropod pests. However, at least three of these pests, if uncontrolled, can devastate the crop in any given year. Although chemical controls are most often used, the populations of at least two of these pests can be controlled, to a certain extent, by non-chemical measures.

The purpose of this article is to acquaint readers with the life histories of and damage caused by the major strawberry arthropod pests found in our area. Chemical control recommendations can be obtained from your county, regional, or State extension personnel. Where appropriate, non-chemical control measures will be outlined.

Tarnished Plant Bug

There are two insect species that are the most troublesome on strawberry buds or fruit, the tarnished plant bug and the strawberry bud weevil ("clipper"). Their damage results in direct fruit loss or loss of marketable fruit. The tarnished plant bug (Lygus lineolaris P. & B.) is an oval-shaped, flattened bug about 1/4 inch long, brown in color, and mottled with irregular blotches of white, yellow, reddish-brown, and black. On the front third of the forewings there is a clear-yellow, triangular area tipped with a black triangular spot. The greenish or yellowish nymphs resemble adults except for their small size and lack of wings. Larger nymphs are marked with 4 black spots on the thorax and one on the base of the abdomen. The tarnished plant bug (TPB) has a 3 to 4 week life cycle; therefore, three to five generations of this insect can occur in any one season.

Tarnished plant bugs overwinter as adults in protected areas such as leaf litter, hedgerows, or even in strawberry mulch. They emerge from their overwintering sites early in spring and feed on developing fruit tree buds, weeds, alfalfa, or other crops. Apparently, strawberry is a preferred crop because it initiates growth early in the spring.

Plant bugs have piercing-sucking mouthparts. As they feed they introduce a toxic saliva into the developing strawberry fruit. This feeding results in misshapen, catfaced berries, which, if abundant, seriously reduce the size and number of marketable fruit. The most critical time for damage appears to be immediately after petal fall, with less damage occurring during full bloom and less to none occurring during the flower bud stage.

Although the basis for control of this pest is properly timed pesticide applications, there are cultural practices that may help. Good weed control will help eliminate alternate food sources as well as egg-laying sites. Be sure to control weeds in bordering crops and hedgerows. Since tarnished plant bugs are early season pests, it may be helpful to avoid planting early maturing strawberry cultivars if this insect is troublesome for you.

In New York state, as few as one TPB nymph per fruit inflorescence is thought to result in 30% fewer fruits with a corresponding 18% loss in berry weight. Therefore, it is very important to be aware of this insect and the potential for damage it can cause.

Strawberry Bud Weevil

The strawberry bud weevil, or "clipper" beetle, (Anthonomus signatus Say) is a dark reddish-brown beetle with black patches on its wings, and measures about 1/10 of an inch in length. Weevils hibernate as adults in trash in or near strawberry fields, coming out to feed and lay eggs in the developing fruit buds in the spring. The female lays an egg in an unopened blossom bud then girdles the stem below the bud so that the bud stem breaks, wilts, and falls to the ground. The beetle grub inside feeds largely on the pollen of the unopened bud. The legless, white grub feeds for about 4 weeks then changes to a pupa and eventually to a weevil within the bud in which it developed. The newly-emerged beetles feed for a short time then go into hibernation until the following spring.

Yield losses due to egg-laying damage caused by the strawberry bud weevil (SBW) can range from 50 to 100%. An average of one cut bud per 1.5 feet of row, or one female beetle found per 40 row-feet, can result in economic damage.

Since strawberry bud weevils overwinter in wooded areas, preferring areas with early flowering species such as red bud and wild brambles, avoiding such areas may reduce potential SBW damage. Also, there is some indication that early flowering cultivars attract overwintering SBW, and therefore can be used as a "trap" crop.

Because of the potential seriousness of this pest, it is important to watch for the incidence of SBW in early cultivars. Look for cut buds, or the tiny adults on the blossoms themelves. (Adults also feed on strawberry pollen.)

To help control SBW, remove excess foliage and mulch from renovated strawberry beds immediately after harvest to discourage overwintering. If SBW damage has been severe, plow under strawberry beds to reduce overwintering populations.

Spittlebug

Spittlebugs (Philaneeus spp.) are soft-bodied, tan to greenish, elongate bugs about 1/8 to 1/4 inch long. The adults have blunt heads and prominent eyes. Wings can be marked with spots, stripes or bands.

Spittlebugs usually overwinter as eggs in the stems of grasses or weeds. Eggs hatch in the spring at about the time new strawberry leaves and flower buds are showing. The small white nymphs settle on the new growth, and as soon as they start to feed they start to excrete the spittle within which they remain, and feed until they transform to adults. There are five nymphal stages which last a month or more, depending on temperatures. Only one generation occurs each year.

Spittlebugs have piercing sucking mouthparts which they use to feed on plant juices. Feeding damage reduces plant vigor and can severely reduce strawberry yields. When spittlebugs overwinter in plant crowns, early season feeding can result in stunted, poorly-colored plants--damage that looks very similar to that caused by cyclamen mites.

Good weed control will help decrease damage by spittlebugs, as will maintaining weed-free hedgerows.

Mites

Two-spotted spider mites (*Tetranychus urticae* Koch) are tiny, light-colored mites that have two reddish to black spots on their bodies. These mites overwinter as adults and become active as temperatures warm in the spring. If spring weather is warm and dry, mites build up rapidly due to their rapid rate of development.

Spider mite feeding results in discolored or blotching of leaves, or under heavy infestations, bronzing and drying of the leaves. Since spider mites spin silken threads as they crawl around on leaf surfaces, in heavy infestations webs may form over entire plants. Eggs are laid on leaf surfaces or are attached to webbing.

Severe mite damage not only affects infested leaves, it also decreases plant vigor and yields and can result in plant stunting and death. Early mite control is essential to maintain plant health and yields. Good weed control and attention to cultural practices may help with spider mite control.

Root Weevils

Over twenty species of root weevils are pests of strawberries. Of these the black vine weevil (*Otiorhynchus sulcatus* F.) and the strawberry root weevil (*O. ovatus* L.) are the most important. Although the adult weevils feed on foliage, the most important damage results from larval feeding on roots. Larvae are small, legless, white grub-like insects found in and around strawberry roots.

Once strawberry root weevils have invaded a strawberry planting they are very difficult to control. Proper identification of the species is essential to adequate chemical control, where chemical controls can be used. Prevention and destruction of infected plantings are the best methods of dealing with strawberry root weevils.

Root weevil populations increase as plantings are held over from year to year. Therefore, cropping for fewer years will help prevent problems. Good sanitation will also assist in preventing infestations.

White Grubs

Like root weevils, white grubs, the larvae of Japanese beetles and other Phyllophaga species, can be severely damaging to strawberry plants. White grubs are generally more troublesome on newly turned sod land, or in very weedy fields. White grubs are C-shaped, about 1 1/2 inches long and have 6 legs. They spend one or more years in the soil while completing their development. To prevent white grub infestations, do not plant strawberries in newly turned sod and keep fields weed free. White grubs are extremely difficult to control once they become established.

For additional information on these and other strawberry insect pests and their control, refer to "Managing Diseases and Insects on Small Fruits" (MA CES C-164R. 1985. D. R. Cooley, J. L. Drozdowski, W. J. Manning, C. F. Brodel, and K. Hauschild) or to the publications referenced below:

Schaeffer, G. A. "Pest Management for Strawberry Insects." In: Handbook Series in Agriculture, Section D: Pest Management. CRC Press, Inc.

Williams, R. N. (Mar-Apr.) 1979. Two Insect Pests Increase in Ohio Strawberry Fields. Ohio Report on Research and Development. pp. 24-26.

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POLMOLOGICAL PARAGRAPH

Market Basket Survey: Good News For Retailers And Consumers

International Apple Institute

A recent EPA-requested market basket study was conducted by Uniroyal, manufacturer of the Alar chemical, and the news is good for retailers and consumers. The study found that a random sample of apples and apple products taken directly from supermarket produce aisles, farm markets, and apple orchards had levels of Alar far below the accepted legal level of 30 parts per million (ppm). Moreover, it was even below the four ppm estimated by the EPA.

Market basket research found that most apples, which contained any trace of Alar, had an average of only 1.65 ppm. (That's roughly equivalent to one and a half cents in ten thousand dollars.) In fact, close to 25 percent of the apples tested had levels so low (0.1 ppm) they were not required for UDMH analysis.

Consequently, because exposure to Alar is extraordinarily low, there is no perceptible risk to public health while additional tests are being completed. In addition, little or no spraying has been conducted due to apprehension about the issue.

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MONITORING AND CONTROL OF APPLE BLOTCH LEAFMINER: AN UPDATE

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In previous issues of Fruit Notes, we reported on the behavior of apple blotch leafminer (ABLM) moths [49(3):19-22] and on the use of red visual traps to monitor this pest [48(2):11-14]. During the 1986 season, we conducted experiments to improve both monitoring and control of ABLM, in cooperation with a number of apple growers.[1]

During the 1985 and 1986 seasons, many growers successfully used visual traps hung horizontally in the tree canopy to determine the need for a pre-bloom insecticide application for ABLM. In 13 of 14 orchards, where the traps were used and no insecticide was applied for ABLM before bloom, the numbers of moths captured on the traps accurately predicted the need for an insecticide treatment.

We have experienced two problems in using this trap. First, in most cases, moth captures have been too few at tight cluster to make a treatment decision. When using Thiodan[Tm] for ABLM control this decision must be made at tight cluster or earlier. Secondly, after a rain ABLM on the horizontal surface of the trap lose their distinctive wing scale pattern, making it difficult to distinguish ABLM from other captured insects.

To correct both of these problems, we experimented with a new trap position, tacking the trap vertically to the south side of tree trunks at knee height. Results from our study of ABLM behavior indicated that the moths accumulate on the lower portion of the tree trunk during the day in early spring, probably for warmth.

Our results this past season (Table 1) suggested that traps in this position captured more ABLM earlier in the spring than did traps in the canopy, although this difference was not statistically significant. ABLM were also more easily recognized on the traps in the new position, even after a rain.

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[1]The authors wish to express sincere appreciation to the following growers who participated in this work: Richard Bargeron, Keith Bohne, Dana Clark, Ed Roberts, and Mike and Tim Smith. Excellent technical assistance was provided by Suong Nguyen and James Mussoni.

Table 1. Number of ABLM moths captured on red visual traps in two positions at tight cluster and early pink, in seven commercial orchards.

Trap position	Mean ABLM captured per trap	
	Tight cluster	Early pink
Horizontal in canopy	1.1 a*	9.3 a
Vertical in trunk	3.8 a	18.1 a

*Means within a column not followed by the same letter are significantly different at the 5% level.

Our results in 1986 suggest that if cumulative captures in this new position exceed 3-6 ABLM per trap by tight cluster or 18-22 by early pink, an insecticide treatment for ABLM may be desirable. This is a very rough approximation, based on results in only 7 blocks. We will continue testing in 1987 to refine these estimates. In the meantime, we have continued confidence in the treatment threshold of 13 ABLM per trap by early pink for traps placed in the tree canopy.

We also tested a spray tank additive, Nu-Film-17^{Tm} (6 oz./100 gal.), with a single Thiodan^{Tm} (1 lb./100 gal.) treatment for ABLM at tight cluster. Growers using Thiodan for ABLM usually have found 2-3 pre-bloom applications to be necessary for good control. We hoped that Nu-Film-17, advertised as a spreader-sticker which extends the residual activity of insecticides, would help to reduce the number of Thiodan applications needed.

Our results did not bear this out, however (Table 2). Nu-Film-17 appeared to have no influence on the efficacy of Thiodan. It is noteworthy that both the single application of Thiodan and the Thiodan + Nu-Film-17 reduced ABLM mine densities, but not below our threshold of 0.13 first generation mines per leaf, supporting previous evidence that a single application of Thiodan pre-bloom usually is not sufficient to control ABLM.

Table 2. Effectiveness of Thiodan^{Tm} + Nu-Film-17^{Tm}, Thiodan alone, and no treatment against ABLM. Applications were made at tight cluster in four commercial orchards.

Treatment	1st Generation mines per leaf
Thiodan	0.13 a*
Thiodan + Nu-Film-17	0.14 a
Untreated	0.26 b

*Means within a column not followed by the same letter are significantly different at the 5% level.

We also tested a new material, Dimilin^{Tm} for control of ABLM. Dimilin is a chitin synthesis inhibitor which acts against both ABLM adults and eggs. Dimilin has long residual activity and is reported to be non-toxic to beneficial predators, reducing the risk of mite and aphid build-up associated with the use of synthetic pyrethroids [see Fruit Notes 51(2):6-8]. A single application of Dimilin (4 oz./100 gal.) was very effective in controlling ABLM when applied at tight cluster (Table 3), as was Vydate^{Tm} (1.5 pt./100 gal.) applied at early pink. ABLM mine densities in the treated trees remained well below treatment thresholds through the second generation.

Table 3. Influence of pre-bloom application of Dimilin^{Tm} and Vydate^{Tm} on ABLM densities in three commercial orchards.

Treatment	1st Generation mines per leaf	2nd Generation mines per leaf
Dimilin at TC	0.04 a*	0.08 a
Vydate at EPK	0.02 a	0.37 b
Untreated	0.26 b	0.60 c

*Means within a column not followed by the same letter are significantly different at the 5% level.

We also tested Dimilin for control of 2nd generation ABLM (Table 4), applying a single treatment at 2nd cover in one orchard, and two treatments (at 2nd cover and 19 days later) in another orchard. Our results showed significant reductions in ABLM larval densities in treated trees in both orchards.

Table 4. Influence of a single application of Dimilin (Block 1) at 2nd cover (2C) and two applications of Dimilin (Block 2), one at 2nd cover and the second 19 days later, on ABLM densities.

Treatment		2nd Generation mines per leaf
Block 1:	Dimilin at 2C	0.41 a*
	Untreated	0.81 b
Block 2:	Dimilin at 2C + 19 days later	0.05 a
	Untreated	0.60 b

*Means within a column not followed by the same letter are significantly different at the 5% level.

Our results with Dimilin agree with results from other states and Europe. Hopefully, Dimilin will be available for use in the near future.

In conclusion, the visual monitoring trap for ABLM has been used successfully to determine the need for an insecticide application before bloom in many orchards. A new position for this trap may improve its usefulness by allowing an earlier treatment decision and reducing confusion in the identification of the insects captured. Dimilin holds promise as a new selective treatment option for ABLM without threatening biological control of mites and aphids.

The ABLM has become an important pest in our region by having developed resistance to organophosphate (OP) insecticides commonly used in commercial orchards. Beneficial parasites which control ABLM very effectively in unsprayed trees are killed by these OP's and other insecticides. Whatever we can do to reduce insecticide use in our orchards, through the use of IPM sampling techniques for example, will help to spare these beneficials and allow them to assist us in controlling ABLM.

* * * * *

POMOLOGICAL PARAGRAPH

State of Maine Suspends Action on Mandatory Tolerances for Alar

International Apple Institute

Robert Deis, Director, Maine Bureau of Public Service, in an October 10, 1986, memorandum to food processors said that because "many food processors have voluntarily decided to discontinue their use of Daminozide-treated raw products and many farmers, particularly apple growers, have substantially reduced their applications of Daminozide--we expect this will lead to a significant reduction in public exposure--we are therefore suspending implementation of mandatory state tolerances in hopes that they will be unnecessary."

The residue guidelines considered in Maine (and the basis for acceptable voluntary action) are 1 ppm for infant and baby food and 5 ppm for general-use, heated, processed food packaged before 10-1-86 and non-detectable and 1 ppm, respectively, thereafter.

Rather than setting mandatory tolerances, it was pointed out the state was taking non-regulatory steps which include a survey of processors to clarify the extent and nature of their Daminozide policies and to monitor residues of Daminozide/UDMH in products sold in Maine. The memorandum to processors indicated that if product is found to have residues above what the state considers acceptable levels, voluntary withdrawal of lots will be requested.

Reprinted from Apple News 17(5):1-2.

REDUCING ENERGY COSTS IN CA STORAGE

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Dedication

This work is dedicated to Professor Robert M. Smock, who in 1938 published the results of his research on evaporator fan cycling to save energy. We are grateful for his constant support and encouragement in this project and in all fruit storage programs. Dr. Smock suffered a fatal heart attack on April 22, 1986 as he walked across the Cornell campus to his office in the Pomology Department.

Introduction

The concept of reducing cold storage energy use through evaporator fan cycling is not new. In 1938 R. M. Smock (2), a Pomologist at Cornell University, wrote of his work, "Certainly no differences were indicated in this study which would justify the extra power cost of continuous blower operation." Smock's study indicated that fan operating time could be reduced by 45% with no detrimental effect on fruit quality and condition. Thirty plus years have elapsed, and now the merits of this original research are being discovered and applied to modern CA storage in New York.

Storage Technology

Fruit storage technology has changed tremendously since the first cold storages were built in New York State. The handling, cooling, and storage milestones are highlighted in Table 1.

Table 1. Commercial loading and cooling rates for apples.

Year	Loading Period	Cooling Time	Room Atmosphere	Handling Method
1924	2-3 weeks	1 week	Air	Barrels
1938	2 weeks	1 week	Air	Bu. Box
1945	1 week	3-4 days	CA	Bu. Box
1965	1 week	2-3 days	CA	20 Bu. Bin
1986	5 days	"overnight"	"Rapid" CA	20 Bu. Bin

The industry began to use on-farm refrigeration for apples stored in barrels around 1924. Professor Smock's study involved refrigerated air storage of apples in bushel boxes in 1938. Around 1945, commercial CA storage was begun, and by 1965, the importance of faster cooling was recognized and 20-bushel pallet bins were in widespread use. Currently, commercial operations are striving for overnight cooling and rapid CA.

The technology change has required increased cooling capacity for pull down, which is reflected in larger evaporators and bigger air handling systems. The very first refrigerated rooms relied upon gravity refrigeration and contained no supplemental air circulating equipment. By 1938, forced air blower units delivered 18 air changes per hour and added approximately 198 watts of heat per 1,000 bushels of stored fruit. Current centrifugal blower units have a 28 air-change-per-hour capacity. Direct throw propeller fans on modern evaporators deliver 90 air changes per hour. The present hardware associated with both types of systems adds approximately 375 watts of heat per 1,000 bushels of fruit. The heat added by the fan motors is now 2 to 3 times greater than the heat of respiration of the fruit (130-180 W/1,000 bushels).

The energy budget for a modern New York State CA storage is shown in Figure 1. These data are for a 120,000 bushel plant equipped with flooded ammonia refrigeration. The daily electrical requirements for compressors and evaporator fans are shown along with the total for the refrigeration system.

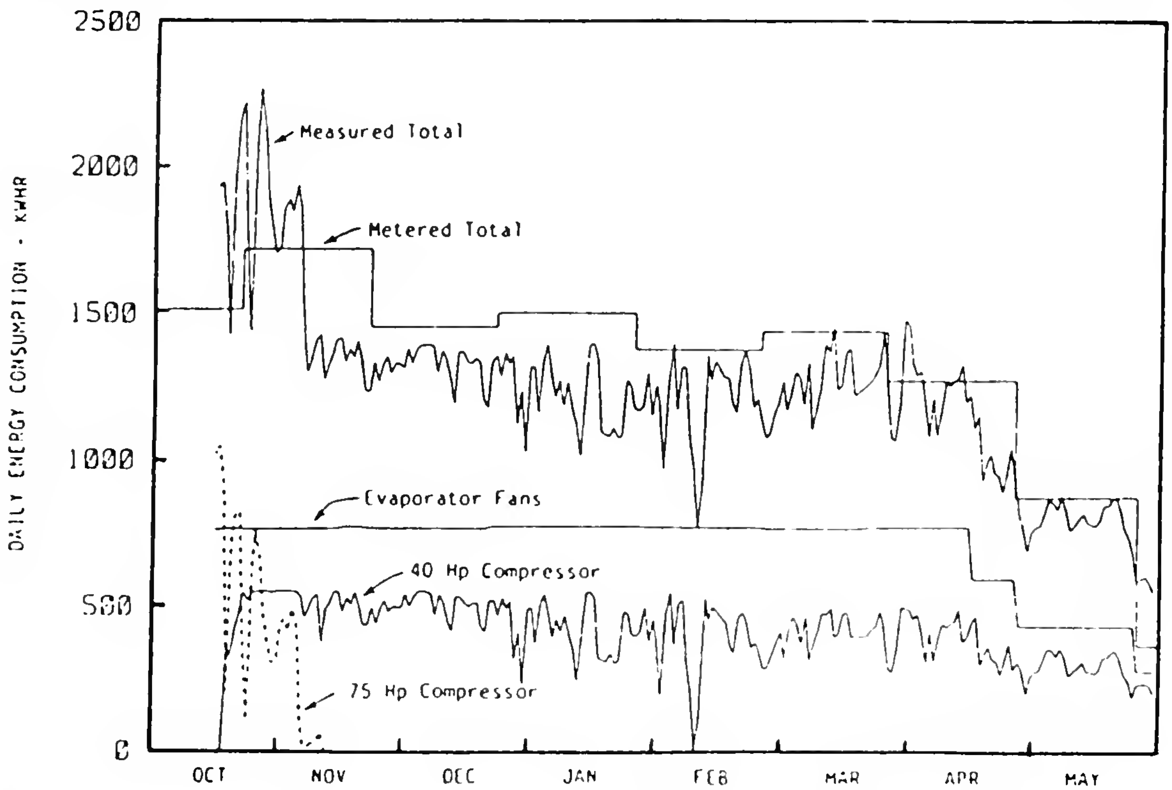

Fig. 1. Daily energy consumptions in a 120,000 bushel CA storage, where fans were operated continuously.

The "measured total" includes the relatively small amount of electricity used by water pumps and condenser fans--a quantity which averages approximately 6% of compressor use. The "metered total" is the daily average electrical use calculated from monthly power company bills. Hot water heating, office space heat, and the electricity used by CA burners and scrubbers are included in the "metered total."

The data in Table 2 indicate that a total energy savings of 40% is possible if evaporator fans could be turned off half of the time. Total savings approach 60% when fans are off 16 hours out of 24 hours. Based on early research by Smock and later reports by Yost (5) half-time reduction in fan operation is feasible and causes no detrimental effects on stored fruit quality or condition.

Table 2. Daily energy use and potential energy savings through fan cycling in 120,000 bushel CA storage

Item	Fans on continuously	Fans cycled 50% on, 50% off	Fans cycled 25% on, 75% off
Fans	750 kWh	375 kWh	188 kWh
Compressor	500 kWh	375 kWh	313 kWh
Condenser	30 kWh	23 kWh	19 kWh
Total use	1280 kWh	773 kWh	520 kWh
% Savings	0%	40%	59%

Air Handler Efficiency

During storage trials (1), we investigated the efficiency of high velocity direct throw air handlers presently used in CA storages. (Efficiency is defined as the quantity of air returning through pallet runner openings compared with the total quantity of air delivered from the evaporator discharge). When efficiency measurements were made in a 30,000 bushel CA room, 70% of the discharge air never passed through the stacks; it simply short-circuited over the top of the bins and back to the evaporator. When air flow was reduced 50% by turning off half the fans, the return air flow decreased only 22%. Since the measured return flow coming out of the stacks was still uniform over the entire room, we concluded that half of the evaporator fans could be safely shut down after field heat was removed and the CA room was sealed.

Control Strategies

The energy crisis of the 1970s prompted eastern growers to begin using evaporator fan cycling to save energy. The first storage operators to employ fan cycling simply turned their refrigeration systems off at night and back on again in the morning during the winter. Research studies (2,4) indicated that temperature variations on the order of $\pm$ 1^{o}F from the set point would be expected when systems were turned off for 12 to 14 hours. We found these variations to be greater than those experienced when refrigeration systems operated continuously. Since fruit quality and condition after CA storage in the cycled rooms was equivalent to that in rooms operated continuously, the cycling practice became widely accepted.

Our fruit storage industry currently employs several control strategies for fan cycling. Manual control is still used by some of the smaller growers. Time clock control is used, and a few new systems employ programmable load controllers to sequence fan and refrigeration operations. Presently, however, the most popular technique is to cycle fans and refrigeration with a solid-state thermostat. This thermostat, accurate to $\pm$ 0.25°F, can be set to control only temperature while fans run continuously during loading and pull down. Later the thermostat is switched to control fans and refrigeration together. Remote temperature sensors are installed in the CA rooms where the thermostat is used to control fan cycling.

Initially we were skeptical of using a single thermostat sensor to control all of the fans in the CA room. Our recommendation still calls for remote temperature sensors in all rooms whether fans are cycled or not. We encourage growers to turn at least some of the fans on for 30 minutes each 12 hours during very cold weather. We have recorded fan cycles of up to 36 hours off and 1 hour on when the thermostat alone was used to cycle the fans with the refrigeration.

After 3 years of experience we are not aware of any fruit condition problems resulting from the fan cycling methods described above. Some freezing damage has occurred in open, partially empty CA rooms, because insufficient respiration heat was available. Our biggest concern is that compressor capacity in older plants now far exceeds the load developed in the CA rooms when fans are cycled. During extended cold periods, machines may sit idle for 24 hours or more, and provisions must be made to keep the compressor room warm. Heat reclaim from these compressors is no longer possible during the storage season when the fans are cycled.

Temperature, Relative Humidity, and Atmosphere Variations Due to Fan Cycling

We find that the temperature controller, not the fan cycling practice, is the cause of major temperature variations in the CA rooms. We have documented temperature variations in excess of $\pm$ 2°F in rooms with continuously operated fans controlled by mechanical thermostats. Temperature variations in cycled rooms controlled by the solid state thermostats average $\pm$ 1° or less.

Few data exist for relative humidity variations. Some very limited data from new storage facilities indicate cycled rooms yield less defrost water than identical continuously operated rooms. In theory, this should be the case, but we do not have sufficient data to confirm it for commercial systems.

We are equally short of data on atmosphere concentration variations. In one study of 1% oxygen storage in a 30,000 bushel CA room, no variation in O_2 levels could be detected after the fans were off for 12 hours. This determination was made by inserting sampling lines into 6 stack locations during loading and monitoring the oxygen level with an electronic analyzer.

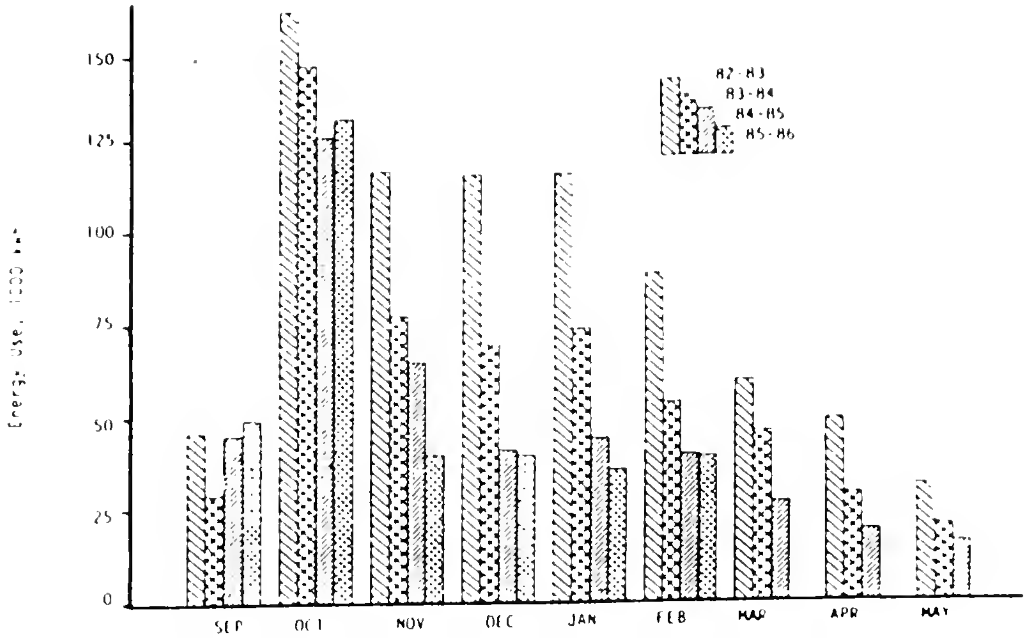

Fig. 2. Monthly energy use in a 300,000 bushel CA storage.

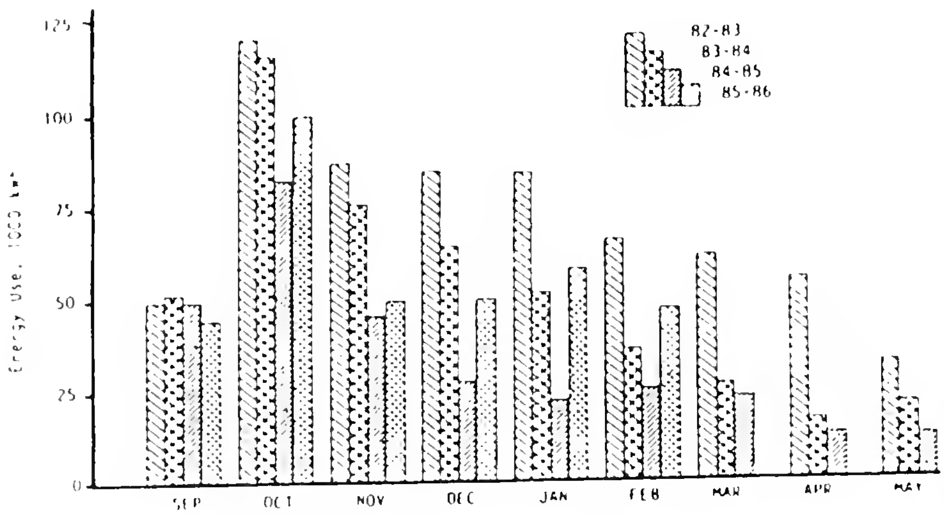

Fig. 3. Monthly energy use in a 175,000 bushel CA storage.

Energy Savings

Eastern storage operators are sold on fan cycling to save energy and dollars. We have documented the monthly savings by two of our commercial cooperators and present these data in Figures 2 and 3. The "base year" is the 1982-83 storage season, when no fan cycling was used. Conversion to fan cycling was completed in 1984-85; total energy use was reduced nearly 50% in the process. The need for good storage management with fan cycling is indicated in Figure 3, where higher than expected use occurred in 1985-86. This was due to a temporary change in refrigeration plant management from October through February in this storage. The new manager was not "comfortable" with fan cycling practices of the previous year and operated the evaporator fans for a longer period of time each day during that season.

The fan cycling practice holds great promise for energy cost savings. Energy rates in the Northeast currently average 11 cents per kWh and electric costs are a significant part of the total storage budget. Our research has shown that fan cycling results in a 60% savings in energy in commercial CA storages. The simple payback on the fan cycling thermostat controller and remote temperature sensing equipment is currently 4 to 5 months. The value of energy saved is equivalent to 16 cents per bushel of storage capacity. We estimate that the potential value of energy savings due to fan cycling is 1 million dollars annually for our CA industry in New York State.

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AN ECONOMIC ANALYSIS OF ORCHARD REJUVENATION IN RESPONSE TO THE REDUCTION OR THE ELIMINATION OF THE USE OF ALAR^{Tm} [1]

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Since about 1966, Alar^{Tm} has been used to extend the harvest season for McIntosh apples by controlling preharvest drop and delaying fruit ripening, enabling growers to efficiently manage harvest labor and cooling capacity. Without Alar^{Tm}, the number of harvest weeks for long-term storage is decreased, thus increasing the quantity of fruit that must be harvested per day. To accommodate this higher harvest rate, picking labor and cooling capacity must be increased, raising production costs. Alternative methods of extending the harvest season would help alleviate this critical problem.

This study examines the economics of replacing 50 acres of mature, seedling-rooted trees (that are difficult to pick and lack good color development) with dwarf and semi-dwarf trees that are more efficient to pick, color well, and allow extension of the McIntosh harvest. It is assumed that the grower must replace this block over a 10-year period, rather than all at once, so that income can continue to be generated each year. The objective of the study was to determine the mix of different McIntosh strains and rootstocks that would best use farm resources under Massachusetts production and marketing conditions during this orchard replacement.

The study was conducted using a multiperiod linear programming model that was developed[2] specifically for Massachusetts apple growers to aid in long-range planning of cultivar selection. That model looked at replacing standard McIntosh acreages with 7 different cultivars. However, given the commercial importance of McIntosh in Massachusetts, we have chose to replant only with McIntosh--but to use a mix of McIntosh strains on semi-dwarfing and dwarfing rootstocks that will spread the harvest season, best use available resources, and maximize profitablility of the orchard.

We tried to achieve goals by selecting strains and rootstocks with specific properties. Our goals and choices were: 1) To produce trees smaller than standard that will produce fruit with better color and ripen earlier (Marshall McIntosh on M.7A); 2) To produce trees smaller than standard but with fruit ripening the same time as standard (Rogers McIntosh on M.7A); 3) To produce much smaller trees capable of producing fruit for rapid, early harvest (Marshall McIntosh on M.26); 4) To produce highly colored fruit ripening later than standard (Marshall McIntosh on OAR1). Please note: OAR1 is an experimental rootstock that has been found to delay ripening of Golden Delicious in Oregon by about 10 days.

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[1]This study was supported by a grant from the Massachusetts Fruit Growers' Association

[2]Hanlon, W. L., C. E. Willis, and R. L. Christensen. 1976. A framework for long range apple variety decisions. Mass. Agric. Exp. Sta. Bull. 621.

Four management limitations (constraints) were inserted into the model, namely, cooling capacity, harvest labor, storage capacity, and replanting acreage. These are described briefly.

Acreage: The planting period for the 50-acre rejuvenated orchard was 10 years. Each year 5 acres were removed and replanted. The model also used a 20-year period--10 years beyond the end of replanting--to evalunte consequences of strain/rootstock selections up to the time the orchard reaches full production. For each planting year, the model decided how many acres of each strain/rootstock combination to plant for maximum profitablility, given the following set of conditions.

Storage. Most orchards divide the marketing of their crop between the fresh market, during and immediately following harvest, and long term storage. However, to simplify the model, we assumed that all fruit produced on the 50 acres was placed in long-term storage.

The storage capacity was set initially at 20,000 bushels. It was increased to 48,500 bushels in year 20 when most plantings had reached full maturity. All trees less than 4 years old were considered nonbearing and used none of the storage capacity. Trees older than 4 years were bearing and their yield used a portion of the total storage capacity.

Harvest labor. The harvest season was divided into eight 3-day picking periods. These extended from September 4 to October 1. A percentage of the total yield for each strain-rootstock combination was harvested during at least 4 of these picking periods. Each combination had harvest labor needs specific to its stage of growth because yield varies with strain, rootstock, and age of tree. The available labor hours for each harvest period were determined by multiplying the number of pickers (set initially at 7) by working hours per day (set constant at 9) and by 3 days per harvest period. For the 50 acres, 189 hours were available for each 3-day period.

Each strain-rootstock combination contributed to the use of harvest labor depending on the yield, the tree's age, the percentage of yield harvested during a particular picking period, and the picking rate. In year 20, when most plantings were mature, additional harvest labor was required. To enable the model to operate, harvest labor was increased to 550 hours per picking period (20 pickers) by year 20.

Cooling capacity. Field heat must be removed from the apples after harvest. The quantity of fruit that can be cooled is limited by the size of the refrigerating equipment. Cooling capacity was evaluated to correspond with the eight 3-day harvest periods. The total capacity was 9,000 bushels for 3 days or 3000 bushels per day.

Each strain-rootstock combination contributes to the orchard's returns to management. This contribution depends on the difference between revenues and costs. In this study, returns to management covered overhead costs, management labor, and profit.

Revenues were dependent on yield, which varies according to the tree's age, the strain-rootstock combination, and the price. Price was held constant for all years but varied with fruit grade. For all trees, yield was assorted as follows: 75% extra fancy, 15% utility, and 10% processing. The bushel prices were $10.00, $5.00, and $2.30, respectively. Obviously, dramatic differences exist between the newly planted trees and the standard trees as to the distribution of fruit into grades, but to simplify the model the proportions were held constant and the differences were accounted for with yield differences.

Total cost for each strain-rootstock combination was the summation of the following costs: site preparation, planting, nonbearing growing years 1 through 3, bearing growing years 4 through 20, harvesting, cooling, and storage. All costs were figured on a per acre basis using current prices.

For the 20-year life span of the rejuvenated orchard, costs and revenues were totaled and returns to management were calculated per acre for all strain-rootstock combinations. An acre planted in year 1 incurred costs of site preparation, planting, and nonbearing maintenance through the first 4 growing years with no revenues received. In year 5, when these trees began to bear fruit, revenues were positive and increased through maturity. Revenues were received from these trees for 16 years. However, an acre planted in year 5 earned revenues for only 12 of the 20 years. Trees planted in year 10 earned revenues for only 7 years within the framework of this study.

RESULTS

The discussion of results is divided between findings of the original set of constraints, called the original model, and findings of the modified models resulting when constraints were changed to reflect changes in availability of orchard resources. Comments are included about each strain-rootstock combination and about each constraint.

Results of the Original Model

Table 1 presents the optimal 10-year planting plan for the 50 rejuvenated acres, as determined by the original model.

Table 1. Planting plan for the original model.

Planting year	Rogers/M.7A	Marshall/M.7A	Marshall/M.26	Marshall/OAR1
1	0	0	5	0
2	0	0	2.2	2.8
3	0	0	0	5
4	0	0	3.9	1.1
5	0	0	5	0
6	0.1	0	4.9	0
7	0	0	5	0
8	0	0	5	0
9	0	0	5	0
10	0	0	0	5
TOTAL	0.1	0	36	13.9

Marshall/M.26. Marshall on M.26 was favored. The model suggested planting 36 of the total 50 acres with Marshall/M.26. The early coloring strain and the more open tree in this combination gives the earliest and longest harvest season of the trees compared. Also, because of its precocity, Marshall/M.26 reaches full production earlier than other strain-rootstock combinations. Therefore, this combination has less competition for labor and cooling capacity, and are the primary factors leading to its selection for the most planting.

Marshall/OAR1. The combination of Marshall on OAR1 composed practically all the remainder of the 50 acres. This strain-rootstock combination should yield later in the season, extending the harvest at least 3 days beyond other combinations. A disadvantage is that full production is not reached until approximately 3 years after Marshall/M.26. Also, it is less precocious and begins bearing later than other combinations. Hence, its contribution to returns to management was delayed. The model decided to plant 5 acres in year 10 because maximum yield would not be reached by year 20, so less burden was placed on storage capacity. OAR1 is, at this time, purely experimental, and we do not know how it will perform with a McIntosh scion and under Massachusetts conditions. However, it is obvious that a strain-rootstock combination which ripens later than normal can be advantageous because of its ability to expand the harvest season and reduce competition for labor and cooling.

Rogers/M.7A. The model suggested planting only 0.1 acre of Rogers/M.7A. Rogers and seedling McIntosh are harvested over a similar time period. Replacing seedling trees with Rogers on M.7A did not expand the harvest season; thus, that action does not alleviate any pressures caused by the nonuse of Alar^{Tm}. However, some benefits may be gained with a smaller tree, such as less picking time per bushel.

Marshall/M.7A. No acreage was suggested for planting Marshall/M.7A given the conditions of the original model. This strain-rootstock combination competes with Marshall/M.26 for resources during the same periods. Marshall/M.7A's have a somewhat shorter harvest season than Marshall/M.26, and a higher percentage of the crop is picked during the first week. Also, Marshall/M.7A reaches full production 1 year later than Marshall/M.26, so it offered no financial advantage.

Some alterations were made in constraints to allow the model to operate. First, to not violate the assumption that all fruit must be stored, storage capacity was increased from 20,000 bushels to 48,500 by year 20. Also, in year 20, cooling capacity was increased from 9,000 bushels to 9,800 to harvest periods 4 through 8, which were the most prolific harvest periods. This change resulted in cooling capacity becoming most constraining in period 3. Harvest labor was set initially at 189 hours per 3-day harvest period. This was increased to 550 hours by year 20 as trees reached full maturity. The 189 hours became constraining in year 11 during the 4^{th} and 5^{th} harvest periods. If labor was reduced in the 5^{th} period, then Rogers/M.7A would not be planted. If the amount of labor increased then the quantity of Marshall/OAR1 selected for planting declined.

Results of Modified Models

After results of the original model were obtained, the magnitudes of the constraints, or resources available, were changed for labor, cooling capacity, and storage. The following is a description of the overall changes made to the constraints and of the responses to those changes. For a more detailed discussion of the modified models, readers should refer to the Extension publication we have written (to be published in January, 1987) that describes this research at greater length.

Increasing the amount of harvest labor, cooling capacity, or both simultaneously caused greater changes in the planting mix than changes in storage capacity. Therefore, storage capacity was increased to handle all apples and then held kept constant. Harvest labor and cooling capacity were increased only in the most constraining 3-day harvest periods in any year, as opposed to being increased in all harvest periods for any year. This enabled the identification of the harvest periods that demanded the greatest amount of labor and cooling capacity. Also, this treatment made it easier to note how the selection of different combinations was influenced by changes in harvest labor and cooling capacity. Cooling capacity was most constraining in year 20, when plantings were mature and produced maximum yields. In this year for harvest periods 4 through 8, cooling was increased in steps from the initial 9,000 bushels per 3 days to 10,000, and finally to 11,000 bushels per 3-day harvest period.

Harvest labor was altered in year 11 for the 2^{nd} through the 4^{th} periods (September 7 to 17). The number of pickers was increased in steps from 7 to 8 to 9 in year 11. With each picker working 27 hours in a 3-day harvest period, the total hours available for each harvest period increased from 189, to 216, and to 243. In year 20 harvest labor was most constraining during the 4^{th} and 5^{th} harvest periods (September 14 to 17 and 18 to 21), so labor hours available were raised to 567 per 3 days (21 pickers) for both periods.

Marshall/M.26. Marshall on M.26 was selected for planting most frequently in all models. Overall, this strain-rootstock combination makes the best use of resources as explained previously. However, the advantages do not imply that Marshall/M.26 should be the sole strain planted on the rejuvenated acreage. Such action would result in high labor and cooling requirements concentrated during the days of Marshall/M.26's peak picking period. Again, the objective was to determine the most profitable mix of strain-rootstock combinations that would use the inputs available efficiently.

If ample harvest labor was available at maturity of the orchard, Marshall/M.26 replaced acreages selected originally for planting with Marshall/OAR1. In the original model, no Marshall/M.26 was chosen in planting year 3. However, 2.5 acres were chosen when harvest labor and total cooling capacity increased. For planting year 9, the original model decided to plant all 5 acres with Marshall/M.26. However, as harvest labor and cooling became less constraining, less of this combination was chosen, with no Marshall/M.26 being selected for year 10. Probably, this situation arose because labor and cooling capacity were not increased to high enough levels.

Rogers/M.7A. In the original model Rogers/M.7A was selected only in year 6 for 0.1 acres. When the number of pickers increased to 9 in year 11 for harvest periods 3 and 4, 1.5 acres of Rogers/M.7A was selected for planting in year 1. However, if the number of pickers was greater than 9 for the same harvest period, planting Marshall/M.26 was more profitable. Acreage of Rogers/M.7A planted during year 3 increased when harvest labor increased during year 20.

Also, selection of Rogers/M.7A was sensitive to cooling capacity. Increasing cooling to 11,000 bu per 3-day period during year 20 stimulated approximately 3 acres of Rogers/M.7A to be planted in year 8. This resulted in a reduction of Marshall/M.26 acreage from 5 acres to about 2 acres in year 8. Rogers/M.7A replaced 1.4 acres of Marshall/M.26 in year 9 for the same reason.

Rogers/M.7A's picking schedule is more similar to Marshall/OAR1 than to Marshall/M.26. The bulk of the crops is harvested during the same 2 weeks, but harvesting of Marshall/OAR1 extends about one half week past that of Rogers/M.7A. However, as more labor and cooling capacity become available Rogers/M.7A acreage increases while that of Marshall/OAR1 decreases, because Rogers/M.7A begins bearing earlier and reaches full production sooner.

Marshall/M.7A. Because of earlier coloring Marshall/M.7A has a longer potential harvest period than Rogers/M.7A. However, its harvest period coincides with that of Marshall/M.26, but the latter has a more efficient use of harvest labor. Therefore, in most cases, Marshall/M.26 was chosen rather than Marshall/M.7A. In fact, Marshall/M.7A never was selected until the 10th planting year.

Marshall/OAR1. OAR1 is attractive because it may delay fruit ripening. Extending the harvest season places demands on resources at times when other strains place less or no demand on harvest labor and cooling capacity. It is the one strain requiring harvesting in period 8, and it competes only with Rogers/M.7A during period 7. In all models, some acreage of Marshall/OAR1 was selected for planting, because it complements other strains as an aid in expanding harvest from 2 weeks to 4 weeks and provides more efficient use of labor and cooling capacity.

CONCLUSIONS

It should be remembered that the results of this study were specific to the 50-acre rejuvenated orchard described by a given set of conditions. Five acres of the orchard was replanted yearly for 10 years. The research used the methodology of multi-period linear programming to determine the number of acres of 4 different McIntosh strain-rootstock combinations that should comprise the replanted acres each year. The objective of planting a mix that generates the greatest profit over the 20 year period was constrained by the amount of storage, labor, and cooling capacity available during harvest.

Given the limits, Marshall on M.26 composed 66 to 72% of the 50 acres replanted in each of the alternative models which used varying levels of harvest labor and cooling capacity. Marshall/M.26 requires more labor and materials at planting time because the trees may require staking and may require more intensive management during the entire life of the tree. However, several characteristics contribute to the selection of these trees as the best economic choice: the trees reach full production earlier, the harvest period is longer, and fruit can be harvested at a faster rate than those of other strains.

OAR1 is an experimental rootstock that is being field tested with McIntosh in Massachusetts. It was used in this study to determine its economic potential. Marshall on OAR1 was selected by the model when harvest labor and cooling capacity were most constraining. Due to the experimental nature of this rootstock Marshall/OAR 1 is not suggested for planting, but these results show that a combination of strain and rootstock which results in later ripening is desirable and can have high economic potential. Recent results suggest that Mark also may delay fruit ripening and may be able to provide benefits similar to those projected here for OAR1. Unfortunately, it also is experimental, but has undergone more thorough testing than OAR1 at this time. Clearly, a rootstock that delays McIntosh harvest has great value in a strain-rootstock mix.

Acres selected for replanting with Rogers on M.7A increased when harvest labor and cooling capacity were more available. At the least constraining levels of resources in the later planting years, Rogers/M.7A substituted for Marshall/OAR1. Thus, availability of labor and of cooling capacity affect decision-making in this rejuvenation framework.

Lastly, Marshall on M.7A was selected minimally. This study did not recommend planting Marshall/M.7A when Marshall/M.26 is an alternative. However, when M.26 is not an alternative because of inadequate soil moisture, too shallow a soil, or a desire to avoid the more intensive management required, Marshall/M.7A would be the obvious replacement.

Every orchard functions under different conditions; yet, similarities among orchards in growing and harvesting practices exist. This study examined a hypothetical orchard. It did not use the costs of any specific orchard. Although the results are specific to the rejuvenated 50 acres in the model, suggestions for replanting schemes can be made. To guarantee that all fruit be harvested in all cases, harvest labor must be increased to 9 pickers for the 50 acres in year 11 and to 21 pickers by year 20. If this is not done, the entire crop at full maturity cannot be picked. Also, cooling capacity must be increased from the original ability to cool 9,000 bushels per 3-day picking period, to 11,000 bushels per period by year 20.

Table 2 is a suggested 10-year planting mix for a rejuventated 50-acre orchard. It is based upon the research results and should be used as an aid for grower decisions. Again, because Marshall/OAR1 is experimental, it is not included in the suggested planting mix. For rejuvenated acreages of differing sizes, the percentage values can be applied. For example, in year 3, 60% of a rejuvenated acreage would be planted with Rogers/M.7A, and 40% planted with Marshall/M.26.

Table 2. Suggested planting mix in a 50-acre rejuvenated McIntosh orchard.

	Rogers/M.7A		Marshall/M.7A		Marshall/M.26	
Year	Acres	% of Planting	Acres	% of Planting	Acres	% of Planting
1	0	0	0	0	5	100
2	0	0	0	0	5	100
3	3	60	0	0	2	40
4	0	0	0	0	5	100
5	0	0	0	0	5	100
6	0	0	0	0	5	100
7	0	0	0	0	5	100
8	2.5	50	0	0	2.5	50
9	3.5	70	0	0	1.5	30
10	5	100	0	0	0	0
TOTAL	14		0		36	
% of total acreage:	28%		0		72%	

The authors would like to thank the Massachusetts Fruit Growers' Association for generously supporting this study.

COOPERATIVE EXTENSION SERVICE
U S DEPARTMENT OF AGRICULTURE
UNIVERSITY OF MASSACHUSETTS
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Fruit Notes

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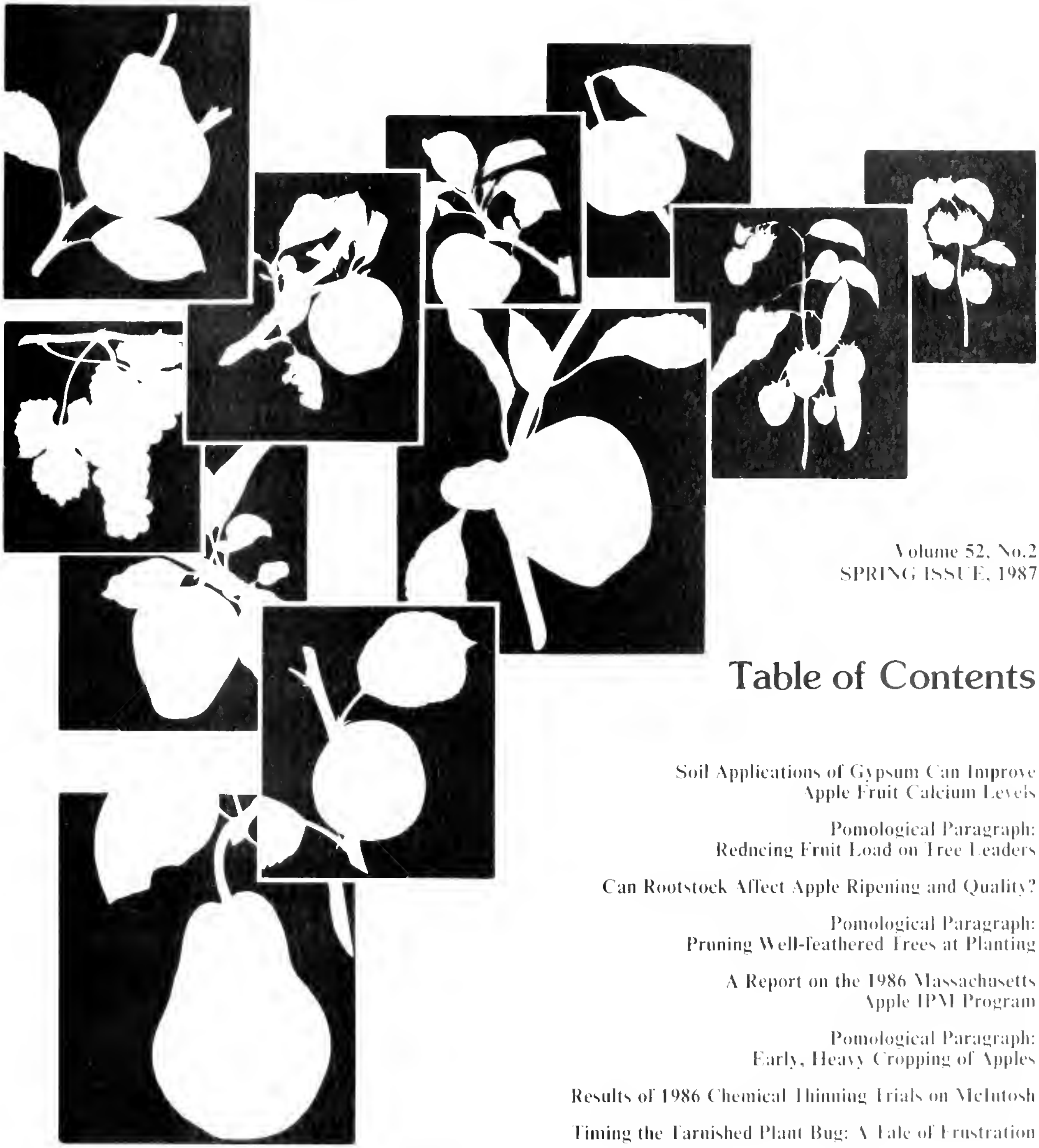

Volume 52, No.2
SPRING ISSUE, 1987

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SOIL APPLICATIONS OF GYPSUM CAN IMPROVE APPLE FRUIT CALCIUM LEVELS

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Calcium (Ca) deficiency in the fruit is a chronic problem in modern apple production. If this deficiency occurs, it causes poorer keeping quality of the fruit.

There are 4 possible approaches available for dealing with potential Ca deficiency in apples. These are cultural practices, soil treatments, foliar sprays, and postharvest dips or drenches. These approaches were addressed recently (Proc., Mass. Fruit Growers' Assn. 93: in press).

Of these approaches, soil treatments are generally the least effective due to the poor ability of apple roots to absorb Ca from the soil solution. We have tried numerous treatments and have obtained marginal benefits at best. However, recent results from applications of gypsum ($CaSO_4 \cdot 2H_2O$) have been better than any from earlier studies of soil treatments and will be described here.

We have conducted 2 major trials with gypsum. The first trial was initiated by Dr. Mack Drake in 1976 in a block of mature, seedling-rooted Cortland trees. Half of these trees received 80 lbs. of gypsum spread under the canopy in April and half received no gypsum. Otherwise, the trees were fertilized and cared for in an identical manner. These applications were repeated annually through 1986.

During this period leaves and fruit were sampled and analyzed for mineral concentrations, and fruit were usually stored in both air and controlled atmosphere (CA) and their quality was assessed after long-term storage. Results for analyses from 1977 through 1984 are summarized in Table 1. It can be seen that gypsum treatments increased Ca concentrations in both leaves and fruit. In addition, they suppressed magnesium (Mg) in both leaves and fruit, and suppressed potassium (K) in the fruit but not the leaves. Treatment had no effect on phosphorus (P) levels in either fruit or leaves.

The increased fruit Ca levels improved keeping quality of the apples (Table 2). Both bitter pit and senescent breakdown were significantly reduced after both air and CA storage. In the case of bitter pit, the reduced levels of both Mg and K in the fruit should enhance the benefit from increased Ca, since it has long been known that high Mg and K worsen the effects of low Ca in causing bitter pit development. It should be noted that in 1985 there was a severe bitter pit problem in the fruit on the trees. As we walked through this block it was very clear which trees had and had not been treated with gypsum, as the appearance of the fruit was markedly different. In contrast, little bitter pit occurred in this block in 1986 and no difference was apparent at harvest time.

The second gypsum experiment was established in 1980 in a block of Delicious trees planted on MM.106 rootstock in 1972. This experiment was set up and conducted by Dr. William J. Lord until his retirement. The trees in this block received either 0, 50, or 100 lbs. of gypsum spread beneath the

Table 1. Effects of annual gypsum applications of 80 lbs. per tree beneath the canopy in the spring on fruit and leaf mineral concentrations. Cortland. 1977-1984.

Treatment	Element			
	Ca (ppm fruit, % d.w. leaves)	Mg (ppm fruit, % d.w. leaves)	K (%)	P (ppm fruit, % d.w. leaves)
		Fruit		
No gypsum	142	303	0.63	420
Gypsum	162	273	0.60	417
Significance[z]	***	***	**	n.s.
		Leaves		
No gypsum	0.82	0.26	1.36	1.90
Gypsum	0.96	0.23	1.39	1.86
Significance[z]	***	***	n.s.	n.s.

[z]Significance: *** = odds of 999:1; ** = odds of 99:1; n.s. = not significant.

Table 2. Effects of annual gypsum applications, 1977-1984, on fruit quality. Cortland.

Factor	No gypsum	Gypsum	Significance[z]
Firmness, lbs., harvest	13.4	13.5	n.s.
After air stg	9.2	9.3	n.s.
After CA	11.0	11.1	n.s.
Bitterpit, %, after air stg	8	3	***
After CA	11	5	***
Breakdown, %, after air stg	20	12	***
After CA	8	3	***

[z]Significance: *** = odds of 999:1; n.s. = not significant.

canopy in April. These treatments were repeated each year until 1986, when the 100-lbs. application rate was discontinued. Each year leaves and fruit were analyzed, and when available (the site is subject to frost), fruit were stored in 32°F air and assessed after long-term storage.

Results are summarized in Table 3. Gypsum increased Ca concentrations in both leaves and fruit, and decreased Mg concentrations in both leaves and fruit. It did not affect fruit K and slightly increased leaf K. Gypsum at 100 lbs. per tree was no better than 50 lbs. per tree in any of these measurements.

Table 3. Effects of annual gypsum applications, 1980-84, on leaf and fruit mineral concentrations. Delicious.

Factor	Gypsum (lbs./tree)			Significance[z]	
	0	50	100	0 vs 50 + 100	50 vs 100
Fruit Ca, ppm	145	153	152	*	n.s.
Mg, ppm	263	258	255	**	n.s.
K, %	0.54	0.55	0.55	n.s.	n.s.
Leaf Ca, %	1.22	1.32	1.36	**	n.s.
Mg, %	0.36	0.32	0.32	**	n.s.
K, %	1.36	1.42	1.43	**	n.s.

[z]Significance: ** = odds of 99:1; * = odds of 19:1; n.s. = not significant.

In this experiment no consistent effect on fruit quality has been measured. In part this probably is due to the large variability in cropping among trees, and the consequent variability in fruit quality. For example, in 1986 a severe bitter pit problem existed but it was found only on the large fruit that were produced on trees that had been damaged by frost. The large effect of fruit size may have masked any possible benefit from the gypsum treatments.

These results indicate that soil applications of gypsum beneath the tree can increase apple Ca concentrations and improve fruit quality after storage. The effects are modest in size but can produce measurable benefit under appropriate conditions.

Use of gypsum can, however, create some problems. The obvious one is suppression of leaf Mg levels. Mg deficiency is common in Massachusetts and results in loss of vigor and productivity of trees. Our results have shown a steady decline in leaf Mg in the Cortland block with continuing gypsum application. Each year leaf Mg was lower than it was the previous year in the gypsum-treated trees. Clearly, Mg levels would have to be monitored carefully and corrective measures applied as needed if a gypsum program was adopted.

We do not know what effects long-term use of gypsum would have on soil properties. These effects must be determined in future assessments.

Likewise, we do not know what application rate is optimum. Since spread of the trees was different in the Cortland and Delicious blocks, it is more useful to consider applications in terms of lbs. per square foot. The Cortland trees were treated with 0.2 lbs. per sq. ft. annually, and the Delicious trees with 0.3 and 0.6 lbs. per sq. ft. Since the higher rate on Delicious was no different from the lower rate, it appears that something less than 0.3 lbs. per sq. ft. may be optimum. However, a comprehensive experiment needs to be conducted to determine effective rates.

Gypsum treatments are both laborious and expensive when applied as we did. The material was evenly spread under the trees, a slow unpleasant task. Our price for gypsum was approximately $0.08 per pound, and therefore the treatment cost between $3 and $5 per tree per year using the rates reported here. However, we do not know if gypsum needs to be applied annually. In 1986 the 100 lbs. per tree treatment under Delicious was discontinued, but fruit mineral analyses showed that Ca level remained equal to that of fruit no longer receiving gypsum.

At this time, I view soil gypsum treatment as an effective way to raise fruit Ca levels when it is applied as we have. Perhaps the best way to use gypsum is in an orchard or a block that is known to consistently produce low-Ca apples. We have another block of Cortland trees that is in very fertile soil and which produces excessive vigor and large fruit, and these fruit are always badly affected with bitter pit and breakdown. In 1986 we established an experiment in this block to see if we can improve fruit quality through gypsum treatments. Our data show that treatments did not influence mineral concentrations in this first year. Fruit were not analyzed the first year in either of the earlier experiments, so this is the first time in which we can determine the rate at which fruit mineral levels change over time. Based on the earlier studies, we should see improvements next year.

I have tried to emphasize that use of gypsum is still very experimental. It will take a number of years before we can make recommendations with confidence. However, it is obvious from the results shown here that soil gypsum treatments <u>can</u> improve fruit Ca levels and quality under some conditions. It is therefore a new weapon in the modern apple grower's arsenal of techniques for coping with the ongoing threat of Ca deficiency in fruit.

* * * * *

POMOLOGICAL PARAGRAPH

Reducing Fruit Load on Tree Leaders

Growers should avoid allowing too many fruit to develop on the leader of young trees. It may be advantageous to remove fruit from the entire tree until the fourth year. Then for the succeeding years, depending upon tree size, the removal of fruit from the leader should be continued.

CAN ROOTSTOCK AFFECT APPLE RIPENING AND QUALITY?[1]

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Interest in the effects of rootstocks on fruit ripening and quality began a number of years ago. In 1930 Wallace (7) published data suggesting that apples from trees on M.9 rootstocks had higher soluble solids (sugar) levels and did not store as well as fruit from trees on other rootstocks. However, if fruit from trees on M.9 were harvested earlier than others, then similar storability was obtained, suggesting that M.9 encouraged earlier ripening. In 1944 Hewetson (4) published similar results using McIntosh trees with various interstocks. Fruit from trees with an M.9 interstock matured and colored earlier. Perry and Dilley (6) confirmed these results using the ethylene climacteric as an index of ripening. In their study Empire apples on MM.111 with an M.9 interstock entered the climacteric significantly sooner than those on MM.111 alone.

Lord et al. (5) used the ethylene climacteric and soluble solids as the primary indices of Empire apple ripening and compared various interstock-rootstock combinations with M.26, M.9, and M.27. They found few consistent differences with respect to the percentage of fruit in the ethylene climacteric 5 days after harvest. However, consistent differences existed in soluble solids content. Fruit from trees on M.27 had significantly higher soluble solids than fruit from trees on M.26, with fruit from trees on M.9 intermediate between the two. These results suggested that M.27 encouraged earlier ripening than M.26, and possibly M.9.

Fallahi et al. (2, 3) compared the ripening and quality of fruit from Golden Delicious trees on seedling roots, M.1, M.7, M.26, MM.106, and OAR 1. Using ethylene measurements they found that fruit from trees on M.26 appeared to ripen earliest, and those from trees on OAR 1 ripened substantially later than those from all other trees. However, OAR 1 also had the highest percent soluble solids, which is difficult to explain.

It is difficult, from the small number of studies, the small range of rootstocks used in each study, and the somewhat inconsistent results to compose a clear picture of the effects of rootstock on apple ripening and quality. The objective of this study was to use a range of rootstocks, from the very dwarfing M.27 to the very vigorous MAC 24, to assess rootstock effects on ripening, size, and quality.

Materials and Methods

Starkspur Supreme Delicious trees on 9 rootstocks (Ott.3, M.7 EMLA, M.9A EMLA, M.26 EMLA, M.27 EMLA, M.9, MAC 9 (Mark), MAC 24, and OAR 1) were planted in a randomized complete block design with 10 replications at the University of

[1]This work was supported in part by a grant from the International Dwarf Fruit Tree Association.

Massachusetts Horticultural Research Center in Belchertown, MA. To assess the effects of rootstock on fruit ripening, quality, and size, 7 of the 10 replications were used, 5 planted in 1980 and 2 planted in 1981.

Starting on September 15, 1986, and continuing at 5 day intervals until October 5, four fruit from each tree were harvested for the measurement of internal ethylene levels. One-ml gas samples were taken from the core of each apple to determine the ethylene concentration.

On September 29, 1986 ten fruit were harvested from each tree for the assessment of fruit weight, length/diameter (L/D) ratio, flesh firmness, percent soluble solids, and watercore incidence. Firmness was measured with an Effegi Penetrometer with a 1 cm head. The percent soluble solids was assessed with a hand refractometer, and watercore was characterized by visual assessment using the method of Bramlage and Lord (1).

Results and Discussion

Table 1 reports the fruit weight, firmness, L/D ratio, percent soluble solids, and watercore incidence. To accurately assess the effects of rootstock on fruit size it is necessary to account for crop load. Table 1 also includes an estimate of crop load in terms of weight of fruit per unit of trunk cross-sectional area. Additional statistical analyses were performed on these data to remove the effect of crop load from that of rootstock, and the differences shown in Table 1 are true estimates of the effects of rootstock on size. Trees on M.9 produced the largest fruit and those on M.27 EMLA and OAR 1 produced the

Table 1. Fruit parameters and crop load for Starkspur Supreme Delicious trees on various rootstocks.

Rootstock	Fruit weight (g)	Flesh firmness (kg)	L/D ratio	Soluble solids (%)	Watercore index[z]	Crop load (kg/cm^2 TCA[y])
Ott.3	184 c[x]	8.39 b	0.97 ab	11.6 abc	2.0 ab	0.98 ab
M.7 EMLA	196 ab	8.57 b	0.99 a	11.1 bc	1.8 ab	0.72 bc
M.9A EMLA	192 b	8.34 b	0.97 ab	11.4 abc	2.0 ab	1.33 a
M.26 EMLA	175 d	8.57 b	0.96 bc	11.3 abc	1.8 ab	0.92 ab
M.27 EMLA	157 e	8.89 a	0.94 c	12.0 a	2.4 a	0.91 ab
M.9	200 a	8.39 b	0.95 bc	11.8 ab	2.3 a	0.95 ab
MAC 9	177 cd	8.34 b	0.95 bc	10.9 c	1.4 b	1.25 a
MAC 24	193 ab	8.48 b	0.97 ab	11.1 bc	2.4 a	0.42 cd
OAR 1	153 e	8.98 a	0.97 ab	11.4 abc	2.2 a	0.27 d

[z]Watercore index: 1 = not present; 5 = most severe.

[y]TCA = trunk cross-sectional area.

[x]Means in a column not followed by the same letter are significantly different.

smallest. Note that trees on M.27 EMLA and M.9 had similar crop loads and trees on OAR 1 had a very light crop, suggesting a substantial effect of rootstock on fruit size.

Few differences were seen in fruit firmness (Table 1) and those that were present can be attributed to size, the smaller fruit being firmer. The L/D ratio (Table 1) was highest for fruit from trees on M.7 EMLA and smallest for fruit from trees on M.27 EMLA. The differences were statistically significant and may be of commercial importance.

The percent soluble solids (Table 1) was highest for fruit from trees on M.27 EMLA, whereas it was the lowest in fruit from trees on MAC 9. Furthermore, watercore was most prominent in fruit from trees on M.27 EMLA and MAC 24 and least prominent in fruit from trees on MAC 9. This relationship suggests that there may be significant differences with respect to the timing of fruit ripening, but soluble solids and watercore are not very accurate indices of fruit ripening.

During the course of ripening, apples exhibit a very rapid rise in the biosynthesis of ethylene, a gaseous plant hormone. Within the core area the concentration of ethylene rises with the increase in biosynthesis, providing a very accurate means of comparing the times of ripening. Figure 1 shows the internal ethylene concentration of apples from trees on M.27 EMLA, M.7 EMLA, and MAC 9. Other rootstocks were deleted from the graph to avoid confusion, but were roughly grouped into 3 patterns. Generally, M.27 EMLA (along with Ott.3, M.9, and M.9A EMLA) encouraged the earliest increase in internal ethylene. M.7 EMLA (along with M.26 EMLA, MAC 24, and OAR 1) resulted in a somewhat later rise, and MAC 9 delayed the increase in internal ethylene.

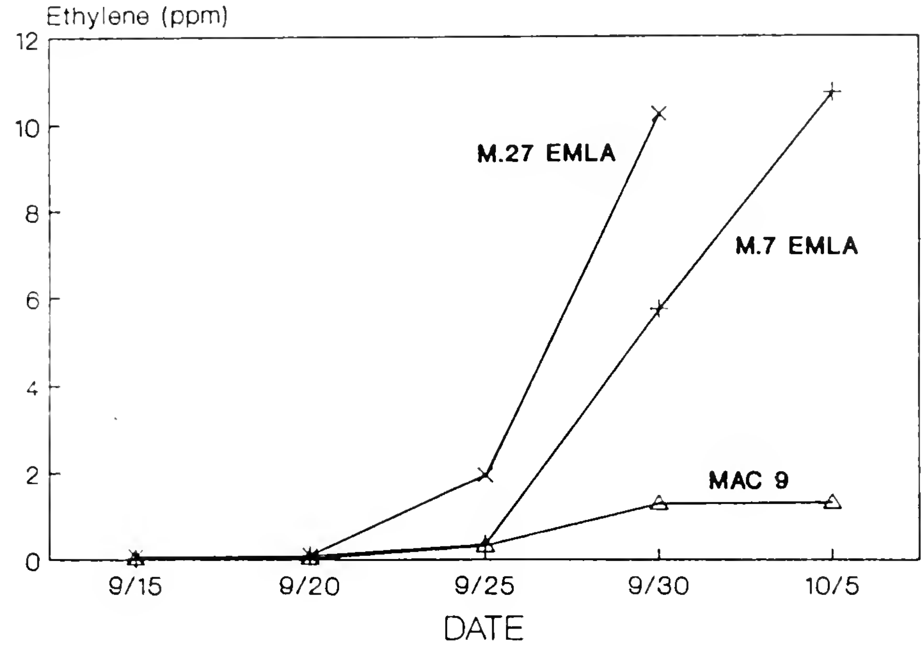

Figure 1. The internal ethylene concentration of Starkspur Supreme Delicious fruit immediately after harvest from trees on MAC 9, M.7 EMLA, or M.27 EMLA.

Figure 2 shows the mean internal ethylene concentration for all harvests, and it is obvious that M.27 EMLA and Ott.3 resulted in higher levels and MAC 9

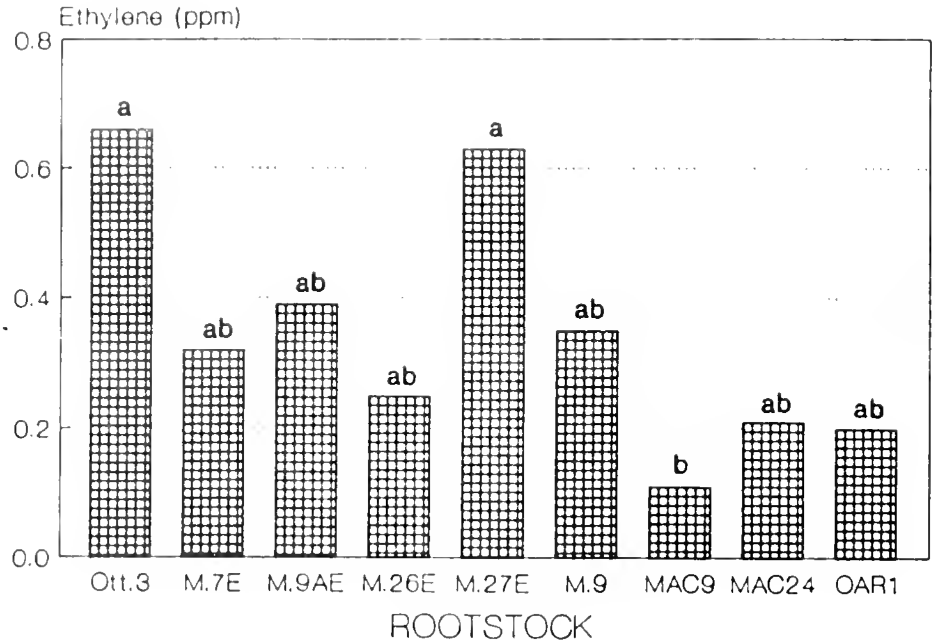

Figure 2. The mean, internal ethylene concentration of fruit harvested September 15, 20, 25, and 30 from Starkspur Supreme Delicious trees on the rootstocks included in this study. E refers to those rootstocks derived from EMLA clones. Bars with different letters represent means that are significantly different at the 5 % level (Duncan's New Multiple Range Test).

resulted in lower levels. These data confirm the effect of these rootstocks on ripening, showing a significant delay in the rise in internal ethylene caused by MAC 9 and enhancement caused by M.27 EMLA and Ott.3. Additional confirmation is provided by the data in Figure 3. This graph shows the postharvest ripening rate of fruit from trees on the various rootstocks. Fruit from trees on MAC 9 ripened the slowest and those from trees on M.27 EMLA ripened fastest, suggesting that the fruit from MAC 9 were less mature when harvested than those from M.27 EMLA.

The ethylene measurements support the suggestion of the soluble solids and watercore data that M.27 EMLA encouraged earlier ripening, whereas MAC 9 delayed ripening.

Conclusions

The results from the first year of this study suggest that rootstocks can alter fruit size, fruit quality (in terms of soluble solids and the incidence of watercore), and the time of fruit ripening. In 1986 M.9 resulted in the largest fruit, while M.27 EMLA and OAR 1 resulted in the smallest fruit. Ripening was enhanced by M.27 EMLA, resulting in higher soluble solids levels, more watercore, an earlier increase in internal ethylene, and faster post-

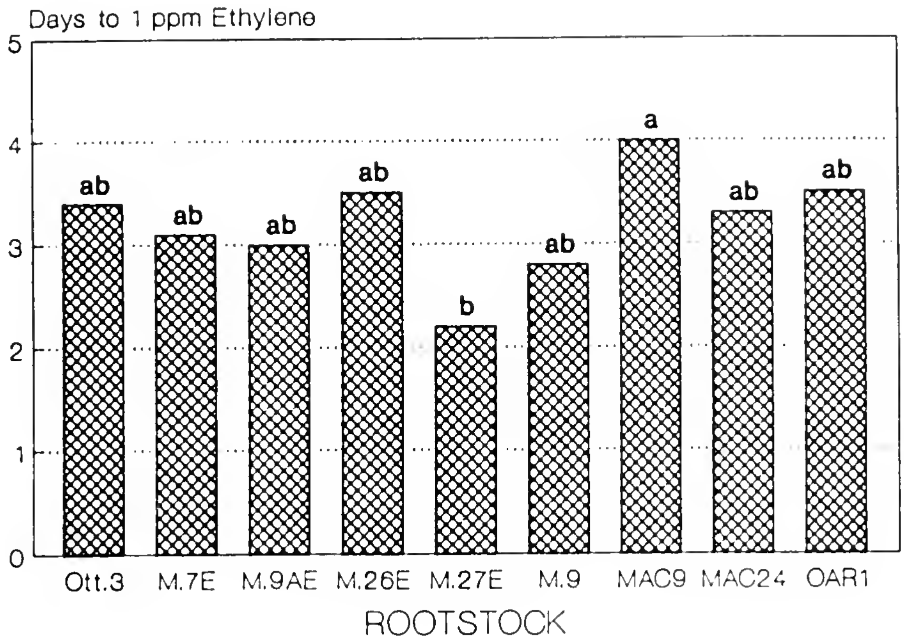

Figure 3. The mean, postharvest ripening rate (days to reach 1 ppm internal ethylene) of fruit harvested September 15 and 20 from Starkspur Supreme Delicious trees on the rootstocks included in this study. E refers to those rootstocks derived from EMLA clones. Bars with different letters represent means that are significantly different at the 5 % level (Duncan's New Multiple Range Test).

harvest ripening rate. MAC 9 delayed ripening, resulting in lower soluble solids levels, less watercore, a later increase in internal ethylene, and a slower postharvest ripening rate. Study of these effects will continue in 1987 to confirm the results presented here.

Are rootstock effects on fruit ripening of commercial significance? The delay that may be provided by MAC 9 (Mark) may only be a few days, but it may be of some help in expanding the harvest season for a single cultivar. Strains of some cultivars are now available which ripen somewhat earlier than normal. If these strains are combined with rootstocks which encourage earlier ripening and the standard strains are combined with rootstocks, like Mark, which delay ripening, significant expansions of the harvest season may be obtained. If Alar® is not available for drop control in the future, it will be necessary to use techniques like the one suggested here for cultivars such as McIntosh to allow harvest of the entire crop.

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POMOLOGICAL PARAGRAPH

Pruning Well-feathered Trees at Planting

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If you receive well-feathered trees from the nursery, it is important to leave as many favorably positioned branches on the trees as possible, because when all but 2 or 3 branches are removed, these tend to grow very vigorously and develop narrow crotch angles when growing conditions are favorable. Head the trees at 39 inches, or 10 to 12 inches above the highest, useful branch, if the tree is well feathered. Do not head the branches, or remove any more low branches than necessary. Heading adds to the problem of excessive vigor on vigorous cultivars and delays production. Low branches contribute to the total leaf surface of the tree. Low branches and extra scaffold limbs can be removed in subsequent years.

A REPORT ON THE 1986 MASSACHUSETTS APPLE IPM PROGRAM

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Acknowledgements: We would like to thank Keith Bohne, Bill and Henry Broderick, Dana Clark, William Flint, Jesse and Wayne Rice, Ed Roberts, and Tony Rossi for their cooperation. We also thank Glenn Morin and Robin Spitko (New England Fruit Consultants) for their scouting reports which we included in the weekly pest message on several occasions, and for the harvest injury data in Table 1. Special thanks to Sue Butkewich and Tom Green.

Program funding was provided in part by U.S.D.A. (Smith-Lever 3(d) Pest Management), the Massachusetts Department of Food and Agriculture, and grower contributions. Individual grower support of the Apple IPM program and the Pest Alert messages totalled $2870 in 1986, an increase from 1985. In addition, the Massachusetts Fruit Growers Association, Inc. provided a grant of $1,600 which was used to replace the aging IPM vehicle. Our "new" vehicle, which we use to travel to monitored orchards and research sites, is a 1983 Ford LTD, and has already begun to develop a sticky trunk. We sincerely wish to thank the growers and the MFGA for their continued interest in and support of the program.

Five commercial orchard blocks (plus a San Jose scale-infested commercial block in Lancaster) and one block at the Horticultural Research Center (HRC) were monitored weekly for arthropods and pathogens affecting fruit trees. Scab-infested leaves which had been placed in wire cages at these 6 sites in March were collected weekly and examined using squash mounts and counts of mature ascospores, to determine apple scab spore maturity. In addition, temperature and rainfall were recorded at the Horticultural Research Center (HRC), and other pest information was gained by occasional orchard visits and reports from Sue Butkewich, Tom Green, growers, Extension workers in other states, and private-sector consultants.

This information was used to reply to grower calls and write twice-weekly Entomology Pest Messages from April 8 to September 10. Plant Pathology messages were written weekly during the primary scab season, and in response to observed problems afterwards. Messages initially were transmitted to regional agents via the University computer's mail program, but after August 1 were shifted to a grant-funded, microcomputer-based, bulletin board system (BBS) called INFONET.

Entomology and Plant Pathology staff made a combined total of about 100 orchard site visits during the year, assessing pest problems faced by large and small commercial orchardists. Staff also gave 27 Extension talks at grower and other group meetings and 2 talks at professional association meetings, and authored or co-authored 5 Fruit Notes articles and several journal or proceedings articles. Entomology staff again cooperated with Dr. Rick Weires, Hudson Valley Lab, on the Annual March Message. Bill Coli gave an invited talk at the 29th annual meeting of the International Dwarf Fruit Tree Association, entitled "Techniques of Integrated Pest Management for Commercial Orchards." Plant pathology initiated cooperative research on delayed, early-season spraying with Dr. William MacHardy of the University of New Hampshire and Dr. David Rosenberger, Hudson Valley Cooperative.

At 4 Twilight meetings in each of the 3 regions, growers were provided with extensive IPM training including 2 hours at each session covering sprayer calibration using the Tree-Row-Volume method. These calibration sessions provided a total of about 450 grower-training-hours, all suitable for pesticide applicator certification credits. A 5-page handout titled "Calibration of Orchard Sprayers Using the Tree Row Volume Method" prepared by entomology staff was distributed at these meetings. This information is also being incorporated into a computerized expert system which should be publicly available in the near future. We would like to acknowledge the support and assistance of Mr. Bill Doe, Doe Ag. Sales, and Mr. Rick Clark, Orchard Equipment and Supply, who provided substantial expertise in fine-tuning the calibration of several diverse types of sprayers. We also would like to acknowledge the contribution of the Regional Agents who assisted in presenting this material at the twilight meetings.

Fungicide, insecticide, and insect growth regulator trials were again performed at the HRC and at grower sites, testing chemicals which may be or presently are a component of commercial spray programs. Evaluation of pesticide effects on mite predators continued as did evaluation of disease-resistant apple cultivars. A commercial test block of disease-resistant cultivars planted in a randomized block design was established at the Rice farm in Wilbraham. This planting is intended to assess the feasibility of using no fungicides and a minimum of insecticides in a commercial setting, and to define further horticultural characteristics and marketability of these cultivars.

Related Entomology research and adaptive studies continued to focus on evaluation of selective, relatively non-toxic pesticides and development of monitoring traps for Tentiform Leafminer, on timing of plant bug injury and pesticide treatment for plant bug, and on the behavioral ecology of the Apple Maggot Fly and the Plum Curculio. Other Entomology studies involved a test of several visual traps for monitoring the Walnut Husk Maggot (an occasional peach pest), a project to collect and identify unusual mite predators first found last season in a low-spray orchard in Stow, MA, and, in cooperation with Dr. Alan Eaton, University of New Hampshire, a survey to determine the distribution in Massachusetts of Psylla mali, the European Apple sucker. P. mali is not found as a pest in commercial orchards, but appears to be expanding its range and may become a pest in commercial blocks in the future.

Insect/Mite Pest Status and Harvest Injury, 1986

Tarnished plant bug - TPB was once again the number one cause of insect injury in the state's commercial apple orchards. In one block we visited weekly, no pre-bloom insecticide was applied, and on-tree injury reached 4%. However, most "dimples" were in or near the calyx, and would not likely have resulted in fruit downgrading.

Plum curculio - Extremely favorable weather in late May caused PC to emerge in most areas over a very short period of time, allowing some growers to control PC with one insecticide application. In a few locations, however, PC egglaying scars were seen in late June and early July.

Apple maggot fly - Trap captures continued this year into October in all areas of the state, although overall numbers of AMF captured were not high, and only one Extension-monitored block sustained any injury. Again this year peak captures occurred in September in commercial blocks and in Dr. Prokopy's orchard.

Table 1. Percent insect-injured fruit in on-tree surveys of 53 commercial blocks, 1986, compared to orchard harvest injury averages from 1978-1985.

	Percent injury[z]	
Insect pest	1986	1978-1985
Tarnished plant bug	0.83	1.74
European apple sawfly	0.01	0.40
Plum curculio	0.75	0.51
San Jose scale	0.11	0.74
Leafrollers	0.02	0.03
Green fruitworms	0.03	0.08
Apple maggot fly	0.05	0.06
Other	0.02	0.01

[z]Data provided by New England Fruit Consultants. Sample consisted of 50 fruit per tree on 6 to 16 trees per block, depending on block size.

Apple leafminers - Sticky, red, visual traps again were very useful in predicting potential LM problems prior to bloom. Traps in 3 of 6 blocks indicated the need to treat, later borne out by counts of sap-feeding mines. In 2 other blocks, overwintering generation moth captures remained just below the provisional action threshold (12 moths per trap), and first and second generation mines likewise never exceeded the economic injury level. In one of these blocks (which also sustained high levels of white apple leafhopper injury and received no Alar®) we noted a higher level of pre-harvest drop than was seen in other monitored sites.

White apple leafhopper - White apple leafhopper was again a problem at many sites in 1986, especially where 1st generation activity was not noted and controlled, or where only organophosphate insecticides were used against the OP-resistant leafhoppers. A few blocks experienced serious, late-season WAL buildup. Also, see later section on potato leafhopper.

Mites - In most orchards mite numbers were very low this year, possibly due to frequent, heavy rains throughout the summer. *A. fallacis* predator numbers were very high in all locations compared to recent years, and seemed to be thriving despite the shortage of red mite adults.

Disease Situation

The 1986 season was characterized by extreme disease pressure largely caused by prolonged wet weather and low temperatures. The major efforts of the program were to monitor *Venturia inaequalis* ascospore maturity from April through mid-June, to develop weekly messages and distribute them to Regional Fruit Agents, to test new ergosterol-synthesis inhibiting fungicides for potential use in the program, to continue with work on disease-resistant apples, and to participate in grower training sessions for sprayer calibration and disease-management information.

Leaves for the apple scab maturity assay were collected from an abandoned orchard in November, 1985, placed in hardware-cloth cages, and left out in a non-sprayed orchard over the winter. These cages were distributed to the 6 sites in March. Weekly collections were made by Kathleen Leahy, Jim Williams, and Bill Coli. Leaves were then examined, squash mounts prepared, and counts of mature ascospores made.

Squash mount data indicated that primary season lagged behind tree development by up to 2 weeks. This meant that early season sprays were not needed. In most areas, fungicide applications could have been delayed until half-inch green or tight cluster at the earliest. In fact, no fungicides probably were necessary until bloom this year. Wetting periods monitored at Belchertown showed that there were no Mill's infection periods before May 7, because during wet periods weather was too cool for scab development. At this time most trees were in early bloom. There were several heavy infection periods through the rest of May. A heavy wetting period (72 hours) occurred June 5-8, and the effects of this are still being discussed. Scab development on late terminals during the end of June suggested that there was a primary infection period at the beginning of the month, and that the maturity evaluations had estimated the end of the season before it had occurred. The alternative suggestion is that during mid-May, primary infections occurred, and during the heavy rains in early June, secondary scab was spread. Scouting in the tops of trees showed lesions on early terminals and clusters, indicating that these infections had occurred in mid-May. Because of frequent rains, extreme pressure continued through the summer, causing greater than normal fruit scab in some orchards.

Pest messages have stressed the need to scout orchards until infections which might have occurred have had a chance to show up. During this period, sprays should be applied as they were during primary season. However, some growers immediately reverted to a reduced frequency and/or rate in their spray schedule at the announced termination of primary season. In our tests, such a reduction this year resulted in terminal scab infections of the type reported around the state. This confirms our original recommendation: after the end of primary season, orchards must continue to be sprayed on a primary schedule for a period sufficient to allow any primary infection to be visible.

Other infections appeared to be caused by a failure to spray before or immediately after critical infection periods in May, or by a failure to cover the tops of large trees. Large trees were infected much more frequently than properly pruned trees on dwarfing rootstocks. Scouting the tops of trees revealed primary infections better than scouting other locations.

Tests at the HRC also looked at the efficacy of 3 ergosterol-inhibiting (EI) fungicides, Rubigan™ (Elanco), Nustar™ (Dupont), and A-815™ (Uniroyal) and compared them to a standard dithiocarbamate, Manzate™ 200. In some treatments, the EI compounds were combined with the Manzate. In general, sterol-inhibiting fungicides were better than Manzate at controlling primary scab. Nustar was superior to other materials. These materials can be applied on an after-infection basis up to 96 hours following the initiation of an infection. Next season, the upper limits of this time will be tested. In addition, an application of one or more of these materials will be made this fall to determine whether they have any effect on the ability of the fungus to overwinter and produce ascospores in the spring. The tests at the HRC represented a 150% increase over such tests in previous years.

There were no reports this year of the bud blast or cankering attributed to fire blight on Marshall McIntosh. The summer may have been too cool for development of the disease, though fire blight did show up in at least one commercial orchard. Alternatively, dormant copper or Bordeaux treatments or in-season streptomycin may be alleviating the problem.

New or Unusual Outbreaks

Potato leafhopper - Widespread leaf yellowing of apple throughout Massachusetts has been identified by New York state entomologists as injury caused by the potato leafhopper. Leaf injury, a diffuse yellowing of consecutive terminal leaves, results from PLH feeding, during which leafhoppers inject a toxic saliva. Injury shows up later, often after leafhoppers have left. With no insects present, PLH injury can easily be mistaken for nutrient deficiency. PLH does not overwinter in the region, but is "imported" from southern states as storms move up the coast. Because the summer of 1986 was characterized by a greater than normal frequency of such storms, PLH numbers on several crops were unusually high.

Catfacing insects on peaches - Catfacing continued well into the summer on peaches in many locations this year, with injury occurring at one monitored site in early August. The causative agent is not known, although a rather damaged specimen which may have been oak hickory plant bug showed up on an AMF sphere in late July. We will be monitoring the situation closely in 1987 to determine if other pests such as stink bugs might be causing this injury.

European corn borer - A grower located close to a corn field experienced late season damage from ECB - larvae tunneling into the calyx and through the core of the fruit. Growers in similar situations would be well advised to monitor ECB populations in August and September. Also, early in the season, one grower reported damage to terminal growth of young trees apparently caused by an insect larva which was collected and tentatively identified as ECB.

Plans for 1987

We will be increasing the number of monitored orchards from 6 to 10 in 1987; two of these sites will very likely be low-spray orchards. In addition, we will be monitoring a number of peach and pear blocks for borers, catfacing insects, psylla, and peach X-disease as well as other problems which may become apparent.

The INFONET computerized bulletin board, operated in cooperation with Dr. Wesley Autio, Department of Plant and Soil Sciences, will be maintained and expanded in 1987. This BBS is the primary means of disseminating topical pest management and horticultural information, pesticide registration news, meeting dates, etc. to regional agents and other interested parties. INFONET will continue to be directly accessible to growers with telecommunication ability. The BBS number in Amherst is 413-545-4717. For information or a user manual, please call Bill Coli or Kathleen Leahy at 413-545-2283 or Wes Autio at 413-545-2244.

We propose to continue most 1986 activities, including: monitoring weather, pathogens, arthropods, and tree development in 10 commercial blocks, writing twice-weekly pest messages, presenting 4 grower training sessions in each of the 3 regions, performing adaptive studies and pesticide trials, authoring extension and other publications, and generating outside funding. In addition, we plan to provide continued support of the National Park Service IPM Program at Adams National Historic Site, which will generate $500 to partially support the Apple IPM technician. If 2 grant applications we have submitted are approved, we will also be initiating a large-scale study in commercial orchards on the influence of ground cover on mite predator prey interactions and buildup of scab inoculum and a study aimed at implementing very low spray programs using traps for controlling directly apple maggot flies.

Calibration will be emphasized, although not as intensively as in 1986. Every attempt will be made to coordinate Entomology and Plant Pathology scouting, with increasing emphasis planned for looking for disease incidence in commercial and abandoned orchards.

We plan to develop computerized expert systems to diagnose and advise on problems. Initially, these will be for use by regional agents, though it is hoped that growers will have access to them in the near future through INFONET. At present, we have initiated work on root disorder diagnostics, fruit disorders diagnostics, scab fungicide application recommendations, and sprayer calibration. This work is also supported in part by the College of Food and Natural Resources, and in part by a Public Service Endowment from the University.

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POMOLOGICAL PARAGRAPH

Early, Heavy Cropping of Apples

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Early, heavy cropping of apple trees is not always desirable when trees are planted at wide spacings. Early, heavy cropping may stunt the trees. This situation has been observed in a row of Cortland on M.26 with the severity of stunting varying considerably within the row. Therefore, we may find that in some instances heading back cuts on the extension growth of the central leader and on shoots of the scaffold (framework) branches is desirable. This procedure will stiffen the central leader and scaffold branches, promote growth, and delay fruiting. An alternative to heading cuts is defruiting.

RESULTS OF 1986 CHEMICAL THINNING TRIALS ON MCINTOSH

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Chemical thinning is one of the most critical activities undertaken by apple growers each year. Effective thinning can mean the difference between profit and loss not only the year of application but also the following year.

There have been no new chemical thinning agents registered in Massachusetts in more than 20 years. However, during this period of time there has been a steadily increasing demand for larger apples. We are continually looking for new and better thinning agents, but until these are found and registered it will be necessary to use more effectively those thinning agents that are presently available.

Experiments were initiated at the Horticultural Research Center in Belchertown in 1986 with two goals in mind: 1) evaluate the effectiveness of several thinning treatments and combinations in an attempt to identify promising treatments for future recommendations, and 2) determine the importance of bloom intensity on final fruit set following a chemical thinning treatment.

Experiment One

Mature McIntosh trees (M.7 rootstock) with a heavy bloom were selected for Experiment One. Thinning treatments were applied 16 days after full bloom on May 26, 1986, when fruit diameter was approximately 10 mm. Treatments used were: naphthaleneacetic acid (NAA) at 5 or 7.5 ppm and benzyladenine (BA) at 50 ppm. These were applied alone as a dilute spray or in combination with 1 lb. carbaryl (50 % WP) per 100 gal. One group of trees received no chemical thinning spray and one received only carbaryl. After June drop all fruit on previously tagged limbs were counted and fruit set was calculated. A 30-apple sample was taken at harvest, weighed, and evaluated for percent color, flesh firmness, and soluble solids (sugars) content.

Generally, a fruit density of about 5.5 to 6.0 fruit/cm limb circumference on McIntosh is considered to be ideal, and all treatments thinned when applied alone, although only BA at 50 ppm and NAA at 7.5 ppm thinned adequately (Table 1). When carbaryl was combined with NAA or BA additional thinning occurred. NAA at 7.5 ppm, BA, and carbaryl alone increased fruit size. Size was increased further when carbaryl was added. No chemical thinning spray influenced flesh firmness, soluble solids, red color, or seed number.

Because of its detrimental effects on mite predators the use of high rates of carbaryl is discouraged. Attempts are being made to minimize the amounts used. Although the effectiveness of carbaryl is somewhat concentration independent, rates of 1/4 lb per 100 gal. or below may be insufficient to thin adequately by itself. NAA is a very effective thinning agent but it is also the compound most likely to over-thin. Lower rates of NAA are frequently chosen to reduce the chance of overthinning. Therefore, the most satisfactory chemical-thinning treatment would be one using a moderate level of carbaryl in combinations with NAA. Acceptable thinning should be achieved without causing overthinning or severely depressing the predator mite population.

Table 1. Effects of naphthaleneacetic acid (NAA), benzyladenine (BA), and carbaryl (50 % WP) on fruit set and fruit weight of McIntosh/M.7 apple trees.

	Fruit/cm limb circumference Carbaryl (1 lb./100gal.)			Fruit weight (g) Carbaryl (1 lb./100gal.)		
Treatment[z]	(-)		(+)	(-)		(+)
Control	13.6	a[y]	8.6	130	b	147
BA, 50 ppm	6.2	b	4.1	153	a	174
NAA, 5 ppm	9.3	b	3.8	142	ab	156
NAA, 7.5 ppm	6.7	b	5.9	150	b	164
Average	8.9	**[x]	5.6	144	**	160

[z]Treatments were applied as a dilute spray on May 26, 17 days after full bloom. NAA was applied as Fruitone N™ and carbaryl as Sevin™ (50 % WP).

[y]Treatment effects on fruit set or weight were significantly different (5 % level, Duncan's New Multiple Range Test) if not followed by a common letter.

[x]The effects of carbaryl on fruit set and fruit weight were significant at the 1 % level (Duncan's New Multiple Range Test).

BA is in the developmental stages as a chemical thinner. It is the only chemical used alone that adequately thinned McIntosh. It has performed equally well as a thinner over the past 5 years on McIntosh as well as on other cultivars. BA presently is being sold as a branching agent on Christmas trees and is also 50% of the active ingredients of Promalin™. We will continue to evaluate this compound.

Experiment Two

A block of 16-year-old McIntosh on MM.106 was selected, and just prior to bloom 70 limbs were tagged and the blossom clusters were counted. Limbs were selected that had a wide range of blossom densities, some having as few as 15 and others having as many as 350. A dilute thinning spray containing 2.5 ppm NAA and 1 lb. carbaryl per 100 gal. was applied with an airblast sprayer on May 27, 16 days after full bloom. Fruit set was determined at the end of June drop.

It was found that the greater the number of blossom clusters at bloom the more fruit that remained after June drop (Figure 1). However, the point that we would like to emphasize is that it requires a large increase in the amount of bloom on a limb to cause a relatively small increase in fruit number. For example, if the bloom on a limb was increased from 5 to 10 blossom clusters per cm limb circumference, the fruit set after thinning would increase only from about 5.5 to 6.5 fruit per cm limb circumference. NAA at 2.5 ppm plus 1 lb. carbaryl per 100 gal. is a moderate thinning treatment, and adequate thinning was obtained on limbs with blossom densities up to 10 to 12 blossom clusters per cm limb circumference. NAA at 5 to 7.5 ppm plus carbaryl would have been a better choice for the limbs having a heavier bloom.

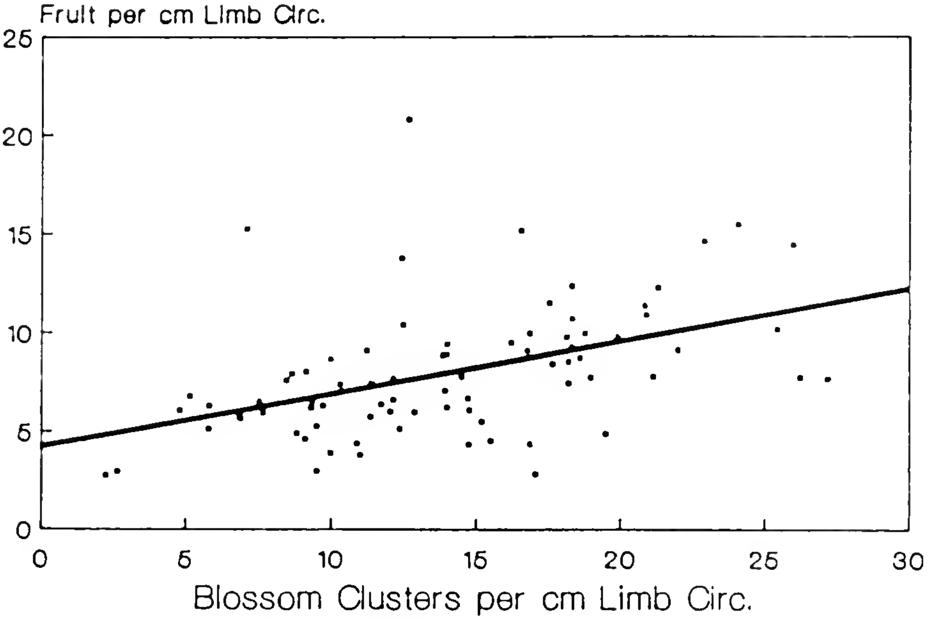

Figure 1. Effect of blossom cluster density on final fruit set of McIntosh apples following a chemical thinning spray of NAA at 2.5 ppm plus 1 lb carbaryl (50 % WP) per 100 gal.

Although blossom density does influence fruit set, treatments can be selected that will operate effectively over a relatively wide range of densities. NAA at 3 ppm plus carbaryl at 1 lb. per 100 gal. should be effective on trees with low to moderate bloom, whereas NAA at 5 to 7.5 ppm plus carbaryl at 1 lb. per 100 gal. would be more appropriate on McIntosh trees with a moderate to heavy bloom.

* * * * *

TIMING THE TARNISHED PLANT BUG: A TALE OF FRUSTRATION

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In 1976 we began what turned out to be 11 consecutive years of research on (a) the stages of plant development during which tarnished plant bug (TPB) injury to apple is initiated, (b) the most efficient method of monitoring the appearance of plant bug adults, and (c) the efficacy of various pesticides for controlling plant bugs. In 4 previous issues of Fruit Notes [43(2):10-14, 44(2):1-5, 45(3):15-18, and 45(4)13-14], we reported our results of the first 4 years. In brief, we found that (a) apple flower buds, blossoms, and developing fruit are susceptible to TPB feeding injury from silver tip to about one month after petal fall, (b) susceptibility to bud abortion (abscission) is greatest from silver tip until tight cluster, while susceptibility to fruit injury (dimples and/or scabbing) is greatest from tight cluster to a month after petal fall, (c) a 6 x 8 inch sticky white rectangle trap placed at knee height near the periphery of the tree offers an effective method of monitoring the abundance of TPB adults, (d) capture of 2.5 or more adults per trap from silver tip through tight cluster or 4.2 per trap from silver tip through midpink indicates an economically justifiable need for treating TPB adults with pesticide, and (e) no given type of pesticide guarantees a high degree of TPB control, though Cygon™ may be the most effective material, followed by various synthetic pyrethroids, Guthion™, Imidan™, and Lorsban™ or Thiodan™, in that order.

One major question that emerged from the first 4 years of work was: how can one predict the best time to apply a pesticide against TPB? In other words, could one piece together knowledge of the time of greatest susceptibility of developing blossoms and fruit to TPB injury with knowledge of the time of greatest abundance of TPB adults in the orchard and determine a time at which pesticide application should be the most effective? For the past 6 years (1981-1986), we have attempted to answer this question through research at the Horticultural Research Center in Belchertown, MA.

Methods

To gain information on the time at which fruit injury was initiated in an unsprayed block, we placed cloth bags over branch terminals harboring developing flower buds to exclude TPB adults for specified time periods. For the first 3 years (1981-1983), we used 2 approaches to bagging buds. In the first experiment, we employed 280 bags (half on McIntosh, half on Delicious) at silver tip. At each of 6 stages (tight cluster, early pink, late pink, petal fall, 1 week after petal fall, 2 weeks after petal fall), we removed 40 bags (20 per cultivar), thereby exposing the buds to TPB from time of bag removal onward. Check bags remained in place the entire season. In the second experiment, no terminals were bagged until tight cluster. At that time and at each of the above stages thereafter, we bagged 40 terminals (half on McIntosh, half on Delicious), thereby preventing TPB from causing injury from time of bagging onward. Check terminals remained unbagged the entire season. In both experiments, all bags were removed from the beginning to the end of bloom to permit pollination. For the last 3 years (1984-1986), we conducted a third experiment in which we used a single approach to bagging buds. We emplaced 280 bags before silver tip (half on McIntosh, half on Delicious). At the start of each of 7 bud development stages (silver tip, green tip, half-inch green, tight cluster, early pink, late pink, and petal fall) we removed 40 bags (20 per cultivar) but replaced the bags at the end of that stage, thereby exposing the buds to TPB only during that stage. In addition, 40 check terminals were not bagged. As before, all bags were removed during bloom for pollination. In all experiments, bagged and check terminals were examined in July or August for TPB injury to fruit.

To acquire information on the abundance of TPB adults in these experimental blocks during each tree development stage, each year at silver tip we hung 20 sticky-coated, white visual monitoring traps (half on McIntosh, half on Delicious) in trees immediately adjacent to the trees with bags. TPB adults were counted and removed from traps at each tree development stage.
To compare time of fruit injury initiation and time of TPB abundance with time of pesticide treatment against TPB, each year in another block adjacent to the above we applied pesticide to 8 randomly-positioned trees (all McIntosh) at each of 4 different tree development stages. On each tree, 60 fruit were examined in August or September for TPB injury.

Results

Over the 6 years in which flower bud terminals were bagged with cloth to assess the time at which TPB fruit injury was initiated, 6904 bagged and check fruit were examined for injury. Normally, 6 years of research involving nearly 7000 experimental fruit is sufficient to gain a detailed impression of any insect interaction with tree fruit. In this case it was not. The data (Table 1) reveal inconclusive, even conflicting trends. Thus, the results of Experiment 1 (in which terminals were bagged at silver tip and bags were removed permanently at successive stages beginning at tight cluster) suggest that progressively less injury to fruit was initiated at successive stages after tight cluster. Conversely, the results of Experiment 2 (in which terminals were bagged permanently at successive stages beginning at tight cluster) suggest that progressively greater injury to fruit was initiated at successive stages after tight cluster. The results of Experiment 3 (in which terminals were bagged permanently except during a given developmental stage) suggest lack of a consistent trend in time at which injury to fruit was initiated.

The visual trap capture data (Table 2) suggest TPB adults were on average most abundant in the unsprayed experimental block from half-inch-green until late pink. Comparatively few were captured before half-inch-green and after pink. Time of peak captures varied considerably from year to year. We should add that the consistent decline in trap captures from pink onward may have been due only partly to decreasing TPB populations. It may have been due also to declining ability of the traps to compete as visual stimuli with developing foliage and blossoms.

The pesticide timing experiments (Table 3) reveal no clear picture of the most effective time of treatment for preventing TPB injury to fruit. The only

Table 1. Percent TPB-injured fruit on terminals bagged with cloth during specified tree development stages. Exp. 1 = terminals bagged at silver tip, free of bags from designated stage onward. Exp. 2 = terminals covered with bags from designated stage onward. Exp. 3 = terminals free of bags only during designated stage.

		% Injured fruit									
Year	Exp.	ST	GT	HIG	TC	EP	LP	PF	1 WK	2 WK	CK
					Bags removed from this growth stage onward						
1981	1	--	--	--	27.4	13.2	15.2	9.7	10.9	5.5	4.6
1982	1	--	--	--	8.7	7.3	5.3	0	0	0	1.7
1983	1	--	--	--	4.5	6.8	0	0	0	2.6	1.5
Average		--	--	--	13.5	9.1	6.8	3.2	3.6	2.7	2.6
Total No. Fruit		--	--	--	243	221	232	237	214	228	216
Injury as % of TC Injury		--	--	--	100	67	50	23	27	20	19
						Bags put on at this growth stage					
1981	2	--	--	--	6.9	5.2	--	12.5	17.2	10.5	12.3
1982	2	--	--	--	5.9	3.9	3.9	2.4	6.5	10.1	10.4
1983	2	--	--	--	1.1	6.5	6.1	3.3	7.4	3.8	11.6
Average		--	--	--	4.6	5.2	5.0	6.1	10.4	8.1	11.4
Total No. Fruit		--	--	--	314	318	243	344	323	461	709
Injury as % of CK Injury		--	--	--	40	46	44	54	91	71	100
				Growth stage during which terminals were exposed							
1984	3	0	1.0	0	1.3	1.8	2.2	1.0	--	--	5.0
1985	3	1.5	2.4	7.4	1.8	0	9.8	6.6	--	--	10.0
1986	3	0	1.0	2.2	0	0	1.3	0	--	--	4.3
Average		0.5	1.5	3.2	1.0	0.6	4.4	2.5	--	--	6.4
Tot. No. Fruit		335	332	247	305	325	384	369	--	--	304
Injury as % of CK Injury		8	23	50	16	9	69	39	--	--	100

Legend: ST=silver tip; GT=green tip; HIG=half-inch green; TC=tight cluster; EP=early pink; LP=late pink; PF=petal fall; 1 WK=1 week after PF; 2 WK=2 weeks after PF; CK=check.

Table 2. Capture of TPB adults on 20 visual monitoring traps at successive stages of tree development. Traps were emplaced at silver tip and removed 2 weeks after petal fall.

	Average no. adults captured per trap						
Year	GT	HIG	TC	EP	LP	PF	2 WK
1981	1.5	--	3.7	--	5.4	2.6	1.4
1982	2.4	--	2.8	--	5.6	1.0	0.4
1983	2.6	--	10.8	--	0.8	0.4	0.4
Average (1981-83)	2.2	--	5.8	--	3.9	1.3	0.7
1984	0	0.9	0.4	5.0	0.7	--	--
1985	0	1.4	1.7	2.0	0.8	0.5	--
1986	0	0.4	0.4	0.4	0.4	0.1	--
Average (1984-86)	0	0.9	0.8	2.5	0.6	0.2	--

Table 3. Injury to fruit by TPB adults on trees treated with pesticide at different times.

		% Injured fruit when pesticide applied at					
Year	Pesticide	HIG	TC	EP	LP	PF	CK
1981	Ambush™ 2EC (6.4 oz/100)	--	2.3	0.3	1.6	3.6	5.6
1982	Ambush™ 2EC (6.4 oz/100)	--	2.6	4.3	2.8	4.4	5.9
1983	Ambush™ 2EC (6.4 oz/100)	--	3.0	3.8	5.3	7.0	5.2
	Average (1981-1983)		2.6	2.8	3.2	5.0	5.6
1984	Pydrin™ 2.4EC (3.5 oz/100)	0.6	0.8	0.4	0.6	--	1.3
1985	Pydrin™ 2.4EC (3.5 oz/100)	0.6	1.3	0.8	1.3	--	0.4
1986	Cygon™ 50EC (16 oz/100)	0.6	1.3	0.6	0.8	--	1.3
	Average (1984-1986)	0.6	1.1	0.6	0.9	--	1.0

consistent trend was that holding off treatment until petal fall resulted in very little reduction in injury. Even so, the best treatments (tight cluster during 1981-1983 and half-inch-green or early pink during 1984-1986) reduced fruit injury by only about 50% compared with unsprayed check trees. This situation was true even though the pesticides used (Ambush™, Pydrin™, or Cygon™) were among the most effective known against TPB.

Conclusions

We conclude that conducting research on the time of initiation of TPB injury to fruit in apple orchards and the time at which it is most efficacious to apply pesticide for TPB control is no less frustrating than attempting to manage TPB effectively in commercial orchards. Examination of 11 years of pesticide trial data of numerous researchers in the eastern United States and Canada reveals a truly incredible amount of variation from locale to locale and from year to year within a locale in the effectiveness of any given material in preventing TPB fruit injury. Our 11 years of sampling fruit at harvest in commercial orchards throughout Massachusetts reveals an equally large variation in TPB injury and in success at controlling TPB. The data presented here on tests conducted in the same experimental orchard over 6 consecutive years likewise are fraught with a high degree of variation, the causes of which are uncertain. In fact, the picture we now have of how to control TPB effectively is nearly as unclear as when we began these tests in 1981. It seems to us no wonder, therefore, that growers have a difficult time dealing with the insect.

If we can conclude anything from the research reported here and from observations we and others have made in commercial orchards, it is this. First, initiation of TPB fruit injury may occur any time from tight cluster through petal fall. Second, populations of TPB in commercial orchards may be sufficiently great at any time from tight cluster to petal fall to cause considerable fruit injury. Third, visual monitoring traps have proven over the years to be sensitive in determining if TPB populations are sufficiently great to merit possible pesticide application. Fourth, materials such as Cygon™ and pyrethroids are probably the most effective sorts of materials against TPB, though their use in no way guarantees good control. Finally, if used, pesticide should be applied against TPB sometime between half-inch-green and late pink. But, based on the data reported here, we would not want to predict what the outcome might be. Perhaps, as Rick Weires of the Hudson Valley Lab and we have pointed out several times, we should be paying less attention to TPB and more attention to factors such as bruising and mechanical injury to fruit during harvest and grading. In virtually every Massachusetts orchard we and others have sampled over the years, bruising, stem punctures and mechanical injury have been responsible for far more culls (average of 29 bushels per acre per year) than TPB and all other insects combined (average of 3 bushels per acre per year).

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COOPERATIVE EXTENSION SERVICE
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Fruit Notes

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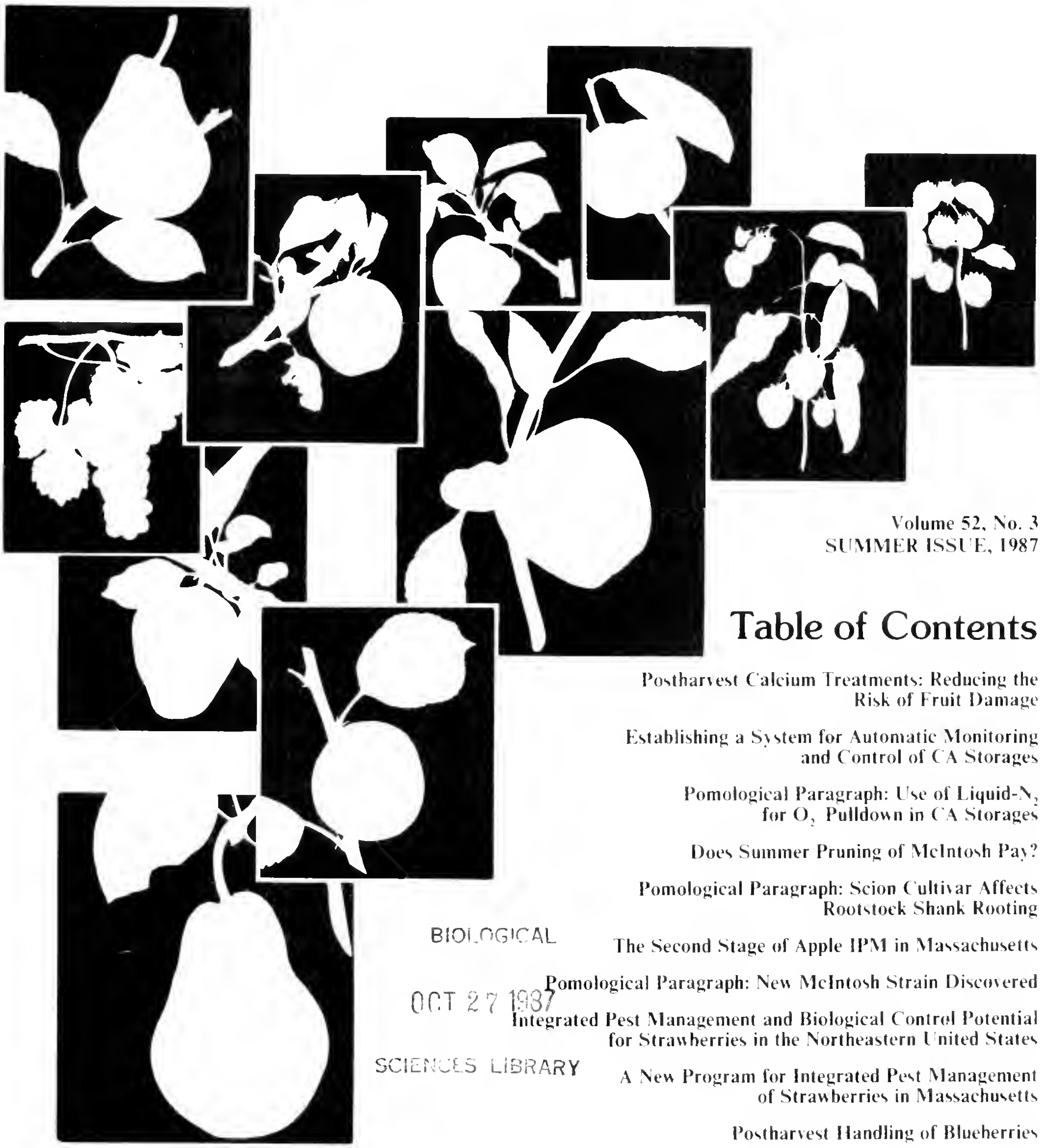
Editors: W. R. Autio and W. J. Bramlage



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SUMMER ISSUE, 1987

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POSTHARVEST CALCIUM TREATMENTS: REDUCING THE RISK OF FRUIT DAMAGE

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Recently, we re-examined the potential benefits and risks from using postharvest calcium (Ca) treatments (Proc. Mass. Fruit Growers' Assn. 1986. 92:106-109). To summarize, if the harvested fruit are low in Ca, they have a reduced storage potential. Postharvest dips or drenches with calcium chloride ($CaCl_2$) can significantly improve fruit Ca levels and storage potential. However, $CaCl_2$ dips or drenches can cause spotting of fruit, usually seen as small, black, sunken areas on the cheeks of the fruit or bronzing at the calyx end, which may be serious enough to downgrade the fruit. Our earlier recommendation of 21 lbs of $CaCl_2$ per 100 gallons of water [Fruit Notes 48(4):18-19] was excessive and led to an unacceptable amount of spotting. More recently we have suggested 12 lbs of $CaCl_2$ per 100 gallons of water. This amount is sufficient to significantly improve fruit Ca levels and potential storage life, yet greatly reduces the risk of fruit spotting.

During the past several years we have conducted a series of tests to try to identify factors contributing to the amount of fruit spotting resulting from postharvest $CaCl_2$ treatments. Here we report the results of these tests.

Time in solution: Most Ca that enters fruit from a conventional postharvest treatment is taken in slowly over time from a residue. Thus, time in solution is not a factor for Ca uptake as long as fruit are covered by solution and a residue is established. In our tests we routinely dip fruit for 20 seconds for uniformity, but a shorter time would be sufficient; there is no benefit from a longer period. There is some direct entry of solution into the fruit through openings in the skin surface. These include the calyx canal, lenticels, and wounds, even ones not visibly apparent. All of these entry sites are variable among cultivars, handling practices, and growing conditions.

Relative temperatures of fruit and water. Dips and drenches normally employ cold water. However, fruit temperature can vary greatly. Our early tests showed that the warmer the apple was at time of dipping, the more Ca it absorbed. To determine the role of fruit temperature in spotting, we dipped 70°F McIntosh and compared them with fruit first cooled to 32°F. The solution was initially 50°F, but it either warmed or cooled during treatments, depending on temperature of the apples. The warm fruit developed much more spotting than did the cold fruit. The reason for this is probably that when a warm fruit is plunged into cold water, the air inside the fruit quickly cools and occupies less volume. This situation creates a partial vacuum that draws solution into the apple through any openings in the fruit surface. Cells around these openings are suddenly in contact with a high $CaCl_2$ concentration and they can be damaged, eventually dying and producing spots. Therefore, if warm fruit are treated with a $CaCl_2$ solution, a lower rate of $CaCl_2$ may be needed to avoid spotting. The better approach probably is to cool the fruit at least partially before treatment or to ensure that the treating solution is at a temperature fairly near that of the fruit.

Fruit maturity. The characteristics of a fruit surface may change during maturation. Thus, fruit maturity might affect solution uptake and development of spots after storage. We harvested McIntosh early-, mid-, and late-season (at 1-week intervals) from the same trees and dipped them in a series of $CaCl_2$ solutions with and without diphenylamine (DPA). Fruit maturity had no effect on the amount of fruit spotting resulting from these treatments. Thus, maturity does not appear to be a significant factor in development of spotting.

Addition of DPA. DPA increases Ca uptake from a solution when combined with $CaCl_2$, as is normally recommended. Why this occurs has not been established. To find out if DPA increased spotting from Ca treatments we compared two different $CaCl_2$ concentrations, with and without DPA. We found that DPA tripled the amount of spotting resulting from a given $CaCl_2$ concentration. We also found that DPA alone caused significant spotting on McIntosh, especially around the calyx area. Why DPA increases spotting is unclear. We tried two different formulations of DPA and got equivalent amounts of spotting, with and without $CaCl_2$. The recommended rate of $CaCl_2$ use for postharvest treatments may have to vary, depending on whether or not DPA is included in the mixture. It should be noted that a number of fruit that were treated with neither $CaCl_2$ nor DPA developed some spotting after storage, apparently as a result of latent damage to cells caused by orchard applications of pesticides. (These trees had not been sprayed with foliar $CaCl_2$.) Clearly, not all spotting of fruit after storage is attributable to $CaCl_2$ or DPA.

To follow up on these findings, in 1985-86 we conducted a large test in which we dipped McIntosh in solutions containing 4, 8, 12, or 16 lbs of $CaCl_2$ per 100 gallons plus DPA, a surfactant, or neither of these materials. After storage we measured both the increase of Ca in the fruit and the amount of fruit spotting. As expected, both Ca uptake and fruit spotting increased in a straight line as the concentration of $CaCl_2$ in the dip solution increased. The presence of DPA in the dipping solution did not increase the amount of Ca in the fruit at the end of storage, but it increased the amount of spotting. Use of the surfactant also had no effect on the final amount of Ca in the fruit, but increased the amount of spotting, though to a lesser extent than did DPA.

Washing fruit after dipping. A report from Australia stated that treated apples could be washed 3 days after dipping or drenching; the wash reduced spotting but not total Ca uptake. To test this approach, we dipped McIntosh in 12 lbs of $CaCl_2$ per 100 gallons, washed them 1, 3, or 7 days after dipping, and measured Ca uptake and spotting at the end of storage as compared with similar samples that had not been washed. Washing 1 or 3 days after dipping greatly reduced Ca uptake, while washing 7 days after dipping produced less of a reduction. In this experiment $CaCl_2$ did not increase spotting, whether or not the fruit were washed. It appears that even if washing controlled spotting, washing 3 days or less after dipping would nearly eliminate any benefit from treating with $CaCl_2$. Furthermore, the logistics of washing after dipping could make this approach prohibitively time-consuming under our storage systems.

Interaction with iron. At a meeting last summer, a colleague from Australia said that the cause of spotting was actually iron, which was extracted from metal and put into solution by the $CaCl_2$. At the same meeting, a report from New Jersey indicated that presence of iron in water was the cause of damage to peaches following hydrocooling. Thus, we conducted an experiment to test the possible role of iron in apple spotting.

We set up solutions containing different concentrations of iron, with and without $CaCl_2$. Iron caused severe spotting, and when it was combined with $CaCl_2$ the spotting was increased. We also prepared $CaCl_2$ solutions, 12 lbs per 100 gallons, in a plastic bucket and in a rusty metal bucket. The $CaCl_2$ solution in a plastic bucket caused no fruit spotting, but the one in the metal bucket caused substantial spotting. Our purpose in this test was simply to find out if this avenue might lead anywhere, and it is obvious that it merits further study. It is also noteworthy that in the washing experiment, described above, we had no spotting from 12 lbs of $CaCl_2$ per 100 gallons in 1986-87, whereas in previous years spotting occurred. The dipping tank used in these tests is made of galvanized iron and after years of use was starting to rust. Last summer it was painted, and so the $CaCl_2$ solution in 1986 was no longer in direct contact with iron. Further tests must be made to establish the importance of iron in this problem but the implications are consistent with the comments of our Australian colleague, who said that eliminating metal tanks solved their spotting problem.

In conclusion, it must be reaffirmed that a postharvest treatment with $CaCl_2$ can significantly increase storage potential of apples. It appears that 12 lbs of $CaCl_2$ per 100 gallons of water is a reasonable compromise, increasing fruit Ca levels significantly with a relatively small risk of spotting. (Note that our assessment of spotting is very intense. Most of our "spotted" fruit would still be in grade.) The $CaCl_2$ must be Briner's Grade or purer, since it is considered by authorities to be a food additive. The solution must contain an appropriate fungicide, or mixture of fungicides, or severe rotting can result. DPA or ethoxyquin can be applied with the $CaCl_2$. We suggest adding 1 pint of vinegar per 100 gallons of solution to protect against possible adverse effects of a high pH due to the $CaCl_2$ (*Fruit Notes* 50(2):18-20).

We suspect that spotting results from the solution that enters the fruit openings *during* the dip. Our studies show that spotting is increased when DPA or a surfactant is included in the mixture, when the fruit are significantly warmer than the solution, or when substantial levels of iron are present in the solution. Under these conditions, perhaps the $CaCl_2$ should be reduced to 8 or 10 lbs per 100 gallons.

We shall continue with these studies, to try to find conditions under which the risk of fruit spotting from postharvest $CaCl_2$ treatments can be minimized or eliminated. These treatments have great value in increasing storage life potential, and are extremely useful as a final technique when you recognize at harvest time that a Ca problem exists. They are used routinely by some Massachusetts growers, and are used extensively for apples in many parts of the world. Their use should not be ruled out because of a fear of fruit damage. However, they must be used with care, just as with any other chemical application.

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ESTABLISHING A SYSTEM FOR AUTOMATIC MONITORING AND CONTROL OF A CA STORAGE

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and

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The Orsat gas analyzer is used almost exclusively in New England to determine the concentrations of oxygen (O_2) and carbon dioxide (CO_2) within a controlled atmosphere (CA) storage. Control of these levels is performed manually by the storage operator. Although the Orsat method is inherently accurate, the procedure itself for sampling and measuring the atmosphere in the rooms contains much opportunity for human error. Also, since this operation is time-consuming, atmospheres are generally measured and adjusted no more often than once per day. Under this type of management considerable fluctuation of the storage atmosphere can occur, and problems can go unnoticed or uncorrected for some time. To compensate for these potential problems, significant margins of error are incorporated into standard CA recommendations. Even so, serious errors in atmosphere maintenance are still common.

There are alternatives to the Orsat method of measuring storage atmosphere composition. Electronic devices for measuring O_2 and CO_2 are widely available. A system using these devices to frequently and automatically measure O_2 and CO_2 levels was developed in England, and quickly was expanded to provide automatic adjustment of O_2 and temperature when they exceeded set tolerance levels. More recently, automatic adjustment of CO_2 has also been developed. These systems are controlled by a programmed computer, and can be purchased as "package" units. However, the costs of such units is discouraging for operators of the relatively small storages that are typical of the New England apple industry.

Another alternative is the "user-built" system, in which a user assembles his own system from available components, developing a system to meet his needs and to stay within his financial resources. Such a system employs separate components which are available for O_2 and CO_2 analysis, a personal computer for data handling and initiation of sampling, measuring, and controlling devices, and the necessary pump, valves, and relays to facilitate the whole process. This approach has been applied successfully to both research and commercial systems at a cost less than that of a package system.

It is our conviction that automatic monitoring and controlling of CA storage atmospheres can significantly improve operation of New England apple storages. To establish a demonstration, "user-built" system for use with the storage rooms at the Horticultural Research Center, Belchertown, last year we received a grant from the Massachusetts Society for Promoting Agriculture. During the 1986-87 season, we assembled and operated this system. It is the purpose of this article to describe the system and provide an initial assessment of its operation.

The Horticultural Research Center contains five storage rooms, four of which are normally operated as CA rooms; two rooms have a capacity of 2500 bushels each and the other two have a capacity of 600 bushels each. Previously, temperature has been monitored by a single mercury thermometer placed inside the door of each room, and any adjustment of temperatures has been done manually. O_2 and CO_2 were measured daily with a single Orsat analyzer, samples being drawn from each room with an electric pump. O_2 was added as needed by operating a controlled leak in the door, and CO_2 was scrubbed when necessary using a lime box. O_2 pulldown was achieved with a liquid-N_2 system.

The system established in 1986 was as follows. Temperature monitoring was upgraded by installing multiple thermocouples in each room, following Cornell University recommendations (Cornell University Agricultural Engineering Extension Bulletin 430). A commercially available paramagnetic O_2 analyzer and a commercially available infrared CO_2 analyzer were obtained to replace the Orsat analyzer. These electronic measuring devices were supplied with air drawn from a room by a new electric pump through the copper sampling lines that previously supplied the air for the Orsat. The existing solenoid valves on these lines were wired via a relay board to a conventional personal computer.

A commercially available software package, designed for use in automatic monitoring and controlling systems, was set up so that an air sample was drawn hourly from each room and passed through the O_2 and CO_2 monitors. Analyses were recorded on both a disc and on a print-out. Also, at each sampling time, temperature at one thermocouple in each room was measured and recorded. Later in the season a dewpoint indicator was purchased for humidity measurement, and subsequently each sample was also measured for relative humidity and these data were also recorded. Thus, an hourly record of O_2, CO_2, temperature, and relative humidity within each room was automatically obtained. (The system could have been programmed for either more frequent or less frequent sampling or recording.)

The system can be programmed so that adjustments of temperature, O_2, and CO_2 can be made automatically when the measured values exceed previously established limits. For example, a temperature of 37^oF might be desired and the program might change the temperature control setting if it falls below 36.5^oF or rises above 37.5^oF. In our first season we continued to control temperature manually and to operate the lime box manually. However, O_2 control was automated. Each room possessed 4-inch PVC inlet and outlet lines fitted with large solenoid valves. A cylinder of N_2 gas and a squirrel cage fan were attached to the inlet manifold. The system was programmed so that when an O_2 reading fell below 2.5% or rose above 3.5%, the control system was activated via the relay board. This system vented either air or N_2 into the room, depending on whether O_2 was too low or too high. Outlet valves were also opened automatically to relieve the positive pressure caused by air or N_2 addition to a room.

The system worked reasonably smoothly, given that this was its first year of operation and we were developing it as time and availability of supplies permitted. During the summer we shall complete some unfinished wiring and plumbing, and we anticipate that we shall go into the 1987-88 season with a completed system and with the operators now being familiar with the operation and the equipment. The operators had little previous experience with computer operation.

A detailed assessment of the operation of this system versus that of an Orsat-monitored system will be published later. However, an obvious benefit was the time-saving achieved by automatic monitoring of atmospheric conditions in the CA rooms. This savings was especially appreciated during the initial pull-down period. At this time, the hourly program was deactivated and a continuous O_2 reading was taken for the room being flushed with liquid-N_2. This allowed the operators to watch the changes in O_2 level as the liquid-N_2 was metered into the room.

Total cost of the equipment was approximately $8500. However, the dewpoint indicator cost $1300 and was included in our system for research purposes. Likewise, our system has greater control capability built into it than a commercial operator might desire, since we may wish to completely automate controls for research purposes.

The establishment of this system has created the opportunity for us to demonstrate the feasibility and advantages of automatic CA operation. This is neither a new idea nor new technology. Similar--and often more sophisticated--systems are in commercial use in many parts of the world. Our objective in this project is to lead the way in upgrading New England storage operations to the level of many of the area's competitors, and through better storage operation to provide a higher quality apple for the market.

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POMOLOGICAL PARAGRAPH

Use of Liquid-N_2 for O_2 Pulldown in CA Storages

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During the past two years a number of New England CA storage operators have used liquid-N_2 for O_2 pulldown. At the Horticultural Research Center, Belchertown, we have used this system and have been very pleased with the results (Proc. Mass. Fruit Growers' Assoc. 92:102-105). Dr. James A. Bartsch of the Department of Agricultural Engineering, Cornell University, recently published a factsheet entitled, "Creating a Low Oxygen Atmosphere with Liquid Nitrogen." This information should be of interest and value to anyone using this system or considering use of it. The factsheet "Agricultural Engineering Facts, EF-9" can be obtained from William J. Bramlage, Department of Plant and Soil Sciences, French Hall, University of Massachusetts, Amherst, MA 01003.

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DOES SUMMER PRUNING OF MCINTOSH PAY?

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The uncertainties about the future of Alar® and the possibilities of adverse results on animal feeding studies led many growers in 1986 to use no Alar® or a reduced amount of Alar® last year. A number of suggestions were made last year to help growers cope with reduced Alar® use, and summer pruning was listed as one of the procedures available to growers to help alleviate problems associated with the nonuse of Alar®. Last year a summer pruning experiment was conducted at the Horticultural Research Center using mature McIntosh trees. The results of this experiment are reported here.

There is a direct relationship between the amount of light a fruit receives and red color development. Fruit that are exposed to direct or near direct sunlight will develop red color early and the intensity of the color will be great enough so that these fruit can be harvested as U.S. Extra Fancy. Alar® has been indispensible to growers in controlling drop and retarding ripening until fruit develop sufficient red color to be sold as U. S. Extra Fancy. In the absence of Alar® fruit may fall to the ground before they develop sufficient red color. If light penetration into the tree can be increased by appropriate pruning techniques, fruit may develop red color early. This early coloring would do two things. First, it would allow early harvest of fruit that would have the potential for long-term storage. Secondly, it would allow the harvest of a larger percentage of the crop as hand picked fruit rather than as drops.

A block of mature McIntosh on M. 7 rootstock that received no Alar® in 1986 was selected, the summer pruning treatments were randomized, then half of the trees were summer pruned during the 3rd week in August. Only 1-year-old wood and unproductive wood were removed. It required about 25 minutes for one person to summer prune each tree. The first harvest on these trees was on September 10.

Large cuts, particularly in the tops of trees, should not be made during the summer. Falling branches, heavy with leaves and developing fruit, can severely bruise fruit below. For summer pruning to be truly effective, large thinning-out cuts must be made during the dormant period. These cuts will open up a tree. The summer pruning further increases light penetration by removing some of the current season's growth and unproductive wood.

There were many positive effects following summer pruning (Table 1). Fruit on summer pruned trees had more red color, considerably more of them graded U. S. Extra Fancy, and a much larger percentage of the crop was harvested during the first picking (September 10). Because a larger percent of the crop was harvested the first time, there were fewer drops and more hand-picked fruit from the summer-pruned trees. Summer pruning did not influence the total yield on these trees. However, approximately 2 more bushels of fruit per tree were harvested as hand picks rather than as drops.

Table 1. Effects of summer pruning on McIntosh fruit.

Parameter	Summer pruned	Not summer pruned	Change (%)
Red color (%)	57	49	+16
U. S. Extra Fancy (%)	72	42	+71
Crop harvested 1st pick (%)	79	59	+34
Crop harvested by hand (%)	81	70	+16
Drop (%)	19	30	-37
Dormant pruning time (min/tree)	11	17	-40

Did summer pruning pay? Let us assume a price of $1.60 per bushel for drops and $8.00 per bushel of hand picks. There were 144 more bushels of hand-picks per acre from summer-pruned trees with an additional return of $932.00. It would take a pruner about 30 hours per acre to do a good summer pruning job on these trees. Unless a grower pays his workers $31.00 or more per hour, summer pruning more than paid for itself. This figure is conservative because it required 40 percent less time to prune summer-pruned trees during the dormant season, thereby producing additional savings. We feel that summer pruning is a procedure that should be part of every grower's maintenance program on mature trees, especially if Alar® is not used.

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POMOLOGICAL PARAGRAPH

Scion Cultivar Affects Rootstock Shank Rooting

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Many nurseries bud apple trees on certain rootstocks 12 to 18 inches above the soil line. When these trees are planted in the orchard a large portion of the originally above-ground rootstock material must be buried. The philosophy behind this practice is that rooting along the long, buried shank may improve the anchorage of the tree and reduce requirements for staking. However, in some cases rooting does not occur and a less stable condition results than if the trees were budded at a lower height and planted only slightly deeper than they were in the nursery. A reason for this lack of rooting is given by Roy Rom and George Moticheck in a study published this year (HortScience 22:57-58). They found that the scion cultivar was the major factor affecting rooting along the buried rootstock shank. In general, nonspur cultivars resulted in significantly more rooting than did spur-types, possibly explaining the poor shank rooting which has been observed with some trees.

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THE SECOND STAGE OF APPLE IPM IN MASSACHUSETTS

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Through 1977, most Massachusetts apple growers controlled apple insect pests by making insecticide applications every 10 to 14 days, irrespective of whether pest insects were present in sufficient abundance to merit such treatment. From 1978 through 1982, our College received funds from a 5-year federal Cooperative Extension Service grant to initiate a pilot program of integrated pest management (IPM) in Massachusetts apple orchards. The entomological part of the program had 3 major objectives: to promote the buildup of natural populations of beneficial predators; to reduce pesticide use; and to maintain or increase the high quality and quantity of fruit produced. Our overall entomological approach to achieving these objectives lay in intensive, careful monitoring of pest and beneficial, natural enemy population abundances in participating IPM orchards, and in advising IPM growers of need, optimal timing, and type of pesticide to be applied.

The results of this pilot program were highly encouraging. In fact, they were so encouraging that 2 biologists in the program decided to form a private IPM-consultantship business: "New England Fruit Consultants". From 1983 through 1986, NEFCO has been very active in providing IPM services to a substantial number of Massachusetts apple growers. "Boston IPM", though active largely in Vermont, has also provided IPM services to a few Massachusetts growers. In 1986, about one-third of the apple acreage in Massachusetts was serviced by these private consultants. In addition, results of a recent survey we conducted [Fruit Notes 51(2):11-16 and 51(3):19-25] indicate that more than two-thirds of Massachusetts apple growers now employ IPM practices.

To what degree have IPM practices benefited Massachusetts apple growers? Table 1 presents a summary of the amount of pesticide used each year in Massachusetts IPM apple orchards from 1977 through 1986.

These results show that compared with pesticide use before the pilot program, there was (on average) a 37% reduction in insecticide use and a 61% reduction in miticide use during the pilot program (1978-82) and a 43% reduction in insecticide use but essentially no change in miticide use in orchards serviced by private consultants (1983-86). On average, fruit quality in IPM orchards has equalled or exceeded that realized before the start of the program. Finally, the growing of "healthier" (less-pesticide-treated) apples and the reduced amount of spray drifting from the orchard into the neighboring environment has created a favorable public image for IPM growers. It can be concluded, therefore, that this first stage of IPM in Massachusetts apple orchards has been a success.

The second stage of apple IPM is aimed at employing new pest control methodologies to achieve a further reduction in pesticide use. The first stage has relied on intensive monitoring of pest and beneficial predator abundances and subsequent judicious application of needed, selective pesticides least harmful to predators. In our opinion, this stage has taken us about as far as it can in terms of pesticide reduction. The second stage will rely on

Table 1. Pesticide use in Massachusetts IPM apple orchards.

Year	No. orchards or blocks	Dosage equivalents of* Insecticide	Dosage equivalents of* Miticide**
1977 (Before IPM)	16	9.1	1.8
1978 (IPM pilot prog.)	8	6.4	0.9
1979 " "	16	6.0	0.4
1980 " "	18	4.8	0.8
1981 " "	19	6.2	0.4
1982 " "	36	5.5	0.9
1983 (Priv. consults.)	33	6.0	1.3
1984 " "	36	5.5	2.0
1985 " "	48	5.1	2.5
1986 " "	51	4.6	1.7

* Dosage equivalent = actual amount of pesticide used divided by amount recommended in Pest Control Guide.
** Does not include oil spray against overwintering mite eggs.

knowledge gained of the behavior and ecology of pests and beneficial predators and on employment of behavior-manipulation techniques as a substitute for use of most pesticide treatments.

For the past 6 years (1981-86), one form of this second stage of apple IPM has been used at my small (50-tree) orchard of disease-resistant apple trees in Conway, MA. The approach has been as follows: (a) application of a pre-bloom oil treatment against overwintering San Jose scale and eggs of the European red mite; (b) 2 applications of Imidan (one at petal fall and another 10 to 14 days later) for control of European apple sawfly, plum curculio, and first-generation codling moth; and (c) use of red-sphere visual traps (1 or 2 per tree) to capture and thereby control apple maggot fly adults. Table 2 is a summary of the average percent (1984-86) of clean and insect-injured fruit on the experimental orchard trees compared with several neighboring (200 meters away), unsprayed trees.

This use of only 2 dosage equivalents of insecticide (compared with 5 to 6 in the average first-stage IPM orchard and 9 in non-IPM orchards) is not the only benefit realized. The absence of any insecticide use from 10 to 14 days after petal fall (early June) through the remainder of the growing season has allowed key predators and parasites of mites, aphids, leafhoppers, leafminers, and San Jose scale to flourish during summer months. The result has been no need to make any application of miticide or other pesticide for control of these secondary pests. In our opinion, this result strongly suggests that the

Table 2. Percent clean and insect-injured fruit from experimental and unsprayed apple trees.

	Experimental orchard trees	Neighboring unsprayed trees
Percent clean fruit	93.7	0
Percent injury by:		
Plant bug	1.6	2.7
Sawfly	0.6	8.7
Curculio	3.5	96.0
Codling moth	0.5	58.0
Leafrollers	0.3	13.7
Apple maggot	0.2	82.3
Other	0	2.3

problems experienced even in IPM orchards with outbreaks of mites and other secondary pests are due in substantial part to detrimental effects on beneficial predators and parasites as a result of insecticide, fungicide or herbicide applications (even judicious use of selective materials) from June onward.

Can this approach used in the Conway experimental orchard be transferred directly and successfully to larger commercial orchards? We doubt that it can because of the amount and cost of labor that would be required to place and maintain apple maggot traps in every apple tree. But variants of this approach that are derived from knowledge we and others have gained of the behavior of key apple pests over the past decade could prove successful. Thus, our recent research on the host-finding behavior of sawfly, plum curculio, and apple maggot adults has suggested that individuals entering an orchard from unsprayed trees in nearby woods or hedgerows are most likely to visit first those apple trees that are at the perimeter of the orchard and then gradually move into interior trees. Because sawfly, plum curculio, and apple maggot populations, as well as populations of every other key pest attacking apple fruit, originate almost exclusively on unsprayed trees outside the orchard, intercepting these insects at the perimeter of the orchard with traps (or spraying insecticide or egg-laying deterring chemicals on the perimeter trees to prevent immigration into the interior of the orchard) could constitute an effective variant of the approach used in the Conway experimental orchard and allow us to enter the second stage of IPM in Massachusetts apple orchards.

At present, the only truly effective traps for direct control of a key apple pest are traps for capturing apple maggot flies. Visual traps developed for plant bug, sawfly, and leafminer adults are effective for monitoring occurrence of adults and are being used extensively in first-stage IPM apple orchards, but they have not proven effective as yet for direct control. Chemicals that deter egglaying (either pheromones emitted by the adults or chemicals emanating from plant tissue wounded by egglaying females) are now known, from our recent research, to exist in sawfly, plum curculio, and apple maggot. None of these chemicals has yet been identified as to structure or has been synthesized. Thus, it will be some time yet before they are available for use. Sex pheromones for codling moth and most pest species of orchard leafrollers have been identified by Wendell Roelofs and his colleagues at Geneva, New York, and have been applied in massive amounts in and around experimental apple orchards in an attempt to disrupt mating behavior and thereby reduce numbers of larval progeny attacking fruit. But this approach will require considerably more work before it is ready for implementation in commercial orchards.

Thus, the picture appears rather bright for behavior-based management of many key apple fruit pests in the future. In the meanwhile, it may be possible at least to begin the second stage of apple IPM using knowledge and techniques presently available.

Toward this end, we have received support from the Massachusetts Society for Promoting Agriculture to carry out a 3-year experiment in several commercial apple orchard blocks in which (a) all insecticide and miticide spraying of the interior of each block would cease at the end of May (following 1 pre-bloom and 1 or 2 post-bloom treatments), and (b) the perimeter of each block would be managed in such a way as to prevent immigration of key apple pests into the interior from June until harvest. The perimeter management techniques would be either (a) placement of sticky-coated, apple-odor-baited red sphere traps for apple maggot flies in perimeter trees or adjacent woods, or (b) application of insecticide to perimeter apple trees every 2 weeks from June until harvest.

We realize this experiment of extreme reduction in insecticide use involves high risk of some amount of insect injury to the fruit. At the same time, we believe that if we do not venture forward into the unknown, we have little chance of moving beyond present pest management practices.

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POMOLOGICAL PARAGRAPH

New McIntosh Strain Discovered

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A new McIntosh strain (EG506--Adams County Nursery) has been discovered in the Hudson Valley of New York which is reported to ripen later than normal and to hold on the tree for a longer period of time. We will be establishing a planting of these trees in 1988 and will compare them with standard strains of McIntosh. If this strain acts as reported then it may be of great value in expanding the McIntosh harvest season.

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INTEGRATED PEST MANAGEMENT AND BIOLOGICAL CONTROL POTENTIAL FOR STRAWBERRIES IN THE NORTHEASTERN UNITED STATES

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Strawberry producers in the northeastern United States are faced with a number of arthropod pests with which they must compete in order to produce a profitable crop. Applications of chemical pesticides has been the standard method of control for many years, but is now being re-evaluated in view of increasing costs, environmental contamination, the development of insect and mite resistance, and the disruption of natural enemy complexes. Integrated pest management (IPM) programs, developed for many major agricultural crops, can improve pest control efficiency by exploiting all possible means of management, including cultural, biological, and chemical, resorting to the latter only when nonchemical methods cannot maintain pest populations below a specific economic injury level. IPM may hold potential for strawberries grown in the Northeast, but alternatives and supplements to chemical pesticides are presently few.

Cultural control techniques for strawberry pests include sanitation, e.g. removing dead plant material and weeds that may harbor pests, adjusting planting times or patterns to avoid peak pest populations, crop rotation, trap crops, and mechanical control, such as burning or flooding. Strawberry production has incorporated some cultural control measures into the general management scheme, such as rotation with other crops that do not share the same pest complex, and renovation, during which disease-infected foliage and insect overwintering sites are destroyed or tilled into the soil. The time of plowing under old beds can affect the status of overwintering pests species. The use of trap crops has received little attention for strawberry pests, but may offer a means of reducing early outbreaks of some insects (9). Physical barriers are effective against some insects, but generally have been considered too expensive or labor intensive to be used (4). However, the recent introduction of lightweight, synthetic row covers and application machinery may stimulate a re-evaluation of this technique. Strawberry plant resistance to certain pest species such as root weevils, aphids, and spider mites has been observed. To date, however, this is not thought to provide economic control (1,7,10).

Biological control refers to the use of natural parasites and predators of insect pests to maintain populations below economic thresholds. This technique may involve searching out and importing exotic, natural enemies, and/or using conservation and augmentation techniques to increase the effectiveness of natural enemies, whether native or imported (3).

Several problems are inherent with the practical application of biological control of northeastern strawberry pests. The strawberry plant is native to the northeastern U.S. The wild strawberry, *Fragaria virginiana*, is thought to be a parent of the now popular cultivated strawberry, *Fragaria ananassa* (2). Therefore, a native pest complex exists that is both established and well adapted. This situation greatly reduces the probability of finding effective exotic natural enemies. In nearly every successful example of control using exotic natural enemies, the pest itself was exotic. Furthermore, success with exotic natural enemies usually occurs in salubrious, stable, and undisturbed environments (3), none of which are characteristic of northeastern strawberry plantings.

Utilizing conservation techniques for native natural enemies could prove more rewarding. Chief among these would be the reduction of nonselective or broad-spectrum pesticide use. Despite their effectiveness on a given pest species, these materials can destroy natural enemy populations, initiating a resurgence and possible population explosion for certain pests, including some not previously considered economically damaging.

The effectiveness of native natural enemies is hampered by other problems as well. Due to long coevolutionary relationships, pest species likely developed resistance mechanisms to most parasites, and the parasites themselves may be plagued with hyperparasites. Native predators may provide some control of strawberry pests. The root feeding larvae of weevils and scarabs are attacked by birds and rodents, but these may themselves damage plants. Predatory beetles also feed on pest larvae, tarnished plant bugs, and mites (9). These predators are relatively nonspecific feeders, however, and are thus less effective as control agents of a specific pest. Because they are native, they will also have their own natural enemies, which will keep their populations, and hence control potential, in check.

Augmentation of natural enemies, whether native or imported, involves manipulation of the population such that control of the pest species is improved. Typically, this is accomplished by rearing natural enemies artificially and releasing them, either inundatively or as an inoculative population (3). Such approaches are usually quite expensive and may not be justifiable on a minor crop such as strawberries.

One of the most important barriers facing biological control potential in strawberries is the relatively high value of the crop. Very small amounts of damage may have significant economic effects due to the high cash return of strawberry fruit. Therefore, when an economic injury threshold is determined, it will be quite low, meaning only small pest populations need be present to justify control measures (9). These thresholds may require pest numbers to be below a level required for the natural predators to remain viable. This condition would necessitate supplementary chemical applications, probably causing greater harm to the natural enemies, or repeated inundative releases of the natural enemy, much like a "biological insecticide".

Perhaps the most promising use of biological control in strawberries to date is against phytophagous mites. In California, cyclamen mite has been effectively controlled with Typhlodromus species. These native predatory mites can provide adequate control without manipulation, but typically not until the third year of a planting. To achieve control in first and second year beds, the predator must be stocked. Research also suggests that stocking young fields with cyclamen mite along with Typhlodromus could improve establishment and effectiveness of the predator (6). Strawberry growers were not receptive to this idea, and have since adopted an annual system of production which eliminates the need for such controls. Strawberry plantings in the Northeast are still maintained for several years, however, allowing cyclamen mite populations to reach damaging levels. Although it is unlikely that the predatory Typhlodromus could successfully overwinter, inundative releases of the predator at specific pest population thresholds potentially could bring about substantial control.

Successful control of the twospotted spider mite has also been achieved with a predator. Releases of the mite Phytoseiulus persimilis before spider mite populations attained an average of one mite per leaf provided effective control in California (8). This predatory mite has also been used successfully in greenhouses and under row covers (5). Control is temporary as the mite completely eradicates its prey and therefore its food source under these conditions. Similar to the Typhlodromus species, P. persimilis would not likely survive the climate extremes of the Northeast. This would necessitate annual releases of the predator, and the cost required may be prohibitive.

Despite inherent difficulties, biological control has some potential as a component of an integrated pest management program for strawberries in the northeastern United States. Research is needed to determine the effectiveness of native natural enemies and the existence of exotic species. The strawberry root weevil for example, is thought to have come originally from Europe, yet no efforts have been reported to seek natural enemies there. Some strawberry pests, including leaf rollers and aphids, are already known to be controlled effectively by natural enemies (9). Only minor manipulation or alterations may be required to bring about much greater biological control of other species.

The increased exploitation of biological control agents, combined with proper cultural practices and improved application strategies for chemicals, could greatly increase pest control efficiency in strawberries and hence, profitability. In addition, such an integrated program likely would reduce the amount of pesticides used, and thereby reduce the potential hazards of frequent and repetitive pesticide use.

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A NEW PROGRAM FOR INTEGRATED PEST MANAGEMENT OF STRAWBERRIES IN MASSACHUSETTS

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Last fall, an integrated pest management program for strawberries was funded by the University of Massachusetts Integrated Pest Management (IPM) program. This article is intended to give a brief outline of the proposed program, and invite comments from interested parties.

Strawberries offer a unique opportunity for integrated pest management, for a number of reasons. Note that strawberries suffer important damage from all pests: diseases, weeds, and insects. We intend to use the term pest in its broadest sense, encompassing any agent which necessitates pesticide applications.

In assessing the potential for strawberry IPM, we saw that while acreage on a given farm is not generally large, the number of small farms producing strawberries has steadily increased in recent years. As a result, there are a number of new strawberry growers in the state. In addition, strawberries require relatively frequent applications of pesticides in order to produce well. This situation is complicated because only a few fungicides are registered for use on strawberries, and the future utility of these compounds is threatened because registration may be removed, fungus resistance has developed, some of the pesticides used on strawberries are potential groundwater contaminants, and some may affect non-target beneficial insects. Also, strawberry growers frequently sell their crop to "pick-your-own" customers, giving the public exposure to not just the product, but the fields in which it is grown. And finally, many strawberry pests have also been studied in recent years, either on strawberry or as pests of other crops. The general biology and suggestions for innovative management strategies for these pests have been developed, but have not been applied generally to commercial strawberry production. Massachusetts is in a strong position to use this knowledge since the three regional fruit agents all have an active interest and good backgrounds in small fruit.

A few years ago, experience in developing and publishing the New England Guide for Managing Diseases and Insects of Small Fruits (3) showed that there was not a great deal of current knowledge on strawberry pest control. However, a recent survey (5) has identified the most important pathogens. Several fungi contributed to berry rots, and several other fungi contributed to root rots. The most significant fruit pathogens (and the diseases they cause) were Botrytis cinerea (grey mold), Phytophthora cactorum (leather rot), Hainesia lytheri (tan brown rot), and Phomopsis obscurans (berry blight). The etiology of each of these pathogens is distinct, but in general wet weather and increasing fruit maturity cause more disease development. In unmanaged situations, fruit rots can destroy the entire crop. Even using recommended controls, adverse conditions can cause significant crop loss. For example, gray mold causes between 20% and 60% loss in Quebec, depending on weather (4). Leather rot losses in Ohio approached 40% in commercial beds in 1980 and 1981 (6). Gray mold is endemic in strawberry fruit, and Botrytis was frequently isolated from all beds in the Massachusetts survey. Leather rot was also frequently observed.

The most damaging strawberry insect and weed pests in Massachusetts have not been determined. According to growers, the most important insect pests are tarnished plant bug (Lygus lineolaris), strawberry bud weevil or clipper (Anthonomus signatus), white grubs (Phyllophaga spp.), and strawberry root weevil (Otiorhyncus ovatus). There is little doubt that tarnished plant bug is the major contributor to misshapen strawberries (8).

Several weeds cause economic problems in strawberries, including several grass species, Galinsoga, and thistle. Though growers cite these as the problem weeds, it is not clear whether this is the case, and if so, how much damage is caused. However, it is clear that weeds are a major factor causing beds to be taken out of production.

Previous work supplies some tools to start an IPM program. Gray mold epidemiology is partially understood. One study has shown that floral and pedicel infections early in the season are more important to future berry infections than direct infections occurring at or near harvest (7). A few applications of a fungicide early in the season may be as effective as a series of applications from bloom through harvest. Such applications could be made more efficient by applying epidemiological data from Quebec which indicate that temperatures from 15 to 20^{o}C and relative humidities from 90 to 100% for at least 28 hrs. are optimal for gray mold epidemics (4). An experimental model for gray mold pressure is in the process of being published (1). A similar model of temperature and moisture effects on leather rot infection has been published recently (6).

Another element in a fruit rot control program would involve studying fungicide retention and redistribution. Presently, growers often apply fungicides every 3 to 5 days around harvest if weather is wet, on the assumption that this will increase protection against berry rots. On apples, captan remains effective for 1 week regardless of rain (9). Frequent applications of fungicide around strawberry harvest may be useless.

Insect monitoring would be a key element in the program. Initial work indicates that tarnished plant bug traps similar to those used in apple IPM (2) could be successful in strawberry. One technique, using non-visual traps, has suggested an economic threshold level of 1 nymph per 25 flower clusters, which would provide a starting point for insect monitoring techniques (8).

Techniques for reducing herbicide use remain poorly developed in all crops. To date, there has not been even a survey of the major weed species affecting strawberry beds, though a survey is planned for this year. It may be possible to reduce herbicide use in new plantings by using a dieback cover crop during the previous season. Spot treatments rather than broadcast treatments may be an effective way to reduce herbicide use post-planting.

Anecdotal evidence and experience in other IPM programs in the state indicate that spray coverage may be one of the most important sources of error in pest management. This can be caused by inaccurate calibration, or by inappropriate equipment and calculations. Such problems could be examined immediately.

At the outset, we have proposed a number of specific objectives for the program.

1. Use crop development and weather data to time fungicide applications for fruit rot control, and compare the results with typical calendar-based timing.

2. Use insect monitoring techniques on three major strawberry pests, tarnished plant bug, strawberry bud weevil, and two-spotted mite, in order to time pesticide applications on the basis of the presence or absence of the pest, and develop information for economic threshold levels.

3. Determine what weed species are important in strawberries in Massachusetts, and determine the efficacy of present control recommendations.

4. Test alternative fungicides against fruit rots, develop improved timing for fungicide application via epidemiological data, and test alternative cultural practices designed to reduce fruit rot.

5. Examine present sprayer calibration and equipment, and determine whether inaccuracies or inappropriate techniques exist. If they do, suggestions on how to improve sprayer efficiency and calibration will be made.

6. Develop appropriate expert system delivery systems for the IPM information, using the INFONET electronic mail system to access Regional Extension staff and interested growers.

7. Distribute pest messages on current status of pest problems and crop development on a weekly basis prior to and during harvest, and at longer intervals as needed thereafter.

The first year of the program we are concentrating on a survey of current pest management practices, and beginning the testing of reduced pesticide recommendations. With a limited number of growers in the Connecticut Valley, we have established small sections of fields which will be treated as IPM plots. These plots will be treated separately from the rest of the grower's field. These plots will also be areas where pest pressure is most intensively studied.

For example, this year there are a number of colored traps in place to test the effectiveness of various colors in monitoring tarnished plant bug populations. Fungicides will be applied according to flowering and berry development, while Botrytis (the primary berry rot fungus) will be monitored on last year's leaves and the developing flowers and fruit. Similar monitoring will be done in non-IPM plots. It will also be possible to test the validity of a new gray mold model (1). Weed species and numbers will be evaluated in plots, and the herbicide practices of growers will be determined. The comparison of pest pressure in IPM and non-IPM plots will allow us to evaluate which practices are the most effective with the least pesticide impact. This information will define directions for pest management practices which will be refined in the following seasons.

We are at the beginning of the program. At this stage, we welcome the comments and advice of any interested people.

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POSTHARVEST HANDLING OF BLUEBERRIES

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Blueberries (Vaccinium corymbosum) are very perishable once harvested and must be handled carefully to maintain quality and reduce postharvest losses. The primary quality factors, as outlined by the U.S. grade standards, are maturity, color, size, and freedom from defect and decay (7). In a 3-year study of blueberries at retail stores Cappellini et al. (3) determined the reasons for postharvest berry losses (Table 1). Of the 15.2% of berries lost,

Table 1. Sources of blueberry losses in retail outlets. From Cappellini et al. (3).

Defect	Percentage lost
Decay	10.7
Overripe or dehydrated	3.3
Mechanical or insect injury	0.2
Immaturity	1.0
TOTAL	15.2

over two-thirds were lost to decay, so efforts to improve postharvest handling of blueberries must reduce the incidence of decay to be successful. In this discussion I will present general changes which occur during blueberry ripening, factors which affect decay, and means for reducing decay and increasing postharvest life and fruit quality.

Ripening

Blueberries are a climacteric fruit, meaning that they exhibit a rapid rise and fall in respiration during the course of ripening. Throughout this period many other changes occur, including a reduction in acidity, an increase in sugar content, and a dramatic increase in anthocyanin content (the source of the blue coloration). Table 2 depicts the timing of the major changes that occur during ripening.

It is interesting to note that blueberries do not attain their full flavor when they first become blue, but actually require an additional 1 to 2 days to develop full flavor (8). This is reflected in Table 2 by a sharp decline in acids (and rise in pH) and rise in sugars after the fruit become blue, both changes improving flavor. The sugar/acid ratio reflects both of these changes, and is what we perceive when we taste the fruit.

Table 2. Biochemical changes associated with Wolcott blueberry ripening. Adapted from Ballinger and Kushman (1).

Stage	pH	Total acidity (% as citric)	Soluble solids (%)	Sugars (%)	Sugar/ acid ratio	Antho- cyanins (mg/100g)
Immature-green	2.60	4.10	6.83	1.15	0.28	---
Mature-green	2.68	3.88	7.20	1.79	0.46	---
Green-pink	2.79	2.36	9.88	5.27	2.28	85
Blue-pink	2.81	1.95	10.49	6.20	3.26	173
Blue	2.96	1.50	10.79	6.87	4.69	332
Blue-ripe	3.70	0.50	12.42	9.87	19.95	1033

Decay

Decay is the primary source of berry loss after harvest (2). The 3 most common decay organisms are anthracnose, gray mold, and alternaria (3). Researchers have observed that decay is most prevalent in late-harvested berries, where there is a higher percentage of overripe fruit. For instance, at retail stores 10.9% of the berries are lost from early season harvests, whereas 20.3% are lost from late season harvests (3). This apparent loss of resistance to decay is related to the advancement of ripening and has been correlated with an increase in the sugar-to-acid ratio (1) (see Table 2). Thus, as fruit ripen their sensitivity to decay during the postharvest period increases, and the sharpest increase is during the very latest stages of ripening.

The primary entry point for decay organisms is the stem scar. Table 3 shows results of a study where some fruit had their stems removed and some did not. Decay increased much more rapidly in those fruit where the stems were removed, leaving stem scars.

Table 3. Percent decay associated with the stem scars of harvested blueberry fruit. From Cappellini and Ceponis (2).

	Days at 70°F		
Treatment	2	4	6
With stems	0.1	0.6	0.9
Without stems	0.7	3.8	6.7

Decay can be controlled adequately with postharvest fungicide dips but resistance to applying pesticide after harvest and problems with application preclude their use. Other means must be used to control postharvest decay.

Postharvest Handling

The simplest and most effective way of maintaining blueberry quality after harvest is with the use of refrigeration. Cold temperatures slow ripening and nearly stop decay. Some resistance to the extensive use of refrigeration of blueberries exists because many growers are concerned that the sweating of fruit after removal from the cold can increase decay, but research has shown that decay is not significantly increased by sweating (4).

The optimum conditions for holding blueberries are 31 to 32°F and 95% relative humidity. Even at 40° there is substantially more loss to decay than at 32° (Table 4). Under most circumstances, blueberries may be kept for 2

Table 4. Percentages lost associated with holding temperature. From Hruschka and Kushman (6).

	Length of storage			
Holding temperature	2 wks	2 wks + 2 days at 70°	4 wks	4 wks + 2 days at 70°
32°	10	18	18	36
40°	13	28	30	55

weeks at 32° with very little loss (4). However, if some loss can be tolerated they may be kept for up to 6 weeks. Late-harvested berries will not store as well as early-harvested fruit, and any decay present at harvest will reduce storage potential by providing an inoculum source (7).

Also, it is critical to cool the berries as quickly as possible. Ceponis and Cappellini (5) studied the differences in losses associated with cooling rate. Berries were cooled in 2, 48, or 72 hours and kept at 35°F for 2 weeks, after which they were removed from storage and kept at 70° for up to 3 days. Table 5 shows their results, and it is obvious that rapid cooling reduced losses, particularly in the first 2 days after being transferred to 70°. Many growers may not have cooling equipment available to reduce the temperature of their berries to 35° in 2 hours, but it is important to cool them as quickly as possible. Some success has been obtained by supplementing existing cooling equipment with liquid nitrogen or CO_2 to speed the cooling process (9).

Modified atmospheres around the fruit may improve longevity. Elevated CO_2 (10 to 15%) seems to be the most advantageous modification because it inhibits the growth of decay organisms. Table 6 shows data on fruit losses to decay

Table 5. The effects of cooling rate on the percent loss of blueberries. From Ceponis and Cappellini (5).

	Days at 70°F after 2 wks at 35°			
Cooling times (hrs)	0	1	2	3
2	0.8	2.0	6.8	17.2
48	2.7	6.9	14.1	20.7
72	3.7	10.8	20.6	24.8

after cold storage with high CO_2. The CO_2 enriched atmosphere significantly reduced loss during and after storage. The use of CO_2 enrichment of storage rooms may not be feasible for blueberry growers, but enrichment of small lots of fruit may be accomplished with the use of plastic films. Research studies have used plastic envelopes to enclose several 1-pint baskets and have injected CO_2 directly into the envelopes to enrich the atmosphere. A high CO_2 environment will develop naturally after enclosure in plastic but will take 5 to 7 days to reach 10-15%. Even with this delay in the development of a high CO_2 atmosphere the benefits of sealing in plastic may be significant. However, plastic must be removed when the berries are removed from cold storage.

Table 6. The effects of CO_2 enrichment on the percent loss of blueberries after cold storage. From Ceponis and Cappellini (5).

	Days at 70° after 2 wks at 35°			
Percent CO_2	0	1	2	3
12 to 15	0.9	2.1	5.7	12.6
0	2.4	6.6	13.8	20.6

CONCLUSIONS

1. Keep blueberries COLD (31 to 32°F). The most effective means of maintaining blueberry quality is through refrigeration.

2. Cool blueberries QUICKLY. Significant benefits exist from rapid cooling.

3. Seal in plastic to increase CO_2 if longer storage is desired. Research has shown that high CO_2 can significantly reduce blueberry losses to decay. Plastic films may be used to develop and maintain a high CO_2 environment around the fruit.

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Fruit Notes

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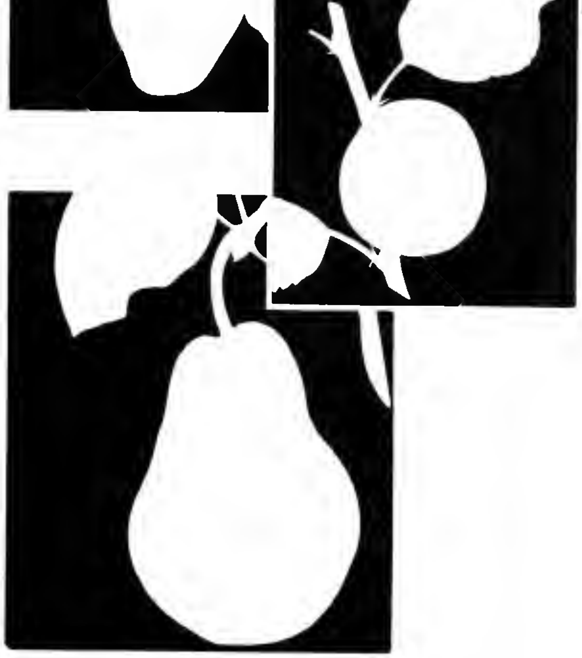

Volume 52, No.4
FALL ISSUE, 1987

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EVALUATION OF MCINTOSH STRAINS IN MASSACHUSETTS

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Many McIntosh strains have been discovered throughout the years. Some have been good and others not so good. To be accepted now, new strains must have a high percent red color, yield well, and emerge from long-term storage with high quality. To assess McIntosh strains, a planting was established in 1979 at Green Acres Fruit Farm, Wilbraham, MA, including Morspur, Marshall, Imperial, Macspur, Eastman, Gatzke, and Rogers McIntosh on M.7A. This planting is maintained by the grower.

Trees have fruited since 1983, and the yields are reported in Table 1. Most strains, with the exception of Eastman, yielded similarly each year and on a cumulative basis. Eastman trees yielded the fewest fruit each year from 1983 to 1986, with a cumulative yield less than half that of the other strains. Eastman also was the smallest tree in terms of trunk circumference (Table 1). However, this fact did not account for the low yields, since they also were the least yield efficient trees from 1983 to 1986 (Table 1).

Table 1. Yield per tree (bu) in 1983 through 1986 and on a cumulative basis, cumulative yield efficiency, and 1986 trunk circumference of McIntosh strains planted in 1979.

Strain	Yield per tree (bu)					Yield efficiency (kg/cm^2)	Trunk circum. (cm)
	1983	1984	1985	1986	Cumulative		
Morspur	0.4 ab*	1.1 ab	1.1 abc	5.2 a	7.7 a	2.31 a	27.7 a
Marshall	0.3 bc	1.4 a	1.1 bc	4.1 a	6.8 a	2.11 ab	27.8 a
Imperial	0.5 a	1.1 ab	1.6 ab	4.8 a	8.0 a	2.11 ab	29.7 a
Macspur	0.3 bc	1.0 ab	1.0 bc	4.4 a	6.7 a	1.72 bc	29.5 a
Eastman	0.2 c	0.1 c	0.5 c	1.9 b	2.7 b	1.52 c	20.5 b
Gatzke	0.2 bc	0.5 bc	1.2 ab	4.3 a	6.3 a	1.88 abc	27.7 a
Rogers	0.3 bc	1.1 ab	1.8 a	4.9 a	8.1 a	2.17 ab	29.4 a

* Within columns, means not followed by the same letter are significantly different.

As fruit ripen their starch is converted to sugar which is observed easily by staining the starch with an iodine solution. The pattern of staining changes during ripening and can be categorized by comparing it to an index chart. As the starch disappears the index value increases. For two harvests in 1983, three in 1984, two in 1985, and one in 1986 starch index values were determined with the starch-iodine test (Table 2). No consistent differences were seen among the strains, suggesting that there were no differences with respects to the time of ripening. However, the starch-iodine test is not very sensitive for assessing small differences.

Table 2. Starch index values of fruit from different strains of McIntosh harvested in 1983, 1984, 1985, and 1986.

	1983		1984			1985		1986
Strain	9-9	9-17	9-4	9-11	9-18	9-3	9-10	9-4
Morspur	1.9 ab*	2.5 a	2.6 a	3.2 abc	4.7 a	3.2 a	4.7 a	3.5 b
Marshall	1.9 ab	2.8 a	2.2 a	3.4 ab	4.1 a	3.2 a	4.1 a	3.8 a
Imperial	1.7 ab	2.7 a	2.2 a	3.2 abc	4.1 a	3.3 a	4.6 a	3.2 c
Macspur	1.9 a	2.6 a	2.2 a	3.6 a	4.5 a	3.4 a	4.7 a	3.6 ab
Eastman	1.3 b	2.8 a	---	---	---	2.5 b	4.0 a	3.1 c
Gatzke	1.8 ab	2.3 a	2.2 a	3.1 bc	---	2.8 ab	4.4 a	3.1 c
Rogers	1.5 ab	2.3 a	2.0 a	2.9 c	4.1 a	3.0 ab	4.1 a	3.4 bc

* Within columns, means not followed by the same letter are significantly different.

During the course of apple ripening the internal C_2H_4 concentration rises dramatically, providing an accurate and sensitive means of monitoring ripening. For three harvests in 1984 and 1985 the internal C_2H_4 concentration was determined for Marshall and Rogers fruit (Table 3). We were particularly interested in determining if Marshall fruit ripened earlier, since they colored significantly earlier than the other strains. Rogers was selected as a standard strain. In both years, Marshall fruit ripened significantly earlier than Rogers fruit, showing higher internal C_2H_4 concentrations at each harvest. In 1986 internal C_2H_4 concentrations were determined for all strains on September 4 (Table 3). Marshall fruit had the highest levels, and over the three years of the study comparison of concentrations suggest that Marshall fruit ripen about 5 days before standard strains such as Rogers.

The primary factor in determining success when growing McIntosh is red color. For an orchard to be profitable, a large percent of the fruit produced must have enough red color to meet the U.S. Extra Fancy grade, i.e. 50 percent red color characteristic of the cultivar. Table 4 shows the percent of the fruit meeting the Extra Fancy grade for each harvest in each year. In all cases Marshall had the highest percent of fruit in the Extra Fancy grade. Also, earlier coloring of Marshall fruit can be observed in those years where multiple harvests were made.

Flesh firmness was measured at harvest each year (Table 5). Significant differences were noted among the seven strains. However, these differences may be attributed to differences in fruit size (Table 6). Generally, the smallest fruit were the firmest.

Table 3. Internal C_2H_4 concentrations of fruit from different McIntosh strains harvested in 1984, 1985, and 1986.

	1984			1985			1986
Strain	9-4	9-11	9-18	8-27	9-3	9-10	9-4
Morspur	---	---	---	---	---	---	0.35 b
Marshall	0.12 a*	4.60 a	11.50 a	0.10 a	3.15 a	14.93 a	1.29 a
Imperial	---	---	---	---	---	---	0.48 ab
Macspur	---	---	---	---	---	---	0.40 b
Eastman	---	---	---	---	---	---	0.46 ab
Gatzke	---	---	---	---	---	---	0.62 ab
Rogers	0.04 b	0.65 b	3.80 b	0.05 b	0.51 b	2.12 b	0.28 b

* Within columns, means not followed by the same letter are significantly different.

Table 4. Percent of fruit meeting the U.S. Extra Fancy grade harvested from different McIntosh strains in 1983, 1984, 1985, and 1986.

	1983			1984			1985		1986
Strain	9-1	9-7	9-14	9-4	9-11	9-18	9-3	9-10	9-4
Morspur	17 b*	20 b	57 bc	13 b	23 b	72 b	30 b	20 b	75 ab
Marshall	64 a	67 a	84 a	51 a	89 a	90 a	77 a	65 a	95 a
Imperial	15 b	23 bc	68 ab	23 b	13 bc	72 b	12 c	21 b	80 ab
Macspur	8 bc	33 b	56 bc	9 b	23 b	63 b	18 bc	17 b	81 ab
Eastman	1 c	6 c	25 d	--	--	--	5 c	4 b	61 b
Gatzke	9 bc	17 c	52 bc	8 b	8 c	--	10 c	14 b	80 ab
Rogers	8 bc	28 b	39 cd	7 b	8 c	67 b	7 c	14 b	73 ab

* Within columns, means not followed by the same letter are significantly different.

In 1985 one bushel of fruit from each tree was kept in controlled atmosphere storage for 7 months followed by air storage for 2 months. In 1986 one bushel from each tree was kept in air storage for 4 months, and one bushel was kept in controlled atmosphere storage for 6 months followed by air storage for 1 1/2 months. The incidences of storage disorders were not significantly different among strains in either year (Table 7). However, some differences existed with respect to fruit firmness after storage in 1986, but these differences may be attributed to fruit size.

Table 5. Flesh firmness (lbs) of fruit harvested from different McIntosh strains in 1983, 1984, 1985, and 1986.

	1983		1984			1985		1986
Strain	9-9	9-17	9-4	9-11	9-18	9-3	9-10	9-4
Morspur	15.5 ab*	14.5 ab	16.6 a	15.3 ab	14.7 a	15.7 a	14.0 ab	14.8 a
Marshall	15.5 ab	14.9 a	16.3 ab	15.5 ab	15.3 a	15.8 a	14.4 a	14.8 a
Imperial	15.3 ab	14.4 abc	16.1 ab	15.5 ab	14.8 a	15.5 ab	14.1 ab	14.6 ab
Macspur	14.7 b	13.8 cd	15.7 b	14.6 c	14.2 b	15.0 bc	13.1 c	14.3 c
Eastman	14.8 b	13.6 d	----	----	----	14.7 c	13.8 b	14.2 c
Gatzke	15.3 ab	14.0 bcd	15.6 b	15.0 bc	----	14.4 c	13.3 c	14.4 bc
Rogers	16.0 a	14.5 abc	16.5 a	15.7 a	15.3 a	15.7 a	14.3 ab	14.7 ab

* Within columns, means not followed by the same letter are significantly different.

Table 6. Diameter (in.) of fruit harvested from different McIntosh strains in 1984, 1985, and 1986.

	1984			1985		1986
Strain	9-4	9-11	9-18	9-3	9-10	9-4
Morspur	2.93 b*	3.01 b	3.13 ab	3.10 b	3.22 b	3.04 b
Marshall	2.89 b	2.98 b	3.03 b	3.04 b	3.10 c	2.95 c
Imperial	2.97 b	3.03 b	3.16 a	3.13 b	3.22 b	3.15 a
Macspur	3.02 ab	3.11 ab	3.16 a	3.09 b	3.25 b	3.05 b
Eastman	----	----	----	3.27 a	3.29 ab	3.20 a
Gatzke	3.13 a	3.19 a	----	3.30 a	3.39 a	3.16 a
Rogers	2.89 b	3.03 b	3.14 ab	3.04 b	3.17 bc	3.03 b

* Within columns, means not followed by the same letter are significantly different.

In summary, Eastman produced a small tree which yielded poorly. Other strains produced trees of similar size and productivity. Marshall produced fruit which colored earlier and to a higher degree and ripened earlier than fruit from other strains. Fruit quality after storage was similar for all strains in this study. Another McIntosh strain trial was established in 1985 with a number of high-coloring strains, including Redmax. Results from this study will be reported in future issues of Fruit Notes.

Table 7. Post-storage quality of fruit harvested from different McIntosh strains in 1985 and 1986. Fruit in 1985 were harvested September 10, kept in CA (3% O_2, 5% CO_2) for 7 months and air for 2 months prior to quality assessment. Fruit in 1986 were harvested September 4 and either kept in air for 4 months or CA for 6 months and air for 1 1/2 months prior to quality assessment.

Strain	Firmness (lbs)	Scald (%)	Decay (%)	Senescent breakdown (%)	Bitter pit (%)	Browncore (%)
			CA--1985			
Morspur	9.8*	0*	17*	14*	--	3*
Marshall	10.1	0	28	23	--	0
Imperial	10.3	0	13	15	--	1
Macspur	8.7	0	30	27	--	0
Eastman	10.0	0	27	14	--	0
Gatzke	9.6	0	22	25	--	1
Rogers	9.6	1	14	19	--	1
			Air--1986			
Morspur	10.1 ab**	6*	8*	11*	5*	--
Marshall	10.0 ab	6	9	7	1	--
Imperial	9.8 ab	10	8	15	4	--
Macspur	9.2 b	3	7	11	3	--
Eastman	9.3 ab	9	7	11	5	--
Gatzke	9.1 b	9	22	12	5	--
Rogers	10.3 a	8	11	6	2	--
			CA--1986			
Morspur	10.7 bc**	2*	3*	2*	5*	--
Marshall	11.6 a	2	2	1	2	--
Imperial	10.8 bc	4	2	0	6	--
Macspur	10.3 c	1	3	1	4	--
Eastman	11.3 ab	1	6	2	3	--
Gatzke	11.2 ab	3	3	1	3	--
Rogers	11.1 ab	1	2	1	2	--

* No significant differences existed among strain for these parameters.

** Within column and storage treatment, means not followed by the same letter are significantly different.

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POTATO LEAFHOPPER IN MASSACHUSETTS APPLE ORCHARDS

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In 1986, many growers, private consultants, and Extension workers noted a "new" type of injury on terminal leaves of apple, consisting of general off-coloration as well as a strong marginal yellowing or burning of the leaves. Since the injury was not particularly severe and no causative agent was found, in most cases it went unremarked during the growing season. It was not until the fall, when Extension workers and private consultants from the Northeast gathered to share information, that the problem was recognized as a widespread phenomenon, and the injury was definitively identified as caused by the potato leafhopper, (PLH) Empoasca fabae. Over the decades. this insect is known to have been an occasional pest of apples, but this has been the most notable outbreak in recent years.

Nymphs and adults of PLH are pale green in color, and tend to move rapidly (often in a sideways fashion) when disturbed. In contrast, nymphs and adults of the white apple leafhopper (the only other leafhopper likely to be seen in Massachusetts apple orchards) are pale yellow to whitish in color and move more slowly when disturbed, usually straight ahead. An additional distinguishing character visible with a hand lens is a rather distinctive whitish "H" pattern on the top of the thorax of a PLH adult. And, of course, the location (new, succulent terminal growth) and type of damage (yellowing and "burn" as opposed to stippling) are also diagnostic.

PLH overwinter as adults in the South, and move northward in warm masses of air, usually beginning in June. They fall out when the warm air collides with cooler northern air. Eggs are laid in the veins and petioles of newly-developing foliage of a variety of plants. Nymphs feed on tender terminal leaves. There are two and possibly three generations of PLH here in the Northeast. Luckily, apple is not the most favored host of this insect. It was discovered in 1841, feeding on beans. By the late 1800's it had become a pest of potatoes, its preferred host. Other favored hosts include clover, alfalfa, and beets. Fortunately, most (but not all) PLH apparently leave apple trees after completing the first generation. By that time, the growth of terminal foliage in most orchards has hardened off to an extent where PLH prefer other plants having more succulent foliage. However, in plantings of young trees or on older trees producing vigorous mid- to late season growth, PLH can continue to be a problem until August.

The first evidence observed in 1987 of PLH on apple in Massachusetts was on July 8 in a Wilbraham orchard. Over the next few weeks, PLH continued to disperse into most locations in Massachusetts. In general, infestations have been heavier this year than they were last. To illustrate, in surveys during July in 18 orchards participating in the second-stage IPM program, we found about 10% of terminals of bearing trees in sprayed (control) blocks manifesting signs of PLH injury.

In most cases observed in 1987, PLH injury first appeared as a general off-coloration (partial yellowing) of new terminal growth. It was only after some weeks that the diagnostic "hopper burn," or yellowing of leaf margins, began to appear. In a few severe cases, particularly where trees were also stressed by drought, leaves later became curled and somewhat browned about the margins.

Since PLH has only been a sporadic pest on apple, the effects of this injury on affected trees are not well known. Because PLH inject a toxin into the plant, in many crops (such as potatoes) the threshold for these insects is very low. It is likely, however, that fruit trees, because of their size and the enormous amount of vegetative growth of which they are capable, can withstand considerably higher numbers of PLH. Until we know better, we have adopted a provisional threshold for PLH that is the same as that for white apple leafhopper, 25 leafhoppers or signs of feeding per 100 terminals observed.

PLH are extremely mobile, rendering monitoring and management decision-making difficult. For one thing, PLH will take flight at a fairly slight disturbance, so that moving terminals for examination may cause the leafhoppers to fly off. (According to researchers working with PLH, ovipositing females are much less easily disturbed than males. This fact may make it possible at least to determine whether the insects are still present, but difficult to assess actual population levels.)

It is also difficult to assess the susceptibility of potato leafhopper to insecticides. In 1986 in New York, where PLH infestation was more severe than it was in Massachusetts, PLH were observed on terminals in blocks which had been treated with organophosphate insecticides. This observation led tree fruit entomologists there to speculate that resistance had developed, but vegetable specialists raised the possibility that reinfestation had occurred in those blocks, and that no resistance was present. Vegetable specialists in both New York and Massachusetts note that PLH are highly dispersed over a wide geographic range and a variety of plant hosts, many of which are never exposed to pesticides. These factors would tend to inhibit the development of resistance in most cases.

Pesticide control results in Massachusetts in 1987 have been inconclusive, but we can state with confidence that we have not seen any sign of continued infestation of trees treated with organophosphate insecticides (OP's). In fact, in the one monitored orchard where an OP was used against PLH, infestation declined from 47% of terminals the week before treatment to 0% the week after. The reason that it is not possible to state definitely that this decline was due to the OP treatment is that similar declines also occurred in untreated orchards, over the same period of time, possibly because terminal growth was beginning to harden off and PLH were moving onto other hosts.

Based on the recommendations of vegetable specialists, and the fact that no obvious OP resistance has been noted on any crop in Massachusetts in 1987, we are proceeding with the assumption that PLH are indeed susceptible to OP's, including Imidan and Guthion.

Since it appears that potato leafhopper migration is determined primarily by prevailing weather conditions in the southern U.S., it is impossible to predict whether this insect will continue to be a problem on apples in Massachusetts. However, since such outbreaks have happened in the past, we hope to be armed with more information to handle the next one, whenever it may occur. We are involved currently with assessing injury levels in heavily-infested blocks in order to determine whether PLH injury affects premature drop, fruit size or color, or fruit set the following spring.

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ERRATUM

A Report of the 1986 Massachusetts Apple IPM Program

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In the article on the Apple IPM Program results published in the Spring issue of Fruit Notes [52(2):11-16], we neglected to acknowledge the contribution of the Regional Fruit Specialists, Jim Williams in particular, to the IPM program. In addition to being responsible for sending the twice-weekly Pest Alert Messages, the Regional Specialists have shared information gathered from their orchard visits with us. Jim also has done regular, weekly IPM scouting in at least one orchard for the past 4 seasons, and his assistance has been of great value to the IPM Program, allowing us to extend our monitoring to parts of the state which University-based scouts are unable to visit regularly. We regret having omitted Jim's name, as well as Dom Marini and Karen Hauschild, from the list of credits for all who have helped the program.

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REDFREE: A HIGH QUALITY, EARLY-SEASON, DISEASE-RESISTANT APPLE

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and

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Early season apples are often thought of as second-rate fruit, stop-gaps until the real show begins with McIntosh. Redfree may not change the attitude we have about McIntosh, but it may offer an excellent opportunity for high-quality, early-season fruit. The disease resistant planting at the Horticultural Research Center, Belchertown, MA, has two Redfree trees, both of which fruited heavily this year. The fruit were ready to pick August 10, making it harvestable at about the same time as Jersey Mac and approximately 1 week earlier than Paulared. When the fruit were harvested, most had approximately

65% red color with a green ground color, while approximately 10% had greater than 80% red color with a yellow-cream ground color. Later taste testing showed that the fruit with the cream ground color were too ripe, though they were sweeter (Table 1). The fruit with a greener background were more tart, similar to Empire. These greener fruit were judged as good, comparing well with any early-season fruit. The texture of the fruit was very good, and the fruit were firm (Table 1).

Table 1. Flesh firmness and percent soluble solids of Redfree divided into average and high-coloring lots and Jersey Mac. One group of Redfree fruit was kept at room temperature for 4 days prior to assessment.

Cultivar	Red color (%)	Time at room temp.	Flesh firmness (lbs)	Soluble Solids (%)
Redfree	82%	fresh	14.9	11.1
Redfree	63%	fresh	18.1	10.5
Jersey Mac	61%	fresh	15.5	10.2
Redfree	63%	4 days	17.4	10.3

Redfree comes from the Purdue-Rutgers-Illinois breeding program, and as such is resistant to apple scab, cedar apple rust, fire blight, and mildew. It may also be resistant to red mite. Among the named parents in Redfree's heritage are Rome Beauty, Jonathan, Red Rome, and Melba. It is an annual bearer. Some descriptions suggest that it may require two pickings, though if the fruit are harvested prior to peak color, this activity may not be necessary and quality may be higher. Redfree presently is available from The Nursery Corporation (Hilltop).

While the information we gathered this year is very preliminary, it looks like Redfree could be an excellent early-season apple, regardless of its disease-resistant characteristics. It is reported to keep for up to 2 months in refrigerated storage, and we found no serious loss of quality in 4 days at room temperature. However, it appears that the fruit should be harvested early rather than at or near full ripeness, since both taste quality and keeping quality are lower in the ripest fruit. When compared to Jersey Mac picked a few days earlier (Table 1), Redfree were sweeter but less juicy. Soluble solids and firmness were both somewhat higher in the Redfree. If this season is typical of Redfree's quality, then it could compete well with any of the popular early-season cultivars.

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EFFECTS OF FERTILIZATION ON APPLE QUALITY

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It is necessary to produce apples with high quality, and many orchard factors can affect quality. However, one of the most important and easiest to alter is nutrition. Below are presented some of the effects of fertilization on fruit quality.

Calcium

Initially, the concern about low fruit calcium was directed at bitter pit and cork spot, but today many other physiological disorders have been at least partly related to low calcium levels in the fruit. In warmer fruit growing areas cork spot and bitter pit remain the most serious effects of low calcium; but in cooler areas various forms of internal breakdown are the most serious calcium-deficiency problems.

Nitrogen

Excessive amounts of nitrogen in the tree and fruit can severely reduce fruit quality. The vigorous growth that nitrogen encourages results in a lower calcium level in the fruit. Moreover, the high nitrogen fruit tend to be larger, greener, and softer; are more subject to preharvest drop; and have more cork spot and bitter pit. These fruit also tend to develop greater amounts of scald, bitter pit, internal browning, and internal breakdown during and after storage.

Potassium

Potassium deficiency has only a mild effect on fruit quality, reducing the acidity of the fruit and reducing red coloration. Excessive amounts of potassium in fruit are a greater danger to fruit quality, since they lead to increased scald, bitter pit, and internal breakdown after storage.

Magnesium

There is little evidence that either too little or too much magnesium directly affects fruit quality. However, excess magnesium interferes with calcium just as does excess potassium, so excessive amounts of magnesium may produce calcium deficiency effects in fruit.

Phosphorus

Phosphorus deficiency can reduce tree growth and yield, and in several parts of the world it also has been shown to cause increased amounts of breakdown of apples during storage. However, in North America there has been very little evidence of phosphorus deficiency in fruit. We recently have found that high levels of phosphorus in apples, especially in combination with low levels of calcium, greatly increases breakdown of apples during storage.

Boron

Boron deficiency can cause internal and external cork development in fruit. Excessive levels of boron in fruit can cause earlier maturation, increased amounts of water core at harvest, and increased amounts of breakdown after storage. Thus, a moderate level of boron is important for good fruit quality.

Boron also influences calcium movement in the tree. If boron is deficient, less calcium moves to the fruit and calcium deficiency can result. It therefore is important to maintain adequate boron levels as part of a program to avoid calcium deficiency.

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POMOLOGICAL NOTE

Rabbits in Orchards

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Cottontail rabbits can be found throughout southern New England and often cause serious damage to young apple trees. Damage generally includes extensive bark removal and severe clipping of lateral shoots.

Habitat control is an effective population control measure. Overgrown ditches, brushy fence rows, and stone walls provide rabbits with excellent food and protection from predators. Elimination of these areas may be all that is needed for adequate rabbit control.

Trees can be protected from rabbits by hardware cloth (1/2" mesh) tree guards that extend 2' above the average snow depth. Orchard perimeter fencing or 1" or 1 1/2" mesh wire that extends 3' above the average snow depth is also effective.

Taste repellents are another effective method of reducing rabbit damage to orchards. Repellents containing Thiram have been effective when applied according to label directions. Other commercial products such as Hinder also provide effective control.

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CRANBERRY IPM IN MASSACHUSETTS — WHAT IT MEANS AND HOW IT WORKS

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In 1986 a record cranberry crop (1.8 million barrels) was produced in Massachusetts, where the total earnings reached approximately $90 million. This level is a 7 percent increase from the previous season, making the 1986 crop the largest in Massachusetts history and makes the state the leading cranberry producer in the U.S. for the third consecutive year. Cranberries are this state's most valuable agricultural commodity, accounting for 23 percent of the total cash receipts in 1985. The average per acre harvest is currently 149.3 barrels, an increase from 70.1 barrels in 1975. The price per barrel also has increased--from $13 in 1975 to $55 in 1985. This figure was between $52 and $54 in 1986. Ocean Spray Cranberries, which markets approximately 80% of the fruit sold in Massachusetts, increased its sales from $361 million in 1982 to $541 million in 1985 and expects to continue this trend.

Results of a pesticide survey conducted for pesticide-treated cranberry acreage in 1983, 1984, and 1985 indicated that greater than 60 percent of all pesticides used on cranberries in Massachusetts were insecticides. Evaluation of the period between 1981 and 1985 showed that the number of insecticide applications for bogs in Massachusetts increased by a factor of 1.6 in 1984; however, this figure decreased to 1.0 in 1985, making 1981 and 1985 equivalent in terms of the number of insecticide application. In all cranberry growing regions, parathion was the most widely used insecticide. It was used on at least three times as many acres as any of the other insecticides. A gradual decrease in the use of parathion in bogs has been noted and may be related to an increase in the use of Lorsban, an insecticide which only recently became registered for use on cranberries in Massachusetts.

Environmental contamination, hazards to human and other non-target organisms, increased monetary costs of pesticide applications, and the increased probability of resistance to pesticides demands that current and future research efforts focus on an integrated approach to pest management, emphasizing minimal use of chemical pesticides. Depressing the use of chemicals is particularly important in highly residential areas, such as southeastern Massachusetts, to help prevent environmental contamination. Pollution of aquifers is of particular importance. Additionally, the proximity of cranberry bogs to homes results in fear of pesticide drift on the part of homeowners. Recently, growers have been faced with public hearings on proposed bills requiring notice 60 days prior to pesticide application. There also have been hearings to ban all aerial applications in certain towns. Pressure from external sources is forcing growers to contemplate alternatives to the standard, prophylactic, calender application of pesticides, a spray schedule which has little or no regard for pest population levels.

Integrated pest management (IPM) means the judicious use of chemical control measures while taking full advantage of cultural, mechanical, and biological controls. With IPM, calender-based spray schedules are replaced by chemical controls which are based on sampling and monitoring pest populations.

By first determining when and at what quantities pests are present, we can time accurately chemical applications to coincide with damaging pest levels. The intent of IPM rarely is the elimination of pesticides. It usually means minimizing chemical use. The benefits of IPM are not only realized at the time of implementation of the program but are also long-term. Ecological, economic, and sociological concerns are paramount when considering development or implementation of an IPM program.

Integrated pest management gives maximum consideration to the fine ecological balances among all of the components of an agricultural system. Attention is paid to the life cycles of the pests and the extent of their interaction with the host plant. Host plant phenology, or the developmental stages of plants, are investigated extensively together with the pest and natural enemy life cycles.

In an IPM program, the decision whether or not to implement control measures is based upon economic threshold levels. These levels are the lowest pest population densities that will result in economic damage. Thus, it is important to monitor pest populations throughout the growing season so that control decisions can be made to prevent economic losses. It is also important that the cost of control does not exceed the marketable value of the commodity. Because pests and their population levels change during the course of the growing season, threshold levels may be different for different plant parts and at different times during the season.

Threshold levels are based on two types of pests: 1)direct pests - those which affect the marketable part of the plant, for example, the berries of a cranberry plant, and 2)indirect pests - those which attack the non-marketable parts, for example, leaves, stem, and roots. Because the fruit are the parts of cranberries which are marketed, the threshold levels for direct pests are extremely low, especially if the berries are sold for fresh-market purposes. Keep in mind, that the importance of attack on the different plant parts varies from crop to crop. In the case of ornamentals where the entire plant is used for aesthetic purposes, direct and indirect pests may be of equal importance from an economic standpoint and the need to control.

The Cranberry IPM program (1983 to 1985) successfully sparked grower interest in the concepts if IPM and demonstrated significant monetary savings. As growers become increasingly aware of the benefits of IPM, they tend to utilize information distributed via this program, regardless of whether of not they are formal participants in the program.

1986 and 1987 Scouting Program

Fifteen growers were involved in the cranberry IPM program in 1986. This figure more than doubled in 1987, with 33 participants. The total number of acres in the 1986 program was 208, increasing to 450 in 1987. The largest acreage contracted from an individual grower was 50 and the smallest was 0.58. All growers were visited in early May by the cranberry IPM coordinator to discuss specifics and procedures for the program. Also at this time, recommendations were made for spring weed control.

Bogs were scouted weekly by the IPM coordinator and summer scouts, from the beginning of May until September. This scouting involved monitoring insect pests with the use of sweep nets, pheromone traps. and vine and berry samples. Diseases and weed pests were also identified and monitored. Growers were notified via telephone or in person regarding the pest status of their bogs and recommendations for control. Copies of weekly reports were given to growers. In September, growers received graphs and reports for cranberry fruitworm and pests which were monitored with pheromone traps. Also in September, bogs were sampled for weed problems to aid in making spring and fall herbicide recommendations. Berry and vine samples were collected to determine end-of-season damage (particularly upright dieback, berry rot, cranberry fruitworm, and cranberry tipworm damage).

Insect monitoring is related to host plant phenology. The following pests are most prevalent in spring and early summer and are damaging to the vine uprights. They are leaf feeders; however, they are most destructive when they damage developing buds. Sampling with sweep nets (25 sweeps/acre) was conducted weekly, from mid-May through the end of bloom.

gypsy moth	blossom worm	black headed fireworm
Sparganothis fruitworm	cranberry sawfly	false armyworm
yellow headed fireworm	cranberry weevil	spanworms

The adult flight activity of the following pests were monitored with the aid of pheromone traps. Traps were set out in late May and were changed and counted weekly, until early to mid August.

cranberry girdler
Sparganothis fruitworm
blackheaded fireworm

Southern red mite is a potential pest throughout the growing season, although its populations are highest during the summer. It was monitored by collecting and inspecting 10 to 15 uprights/acre for eggs, immatures, adults, and damage. Large populations may also be seen during sweeping. Cranberry tipworm is a potential pest during most of the growing season, damaging the tips of uprights. Uprights were collected and inspected in the laboratory for the presence of eggs, larvae, pupae, and damage. Following the first two cranberry fruitworm sprays, which are timed depending on when the plant is 50% out-of-bloom, 50 berries/acre were collected every five to seven days and inspected for the presence of viable cranberry fruitworm eggs until there was no longer the danger that viable eggs were being deposited. The percentage of parasitized eggs was also determined at this time.

Just prior to harvest, 50 berries/acre and 10 vines/acre were collected and brought into the laboratory for inspection. Insect, disease, and mechanical damage were identified.

This article is intended to be an introduction to the Cranberry IPM program, some of the cranberry pests, and the procedures used during pest monitoring. More detailed results will be presented in future issues.

* * * * *

GROWTH REGULATORS IN ORCHARD MANAGEMENT

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Growth regulators are an important component of apple production. They are used more intensively on apples than on any other horticultural crop, and they can regulate important physiological processes, resulting in higher and more consistent yields of high-quality fruit. Growth regulators include hormones found naturally in the plant and similar synthetic compounds.

Chemical Thinning

The oldest, yet probably the most important, use of plant growth regulators remains in the area of chemical thinning. Apple trees frequently produce too many flowers, and if all flowers set fruit which develop to maturity, the fruit will be too small and flower bud formation for the crop the following year will be either reduced or eliminated. Chemical thinners can be applied from shortly after bloom until about 4 weeks afterwards. Weather conditions determine the exact length of time during which fruit can be thinned chemically.

Carbaryl is the mildest and safest thinning agent, but it should not be used at bloom time because it is especially toxic to honey bees. Some growers also are reluctant to use this compound because of its possible adverse effect on predator mites.

Naphthaleneacetic acid (NAA) is a more potent thinner and is used on the more difficult to thin cultivars and on those cultivars that have a particularly heavy bloom. Naphthaleneacetamide (NAAm or NAD) is milder than NAA and is used when NAA could cause injury or leaf dwarfing. NAD is not recommended for use on Delicious because of the possibility of producing many small, seedless fruit called "pygmies." Promalin™, applied with a surfactant, has some thinning ability when used to elongate Delicious. Spray combinations of carbaryl and NAA or NAD are becoming increasingly popular--especially where growers want to get increased thinning, yet reduce the possibility of overthinning or foliar damage seen with the higher rates of NAA or NAD.

Preharvest Drop

Daminozide (Alar-85™) is the most important compound used to control preharvest drop. It is most effective when applied near harvest, but label restrictions specify that it cannot be applied within 60 days of harvest. Since daminozide is less effective when application is made earlier in the season, it should be applied as close to harvest as the label will allow. Daminozide is under review by the EPA and its future registration status is in question.

NAA also retards preharvest drop. It becomes effective within one day of application, and it can control drop for 7 to 10 days. If needed a second application may be made. NAA has the negative effects of advancing ripening and causing fruit softening.

Advancing Fruit Ripening

Ethephon (Ethrel™) can advance the marketing season of most cultivars by increasing red color and advancing ripening. Also, it will accelerate fruit drop if applied alone. Therefore, this compound should either be applied with NAA or on trees that received daminozide earlier in the season. If temperatures are very high following application and the weather remains cloudy, sufficient red color may not develop on treated fruit until ripening is significantly advanced. Because of this potential problem, ethephon should be used on young trees, since light penetration is usually very good and fruit on these trees frequently is too large to have a long storage life. Ripening may advance rapidly on ethephon-treated trees. They should be watched very carefully so that harvesting can be done before excessive fruit drop occurs.

Growth Control and Flower Bud Formation

Frequently young trees grow too rapidly thus failing to flower and set fruit. Also, older trees may become too vigorous due to over-fertilization, excessive pruning, or the loss of a crop due to frost. Daminozide, ethephon, or a combination of daminozide and ethephon may be used to retard growth and increase flower bud formation. Treatments should be applied when terminal shoot growth is 4 to 6 inches long. Concentrations of ethephon high enough to reduce terminal growth will also cause excessive fruit thinning. Therefore, ethephon must not be used on trees where cropping is desired the year of application. Young trees should not be sprayed with daminozide and ethephon until they are large enough to bear a crop.

Water Sprout and Root Sucker Control

Water sprouts are vigorous, upright shoots arising from any portion of the above-ground part of a tree. They are most prevalent on vigorous trees carrying a light crop. Heavy pruning encourages water sprout growth. It is desirable to restrict growth of these shoots for two reasons: the shade they produce retards red color development, and removing them adds to the pruning costs. Tre-Hold Sprout Inhibitor A112™ (ethyl ester of NAA) is used to inhibit growth of these shoots. It usually is mixed with interior latex paint and applied to pruning cuts. The paint allows the applicator to see the treated areas, and the increased viscosity of the mixture reduces movement to nontarget areas of the limb. It is important that the inhibitor be applied during the dormant season, because volatilization of the NAA from applications made after the buds start to grow can cause some leaf epinasty and fruit thinning.

Root sucker control also may be achieved with Tre-Hold. Root suckers should be pruned during the dormant season and the regrowth treated with a Tre-Hold spray. Application should be delayed in the spring until four weeks after bloom to reduce the possibility of fruit thinning. Thorough coverage is essential for success. If there is tall grass or weeds on the orchard floor, it may be useful first to spray under the trees with a contact herbicide such as paraquat. Ten to fourteen days later, follow the herbicide application with the Tre-Hold treatment. Extreme care must be taken to prevent drift since the recommended rate of Tre-Hold is 500 to 1000 fold higher than the recommended rate of NAA for chemical thinning or drop control.

Lateral Branching

Many young trees, especially spur types, fail to branch adequately. This lack of branching can limit the ultimate productivity of the tree, because the allotted space will not be filled. To stimulate lateral branching, Promalin may be applied in the spring when terminal growth is 1 to 4 inches long. Only vigorous, healthy trees should be treated, since Promalin will not overcome a lack of branching due to poor growth. The high rate of Promalin should be used only on difficult-to-branch trees. High rates of Promalin on easily branched trees can stimulate too many lateral shoots, all of which will be too short to develop into good scaffold limbs. Promalin should be used only on nonbearing trees. because the rates required to stimulate lateral branching will thin the crop the year of application and inhibit flower bud formation for the following year.

Elongate Delicious

The Delicious grown in New England normally are not as elongated as those grown in the Pacific Northwest. To elongate Delicious fruit, Promalin may be applied when the king flower is open. Promalin can thin, especially if a surfactant is included and the highest rate of Promalin is applied (2 pts/acre). Promalin should not be used on young trees until they are old enough and ready to be chemically thinned.

* * * * *

POMOLOGY GROUP MOVES

In the middle of August three members of the pomology group of the Department of Plant & Soil Sciences at the University of Massachusetts moved from French Hall to Bowditch Hall. The new addresses and telephone numbers for Wesley Autio. William Bramlage, and Duane Greene are listed below. James Anderson, William Lord, and Franklin Southwick will remain in French Hall.

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ORCHARD MICE AND VOLES

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Mice and voles are closely related rodents that can be distinguished from each other on the basis of tail and ear size, among other minor differences. In New England, mice are not a problem in orchards. but two species of voles frequently cause serious damage. These pests are the meadow vole and the pine vole. Meadow voles range throughout New England, but pine voles are known to be present only from southern New England to southern Vermont, New Hampshire, and the southern tip of Maine.

Meadow voles inhabit the orchard floor, developing a network of surface trails through the groundcover and feeding primarily on grasses and fleshy herbs. This species usually does most of its damage during the winter when herbage is less abundant, but damage is possible at any time of the year. They chew away areas of bark and cambium that can be reached from the ground or from higher positions in or on snow cover. In some soils they will burrow and sometimes are responsible for trunk girdling several inches below the ground surface.

Pine voles travel either in surface trails or in burrows 3 or more feet deep depending somewhat on soil conditions. In solid grass sods, they may be almost totally subterranean; but where the groundcover contains a high percentage of broadleaf herbs, pine vole may travel on the surface. During the cold months, their activity is pretty much limited to the underground burrows. When herbage is abundant, pine voles store caches in the tunnel system for later use. They feed upon bark and cambium primarily below the soil line, and chew off small roots up to about the diameter of a pencil. All commercial apple cultivars and their seedlings, as well as the available rootstocks, are very susceptible to vole feeding.

Identification of Pest Species

When vole damage is apparent, it is important to determine which species is responsible. Some of the management practices used for meadow voles are not effective against pine voles. Identification of the species may require trapping. Use snap traps baited with rolled oats, or peanut butter, or a 50:50 mixture of these two. Fresh apple pieces are also a good bait. Place traps across active runs, including those that lead into underground burrows if they are present. Cover the trap with an apple box or a similar cover. This will exclude birds and cats and help you locate the trap trees in the orchard. Set enough traps to be sure of catching 5 to 10 voles from various locations in the orchard. Check the traps after only one or two days. Tail length is useful for identification. The pine vole tail is very short--about the same length as the hind foot (not the leg!), measuring 3/4 inch or less. The meadow vole's tail is about twice the length of its hind feet, reaching 1 1/2 to 1 3/4 inches on adults. Both species have chunky bodies and small beady eyes, and their ears are small and almost concealed in fur. The fur color is dark brown or gray-brown. If you catch a long-tailed specimen, it is likely to be a whitefooted mouse. This mouse's tail is well over 2 inches long, and all underparts of this mouse are covered with white fur. It is reported to eat the bark of young trees occasionally, but it is generally considered a non-pest species in orchards. Your traps may also catch a shrew, which is a beneficial small mammal, or a mole, which is neither harmful nor beneficial. A shrew can be identified by its long, pointed snout and its needle-pointed front teeth. Moles can be identified by their front feet, which are very large, with prominent digging claws.

Orchard Floor Management

Prevention of vole population build-ups offers the most practical method of reducing tree injury.

1. Mow orchard floor sod frequently during the growing season.

2. Maintain a vegetation-free area within at least 3 feet of the tree trunks. The use of herbicides may be necessary to accomplish this.

3. Eliminate brush and thick vegetative cover around orchard perimeters.

4. Completely remove all fruit drops from the orchard.

Tree Guards

Maintenance of proper tree guards is the most effective measure for preventing tree girdling by meadow voles, unless snow depth exceeds the height of the guard. Voles tunnel through snow to any depth. Also, trunk guards do not prevent underground damage by pine voles.

Galvanized hardware cloth is one of the best materials for tree guards. One-quarter-inch mesh in 24-inch width is preferred. The cloth is cut large enough to completely encircle the tree and allow enough room for 10 or more years of growth. The cloth is formed into a cylinder and fastened together so that no gaps are left through which the mice can gain entry. Two or 3 short pieces of wire may be necessary to secure the seam. The guards are embedded at least 2 inches into the soil to prevent the rodents from burrowing underneath. An annual check of the guards is recommended, preferably before the ground freezes. The disadvantages of hardware cloth are that it is difficult to work with and installation is time-consuming.

Several rigid, perforated polyethylene or plastic mesh products are being promoted for use as tree guards. Each is used in a way similar to that of galvanized hardware cloth to form a cylinder which is buried in the ground and is of large enough diameter to give free circulation to air and to allow for tree growth. These products are easier to handle than wire guards, but some may be broken down by ultraviolet light and may have a limited life.

Wrap-around plastic guards are readily available, cheap, and easy to install but are not recommended unless they are removed each spring and installed again in the fall. Various borers seem to prefer trees with wrap-around plastic or paper guards. Also, the bark beneath plastic guards remains tender and hardens slowly. the plastic may become brittle when weathered, and these guards are difficult to keep in place on trees with uneven trunks or swollen graft unions.

Paper wrap-around guards are not recommended. They must be tied off with string which can girdle the tree unless it is removed in the spring. Very high populations of bark borers have been found in trees protected with this material. The treated paper also weathers quickly, and the protected bark remains tender and hardens slowly.

Rodenticides

Poison baits are of two types: zinc phosphide and anti-coagulant. Just one or two fresh grains or pellets of zinc phosphide-treated bait can quickly kill the vole that eats it, whereas it may take several days of feeding on anti-coagulant baits to kill voles. Owing to the caching habit of pine voles, poison baits that are taken by the species may not be consumed until much later, or not at all. Zinc phosphide breaks down slowly in moist air, and it loses its toxicity rather quickly if the bait becomes wet. To preserve the toxicity of unused zinc phosphide baits, place the opened package within a plastic bag and seal the bag tightly.

Rodenticide Techniques

Broadcast. Broadcast applications of baits can be effective against meadow voles. However, they are usually not effective against pine voles. Bait should be directed into live ground cover where meadow voles forage, rather than into herbicide-treated strips. Most product labels limit treatments to the postharvest, dormant period. The presence of dropped apples can make baiting ineffective; however, as apples are a preferred food for voles. All sound drops should be removed before bait is broadcast. If the weather is wet and dark during the first few days after broadcasting, the baiting effort will have been wasted. Wet weather and dark days discourage vole activity, and wet bait loses potency and palatability. Try to bait just before a mild, fair-weather period of several days.

Baiting in Artificial Trails. Mechanical trail-builder baiting machines construct trails beneath the soil surface and supply baits at regular intervals for meadow or pine voles that enter those trails. According to the U.S. Fish and Wildlife Service, which can furnish plans to construct the device, this technique can be effective against both pine and meadow voles. Sod cover and reasonably moist soil are required at the time the machine is pulled through the orchard. Generally, one trail is made along each side of the tree rows, beyond the wheel tracks, beneath the drip line of the trees, and in sod. Trails should be cut 2 to 4 inches deep, with bait placed at 4- to 5-foot intervals.

Hand-baiting. Hand-baiting implies selective placement of baits where vole activity is most likely or where active trails or burrows are located. Bait is placed in quantities of one teaspoon, at the rate of 2 to 3 lbs per acre. To greatly speed bait placement, bait stations such as asphalt roofing shingles or split tires should be distributed beneath the trees in sodded areas well in advance of baiting time. Over a period of weeks or months voles develop trails under these bait stations--trails that can be baited quickly after harvest.

Orchard Floor Sprays. Liquid Rozol™ (chlorphacinone) is an anticoagulant formulated for spray application. In order for it to be effective, it must thoroughly wet and penetrate the ground cover. Before the spray is applied, the ground cover should be dry and mown short enough for maximum penetration. Voles are killed after repeated exposure to residues on the ground and cover crop. Liquid Rozol will not be effective when there is no surface-feeding activity.

Estimating Vole Activity

Vole activity can be estimated by placing apples in runways or tunnel entrances. Place whole, firm apples, with a thin slice removed, at regular intervals throughout the orchard where activity is suspected. After 24 hours, look for small teeth marks in the apples. If such a check indicates voles are present 2 to 3 weeks following a baiting, a second treatment may be needed.

Re-treatment with Baits

Where some voles have been sickened by a rodenticide treatment but have survived, the acceptance of the same bait a second time within a few weeks will be poor. This problem seems to be more common with zinc phosphide baits than with anticoagulants. If a second treatment is needed, use a different bait (e.g., if zinc phosphide was used in the earlier treatment, use an anticoagulant for the follow-up). Obviously, the best way to deal with this problem is to prevent it from occurring: do everything possible to kill all of the voles with the first treatment.

Orchard Borders

In the brushy areas immediately adjacent to a vole-infested orchard, one can generally find a relatively high population of the same species that is present in the orchard. If these border areas are not baited, they will be a source of reinfestation of the treated orchard.

Caution

Rodenticide baits may be attractive to domestic pets, wild birds. and other nontarget wildlife. Exposed bait, and especially exposed piled bait, increases the chances of nontarget injury. As with all pesticides, use good judgment and take reasonable precautions to avoid problems.

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Fruit Notes

Prepared by the Department of Plant & Soil Sciences

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties cooperating.

Editors: Wesley R. Autio and William J. Bramlage

Volume 53, Number 1
WINTER ISSUE, 1988

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APPLE SCALD, A COMPLEX PROBLEM

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Symptoms. "Scald" is a term loosely applied to a group of skin disorders of apples and pears. It involves brown or gray discoloration of irregularly shaped areas on the surface of the fruit during or following storage. On apples, Wilkinson and Fidler (5) described the following forms of scald:

a. *"Rugose scald"*: skin initially develops a faint bronze color, but later these areas turn light brown to very dark brown. The surface layers of cells are dead and so they dry out and collapse, leaving a brown, sunken appearance. Usually, many lenticels remain green, however, standing out prominently from the sunken areas.

b. *"Browning scald"*: the lenticels do not remain green, the injury progressively invades deeper into the flesh, and areas often slough off because they remain moist.

c. *"Lenticel spot scald"*: the injury is predominantly around the lenticels, so that it appears as a spotting rather than a blotchy disorder.

d. *"Stem-end browning"*: the injury is primarily on the shoulder, radiating from the stem-end cavity, which remains relatively free of the disorder.

It appears that all of these forms are expressions of the same problem, with specific cultivars being more prone to one form or another. However, there are many other forms of fruit injury that also may cause skin damage that is similar to one of these forms of scald. For example, we have noted frequently a large amount of lenticel spotting after storage which is clearly the result of field treatments, presumably pesticides, even though there was no evidence of damage at harvest. This spotting could easily be mistaken for "lenticel scald". Especially on McIntosh, we often see "black scald", a clearly defined black area almost always occurring on the red side of the fruit. This injury is actually a form of sun scald, even though it usually is not present at harvest, and could be confused with "browning scald". With very ripe fruit, friction damage can cause injury that could be confused with either "browning scald" or "stem-end browning". On pears, "scald" is often a symptom of over-storage. Thus, there is often much confusion about what is being called "scald".

Nature of scald. True scald is an expression of damage and death within the surface layers of cells in localized regions. It never occurs on the tree, only after relatively long periods of storage. Its development is believed to be divided into four stages: 1. The first 6 to 8 weeks after harvest, when changes occur in the fruit that create the potential for scald development, although scald does not yet occur; 2. The next 5 to 8 weeks when changes continue so that scald can no longer be prevented although it still has not appeared; 3. The remainder of storage, when scald may slowly appear; 4. Post-storage, when scald rapidly develops. Thus, the first 6 to 8 weeks after harvest are crucial for applying scald control measures, and post-storage conditions can determine how extensively the scald symptoms will appear. For example, we have noted much more scald under humid post-harvest conditions than under dry ones.

An outstanding series of research papers in the late 1960's and early 1970's, mostly from Australia, established much of what we know about the chemistry of scald development. It was shown that early in storage fruit accumulate a chemical called alpha-farnesene; being a volatile compound, much of it can evaporate from the fruit. As storage time lengthens the alpha-farnesene is oxidized to a group of compounds called conjugated trienes, which do not evaporate and continue to accumulate as long as the fruit are kept in storage. These conjugated trienes apparently are toxic to the cells, damaging them and eventually causing their death, which is accompanied by their brown or black discoloration, drying out, and collapse. Since most of the alpha-farnesene is found in the fruit peel, most of the conjugated trienes are made in the peel, and therefore these are the cells that are killed.

Factors affecting scald. Different cultivars vary greatly in scald susceptibility. For example, Cortland is extremely susceptible and nearly was abandoned until effective scald-control methods were developed. On the other hand, Golden Delicious has very low susceptibility. The huge increase in production of Granny Smith worldwide has intensified concern about scald, since this cultivar is extremely scald susceptible.

Susceptibility of a given cultivar is not constant, however. It is widely recognized that immature fruit tend to be more susceptible than over mature ones. Although this relationship is not invariably true, it is strong enough that growers should be much more concerned about scald on early-picked than on late-picked fruit.

Color is another important factor. Scald is more likely to occur on a green area than on a well-colored area of the fruit. This relationship is probably indirect; good exposure to sun is probably what reduces scald susceptibility, rather than red pigments. Thus, the production of red strains of susceptible cultivars largely obscures the fact that shaded areas and shaded fruit are more susceptible than exposed areas and exposed fruit. Excessive tree vigor and inadequate pruning (hence, fruit shading) probably increase scald susceptibility, while summer pruning probably decreases it.

Scald susceptibility varies considerably from year to year for a given cultivar. To a large extent this variability is the result of the influence of weather on scald susceptibility. Studies in England (2) showed that weather conditions from late July to the beginning of September were very important: hot, dry weather increased scald susceptibility; cool, damp weather decreased it. Indications were that water stress may have been more important than temperature in this relationship. Studies in New Jersey (3) showed that hot weather shortly before harvest increased scald susceptibility; when Stayman Winesap apples had experienced 190 or more hours of temperatures below 50^{o}F they did not develop scald, but as this total dropped scald susceptibility increased. Thus, a cool moist August and a cool harvest season should greatly reduce scald susceptibility; whereas, a hot dry August and a hot September should increase it. How these two periods interact is not clear. For example, 1987 had a hot dry August but a cool September. Is one of these situations more important than the other?

Control measures. Numerous approaches to controlling scald have been developed, since losses to the disorder can be devastating. Early approaches recognized that scald was caused by a volatile compound and were aimed at maximizing evaporation of the compound from the fruit during storage. These techniques included use of air purifiers in the storage, storage ventilation, and paper wraps that were impregnated with mineral oil. These techniques reduced the amounts of scald that developed, but did not control it.

CA storage greatly reduces scald. Both low O_2 and high CO_2 can be effective. However, since CO_2 is most effective at concentrations above 5% and most cultivars are susceptible to CO_2 injury above 5%, for most cultivars the greatest benefit from CA is from the low O_2. The low O_2 impedes oxidation of alpha farnesene to conjugated trienes, the toxic materials. This effect is much greater at 1 to 2% O_2 than at 3% O_2, and many researchers have shown that scald can be nearly completely controlled at 1 to 1.5% O_2. However, in the Northeast we have generally been unable to store fruit at less than 3% O_2, so we are unable to take full advantage of the scald control from CA. At our recommended CA conditions, scald is still a potential problem.

An important factor in scald control through CA is rapidity with which CA conditions are established. Delayed sealing or slow generation of an atmosphere can greatly increase the risk of scald development after storage. Rapid CA is an excellent scald control measure, especially where O_2 cannot be reduced below 3%.

Ethylene-scrubbing during CA storage can also control scald. In England, scald virtually was eliminated from fruit taken from a commercial ethylene-scrubbed storage (1). However, the feasibility of ethylene scrubbing in commercial storage for most cultivars is doubtful, so this method seems to have limited application.

The most reliable scald-control measure is probably the use of the antioxidant chemicals diphenylamine (DPA) and ethoxyquin. In the mid-1950's Smock (4) found that these materials provided excellent control of scald, and following their approval by the Food and Drug Administration they became standard commercial treatments as postharvest dips for fruit destined for long-term storage. These materials interfere with the oxidation of alpha farnesene to conjugated trienes, as does low O_2 in a CA atmosphere.

Use of antioxidants is not without its problems. The materials must be used with care, since excessive dosage can cause severe fruit injury. Even use at recommended dosage often leads to injury due to entrapment of solution in cavities, between fruit, or in wooden containers. As this trapped solution evaporates, the antioxidant concentrates to injurious levels. There is also concern about the risks to consumers from residual antioxidants; since these materials are volatile, little or no residue should persist at the end of storage if the material is used properly. However, these materials have not been approved in some countries, so treated fruit cannot be exported to such countries.

Current directions. During the past 3 years we have been conducting extensive studies on scald. Our goal is to reduce dependence on the antioxidant chemicals for control. Current recommendations are generally based on a "worse-case scenario," since growers simply cannot risk scald development. However, as is described above scald susceptibility is extremely variable and maximum treatment is often (usually?) not necessary. If we can better quantify the factors affecting scald, we should be able to quantify the potential for scald and adjust the recommended treatment to the actual need. One approach to this is through careful collection of climatological data in relation to scald development. A cooperative study involving a number of fruit researchers and directed by Dr. David Blanpied at Cornell University is in progress. We are attempting a different approach: a search for a chemical index of scald susceptibility in the fruit that might signal the need (or lack thereof) for chemical treatments at the time of harvest.

Scald was probably the single most important postharvest problem for apples until antioxidant chemicals were approved. For 20 years after approval little further attention was given to this problem. Now interest is renewed, largely due to the need to reduce the use of chemicals wherever possible. Growers can expect to hear much more about scald control measures in coming years.

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CAN M.9 ROOTSTOCKS BE USED PROFITABLY IN MASSACHUSETTS APPLE ORCHARDS?

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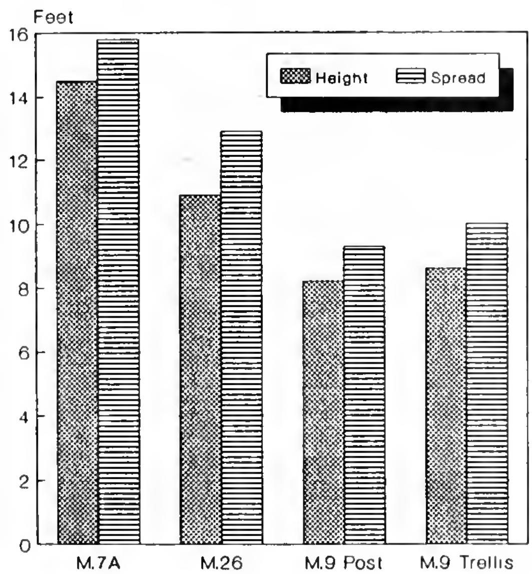
The title of *New York Agricultural Experiment Station Bulletin* No. 406 (1915) is "Dwarf Apples Not Commercially Promising." The opinions expressed in that publication certainly do not reflect those held by the current researchers at the New York Agricultural Experiment Station, Geneva; however, there is still much resistance among growers to the idea of planting fully dwarfed apple trees. In this article data will be presented that show that fully dwarfed trees on M.9 can be substantially more profitable than the much larger trees on M.7, particularly during the early fruiting years.

Figure 1
Size of Rogers McIntosh trees planted in 1979.



M.9 was one of the earliest dwarfing rootstocks available. It was selected as a chance seedling in France in 1879 (2) and produces a tree only 25 to 50 % of the size of a standard, seedling-rooted tree. A number of dwarfing rootstocks which produce a tree similar in size to that produced by M.9 now are being evaluated and some are available, but M.9 still is used more extensively worldwide than any other very dwarfing rootstock (2). In the U. S. the strain of M.9 which is most commonly available is M.9 EMLA. It was originally propagated from a virus-free strain produced by the cooperation of East Malling and Long Ashton Research Stations in England, hence the EMLA designation. A tree on M.9 EMLA is somewhat more vigorous than one on standard M.9. In this study the size, productivity, and profitability of trees on M.9, M.26, and M.7 were compared.

Table 1. Trunk circumference in 1987, calculated tree density, and approximate spacing of Rogers McIntosh trees planted in 1979.

Rootstock	Trunk circum. (cm)	Calculated density (trees/acre)*	Approx. spacing (ft)
M.7A	43.2 a**	101	17 x 25
M.26	30.3 b	145	14 x 22
M.9 Post	19.7 c	277	9 x 17
M.9 Trellis	19.7 c	277	10 x 16

*Calculated from 1987 tree spreads (Figure 1).
**Means within columns are significantly different if not followed by the same letter.

In 1979 a replicated planting of Rogers McIntosh and Macspur trees on M.7A, M.26, and M.9 was established by Dr. Franklin W. Southwick at the Horticultural Research Center, Belchertown, MA. Half of the trees on M.9 were trained to individual posts and half were trained to simple, 3-wire trellises. At the end of the 1987 growing season (ninth leaf) trees were nearing their mature size. Figure 1 depicts the height and spread of the Rogers McIntosh trees, and Table 1 reports trunk circumferences. As would be expected, trees on M.7A were the

Table 2. Yield per acre from Rogers McIntosh trees and the percent of fruit making the U. S. Extra Fancy grade in 1987 from Rogers McIntosh and Macspur trees planted in 1979.

Rootstock	Yield per acre (bu) in year: 4	5	6	7	8	9	Total	U.S. Extra Fancy-1987 (%)
M.7A	67 b*	147 b	163 b	385 c	152 b	388 b	1302 c	30 b
M.26	84 b	183 b	168 b	426 bc	165 b	441 b	1467 c	55 a
M.9 Post	147 a	217 a	294 b	512 ab	202 b	667 a	2039 b	59 a
M.9 Trellis	180 a	307 a	463 a	548 a	335 a	669 a	2502 a	50 a

*Means within a column are significantly different if not followed by the same letter.

largest, reaching nearly 15 ft in height, and trees on M.9 were the smallest, not reaching 9 ft. The 1987 tree spreads were used to calculate tree densities and spacings (Table 1) so that potential yields per acre could be estimated. Please note that these densities represent optimal spacings for this planting site, and those used by growers should be adjusted as to cultivar, site, and soil conditions.

Table 2 shows yields from years 4 through 9. Each year the trees on M.9 produced more fruit than those on M.7A or M.26. Additionally, in later years and on a cumulative basis trees trained to trellises yielded more than those trained to individual posts. This observation is likely related to a higher fruiting surface per acre because of the support given to limbs by the trellis. Also in Table 2 are reported the percent of fruit making the U. S. Extra Fancy grade in 1987. These percentages are particularly low because harvest occurred prior to optimum coloring (September 8). Trees on M.9, both posted and trellised, and M.26 had similar percentages but all had significantly more Extra Fancy fruit than those on M.7A. These smaller trees were more open and allowed more light penetration and coloring than did the more vigorous trees on M.7A.

Higher yields and better potential packout suggest that there are significant advantages to planting trees that have been budded to M.9. However, this information is not adequate to recommend M.9 over the other rootstocks, since the costs of producing apples on fully dwarfed trees exceeds those of growing larger trees. Therefore, it is necessary to look more closely at the costs of production for trees on these rootstocks and compare that information with the potential monetary returns.

Table 3. Estimated per-acre establishment costs of a McIntosh orchard on M.7, M.26, and M.9 rootstocks.

Activity	M.7	M.26	M.9 Post	M.9 Trel.
Site prep.*	700	700	700	700
Layout	20	30	60	60
Trees	500	725	1400	1400
Planting*	125	175	350	350
Posting*	0	300	600	0
Trellising*	0	0	0	1200
TOTAL	1345	1930	3110	3710

*Includes cost of supplies, labor, and equipment.

Cost data presented in this article are estimates based on information from several sources, including observations at the Horticultural Research Center and published data from Cummins and Norton (1), Gerling (3, 4), Hanlon et al. (5), Kimball and Autio (6), and Norton (7). Plantings of trees on M.9 cost significantly more to establish than plantings on

M.7. Table 3 shows estimated establishment costs. The more dwarfing rootstocks required a higher tree cost, since more trees were planted per acre. They required more labor in layout and planting. Also, the cost of posting or establishing a trellis was quite high and neither is required for trees on M.7.

Table 4. Itemized per-acre costs of growing McIntosh trees during their second season.

Activity	M.7	M.26	M.9 Post	M.9 Trel.
Labor				
Pruning	40	40	40	40
Training	0	25	50	150
Spraying	35	45	60	60
Other	50	50	50	50
Equipment	150	200	250	250
Chemicals	140	140	140	140
Other	20	20	20	20
TOTAL	435	520	610	710

Table 5. Itemized per-acre costs of growing McIntosh trees during their ninth season.

Activity	M.7	M.26	M.9 Post	M.9 Trel.
Labor				
Pruning	195	130	65	65
Training	0	0	40	100
Spraying	45	70	90	90
Other	35	35	35	35
Equipment	250	300	450	450
Pesticides	250	200	150	150
Fertilizers	50	50	50	50
Other	20	20	20	20
TOTAL	845	805	900	960

Growing costs differed as the trees on the different rootstocks matured. Tables 4 and 5 itemize the growing costs for the second and ninth growing seasons, respectively, to illustrate differences in the costs of maintaining nonbearing and bearing trees on these rootstocks. Table 6 gives the individual and cumulative costs for 9 years for each rootstock. The major differences among rootstocks related to training requirements, with the trellised trees requiring significantly more labor to maintain. Also, equipment usage was higher with the dwarfed trees because of the greater number of rows per acre to travel. The amount of spray material required was considerably lower for trees on M.9 because of the lower tree volume per acre. Additionally, the pruning time was less for the small trees.

Table 6. Estimated per-acre cost of growing McIntosh trees during years 1 through 9.

Year	M.7	M.26	M.9 Post	M.9 Trel.
Year 1	400	450	500	600
Year 2	435	520	610	710
Year 3	520	600	700	800
Year 4	600	630	750	900
Year 5	650	670	800	920
Year 6	720	710	880	940
Year 7	800	760	880	950
Year 8	840	800	890	950
Year 9	845	805	900	960
TOTAL	5810	5945	6910	7730

The costs of trees on M.9 trained to posts and M.9 trained on trellis, including establishment, growing, and harvesting (Table 7), were 36% and 57%, respectively, greater than for trees on M.7. However, the returns (Table 7), accounting for yield differences and some variation in packout during the later seasons when the trees were larger, were 60% and 96% greater than for M.7 The net profit for the first 9 years (Table 7) was $405 per acre for trees on M.7 and $4780 for trees on M.9 trained to a trellis.

These data suggest that during the early fruiting years McIntosh trees on M.9 are considerably more profitable than those on M.7. As these trees reach full maturity the

Table 7. Total per-acre costs and returns from McIntosh trees during their first 9 growing seasons.

Activity	M.7	M.26	M.9 Post	M.9 Trel.
COSTS:				
Establishment	1345	1930	3110	3710
Growing	5810	5945	6910	7730
Harvesting*	2900	3100	3700	4300
Total	10055	10975	13720	15740
RETURNS:**	10460	12030	16720	20520
NET:	405	1055	3000	4780

*Based on a fixed per-acre cost related to equipment, picker housing, picker travel, etc. plus a per-bushel cost related to harvesting.
**Based on yields reported in Table 2.

differences in yield and maintenance costs may decline; however, the differences in packout may increase. Rough estimates comparing the costs and returns for the first 20 years of the planting suggest that trees on M.9 trained to a trellis can net $10,000 per acre more than trees on M.7, accounting for differences in training, spraying, yield, and packout. It is important to note that the cost estimates used in this study could vary greatly from those for an individual farm, but they give a basis for some comparison of these rootstocks.

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NINE YEARS OF APPLE IPM IMPLEMENTATION AT THE HORTICULTURAL RESEARCH CENTER

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Commercial fruit grower adoption of IPM is well established in a majority of Massachusetts orchards (*Fruit Notes* 51(2):11-16; 51(3):19-25), and such orchards represent a change from pre-IPM pest management -- a single-minded focus on chemical pest controls -- to a more holistic IPM approach integrating techniques, and disciplines of pest management. In the 1987 *March Message*, we described a range of characteristics which we believe represent a typical "first-stage" IPM orchard. In addition, we have published results (*Can. Ent.* 117:581-585,1985) from Prokopy's Conway orchard of 50 disease-resistant apple trees that show reduced pesticide use even below first-stage IPM levels.

Since most commercial orchards will not contain primarily resistant cultivars for the foreseeable future, we believe it is important to demonstrate "how low one can go" with pesticide use in first-stage IPM blocks which contain the usual commercial apple mix, without sacrificing fruit quality or quantity. Consequently, we think growers would be interested in data we have collected in a test orchard that used first-stage IPM practices for a number of years.

This article presents the results of 9 years of IPM implementation at the Horticultural Research Center (HRC), Belchertown, MA. Although the HRC is operated in most respects like a typical commercial orchard, it allows us to test new approaches to pest management and be somewhat less risk-aversive than growers whose livelihood depends on successful pest management year after year.

Since 1979, the authors have cooperated to implement a minimum-spray program in Block C at the HRC, a 2-acre interior block, west of Sabin Street and just north of the cold storage building. Composed of mostly Delicious strains on M.7 rootstocks, with a few McIntosh mixed in, trees are well pruned and fertilized.

Because of the demands of other research being conducted in Block C, fungicide programs in the early years were moderately conservative, but insect and mite sprays were applied only if justified by observations or trap captures in excess of economic thresholds. Over the past 3 seasons, the effort to reduce fungicide in the block has been intensified, and has consistently included pre-application consultations. Where pesticide labels allowed a range of rates (e.g., 4 to 6 oz/100 gal), we used the low end of the range, or lower. Anthony Rossi, the orchard foreman, received weekly scouting reports and sometimes recommendations. Final spray decisions were always his, although he followed IPM guidelines very closely. Wherever practical, sprays were avoided deliberately, and we attempted to avoid the use of predator-harsh pesticides (e.g. pyrethroids, carbamates, etc.) as a matter of course. When sprays were applied, few were at full, labeled rates. Sprays were applied with well-calibrated airblast sprayers and whenever possible at the same time that the rest of the orchard was being covered. Each year, we performed harvest surveys and examined closely 800 to 1000 fruit on the trees.

<u>Pesticide use</u>. On average, 2.9 dosage equivalents (DE) of insecticide, 1.0 DE oil, 1.3 DE miticide, 6.0 DE fungicide, and 0.1 DE aphicide were applied (Table 1). Insecticide, miticide, and fungicide use were all below statewide IPM averages (*Fruit Notes* 52(3):9-12). For reasons that are unclear, the HRC has never had a problem with apple leafminers, although

Table 1. Number of spray applications (A) and dosage equivalents (DE) of pesticide used in Block C, University of Massachusetts Horticultural Research Center, 1979-87.

Year		Insecticide	Oil	Miticide	Fungicide	Aphicide	Total DE
1979	-A	3.0	1.0	2.0	9.0	0	
	-DE	2.3	1.0	1.2	4.5	0	9.0
1980	-A	5.0	1.0	2.0	9.0	0	
	-DE	3.0	1.3	0.8	4.8	0	9.9
1981	-A	3.0	1.0	3.0	8.0	0	
	-DE	1.6	1.0	1.2	5.6	0	9.4
1982	-A	4.0	1.0	2.0	8.0	0	
	-DE	2.8	1.0	2.0	5.6	0	11.6
1983	-A	2.0	1.0	2.0	11.0	0	
	-DE	0.8	1.0	0.8	7.7	0	10.3
1984	-A	3.0	1.0	3.0	11.0	1*	
	-DE	1.6	1.0	1.8	9.1	1	14.5
1985	-A	2.0	1.0	2.0	7.0	0	
	-DE	2.0	1.0	1.5	4.7	0	9.2
1986	-A	2.0	1.0	2.0	8.0	0	
	-DE	1.6	1.0	0.8	7.2	0	10.6
1987	-A	5.0	1.0	2.0	6.0	0	
	-DE	4.1	1.0	1.8	5.0	0	11.9
9-Year Average							
	-A	3.2	1.0	2.4	8.5	0.1	
	-DE	2.9	1.0	1.3	6.0	0.1	10.7

*Endosulfan used against green aphids but timed to coincide with first summer generation LM adult flight.

they are present in the orchard (most noticeably in the third generation) and a nearby orchard has experienced severe leafminer outbreaks and injury. Fortunately, this pest has never exceeded action thresholds, and no carbamate or pyrethroid insecticide has been used in Block C.

In addition to helping keep insecticide DE below state IPM averages, the absence of predator-harsh pesticide also has made mite control relatively easy in this block, even though Red Delicious predominate. The occasional late outbreak of ERM, and resulting egglaying, do not appear to be something that annual oil applications (Table 1), endemic mite predators, and split applications of low miticide rates cannot handle.

Only in one year was any pre-bloom insecticide applied against TPB. Typically, the first insecticide was applied at petal fall against sawfly and curculio. An average of 1.6 spray applications (range 1-2) were directed against curculio. It seems clear that in some blocks at least the 3, 4, or even 5 insecticide applications some growers use against PC are not required.

A likely contributing factor to the relative ease of mite control in Block C is the relatively low number of spray applications (avg. 1.6, range 1-3) used against AMF. In over half of the years (57%), first capture of AMF on red sphere traps was late enough, and trap captures low enough, to enable excellent AMF control with only 1 well-timed spray. Only once were 3 sprays needed, based on monitoring.

As mentioned above, the fungicide program in Block C was moderately conservative and, although partly based on hygrothermograph and weather monitoring and spore maturity determination, likely could be improved upon. Fungicide use in Block C largely was driven by a perception that the cost:benefit ratio for fungicide use was low. To eliminate the perceived risk, fungicides were often applied with insecticides and oil sprays. From a high of 11 applications and over 9 DE in 1984, fungicide use was reduced in 1987 to the fewest number of spray applications (6) and the third fewest number of DE (5.0) since we began record-keeping in 1979. This situation was at least partly due to the incorporation of a new sterol-inhibiting (SI) fungicide into the program.

Aphicide use in Block C was essentially nil, with predators providing control in most years. If needed, Anthony Rossi has been able to coordinate application of endosulfan against aphids and first summer generation adult leafminers.

Harvest survey results (Table 2). Levels of pest injury in Block C were well within acceptable ranges for commercial orchards in spite of the much lower than average pesticide program.

As noted in Table 2, disease injury in all years was negligible, reflecting a consistently successful fungicide program even when less than full rates were used.

Tarnished plant bug was the most frequent injury found in samples. A high infestation in 1983 drove average injury up to 2.4%. However, most of the 1983 injury was of the severity and type that would not have affected fruit grade. In 1983, plum curculio injury reached 1.6%.

In two years, we experienced late season mite buildup. Red mite eggs in the fruit calyx were observed, although this "injury" is not considered serious by most growers and again should have no effect on grade.

Table 2. On-tree harvest surveys: percent insect, mite, and disease injury, Horticultural Research Center, 1979-87.

Year	TPB*	PC	EAS	AMF	Other insects	ERM eggs**	BER	SCAB	FS
1979	0.8	0	0	0	0	0	0.2	0.1	3.0
1980	1.8	0.3	0.4	0	0	0	-***	-	-
1981	0.2	0	0	0	0	3.7	0.2	0.2	0
1982	1.0	0.3	1.0	0	0	0	0	0	0
1983	11.5	1.6	0	0	0	0	0	0	0
1984	0.2	0	0	0	0	3.7	0.2	0.2	0
1985	1.5	0	0	0	0	0	0.5	0	0
1986	-	-	-	-	-	-	-	-	-
1987	0.3	0.1	0.1	0	0	0	0	0.1	0.1
9 Year Average	2.1	0.3	0.2	0	0	0.9	0.1	0.1	0.4

(Average Injury 4.1%)

*TPB, tarnished plant bug; PC, plum curculio; EAS, European apple sawfly; AMF, apple maggot fly; ERM, European red mite; BER, blossom end rot; SCAB, apple scab; FS, fly speck.
**Eggs in calyx of fruit at harvest.
***Data not available.

Table 3. Cost per acre of spray materials, Block C, Horticultural Research Center, 1980-87*.

Year	Insecticide	Oil	Miticide	Fungicide	Aphicide	Total yearly cost
1980	$34.55	$25.94	$18.50	$48.91	0	$127.90
1981	$14.48	$26.16	$24.98	$48.73	0	$114.35
1982	$38.29	$21.60	$43.80	$67.96	0	$171.65
1983	$ 9.24	$21.60	$18.24	$72.67	0	$121.75
1984	$18.50	$21.60	$41.04	$82.01	$41.04	$204.19
1985	$18.48	$21.00	$40.77	$46.47	0	$126.72
1986	$18.50	$21.60	$18.24	$67.96	0	$126.30
1987	$43.61	$21.60	$27.51	$50.87	0	$143.59
8 Year Average	$24.46	$22.64	$29.14	$60.70	$5.13	$142.06

*Based on 300 gal/acre dilute base and non-discounted chemical costs.

It is interesting to note that although apple maggot flies were caught in the block, no AMF injury was ever detected. In the case of mobile pests like the AMF, which normally do not establish resident populations in sprayed blocks, orchard edges typically experience more pest pressure than interiors. We have looked at hundreds of fruit in Block C over the years, and we have never seen a single fruit damaged by apple maggot egglaying. While it is true that Block C is an interior block, this points out the possibility that growers may be applying more insecticide than is needed in similar blocks elsewhere. The protection afforded interior blocks such as Block C by sprays applied to surrounding sprayed blocks may allow some growers to achieve significant decreases in pesticides required for acceptable pest control.

<u>Pesticide costs and potential for further reduction</u> (Table 3). By better using spore maturity and weather monitoring and by including SI fungicides against apple scab, we believe that fungicide costs can be reduced further. This past year, Rubigan™ allowed longer spray intervals between applications during frequent wetting. It also gave us the confidence to wait until after an infection period had occurred before making an application. Additionally, information was available from both a Reuter-Stokes scab predictor and a modified hygrothermograph. Having reliable weather information and a fungicide with 96 hours post-infection activity reduced the perceived risk.

Without large-scale use of red sphere AMF traps, it is unlikely that further significant reductions in insecticide use can be achieved, so that little additional cost saving compared to pre-IPM levels is expected. However, simply reducing the total pesticide load in an orchard should enhance the survival of mite predators and reduce the difficulty of mite pest management. Because of the importance of spider mite pests, oil is an essential component of apple IPM, and will remain a more or less fixed cost. Of course, fluctuations in the price of oil could significantly increase the cost of annual treatment, as in 1980-81. The use of mite predator releases in the future may provide a way to apply oil only every 2 or 3 years, and hence reduce the cost of this material.

The cost of aphicide would not be expected to increase in low-spray blocks, due to enhanced survival of aphid predators. Proper tree pruning and fertilization will help deter aphid buildup beyond economic thresholds. However, occasional outbreaks (rosy aphid) could require aphicide use.

Conclusions. From our experience at the HRC, we conclude that it is possible, using first-stage IPM strategies and technologies, for some commercial growers to further reduce amounts of pesticide used, and consequently, reduce costs (at least in certain interior blocks) without sacrificing fruit quality. We urge growers to consider a scouting/low-spray approach in a trial block so that they can achieve the lowest possible spray usage from first-stage IPM. As growers move beyond pesticide management toward the "Second-Stage" of IPM, pest management potentially will include such techniques as resistant cultivars, insect growth regulators, predator/parasite release or enhancement, trapping out pests, mating disruption, oviposition deterrents, etc. We are hopeful that second-stage IPM research (now under way) will result in even greater savings in pesticide cost and improvement in farm profitability.

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DORMANT PRUNING TO IMPROVE PACKOUT OF MCINTOSH

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A U. S. Extra Fancy McIntosh apple must have at least 50% typical red color, and an apple will develop red color only if it is exposed to the sun. The higher the light intensity reaching an apple, the earlier its red color will develop and the more intense its red color will be. The type, severity, and location of the pruning cuts determine the extent to which fruit on a tree will be exposed to adequate light for good red color development. Therefore, it is important for all growers to conduct dormant pruning that will assure good light penetration into the tree canopy and high packout.

Types of pruning cuts and their use. Three basic types of cuts are used during the pruning of apple trees. These are described below.

1. *Thinning-out*. These are cuts that involve removal of an entire shoot or branch at its junction with another shoot, a branch, or the trunk. This type is the most useful pruning cut on mature trees. It can be used to redirect branch growth and open up the tree for greater light penetration.

2. *Stubbing*. This type of cut involves the removal of a portion of a branch back into 2-year-old or older wood. Stubbing is usually done to reduce the length of a limb or to stiffen a limb so that it does not bend down and shade branches below. Lateral branching may be increased by this type of a cut. Excessive regrowth from stubbing can be reduced by cutting to a weak sideshoot.

3. *Heading*. A heading cut removes a portion of 1-year-old wood. On bearing trees heading cuts are not recommended, because they encourage the development of lateral shoots clustered near the cut, which have narrow, weak crotch angles. If heading cuts are made on a tree over a number of years, a mantle of bushy growth will develop that will inhibit light penetration. Since some of the most productive buds are removed each year and others are forced to grow into lateral shoots, cropping potential on these trees is reduced considerably.

Pruning the bearing tree. The goals of dormant pruning of mature apple trees are to remove unproductive wood, to encourage the continued development of productive wood, and to allow maximum light penetration into the tree canopy. The types of pruning that are most frequently performed to achieve the above goals are listed below.

1. *Eliminate branches that are crossing.* These branches shade fruit and result in low quality and poor coloring.

2. *Remove large branches in the tops of trees.* A conical tree allows the most efficient interception of light. A program of limb rotation in the upper 1/3 of a tree should be conducted to assure that no large limbs will develop that might shade fruit or prevent the development of scaffold limbs below. It is critical that these limbs be eliminated if summer pruning is to be effective. They cannot be removed during the summer and if present even severe summer pruning will not be sufficient to overcome the shading.

3. *Eliminate large upright branches.* Extremely strong branches that compete with the central leader will cause problems until they are removed. They prevent the development of good scaffold branches and they frequently cause too much shading.

4. *Remove branches growing toward the center of the tree.* Branches growing toward the center of the tree will increase shading in an area prone to low light.

5. *Remove branches with narrow crotch angles.* Branches with narrow crotch angles are weak and frequently break under a fruit load or during ice or snow storms. It is important to remove branches with poor crop potential to allow the growth of better limbs with greater potential.

6. *Remove weak wood.* Fruit that develop on weak branches are characteristically small and have poor quality. When fruit on these branches begin to grow the branches bend down and shade other fruiting branches below.

7. *Lower tree height.* When trees get too tall they become difficult to harvest and spray, and the upper portions can shade productive branches below. Trees on M.7 can be lowered to 10 to 14 feet without appreciable loss of yield if they have been trained to a central leader.

<u>Don't try to do it all at once</u>. If a tree has not been pruned or only has been pruned lightly for several years, extensive pruning may be necessary. However, growers should not make all of the cuts in one year if extensive wood removal is necessary. Tree renovation should be distributed over at least 2 years. If too much wood is removed in one year poor fruit set and excessive vegetative regrowth may occur. It is important to make sure that there is adequate fruit set so that the crop can help control regrowth.

<u>The recommended pruning approach</u>. We feel that the pruning approach most useful in Massachusetts will involve a combination of dormant and summer pruning. It is essential to establish the tree shape and make major cuts during the dormant season. Large cuts made during July and August likely will result in extensive fruit bruising caused by falling branches. Pruning during the summer should emphasize the reduction of shading by removal of young, nonfruitful wood. Summer pruning is not an expense that is added directly to your dormant pruning costs. At the Horticultural Research Center dormant pruning of trees that were previously summer pruned required 40% less time than trees that were not summer pruned. Prepare your trees now for summer pruning.

* * * * *

ARE ASIAN PEARS FOR NEW ENGLAND?

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Asian pears that we see on the fruit counters of local supermarkets are the cultivated forms of *Pyrus serotina* (pyrifolia) and *Pyrus ussuriensis*. They are unique in flavor and are sometimes called salad pears, apple pears, or oriental pears. They are firm, crisp, crunchy, and juicy when ripe. Unlike many of our domestic pears (*Pyrus communis*), they obtain their best quality when ripened on the tree.

The Asian pear found its way to the United States in mid-1800's during the Gold Rush when early Oriental miners brought seeds with them from China where these pears were first grown in 693 A.D.

Cultivars. The most commonly grown cultivars in California are: Shinseiki (early), Kikusui (mid-season), Twentieth Century, Chojuro, and Ishiiwase (late). Most Asian pear cultivars are partly self-fruitful, but better crops can be expected when two or more cultivars are planted together.

Spacing, training, and culture. Asian Pears can be planted anywhere standard pears can be grown. They must have 400 to 900 hours of chilling temperatures below 45^{o}F. They are planted in the spring as with standard pears. We have little experience with spacing requirements; however, in California spacings vary from 7.5 x 15 feet to 15 x 20 feet, depending on the rootstock used. These trees can be maintained as free-standing, central leader or modified-central leader trees. Trellising in Japan using the Pergola system gives a continuous, single-layer canopy kept at approximately 5 feet off the ground. High quality, large fruit are harvested without the use of ladders. The Tatura or modified Tatura systems, which are "V"-shaped, are established with trees spaced 5 x 16 feet and with the two main scaffolds sloped 60^{o} from horizontal. Fertilizing and other cultural practices are similar to those for standard pears.

Rootstocks. *Pyrus betulaefolia* is the most commonly used rootstock for Asian pears because of its vigor, tolerance of wet and poorly drained soils, and effect on fruit size. Most Asian pears are severely dwarfed on *P. communis* rootstocks, but a few such as Tsuli and Ishiiwase are compatible and have done well in California.

Fruit thinning. Thinning of the fruit is of prime importance because premium prices are paid for large fruit. During the winter of 1986-87 New England supermarket prices for Asian Pears ranged from $2 to $3 per pound! Heavy crops are frequently set, often with 6 to 8 fruit per cluster. Thinning to one fruit per cluster and to 5 inches apart will insure good-sized fruit. Most growers hand-thin fruit 3 to 6 weeks after petal fall. When trees are not thinned, alternate bearing can develop.

Pests. Pear psylla is the most serious pest of Asian pears, but Asian pears appear to be less attractive and suffer less damage than standard pears. Codling moth and mites are lesser problems but bear watching. Fireblight can be a problem but so far has not seemed as severe as with Bartlett and Bosc.

Harvest. Harvest times in our area have not yet been established but there are several cultivars available that likely will ripen in September and October. (Note: To begin obtaining some information, such as harvest dates, the three regional fruit agents in Massachusetts are establishing Asian pear cultivar trials including about 10 to 12 trees on a site. Growers who are interested in being involved in this study are urged to contact one of the regional agents.) When harvesting Asian pears care must be taken, because scarring and bruising can occur very easily. Fruit should be picked into lined baskets. Yields in California range from 150 to 200 pounds per 8- to 10-year-old tree.

Storage. Most Asian pears can be stored for up to 6 months at 32^{o}F, although some cultivars store better than others. So far, extended storage has not been required to a great degree in California, since market demand has remained high early in the season.

Market. A New England market for Asian pears has already been established by Western U.S. fruit marketers, but it is felt that a few enterprising local growers could find a niche in our markets for this group of fruits.

Information for this article came from Fowler Nurseries, Newcastle, CA, and from articles in *HortScience* (15:13-17) and *California Agriculture* (W. H. Griggs and B. T. Iwakiri. January, 1977).

* * * * *

VARIABLE CONDITIONS IN CA STORAGE CAN CAUSE FRUIT DISORDERS AFTER STORAGE

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We frequently receive samples of fruit after storage which contain some disorder(s), and are asked what caused the problem. Even when we see a copy of the storage log, it is often difficult to specify the problem. We can usually identify the disorder, but pinpointing its cause is often little more than a guess, because storage (and prestorage) conditions often interact to produce problems.

This interaction of conditions was addressed in a recent paper by C. R. Little and I. D. Peggie of the Horticultural Research Institute, Victoria, Australia (*HortScience* 22(5):783-790). The paper reported results from an extraordinarily complex series of experiments that spanned 8 years and included 7 cultivars of apples and 2 cultivars of pears. All fruit were harvested preclimacteric and were stored in small experimental chambers where conditions could be carefully controlled.

The primary objective was to test various low-O_2 regimes. In this experiment, they compared Conventional CA (2 to 5% CO_2 and 2 to 5% O_2, depending on cultivar), Ultra-low O_2 (1% CO_2 and 1.5% O_2), and Hyper-low O_2 (0.5% CO_2 and 0.7 to 1.0% O_2). They also applied Initial Low-O_2 Stress (less then 0.2% O_2 and less than 2% CO_2 for the first 10 days of storage), followed by one of the other low-O_2 systems. In addition to comparing the various O_2 regimes, they examined the interaction of Rapid CA (at-temperature 1 day after harvest and at-atmosphere in less than 6 days after harvest), Slow CA (at-atmosphere 14 to 20 days after harvest), inappropriate temperatures, high CO_2 levels, and ethylene scrubbing.

Results were judged in terms of the percentages of disorders that occurred, primarily scald, flesh browning, and core flush (a disorder somewhat similar to brown core in McIntosh). Most of the experiments were with Jonathan and Granny Smith apples.

Among the findings of the study were these:

1. The lower the O_2 level, the less scald developed. However, below a certain O_2 level (depending on cultivar), the percents of flesh browning and core flush increased. At these levels, off-flavor and purpling of the skin were noticeable in some cultivars.

2. Very low levels of O_2 at the beginning of storage were effective when Rapid CA was used, but caused disorders when Slow CA was used. Also, the Initial Low-O_2 stress caused disorders if it lasted more than 10 days.

3. If the atmosphere was changed part-way through storage, it was beneficial if it became less severe but was detrimental if it became more severe. The change was more consequential if it occurred at 100 days than if it occurred later than this.

4. When temperature was kept either above or below what was recommended for a cultivar, greater amounts of disorders occurred. If the incorrect temperature was combined with low O_2, the effect was made worse.

5. Disorders that were intensified by very low O_2 and by low temperature were made worse when CO_2 was too high. The worst situation was when very low O_2 was combined with both too low a temperature and too high a CO_2 level. All 3 factors interacted to worsen problems.

6. Ethylene scrubbing reduced disorders, especially scald. However, either 6% CO_2 or extremely low O_2 levels were just as effective as ethylene scrubbing in controlling scald.

7. When CO_2 was higher than O_2 in a storage atmosphere, disorders tended to be increased. Low O_2 and high CO_2 interacted to intensify disorders other than scald, but the presence of ethylene did not make these problems worse.

The technology involved in these studies generally is not applicable in the Northeast fruit industry today. However, the principles that are seen in the results are meaningful.

Clearly, anyone wishing to modify standard storage recommendations must do so with great care. Lowering O_2, increasing CO_2, or lowering temperature possibly can reduce fruit softening, but any of these factors can also lead to disorders: low O_2 injury, high CO_2 injury, or brown core. Thus, each modification involves a calculated risk. What is generally not recognized but is made clear in these studies is that if one factor is changed (e.g., O_2 is lowered), the risk of damage from the change is greatly increased if temperature is also changed or CO_2 is also raised, or worst of all, if all 3 modifications occur. Most often, these additional changes are not intended but result from operator errors or equipment malfunctioning. The less reliable and accurate that storage operation is, the greater is the risk of a detrimental result if a storage condition is deliberately modified.

The corollary of this situation is: if a storage operator wants to modify standard recommendations, storage management must first be made precise and accurate. It is hazardous to modify storage conditions without first making certain that storage operations are precise. If you want to modify one condition, you must be able to control other factors so that a stressful combination of factors can be avoided.

Should a storage operator discover that adverse conditions have developed, he should react by lessening the stress on the fruit. For example, he may be operating at a less-than-recommended O_2 level when he discovers that CO_2 is creeping out of control. Since he is losing control of CO_2, he needs to increase the O_2 to avoid a double stress. The sooner this is done, the less likely it is that damage will result.

Little and Peggie concluded that percent CO_2 should not exceed percent O_2 in a storage atmosphere. We recommend 5% CO_2 and 3% O_2 for McIntosh, which appears to violate their conclusion. However, ours is a very conservative recommendation for McIntosh, recognizing the lack of sophistication in operation of most of our storages, and is outside the consideration of these authors. Yet, it is probably a good rule-of-thumb that should you lower O_2 below the standard recommendation, you should follow Little and Peggie's advice: keep CO_2 lower than O_2.

The results of this study emphasize that storage operation is a system, in which O_2, CO_2, and temperature are in balance. Preharvest conditions, fruit maturity, speed of atmosphere generation, and possibly ethylene enter into this balance. Our standard storage recommendations are deliberately conservative to allow for some variability among these factors. If a storage operator chooses to modify these recommendations, he must be able to control the other factors in this balance, so that multiple stresses do not result. Unless he can provide this control, he should not deviate from the standard recommendations unless he is prepared to accept possibly serious development of disorders in fruit during and after storage.

* * * * *

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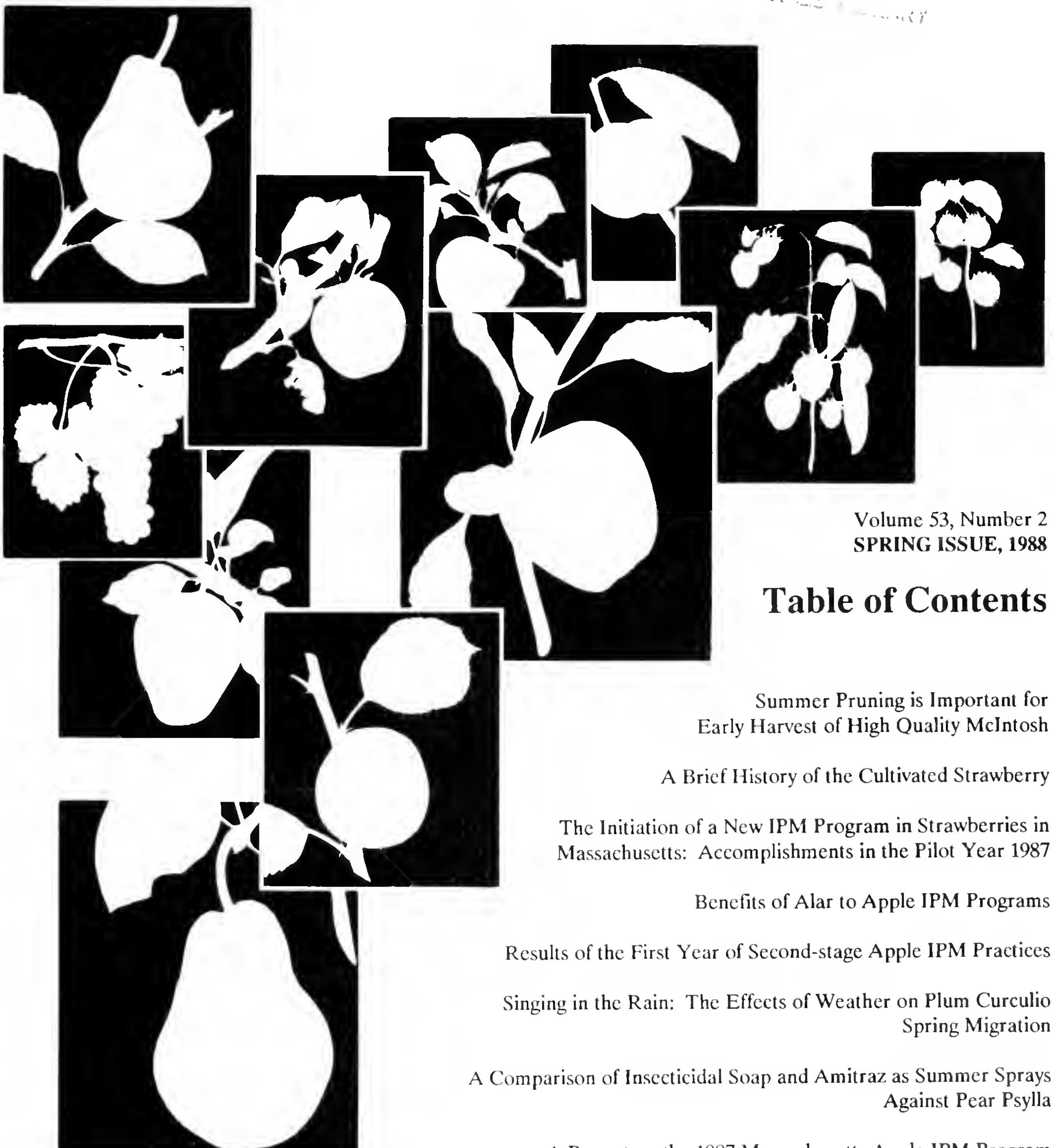
ISSN 0427-6906

Fruit Notes

Prepared by the Department of Plant & Soil Sciences

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties cooperating.

Editors: Wesley R. Autio and William J. Bramlage



Volume 53, Number 2
SPRING ISSUE, 1988

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

Fruit Notes
Department of Plant & Soil Sciences
205 Bowditch Hall
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COOPERATIVE EXTENSION POLICY:

SUMMER PRUNING IS IMPORTANT FOR EARLY HARVEST OF HIGH QUALITY MCINTOSH

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Summer pruning is a useful technique for increasing red color and allowing early harvest of McIntosh apples, as we have previously reported (*Fruit Notes* 52(3):7-8). Most researchers conclude that August is the best time to summer prune. It is reasoned that at this time regrowth following summer pruning will be minimal, there will be little risk of encouraging winter injury, and it will not be too late to enhance color development. The goals of our research in 1987 were to confirm the benefits of summer pruning and to evaluate the potential for expanding the timing of summer pruning to include July.

Dormant Pruning is Necessary. Previously we emphasized the need for proper dormant pruning to achieve the maximum benefits from summer pruning (*Fruit Notes* 53(1):12-13). Large branches in the tops of the trees that cause shading must be removed during the dormant season, because removal during the summer causes too much fruit damage and drop as cut branches fall through the tree canopy. A program of limb rotation in the tops of trees should be conducted in the dormant season to maintain a conically shaped tree and to assure that there are no major obstacles to light penetration into the tree canopy.

Summer Pruning Procedure. Summer pruning cuts should maximize light penetration. Generally, these are made in the tops and on the periphery of the tree. Specific suggestions are listed below.

1. Remove vigorous, upright branches that will not be productive.

2. Remove weak, hanging branches that are shading productive wood below them.

3. Remove watersprouts; however, leave a sufficient number with wide crotch angles to serve as potential replacements for large branches in a limb rotation program.

4. Do not remove branches larger than 1 inch.

5. Use thinning cuts rather than heading cuts, since thinning cuts generally will result in less unwanted regrowth.

Research Results in 1987. In June 90 mature McIntosh/M.7 trees were selected and distributed among 15 groups of 6 trees each. One tree in each group was not summer pruned and served as a control. Each of the remaining 5 trees in each group was summer pruned on either July 1, July 15, August 4, August 14, or September 1.

The first harvest in this block was on September 15. Twelve percent more fruit were picked from summer pruned trees at this harvest (Table 1). A random sample of fruit taken immediately before harvest showed why this effect occurred: summer pruning resulted in 10% more red color and 30% more fruit making the U.S. Extra Fancy grade (Table 1). There were no detrimental effects observed due to summer pruning. Additionally, it appeared to make no difference when the trees were summer pruned, i.e. similar benefits were obtained from all treatments. However, it should be noted that it took longer to prune each tree as the season progressed, 11 minutes per tree on July 1 and 16 minutes per tree on September 1.

The results reported here have important practical significance. The beneficial effects of summer pruning on red color and packout again have been confirmed. Additionally, more fruit may be picked in the early portion of the harvest season when they have the maximum storage potential. Furthermore, summer pruning may be done equally well any time during the months of July and August. Therefore, growers may summer prune trees during slack periods using existing help, or it may be advantageous to bring in off shore labor early, specifically to summer prune McIntosh trees.

Table 1. Effects of summer pruning in 1987.

Treatment	Red color (%)	U. S. Extra Fancy (%)	First harvest (%)
Control	52	44	43
July 1	61	71	53
July 15	62	76	55
August 4	64	76	57
August 14	64	89	54
September 1	61	73	55

A BRIEF HISTORY OF THE CULTIVATED STRAWBERRY

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The cultivated strawberry, *Fragaria ananassa* Duch., is a relative newcomer to agriculture. The cultivars now grown are the result of hybridization by humans, the fruit being quite different from those of their natural ancestors. The unique developmental nature of the fruit has made it the center of much study. The plant itself also presents features of interest in its vegetative reproductive ability, and its response to environmental conditions. In a more practical sense, the strawberry has become the basis of a large commercial industry, and is considered to be the most popular small fruit in the United States.

The exact origin of the modern cultivated strawberry is unclear, but the best evidence indicates that it is derived from a cross between two native American species, *F. virginiana* Duch., and *F. chiloensis* Linn. The former is a common inhabitant of the eastern coast of North America that greatly impressed early seventeenth century colonists. The natives commonly used the fruit in breads, but Roger Williams noted in 1643 that "the English have exceeded and make good wine". The species was introduced in England, and soon became a favorite in local gardens.

Prior to these introductions, the prevalent strawberry in England and Europe was *F. vesca* Linn., commonly known as the wood strawberry. This berry has a history dating back to the Romans, who favored it served with cream and sugar, or soaked in wine. It is doubtful, however, that the plant was widely cultivated at that time. Supplies were probably obtained from the plentiful populations growing wild. By the fifteenth century, large-scale cultivation of this species was occurring, but it was eventually replaced by an early-ripening, bright red clone of *F. virginiana*, developed from the stock originating in the colonies.

In 1712, while gathering information about Spanish fortifications along the west coast of South America for the French navy, Captain Amede Frezier was impressed by the large-fruited strawberries cultivated by the natives. Being an amateur botanist in addition to a spy, he collected some plants for the voyage home. Two of the few surviving specimens were given to the Royal Garden in Paris along with the statement that they bore fruit "as big as walnuts". Antoine de Jussieu, director of the garden at the time, must have been disappointed when the plants produced only small, deformed berries if any.

The plants Frezier took back to France were *F. chiloensis*. This species is dioecious (requiring both male and female plants for productivity), and unfortunately he had collected only females. The problem was simply a matter of pollination, but this fact apparently was not realized until many years later. Fortunately, plants were retained in some collections and the species was later redeemed when in Brittany it was discovered that interplanting it with *F. virginiana*, a plentiful pollen producer, resulted in excellent crops. *F. chiloensis*, or the Chilean strawberry, soon became the major species of commerce. Brittany was the European center of production, shipping fruit to Paris and London. Despite its impressive size, however, this strawberry was pale, seedy, and faint of flavor.

Probably as a result of the cross pollination technique used to produce Chilean strawberries, seedlings of *F. chiloensis* x *F. virginiana* crosses began to appear in European gardens. Some of this progeny bore fruit of large size with a deep red flesh. The flavor was somewhat reminiscent of pineapple, and for this reason these plants became known as the pineapple strawberry or pine strawberry. Although the origin was initially clouded, probably by businessmen in hopes of high profits, Antoine Nicholas Duchesne published a hypothesis of its hybrid origin in 1766, based upon his experience with strawberry breeding and knowledge of the Brittany practices. The pine strawberry was named *F. ananassa* Duch.

In America, the early commercial strawberry industry was dependent upon the European introductions of *F. virginiana* and *F. ananassa*. However, in 1838, Charles Hovey, of Cambridge Massachusetts, introduced the 'Hovey' strawberry. This cultivar was the result of crossing a European pine strawberry with a native *F. virginiana*. 'Hovey' is credited with being the first cultivar of any fruit made from an artificial cross in the United States. The high quality of both the fruit and plant stimulated a great new interest in strawberries throughout the country. This cultivar and later U. S. introductions such as 'Wilson' and 'Howard' provided the basis for future breeding programs and led to the large and successful commercial industry we know today.

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THE INITIATION OF A NEW IPM PROGRAM IN STRAWBERRIES IN MASSACHUSETTS: ACCOMPLISHMENTS IN THE PILOT YEAR 1987

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Strawberries are the most extensively planted small fruit in Massachusetts. According to current estimates by the Massachusetts Department of Food and Agriculture there are approximately 500 acres of strawberries grown commercially in the state. The estimated yearly value of the crop is $5,000 per acre for an overall value of approximately $2.5 million. An individual's actual crop value is determined largely by the marketing methods used and the price that he is able to obtain. It is clear, however, that strawberries are a valuable crop and can provide significant returns under the proper conditions.

Most Massachusetts growers do not produce large acreages of strawberries. The average grower manages 3.5 acres, which illustrates the fact that strawberries are often used as a cash crop to augment the income from other fruit or vegetable crops. Strawberries fit in well with these other cropping systems in terms of land requirements, machinery needed, and timing of harvest.

Strawberry culture requires significant inputs in production and pest control. The increased awareness of the ecological risks and the rising costs of pesticide application are putting a strain on Massachusetts growers and are providing incentives for developing new management strategies. Additional incentives include: the development of resistance by pests and pathogens to certain pesticides; the loss of registration of some pesticides because of potential health hazards; and, the risk of exposure by the public to the spray materials used in commercial strawberry production. This danger is enhanced by the fact that most of the berries are sold on a pick-your-own basis, so consumers may be exposed to pesticide residues in the field.

With this situation as a backdrop, the Strawberry IPM program embarked on its first season with a set of objectives as stated in the Summer, 1987 issue of *Fruit Notes* (6). To summarize these objectives, we sought to: (1) identify the key pests causing economic injury to strawberries in Massachusetts; (2) establish consistent and accurate sampling techniques for each key pest; (3) study available management and control methods; (4) determine what the current pest control practices are and the areas for potential change; (5) conduct trials using alternative fungicide spray recommendations and evaluate their efficacy; and (6) distribute a regular Strawberry Pest Message. Efforts to address these objectives were made in several ways: (1) surveys were conducted at 4 locations on a weekly basis throughout the season to monitor pest pressures; (2) observations were made at 10 additional locations; (3) sampling methods for all pests were developed and evaluated at these locations; (4) scouting results were reported weekly through harvest and occasionally thereafter; (5) limited-fungicide spray recommendations were made and evaluated; (6) literature searches were conducted to determine the current state of knowledge on strawberry pest management; and (7) all Massachusetts strawberry growers were surveyed to obtain information on current practices and concerns. The results of these efforts follow.

Strawberry Pests

Pest control in strawberries includes efforts in all three pest groups: insects, diseases, and weeds. Key insect pests, those which cause economic injury and concern to the grower, include tarnished plant bugs (*Lygus lineolaris*), strawberry bud weevils (clipper) (*Anthonomus signatus*), and two-spotted spider mites (*Tetranychus urticae*) (12). Other insect pests exist but are of lesser concern to growers.

Important plant disease organisms include bacteria, viruses, and fungi, with fungi being the most prevalent. Fungal pathogens fall into four categories: berry rots, leaf diseases, crown rots, and root rots. The two key diseases of concern are a berry rot, grey mold (*Botrytis cinerea*), and a root rot, black root rot (*Rhizoctonia fragaria*) (12). Red stele (*Phytophthora fragaria*) is also a problem in the Northeast but generally is managed successfully through the use of resistant cultivars and soil fumigation.

Key strawberry weeds vary widely throughout the state but grasses and other perennial weeds are of most concern. These weed problems include dandelion (*Taraxacum officinale*), goldenrod (*Solidago canadensis*), orchard grass (*Dactylis glomerata*), quackgrass (*Agropyron repens*), and yellow wood sorrel (*Oxalis stricta*) (12). Heavy weed infestations will affect yield, plant vigor, and bed longevity.

Key Insect Pests

Tarnished plant bug causes misshapen berries with the typical "cat-facing" or apical seediness. It is ubiquitous and can cause severe losses of yield if not controlled. The damage is caused by the feeding of adults or nymphs on the newly developing fruit. Feeding prevents individual achenes from developing, thus causing the deformity. The later in the development of the berry that feeding occurs, the less significant the injury. However, under heavy infestations, 30 to 50% crop reductions have been reported (10). Current practices include 1 to 3 sprays in the early season with malathion or thiodan.

Tarnished plant bugs overwinter as adults and lay eggs in early May. Eggs hatch at approximately the same time as the strawberries are approaching 10% bloom. The nymphs cause the majority of the damage and must be the target of a management plan. Sampling for these nymphs may be done by shaking 25 flower trusses from a 2-foot section of row individually over a dish at a number of locations. The current threshold number using this method is 1 nymph per 25 flower trusses (10). We were unable to evaluate this method satisfactorily in 1987, because the IPM program began at the end of the flowering period. A second monitoring method that we tried was the use of sticky traps to catch the adult tarnished plant bugs, as has been shown in apple orchards (4). This procedure was not satisfactory, because it was difficult to correlate trap catches and damage and to set threshold levels. The use of models for egg hatch and nymphal development according to thermal accumulation has been studied in Quebec (1) and may prove useful in combination with sticky traps for determining first incidence of tarnished plant bug activity. The Massachusetts Strawberry IPM Program will be using the flower truss/nymph method this year to make spray recommendations based on threshold numbers. The objective is not only to reduce the number of sprays but also to improve the timing of sprays and to fine-tune the rates and materials used against tarnished plant bug.

Strawberry bud weevil causes a reduction of yield by laying eggs in the newly exposed buds and girdling the pedicel of these buds, which then will not develop. This pest, otherwise known as the clipper because of the nature of the injury, is not as common in Massachusetts as is the tarnished plant bug, but when it occurs, it can cause severe losses; up to 90% damage has been reported in some states (11). Current practices include 1 to 3 pre-bloom sprays per season of guthion, parathion, or lorsban.

The strawberry bud weevil overwinters as an adult in hedge-rows or woods and is active when temperatures are above 60°F and buds are available. Sampling for this pest is performed by counting the number of clipped buds per 2 feet of row. Unfortunately, this procedure counts the damage after the fact but is the only satisfactory method available. The threshold number that we are currently using is 1.2 clipped buds per 2 feet of row (11). Samples should be taken from near the field borders, hedge-rows, and woods since these are areas where we expect to find the clipper first, and we want to halt the invasion of it into the field. When the threshold level is reached, we recommend spraying with guthion at labeled rates. As with the tarnished plant bug, the objective not only is to reduce the number of sprays but to improve effectiveness by improving the timing. Experiments are planned to aid in the development of a trap or lure similar to that used for the boll weevil, so that we can monitor populations before damage occurs.

Two-spotted spider mites affect the yield of strawberries indirectly by sapping the vigor of the plants. These tiny arthropods live on the underside of leaves and feed on plant juices. Under heavy infestation (over 100 mites per leaflet) two-spotted mites can have significant impacts on yields and on the longevity of a bed (9). Many growers do not spray for two-spotted mites because their heaviest populations occur during harvest. Spraying during this time is not recommended and growers can wait and get adequate control simply with renovation when the foliage is mowed off. However, for growers who feel they must spray before harvest or after renovation one or two sprays of kelthane or plictran may be used. Both of these materials were removed from the market during 1987, but some formulations of kelthane are available for use in 1988.

Two-spotted spider mites overwinter as adults and become more active as temperatures increase during the summer. Dry, hot weather favors these mites. There is a danger that populations can explode in a very short period of time. The strawberry IPM program is refraining from making recommendations for mite control based on threshold numbers, because there is little agreement among researchers on what population levels are tolerable. We will, however, report levels to growers. The current concern is the lack of availability of miticides for those growers who want to control mites. We plan to explore the use of biological control of two-spotted mites with the use of indigenous predacious mites (*Amblyseius fallacis*) (8). This type of control can be accomplished either by encouraging the growth of natural populations of these predators or by the release of artificially-reared populations to augment the naturally occurring ones. In addition, the use of "soft" pesticides such as insecticidal soaps, which have been successful in greenhouse settings, will be evaluated for efficacy in strawberries during 1988.

Key Disease Organisms and Their Damage

Grey mold (*Botrytis cinerea*). This fruit rot is, by far, the problem of most concern to Massachusetts growers in terms of potential for yield reduction (12). The Botrytis fungus infects the flower petals or sepals and then proliferates in the developing fruit causing it to rot. The berries may rot on the plant or shortly after they have been harvested. Grey mold can cause very heavy losses in years with damp wet weather in the spring, especially if it occurs during bloom. If not managed, under these conditions a nearly complete crop loss is possible. Even under a fungicide spray program a significant yield reduction may occur. Current practices include 1 to 12 sprays per season with captan, benlate, captan/benlate, or ronilan.

During 1987 an IPM spray regime consisting of 3 bloom sprays of captan or ronilan was compared with a typical spray regime. We found no significant difference in the amount of berry rot found with either regime (12). These results concur with work done by other researchers (3) and suggest that 3 well-timed bloom sprays are as effective for grey mold control as the 4 or more sprays normally used from bloom through harvest.

In Ontario, grey mold has been shown to overwinter in the green leaf tissue under the winter mulch (2). This fact, if it is also true in New England, has significant implications for disease management. According to the Ontario work, spores from infected crop residues land on newly formed and expanding leaves in the fall. The spores germinate and invade the leaf tissue and then enter a quiescent state for the winter protected by the winter mulch. At that time there are no visible symptoms of infection. Then, in the spring when these leaves begin to senesce and die, the fungus grows and produces new spores which are available to infect the tender blossom petals, which then infect the fruit. Using this information, one can protect the leaves from infection in the fall or knock back the initial inoculum in the spring before the blossoms appear. This treatment eliminates the need for numerous sprays, and the potential for any fungicide residues on the fruit. Since no developing fruit will be present at the time of sprays, they cannot accumulate fungicide (13). Leaf protection can be accomplished by applying fungicides to the surface or by providing competitive organisms which will inhibit the ability of the fungus to germinate or penetrate the surface of the leaf tissue (5). Two yeast species and one bacterial species which occur naturally on the surface of strawberry leaves and provide effective biological control of grey mold in Ontario have been identified (13). The Strawberry IPM program is determining the efficacy of these methods in Massachusetts.

Grey mold management presents a major challenge to pesticide reduction strategies. We are targeting a reduction in the number of sprays, adjusting spray timing to early season, and exploring the potential for biological alternatives to reduce the pesticide load on the environment. Our approach is especially timely since captan's registration is under special review and grey mold has developed resistance to benlate and ronilan in some areas. Furthermore, benlate has been shown to adversely affect populations of predacious mites in apples and may do the same in strawberries.

Black root rot is a complex of organisms which results in the decay and blackening of the perennial and feeder roots. The causal fungus, *Rhizoctonia fragariae* (Ceratobasidium sp.), commonly is associated with strawberry roots. *R. fragariae* invades strawberry roots by direct penetration, causing cortical decay and rootlet death. This injury results in reduced plant vigor, and degeneration and premature death of plants.

Black root rot is difficult to manage with existing measures. In Massachusetts, we suggest planting in well-drained soil, using "healthy" plants, mulching to reduce winter injury (a contributing factor), and using soil fumigants before planting. While these fumigants may help black root rot management, traces of them may also end up in underground water supplies.

The IPM program plans to evaluate the use of reduced rates of standard fumigation materials, the effect of certain cover crops for reducing inoculum in the soil, and the possible use of biological control methods by inoculating the roots at transplanting with avirulent strains of *Rhizoctonia*. This work has been initiated by Janice Drozdowski and Dr. William Manning at the University of Massachusetts (7).

Weeds in Strawberries

Weed control in strawberries poses one of the greatest challenges to commercial strawberry growers. Since strawberries are a perennial broadleaf plant, management of other perennials, particularly grasses, is difficult. If weeds proliferate they can significantly shorten the longevity of a planting, reduce yields, and discourage pick-your-own customers from picking in certain areas. Seventy-seven percent of Massachusetts strawberry growers use herbicides, as compared to 70% who use fungicides, 64% who use insecticides, and 28% who fumigate (12). The average number of herbicide applications for those who use herbicides is 3.2 sprays per season. This use level is more than that for most other crops.

This year the IPM program surveyed strawberry plantings throughout the state to establish which weeds and weed types posed the most problems to growers. This work will continue in 1988 to provide a more complete picture of the situation. The strawberry IPM program plans to establish field plots to evaluate alternative weed management strategies using reduced rates of certain herbicides and using certain mulching practices. The objective is to develop a management program with fewer herbicide applications without reducing yield and bed longevity.

Conclusions

Integrated pest management of strawberry has great potential for several reasons. First of all, strawberries suffer important damage from diseases, weeds, and insects. Secondly, pesticide applications are expensive both economically and ecologically. Also, several of the key pests of strawberries are significant pests in other crops and have been studied in the IPM context before, and this information gives us a head start in strawberry IPM. In addition, many of our Massachusetts growers are involved in or familiar with other Massachusetts IPM programs, i.e. corn, potatoes, or apples. The success of these programs has paved the way for an enthusiastic reception by growers to the Strawberry IPM Program.

The first season of the Strawberry IPM program has been one of establishing baselines for current practices and knowledge of pest control, testing our scouting methods and making some trial recommendations, and for introducing ourselves to the Massachusetts growers. The key to success of the strawberry IPM program is involvement of the growers, because their input is instrumental in directing the course of this program.

We will be expanding our grower base from 4 in 1987 to 15 in 1988. With a larger number of growers, we hope to be able to generate more information. We are particularly interested in how well the relatively untested techniques described in this paper will work in the field. Our new reporting forms will facilitate communication with growers. These forms will be used to report to growers the scouting results for the week and recommendations based on those results. We look forward to a successful 1988 season.

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BENEFITS OF ALAR TO APPLE IPM PROGRAMS

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Based on highly equivocal, unsubstantiated evidence, the U. S. Environmental Protection Agency (EPA) in August of 1985 announced the intent to cancel the registration of Alar™ (daminozide). When the press heard of the EPA's intent to cancel Alar, the issue quickly received extensive national coverage, with ensuing strong condemnation of the material by the press and the public. Even though the EPA's ultimate decision was to reduce permissible levels of Alar on fruit, rather than cancel completely the use of Alar, the initial irresponsible announcement of intent to cancel use was sufficient to flag Alar as a dangerous chemical in the mind of the public. The Massachusetts Department of Public Health expanded upon the original EPA announcement by phasing out tolerances for Alar residues in processed products. As you well know, the end result has been strong reluctance on the part of brokers, processing firms, and supermarkets to accept apples treated with Alar for fear that consumers would refrain from buying them. In turn, many growers were reluctant to use Alar in 1986 and 1987 for fear that they could not sell their apples, even though it technically has remained legal to use it. This nonuse resulted in premature drop of nearly 30% of all McIntosh and reduction in storability of those apples that were harvested.

This situation in itself is most unfortunate. But, an equally great misfortune is the highly counter-productive effect discontinued use of Alar has had on present and potential integrated pest management (IPM) practices on apples. In regard to present practices, Alar is frequently used not only to positively affect fruit quality but also, when applied in mid-or late-June, to slow the growth of watersprouts and terminals. A positive benefit of this use to pest management lies in depriving aphids of rapidly-growing foliar tissue. Hence, aphid populations tend to be lower in blocks treated with Alar in June. Another benefit of Alar to current IPM practices is associated with tolerable levels of leafminers and spider mite populations. When present in substantial numbers (and even in only moderate numbers in dry years), leafminers and mites can cause premature fruit drop, reduce fruit coloration, and diminish the keeping quality of fruit. Without Alar, many growers have had to use a greater amount of pesticide against leafminers and mites to maintain these pests at levels lower than can be tolerated in Alar-treated blocks. With Alar, we can tolerate more leafminers and mites to maintain these pests at levels lower than can be tolerated in Alar-treated blocks. With Alar, we can tolerate more leafminers and mites without ill effect.

In regard to future IPM practices, particularly second-stage IPM practices, Alar (or another compound that is equally effective) must play a major role or else most second-stage practices will come to naught. In nearly all orchards treated with Alar, few pests can survive within the orchard itself because the fruit (and any pests the fruit may harbor) are picked before they drop. Thus, the pests are taken away with the fruit. When the fruit drop, however, pests may remain in the orchard, overwinter there, and pose an immediate threat to the crop next summer. The low price paid for dropped apples does not usually warrant investment of labor to pick them up, so many are left on the ground to rot. Such a situation is not amenable to management by a second-stage IPM approach of intercepting pests at the orchard border, before they enter the orchard. Thus, without Alar, growers are denied the opportunity of reducing pesticide use against pest insects and mites by using a second-stage IPM approach, and are denied the opportunity of producing healthier, more pesticide-free apples.

We feel the EPA and the Massachusetts Department of Public Health did not consider the multiple benefits of Alar to fruit growers and the environment when it announced in 1985, without good evidence, that Alar was a dangerous chemical. In truth, the EPA's decision not only has caused a great economic hardship to fruit growers, but also has been counter-productive to the EPA's own best interest in providing for a healthier environment. The EPA's 1985 announcement has and will continue to cause greater use of more toxic (but nevertheless legally used) pesticides than otherwise would be necessary with Alar. We hope that the EPA and the Massachusetts Department of Public Health in the future will consider more fully the positive benefits of an orchard chemical when making a cost/benefit analysis of the future use of a compound.

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RESULTS OF THE FIRST YEAR OF SECOND-STAGE APPLE IPM PRACTICES

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Since 1978 we have conducted a program of integrated pest management (IPM) in Massachusetts apple orchards. The first-stage of this program, from 1978 through 1982, was funded by a 5-year federal Cooperative Extension Service pest management grant to initiate a pilot IPM program. A maintenance phase followed the pilot program and has been ongoing since 1982.

Initially, there were 3 major objectives: to promote the buildup of natural populations of beneficial predators, to reduce pesticide use, and to maintain or increase the quality and quantity of fruit produced. The overall entomological approach to achieving these objectives was to intensively and carefully monitor abundances of pests and beneficial natural enemies in participating IPM orchards and to give advice to IPM growers as to the need for, optimal timing of, and type of pesticide to be applied.

The results of this pilot program were highly encouraging. Compared with pesticide use before 1978, there was a 37% reduction in insecticide use and was a 61% reduction in miticide use during the pilot program, along with a reduction in the loss of fruit due to insect damage. The results were so encouraging, in fact, that 2 persons trained in the program formed "New England Fruit Consultants". Over the past 5 years (1983-87) they have been hired by commercial growers to provide IPM scouting and advisement services on more than one-third of the apple acreage in Massachusetts.

Results of a recent survey indicated that about two-thirds of Massachusetts apple growers now employ IPM practices. Thus, over the past decade, this first stage of IPM in Massachusetts apple orchards can be considered a success, although this success must be tempered by the knowledge that the uses of miticides as well as non-selective insecticides directed against apple blotch leafminers and white apple leafhoppers have been on the rise in IPM orchards over the past 5 years (partly due to development of resistance to materials previously effective). Having substantially achieved our goals, we initiated the second stage of the apple IPM program in 1987.

Second-stage IPM employs behavioral, ecological, and biological approaches to pest management as substitutes for most pesticide treatments. The major goal of the program is to eliminate use of insecticides and miticides after the last curculio spray. This elimination allows important predators and parasites of key foliage-feeding pests (mites, aphids, leafminers, and leafhoppers) to build up to numbers sufficient to provide control of these pests. To facilitate this goal, we emphasize the use, during April and May, of those pesticides least likely to be harmful to beneficial predators and parasites.

In the summer of 1987, 18 commercial orchards participated in the second-stage IPM program comprised of the following 4 elements:

(1) application of oil or other needed selective pesticides (1) during April and May to control European red mite, San Jose scale, tarnished plant bug, European apple sawfly, plum curculio, green fruitworms, and early-season leafrollers;

(2) no use of any insecticide or miticide following the last plum curculio spray in May to permit buildup of beneficial predators and parasites in a pesticide-free habitat (except for fungicide use against diseases);

(3) removal of abandoned apple, pear, hawthorn, and quince trees within 100 yards or more of the orchard perimeter to greatly reduce or preclude immigration of key mid- and late-season lepidopteran pests (codling moth and summer leafrollers) attacking apple fruit; and

(4) intercepting apple maggot flies (a key summer pest attacking the fruit) before the great majority of flies can penetrate the orchard interior, either by ringing the orchard perimeter with odor/visual maggot fly traps (sticky red spheres baited with synthetic apple odor) or by spraying perimeter-row apple trees periodically to kill entering flies.

Of the 18 blocks (2 to 4 acres each) there were 6 in which odor/visual traps for apple maggot flies were placed every 10 yards in the woods surrounding each block, 6 in which odor/visual traps were placed every 10 yards in perimeter apple trees, and 6 in which perimeter apple trees were sprayed every 3 weeks during June, July, and August. We compared results in these blocks with a comparable-size nearby block in each orchard sprayed by growers in normal fashion during June, July, and August.

Table 1 shows that on average 1,062 maggot flies per orchard were intercepted in test blocks where traps were put in the woods, compared with 2,054 where the traps were placed in perimeter apple trees. One hundred percent more flies were caught on nonbaited monitoring traps placed in interior apple trees in woods-trapped test blocks than in grower control blocks, suggesting that twice as many flies were active in the interior of these test blocks than in the adjacent control blocks. About 46% more were caught on monitoring traps inside the apple-tree-trapped test blocks and 65% more in the border-row-sprayed test blocks than in the adjacent control blocks. Although none of the 3 approaches to intercepting maggot flies before fly penetration into the block interior was completely effective, the latter 2 types gave promising results.

Table 1. Apple maggot fly captures per block.

Type of block	Interception traps*	Monitoring traps**
AMF traps in woods	1,062	352
Grower control	--	176
AMF traps in orchard	2,054	123
Grower control	--	84
Border row sprays	--	104
Grower control	--	63

*Odor-baited traps at orchard perimeter.
**Nonbaited traps on interior apple trees.

Table 2 shows the percent fruit damaged by each type of fruit-injuring pest. For all 3 test block types, combined injury by early season pests (plant bugs, sawflies, curculios, and fruitworms) was greater in the test blocks than in the grower control blocks. These pests would have been controlled by sprays applied during April and May (prior to the start of the program). Hence, it appears that pest pressure in and around the average test block was greater than that in and around the average control block (so the cards were partly stacked against us). Maggot flies caused about 4 times as much damage in woods-trapped test blocks as in control blocks (9.3 vs. 2.3%), about 3 times more damage in apple-tree-trapped test blocks as in control blocks (1.4 vs. 0.5%), and about the same amount of

Table 2. Fruit-injuring pests.

Type of test block	Injured fruit (%)* TPB,EAS,** PC,GFW	AMF	SJS,CM,LR other
AMF traps in woods	14.0	9.3	2.4
Grower control	12.6	2.3	1.1
AMF traps in orchard	6.3	1.4	0.1
Grower control	2.3	0.5	0.2
Border row sprays	2.4	0.6	0.3
Grower control	1.9	0.8	0.3

*700 fruit sampled per block in July, August, and September.

**Key:
AMF - apple maggot fly
GFW - green fruitworm
TPB - tarnished plant bug
EAS - European apple sawfly
PC - plum curculio
SJS - San Jose scale
LR - leafroller
CM - codling moth

damage in border-row-sprayed test blocks as in control blocks (0.6 vs. 0.8%). Damage by other mid- and late-season pests (scale, codling moth, leafrollers, and others) was about twice as great in woods-trapped test blocks as in control blocks (2.4 vs. 1.1%), but was no different in apple-tree-trapped and border-row-sprayed test blocks compared with control blocks. Although none of the test blocks yielded all perfect fruit, we feel these results are encouraging in terms of the potential effectiveness of either traps placed in perimeter apple trees, or border row sprays (in combination with removal of nearby host trees) as an alternative approach to managing maggot fly, codling moth, and leafrollers.

Table 3 shows populations of foliar-feeding pests found during sampling in each block. Although populations of European red mites and two-spotted mites averaged 37% higher in the test than in the control blocks, populations of mite predators averaged 137% higher in the test blocks. This result is precisely the sort of outcome we were hoping to see. If the test blocks were to remain free of insecticide and miticide after May for the next 2 years, we would expect mite predators to increase even further to a point where they alone (in conjunction with pre-bloom oil sprays) might be able to control pest mites. Woolly apple aphids were low in numbers in all blocks. White apple leafhoppers averaged 57% more abundant in the test blocks, but here again we expect leafhopper parasites to

Table 3. Foliar-feeding pests.

Type of test block	Leaves (or terminals) infested (%)* ERM,** TSM	Predatory mites	WAA	WAL	PL	ABLM
AMF traps in woods	23	11	1	13	11	23
Grower control	20	4	3	8	8	12
AMF traps in orchard	20	7	2	9	17	10
Grower control	13	4	2	5	10	14
Border row sprays	24	1	5	0	9	5
Grower control	16	0	5	1	10	4

*200 leaves (or terminals) sampled per block in July and August.

**Key:
ERM - European red mite
PL - potato leafhopper
WAL - white apple leafhopper
WAA - woolly apple aphid
TSM - two-spotted mite
ABLM - apple blotch leafminer

increase in future years. Potato leafhopper averaged 32% more abundant in the test blocks, but we still have no solid evidence that this insect is truly injurious to bearing trees. Leafminers were 27% more abundant in the test blocks, but we fully expect leafminer parasites to increase to substantial levels during summer months in future years.

Second-stage IPM research for 1988 will concentrate on repeating the experimental designs for border row sprays and apple maggot traps placed in perimeter apple trees. The design which called for apple maggot traps in the woods around an orchard will be eliminated.

In conclusion, results of the first year of implementation of several second-stage IPM practices in commercial orchards give us cause to be optimistic about the future of these practices in preventing injury to apple fruit during June, July, and August and in fostering buildup of important natural enemies of foliar pests. In succeeding years, we will work on refining our second-stage techniques (including possible substitution of sticky spheres with insecticide-impregnated non-sticky spheres), with the aim of being able to recommend with confidence a truly integrated behavioral, cultural, and biological approach to orchard pest management.

Acknowledgements. We thank the Massachusetts Society for Promoting Agriculture and the Northeast Regional Project on Integrated Management of Apple Pests (NE-156) for supporting our work on second-stage apple IPM. Special thanks go to Leslie White and Esther Ruiz who worked on the 1987 studies. Bill Coli, Kathleen Leahy, Sue Butkewich, and Dave Stanley also participated in this program.

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SINGING IN THE RAIN: THE EFFECT OF WEATHER ON PLUM CURCULIO SPRING MIGRATION

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The plum curculio (PC), *Conotrachelus nenuphar* (Hebst), is a serious pest of stone and pome fruits east of the Rocky Mountains. It is also one of the two most important species attacking apples in the Northeast. Less is known about the plum curculio than about any other key apple pest. Several factors have been responsible for limiting our success in understanding this insect. PCs are cryptically colored and feign death when disturbed, making behavioral studies difficult. In their northern range, PCs overwinter in leaf litter outside the orchard and return to host trees in the spring. The behavioral adaptations involved in leaving the orchard in the fall, returning in the spring, and locating a host, are complex and not well understood.

From a control standpoint, detection of PC movement into an orchard in the spring is critical since PCs can crawl quickly throughout a host tree, causing significant damage to fruit in a short time. To illustrate the rapidity with which PC injury may appear, in 1987 untreated trees in Conway, MA had 9% fruit injury on May 21 and 96% on May 24! PC populations are difficult to monitor since they usually are clumped rather than distributed. Presently, control practices are initiated when feeding and egglaying scars on fruit reach economic threshold levels; however, by the time fruit damage is detected, considerable fruit injury already may have occurred throughout an orchard. More effective techniques for monitoring PC appearance on host plants in the spring would help us to overcome a major stumbling block in pest control within apple integrated pest management programs in the Northeast.

Many researchers have felt that PC spring migration is influenced by environmental factors. Quaintance and Jenne (3) developed the mean temperature "rule" as an index of PC activity, where a mean temperature above 60°F for 3 or 4 days will result in large migrations. Snap (5) agreed with these conclusions. Whitcomb (6) found that

55° was the minimum temperature for PC activity and that 75° for 2 or more consecutive days was optimum for migration. Furthermore, he suggested that cool weather following a warm period may reduce or suspend migration until optimum temperatures are reached once again. Lathrop (1) believed that other environmental factors besides temperature may be important to spring migration. Smith and Flessel (4) found that mass migration was correlated with humidity as well as temperature. They indicated that water loss during periods of low humidity may reduce migration. McGiffen and Meyer (2) suggest that low temperatures suppress PC activity and aid in the conservation of resources until daily air temperature and saturation deficits are conducive to flight. They believed that temperature must be above the flight threshold, with saturation deficit below the desiccation range, for migration to occur.

Over the past 4 years, we have gathered data to determine the influence of weather on the spring migratory flight of PCs from overwintering sites. Our studies indicate that PCs are especially likely to move into orchards during late day or evening hours under humid, warm conditions when the air is relatively calm. Heavy movement occurred even during lulls between intermittent rainfall, especially when the temperature was above 70°F.

Based on these findings we want to stress the importance of careful daily monitoring of fruit for PC feeding and egglaying, especially when weather conditions are ideal for migration. Examine 5 or 10 developing fruit per tree for fresh feeding or egglaying scars on several trees along rows that border woods. Feeding injury appears as a small round hole, often undercut so that the hole is larger beneath the skin. Oviposition scars are crescent-shaped.

Our research indicates that during migratory flight into an orchard, PCs may use visual and olfactory cues to locate a host tree. However, it appears that odor alone is a stronger stimulus than vision alone. Furthermore, in laboratory studies, we found that host odor aids PCs in fruit location and actually "turns on" feeding behavior. PCs readily locate and feed on sap exuding from cut or wounded branches. We therefore wonder if PCs might be attracted to recently pruned trees.

Because PCs attack border rows first before moving toward the block interior, we recommend only a border row spray early in the season, with a full-block spray at peak PC activity and a border row spray toward the end of the PC season. Guthion and imidan have been the most effective materials against PC.

Timing of the first border spray is critical and should commence as soon as PC damage is observed on fruit, even if rain is predicted, because PC movement to host trees is likely to commence as soon as the rain slows or stops. The rain may reduce residue longevity, possibly making another insecticide application necessary. However, delay of a spray may leave you with a heavily damaged crop when you awake in the morning! Weigh your choices carefully.

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A COMPARISON OF INSECTICIDAL SOAP AND AMITRAZ AS SUMMER SPRAYS AGAINST PEAR PSYLLA

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The pear psylla (*Psylla pyricola*) is well known as an important pest of pears, causing damage in the form of reduced tree vigor and through the accumulation of excrement (honeydew) and resultant sooty mold fungus on fruit, foliage, and wood. In commercial pear orchards, psylla are often difficult to control due to pesticide-induced resistance to many registered pesticides. We frequently have seen excessive psylla injury, giving trees a blackened appearance, even in blocks which received a regular spray program, and a number of growers have reported increasing difficulty with psylla control in recent years.

To some extent, psylla are a problem because growers often do not recognize that a particular material that had been effective in the past is no longer providing control. For example, some growers may still be able to use azinphosmethyl or phosalone against psylla, but in many instances these materials will not adequately control the pest. Synthetic pyrethroids generally still are effective, but continued use, especially of multiple applications in a season, will almost certainly result in the development of resistance. For most pear growers, dormant oils will suppress psylla in the early part of the season, but frequently one or more applications of amitraz, a highly toxic material, are required during the July through August period.

Because of the potential for psylla to develop resistance to amitraz and the negative effects of this and other registered pesticides on beneficial arthropods, it is imperative that alternative approaches to managing pear psylla be developed and tested. For example, researchers in Washington achieved limited success by washing honeydew from fruit with water sprays. In this article, we describe a trial conducted in 1987 at a small commercial pear orchard to determine if insecticidal soaps have any potential in commercial psylla control programs by "cleaning" fruit, by direct psylla control, or by both. For more information on pear psylla management strategies, see the *1988 March Message* (University of Massachusetts Cooperative Extension).

The trial was conducted in a 1 acre orchard of well-pruned, 8-year-old Bartlett pear trees in Belchertown, MA. Treatments were laid out in a randomized complete block design, using 6 replications of 3-tree plots for each treatment. Weekly sampling for all psylla life stages (eggs, softshell nymphs, hardshell nymphs, and adults), honeydew, and beneficial arthropods was conducted by observing the last four leaves on 10 succulent terminals from throughout the canopy of the center tree of each plot.

Treatments were: (1) untreated check, (2) amitraz @ 2 pints per 100 gal. water, and (3) SaferTM soap @ 2 gal. per 100 gal. water. All treatments were applied until runoff with a motorized hydraulic handgun sprayer at 200 psi, after 30% of terminals were infested with active psylla stages (July 28). Because trees were not cropping heavily, at harvest fruit from all trees in each 3-tree plot were combined and examined closely for signs of injury. Data were analyzed using analysis of variance, and means were separated using Duncan's New Multiple Range Test.

Data in Figure 1a indicate that both the soap and amitraz treatments caused a significant reduction in numbers of all active psylla stages (softshell, hardshell, and adult) compared to the check on August 7 and August 12. By August 19, the quantity of active psylla stages on treated trees did not differ significantly from those on the check; however, treatment-related pest reduction allowed fruit to be harvested with no further treatment and with no downgrading of fruit from honeydew or sooty mold when soap or amitraz was used.

When life-stage data were analyzed separately, results indicated that neither treatment caused a significant reduction in numbers of softshell nymphs (Figure 1b). This result may be due to the protection afforded this stage by drops of honeydew which they secrete and hide within. Softshell nymphs typically also are protected by their tendency to feed in leaf axils where sprays may not adequately reach. Also, since neither treatment was expected to have an effect on eggs, undoubtedly a certain portion hatched after the treatment date, resulting in higher softshell nymph numbers. This finding suggests that there is a need for back-to-back soap applications to prevent nymph numbers from continuing to expand, which is important because it is nymphal feeding and excrement which sap the tree of its fluids and soil the fruit. Hardshell nymphs were reduced by both treatments as of the August 7 sample date (Figure 1c). Although significant differences disappeared by subsequent sample dates (as surviving soft

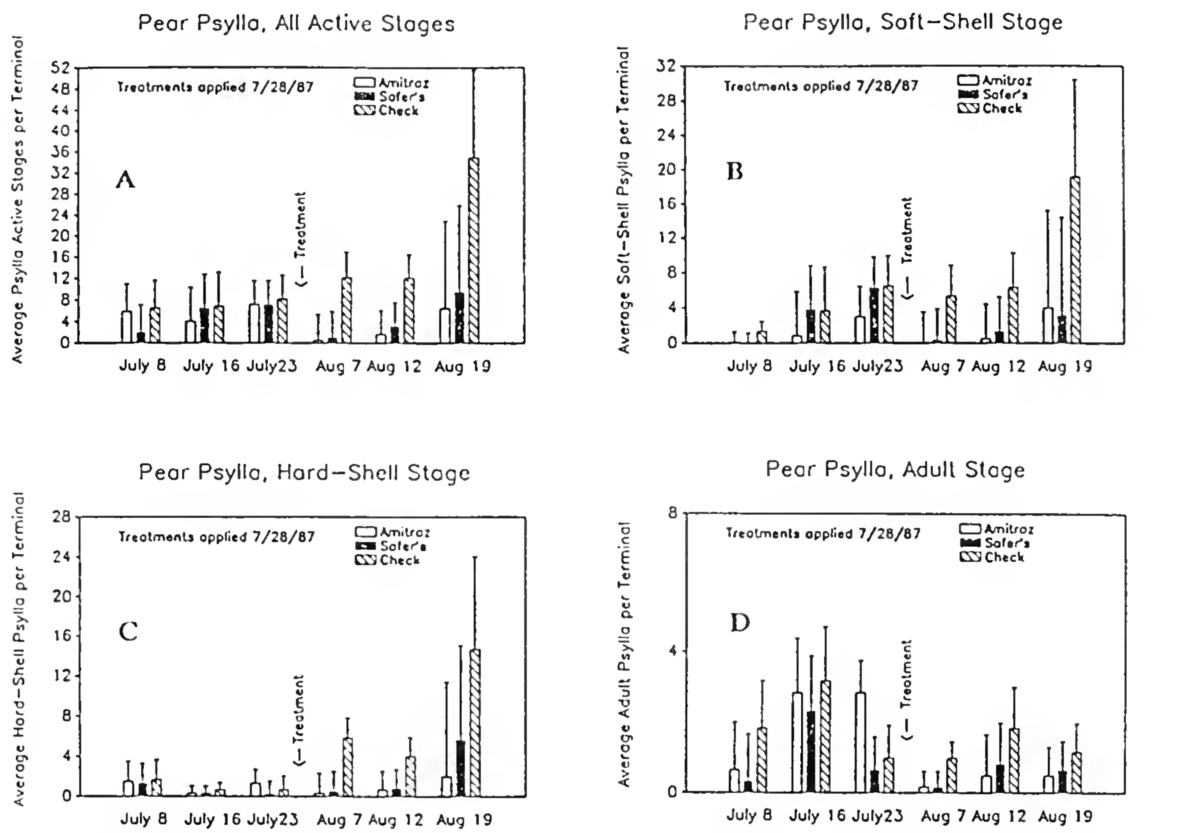

Figure 1. Number of active stages of pear psylla on check, Safer soap-, and amitraz-treated Bartlett pear trees.

shells continued to develop), in practical terms, psylla populations under both spray treatments likely were below most growers' "visual action threshold" through harvest. Nonetheless, in blocks where psylla build up earlier in the season, further applications of soap and amitraz likely would be required.

Numbers of psylla adults (Figure 1d) also were reduced significantly by both soap and amitraz. Because adult numbers were significantly higher in amitraz plots on July 23 (pre-treatment), it can be argued that amitraz performed better than soap against this stage. The residual effect of amitraz compared to non-residual soap could account for this apparent difference.

Although check terminals were infested completely and showed honeydew and sooty mold growth as early as August 7, at harvest only a few fruit from check trees showed signs of honeydew. While no evidence of spray toxicity to foliage was noted in this trial, 49% of Safer-treated fruit were found to be injured at harvest. Phytotoxicity consisted of dark-colored surface lesions about 1 cm in diameter, apparently formed when soap concentrated at the bottom of treated fruit. This injury might be avoided by the use of spreading agents to reduce soap accumulation, by use of a different rate, or by spraying when drying conditions are optimal.

We compared the cost of applying amitraz and Safer soap using a price of $45 per gallon for amitraz and $9 per gallon for Safer soap (retail price when purchased in volume) and recommended rates. The use of Safer soap ($54 per acre using a 300 gal. dilute base) was 37% more costly than amitraz ($34 per acre) under the conditions of our test. However, the manufacturer reports that they are working on a second-generation material which is hoped will be as effective as the present soap but at 30% to 50% of the cost. Moreover, it is difficult to estimate the value of reduced pesticide resistance, reduced outbreaks of secondary pests (e.g., mites), and of reduced negative effects on beneficial species that may result from the use of soaps. Also unknown at this time is whether or not growers could receive a premium price in specialty markets by growing "low-spray" or even "organic" pears using dormant oils and soap sprays as the basis of a spray program. Positive results in these areas could easily affect the economics of spray decision-making.

We conclude that insecticidal soaps may have a role in future pear psylla control programs in spite of their higher cost; however, more work needs to be done using spray additives to reduce or eliminate fruit phytotoxicity. Because insecticidal soaps are non-selective, possible negative effects on beneficial species (aphid predators, spiders, minute pirate bugs, etc.) must be investigated. Further, other than learning that defoamers are essential when applying soaps, we know very little at present about their application through air-blast sprayers, or whether they may be applied using low-volume techniques. Consequently, we are not prepared at this time to recommend insecticidal soap on a large scale, although growers are encouraged to experiment in small blocks.

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A REPORT ON THE 1987 MASSACHUSETTS APPLE IPM PROGRAM

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Acknowledgements: We wish to thank Keith Bohne, Alex and Charlie Dowse, Tony Lincoln, Frank Parker, Jesse and Wayne Rice, Ed Roberts, Bill Rose, Mike and Tim Smith, Tony Rossi, and National Park Service staff, Ron Catudal and Gene Gabriel, for their cooperation. Thanks also to New England Fruit Consultants, Sue Butkewich, and Tom Green for information they provided which we included in pest messages and reports. Special thanks to Regional Fruit Agents, Jim Williams and Dom Marini, for performing weekly scouting of a commercial orchard in their region and reporting their findings for use in pest alert messages. Thanks to all Regional Fruit Agents for speedy turnaround of pest messages.

Extension Program Activity

As in previous years, the apple IPM program was funded by a combination of state, federal, and grower sources. Voluntary grower contributions totaled $3,200 in 1987, a 14% increase from last year. We greatly appreciate this continued support, and we consider it further evidence that Massachusetts apple growers, through hiring IPM consultants and support of Extension programs, have adopted IPM on a large scale.

Program activities were similar to those in 1986, and continued to focus on grower and other group education, information-transfer using newsletters, code-a-phones, twilight meetings, and orchard visits, and on performing appropriate adaptive studies. Eight commercial orchard blocks, two blocks at the University of Massachusetts Horticultural Research Center (HRC) in Belchertown, and one at an historic orchard in Quincy were monitored weekly for arthropods and pathogens affecting tree fruits. Increased emphasis was placed on monitoring peach and pear pests and including this information in pest messages. Scab infested leaves which had been placed in wire cages at cooperator sites in November, 1986, were collected weekly and examined to determine apple scab spore maturity. In addition, temperature and rainfall were recorded at the HRC, and other pest information was gained by occasional orchard visits, and by reports from Sue Butkewich, Tom Green, growers, Extension workers in other states, and private scouts and consultants.

Plant Pathology expanded the *Venturia inaequalis* (apple scab) ascospore maturity monitoring to cover more effectively the range of development in the state. As a side benefit, it was possible to begin to model the development of ascospores, and relate it to degree days. In New Hampshire, such a model has eliminated the need for frequent maturity sampling. However, discrepancies between the New Hampshire results and tests in other states make it advisable for us to test the model in Massachusetts.

Cooperating growers were strongly encouraged to buy modified recording hygrothermographs, which were made available at a bulk discount along with weather shelters or plans for their construction. Weather data from these stations, as well as from the HRC, were used to advise growers on the intensity of the scab pressure.

Scouting information was used to reply to grower calls and to write twice-weekly Entomology Pest Messages from April 7 to August 25. Plant Pathology messages were written weekly during the primary scab season, and in response to observed problems thereafter. Messages were transmitted via the INFONET computerized bulletin board system (BBS). The 3 regional fruit agents again distributed messages as weekly newsletters and via 24-hour code-a-phones. Recorded code-a-phone messages continued to be used by growers at levels comparable to past years. A few growers accessed the INFONET BBS directly from their own computers.

Entomology and Plant Pathology staff members made a combined total of approximately 150 orchard site visits during the year, assessing pest problems faced by large and small commercial orchardists. Staff assisted pomologists with apple maturity assessments during harvest using the starch-iodine test, and this information was disseminated via INFONET and newsletters. Maturity alerts provided an important harvest management tool for growers, especially when less daminozide (AlarTM) was used.

Staff members gave a total of 28 talks at grower and other group meetings and authored or co-authored 6 *Fruit Notes* articles, 20 journal articles, and 1 proceedings article. Entomology and Plant Pathology staff also collaborated with Dr. Rick Weires, Hudson Valley Lab, on the annual *March Message*.

Table 1. Percent insect- and disease-injured fruit in 8 commercial blocks in 1987, compared to 1978-86.

Injury type	Fruit infested (%) 1987	1978-86
Tarnished plant bug	1.30	1.64
European apple sawfly	0.20	0.36
Plum curculio	0.71	0.54
Apple maggot fly	0.89	0.06
San Jose scale	0.01	0.67
Leafrollers	0.08	0.03
Green fruitworm	0.02	0.07
Codling moth	0.00	0.01
Other insects*	0.00	0.01
Apple scab	0.32	0.83
Calyx end rot	0.28	0.20
Black rot	0.03	0.14
Fly speck	0.72	0.05
Other diseases**	0.07	0.12

*Other insects include: white apple leafhopper, aphid honeydew and sooty mold

**Other diseases include; sooty blotch, moldy core, white rot, and quince rust.

In 1987 we completed year 2 of a cooperative agreement with the U.S.Dept. of the Interior, National Park Service, which seeks to implement IPM in historic orchards at the Adams National Historic Site (NHS), Quincy, MA, at the Roosevelt/Vanderbilt NHS, Hyde Park, NY, and at the Morristown NHS, Morristown, NJ. Under our direction, park staff pruned trees, monitored insects, recorded temperature and leaf wetness, and applied pesticides based on scouting. The Adams Historic orchard shows the most completely developed pest management plan, and produced a crop of good quality apples this season for the first time in recent history.

A Training Workshop held at the University of Massachusetts February 24-26, 1987, as part of the USDI--NPS cooperative agreement was attended by 22 National Park Service staff from throughout the U.S., and provided training in concepts and techniques of IPM for historic orchards, including lectures by several University faculty and staff. Participants identified 26 historic fruit plantings in the NPS system, the earliest site dating from 1752. Evaluations indicated highly positive response to workshop structure and content.

Insect and Mite Status, 1987

Tarnished plant bug (TPB) was again the single most important cause of fruit injury noted at harvest in Massachusetts orchards (Table 1), and TPB remains a difficult pest to manage. The goal of predicting the optimal timing of TPB sprays still eludes us. However, we rarely observe severe fruit distortion from TPB feeding in commercial orchards. Thus, much of the injury we see has comparatively little effect on grade.

European apple sawfly (EAS) activity was very high in 1987 throughout Massachusetts and in other parts of the Northeast. Activity began shortly before bloom (5/14 to 5/21) in most areas, although a few EAS were caught on white plant bug traps a week before bloom. Record captures of EAS were noted, especially in a Wilbraham block wherein cumulative average captures exceeded 39 per trap by 5/14. The highest single trap capture was 89 EAS, a new "record" for us, although Lorraine Los at the University of Connecticut has us beat, with her report of up to 100 EAS per trap! Numerous EAS-scarred or -infested fruit were seen in orchards in June, but most fell from the tree, and harvest surveys showed only an average amount of EAS fruit injury (Table 1).

Apple maggot fly (AMF) was first reported on 7/6 on a red sphere in Westborogh, and activity was early and high. In some parts of the state, fly emergence and activity followed normal patterns, but in others, where rain showers were infrequent, AMF activity in August was below normal. In one warmer block of Delicious peak nonbaited-sphere capture (mean of 4.5 per trap) occurred during the week ending 9/11. AMF fruit injury in 8 monitored blocks averaged 0.89% (Table 1), and in an additional 18 grower-sprayed blocks injury averaged 1.4%, unusually high levels for sprayed commercial blocks. Overall, AMF trap captures were high, with an average of 25 flies per trap in the 18 aforementioned blocks from early July to early September.

European red mite activity also began early, with up to 20 mites per leaf seen on 5/14 in a Granville block which had received an oil treatment and which did not have a history of using predator-harsh materials. Two monitored blocks needed treatment for mites before the end of May. Perhaps due to early prey mite buildup, predator mite activity was also very high later in the season. *A. fallacis* and the Stigmaeid mite, *Z. mali* (yellow mites), were common in some monitored blocks. Some orchards had as many as 20% of leaves with *A. fallacis*, and up to 40% with *Z. mali* in August. In addition, some unusual predators, such as the Coniopterix, were noted in Granville on 7/14; however, the Coccinelliid beetle, *Stethoris punctum*, an important mite predator in Pennsylvania and parts of New York, was not reported anywhere in Massachusetts this season.

Plum curculio pressure began shortly after bloom and continued for 3 to 4 weeks. Most growers maintained an insecticide cover through the period, and PC damage was not significant in monitored blocks.

Leafminers (LM) showed unusually low activity throughout the state. Overwintering generation LM emergence was apparently affected by very cold weather and snow during the time of emergence. Adults which had begun to move from the groundcover to tree canopies may have been "knocked down" by the cold. After that, visual trap captures continued at a low level into bloom. The few growers who had a leafminer problem had difficulty timing sprays correctly, and few monitored blocks had 100% leafminer control. Third generation LM injury (late season) was high in several blocks, which should also have resulted in an increase in parasitism, normally highest in that generation.

Potato leafhopper (PLH) was first spotted in a commercial orchard in Wilbraham on July 8, and activity continued in some parts of the state through August. By harvest, "hopper burn", a yellowing of leaf margins, sometimes progressing to death of leaf margins, was widespread in the state. A single azinphosmethyl spray appeared to provide control at the HRC, and we have had no reports of apparent PLH resistance to other organophosphates.

Apple grain aphids and green apple aphids both reached high numbers before bloom in many instances. Green aphids dispersed onto apple fruit early as well, although absolute numbers of aphids on fruit remained low. In monitored orchards, however, no significant honeydew and no sooty mold problems were noted during harvest surveys in spite of aphid presence earlier. Cecidomyiid predator larvae were present in overwhelming numbers (5 to 10 per terminal). Syrphid larvae were not really a factor in biocontrol until near the end of aphid activity.

Japanese beetles were noted in unusually high numbers in some commercial orchards in 1987. Although one grower reported high enough defoliation to warrant treatment, most problems were not that severe. Beetle problems were typically localized and could have been spot-treated.

Birds caused a significant amount of damage to fruit this year. Cortlands continued to be a favorite target of crows, bluejays and other species. Peaches also received much damage statewide. It has been suggested that the dry summer forced birds to look for moisture sources wherever they could, and that recurrence may be reduced in similar years by providing bird baths or other clean water sources.

Disease Status, 1987

Scab incidence was generally light, but variable. In the eastern part of the state, within 50 miles of the coast, scab was heaviest. Early season rain in the eastern part of the state lasted for longer periods, though temperatures in both east and west were similar. Infection periods, therefore, occurred in the east when they did not in the western areas. A dry summer meant that there was little, if any, secondary spread after June. Fruit scab was generally confined to the calyx end, indicating early season infections which spread.

Blossom end rot was heavier than normal in some orchards. The same weather which promoted calyx-end scab undoubtedly promoted end rot. The causative organism for this was not *Sclerotinia* but *Alternaria*.

Powdery mildew developed into a more serious problem than usual last year. We used the pest messages to advise growers that the disease was becoming widespread, and that fungicides which affect both mildew and scab should be used.

Related Research and Adaptive Studies

An important part of 1987 activity involved embarking on the second stage of apple IPM in a large number of commercial orchards. Second-stage IPM projects focusing on apple maggot fly (the key insect pest after May) and key lepidopteran pests and on phytophagous mites and apple scab were initiated with funding from outside grants. As part of the mite biocontrol project, groundcover surveys of 36 second-stage blocks were undertaken. Results of these surveys will enable us to establish orchard classifications (mowing vs. herbicide, hard vs. soft spray program, and broadleaf vs. grass groundcover) prior to the start of 1988 mite sampling. We wish to acknowledge the significant contribution of James Williams and Karen Hauschild who assisted with these surveys, and Dr. Prasanta Bhowmik, who provided training and assistance in orchard weed identification. We will report more fully on all second-stage IPM projects in other *Fruit Notes* articles.

Fungicide, insecticide, and insect growth regulator trials again were performed at the HRC and at grower sites in 1987. This activity involved testing chemicals which may be or presently are a component of commercial spray programs. Evaluation of pesticide effects on mite predators continued, as did the evaluation of disease-resistant apple cultivars. Monitoring continued in a commercial test block of disease-resistant cultivars established at the Rice farm in Wilbraham. This planting is intended to determine the feasibility of using no fungicides and a minimum of insecticides in a commercial setting.

A set of 5 ergosterol biosynthesis-inhibiting chemicals (SI's) was tested at 10-day application intervals, following delayed application (tight cluster was the first application). This study was designed to test the feasibility of increasing intervals and delaying the first fungicide application using SI's. This work will be described in other *Fruit Notes* articles.

IPM blocks at the HRC were treated with a registered SI (RubiganTM) on a delayed application basis under Plant Pathology supervision. Effective control was obtained with 2 fewer fungicide applications than in previous seasons. Another experimental material (not an SI), with potential for long-term residual fungicidal activity combined with low environmental hazard, was tested. Two applications of the material, made in early and late June, effectively stopped scab development. Next season, the material will be tested in a series to determine whether it might offer a means for drastically reducing summer cover sprays and possibly primary season sprays as well.

Two root fungicides and various planting hole amendments were tested for effect on early tree growth. This experiment is a continuation from 1986 and indicates that a 50% peat amendment and one of the fungicide treatments (AlietteTM) are the two most effective techniques for promoting the growth of newly planted trees. A further report will appear in a future *Fruit Notes* article.

Daniel Cooley began work on a regional IPM project with Dr. William MacHardy (NH) and Dr. David Rosenberger (NY), to determine if the scab inoculum dose from the previous season will predict the length to which the first application of fungicide can be delayed the following season. One Massachusetts orchard was involved in this study, and plans were to expand the project to second stage IPM blocks last fall.

Cooley also developed a prototype expert systems (computerized decision support software) for apple scab and apple root problems in conjunction with Dr. Paul Cohen of the Computer and Information Science Department, using Public Service Grant funding. We have been exploring ways to integrate this technology into the overall IPM program.

Disease-resistant apple cultivar evaluation continued, with emphasis on horticultural factors, such as maturity and storability. Plans were made and funding obtained for a major disease resistant block at the HRC. Observation of an immature block planted in Wilbraham continued, and bud wood was distributed to a commercial grower, suggesting that such a program might promote disease-resistant cultivars.

Related entomology research and adaptive studies in Prokopy's lab continued to focus on improvement of monitoring traps for apple leafminers and on the host-finding behavior of the apple maggot fly and the plum curculio. Other related entomology studies involved a test of insecticidal soap against pear psylla (*Psylla pyricola*), the most important pear pest in most orchards. In cooperation with Dr. Alan Eaton, University of New Hampshire, we continued to survey the distribution, in New England, of the European apple sucker, *Psylla mali*, potentially a serious pest in commercial blocks in the future. Although not yet found as a pest in commercial orchards, *P. mali* appears to be present in abandoned orchards throughout the central and western counties in Massachusetts, west into New York's Hudson Valley and south into Connecticut.

Plans for 1988

We propose to continue most of the 1987 activities, including: monitoring weather, pathogens, arthropods, and tree development in at least 8 commercial blocks; writing twice-weekly pest messages; presenting 4 grower training sessions in each of three regions; performing adaptive studies and pesticide trials; authoring extension and other publications; and obtaining outside funding.

Both second-stage projects will continue in 1988. The apple maggot-lepidopteran pest project, aimed at preventing immigration of these apple pests into an orchard, will utilize most of the same 18 orchards as in 1987. The orchard understory work will begin its first full field season, with extensive sampling of mites and mite predators in about 30 commercial orchards with different groundcover characteristics and management regimes. Beginning in mid-May, mite sampling in the tree and in the row or aisle groundcover will commence. Sampling will consist both of visual scans and sample collection at 10 locations within the block and at block borders. Pathologists will measure leaf litter decomposition relative to groundcover type, and isolate fungi and bacteria to determine their effectiveness in decomposing fallen apple leaves. A complete description of this project will be forthcoming.

Spore maturity and weather data will be obtained on the same scale as in 1987, and Pathology staff will continue to evaluate disease-resistant apples including a new block to be planted at the HRC. We also will look at the possibility of early season fungicide reduction in a program which requires early-season estimation of scab inoculum dose, and late-season estimation of infection. This program could eliminate all fungicides up to tight cluster or pink, and fits well into a second-stage IPM program.

Work on expert system development will continue, hopefully in conjunction with others in the northeast region. Expert systems are highly relevant to the future of IPM, since applications of this technology are a natural outgrowth of the apple IPM program, and have the potential to make it even more effective. We plan to pursue regional and University funding and cooperation in the development of a comprehensive apple IPM expert system, which, when released, should be a valuable educational as well as managerial tool.

Continued field tests of insecticidal soap against psylla, aphids, and mites are planned, contingent on funding from outside sources. An additional activity planned for 1988 is an update of previously-established economic thresholds, taking into account price changes for fresh fruit and pesticides and new data on pest severity.

This year will be the first of a new cooperative agreement with the National Park Service, which will involve a survey and inventory of historic orchards and fruit tree plantings in the NPS system throughout the U.S. Inasmuch as some NPS sites may contain examples of historic fruit cultivars which are not available elsewhere, this work is being carried out under a directive from the Secretary of the Interior to conserve unique genetic resources (in the form of apple cultivars).

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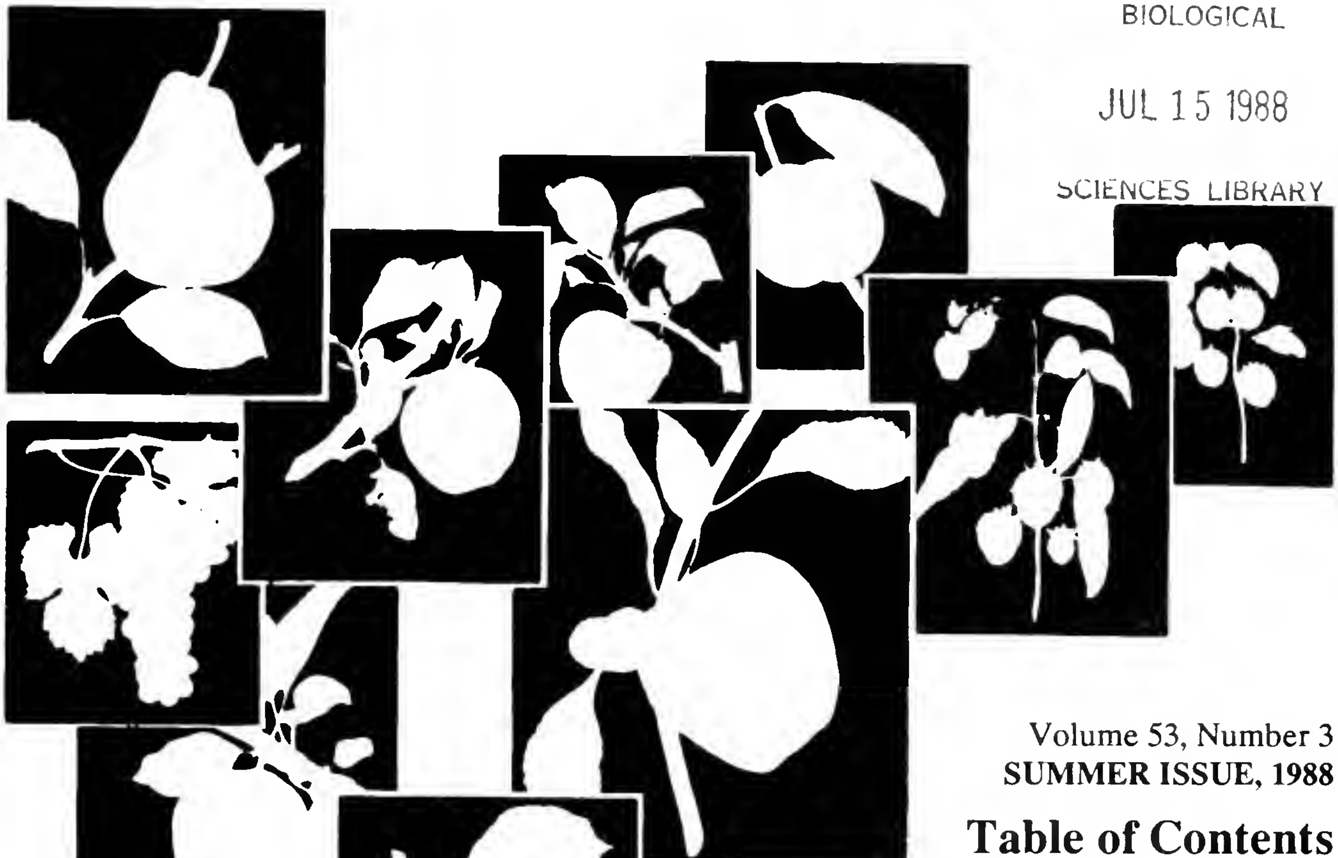
Fruit Notes

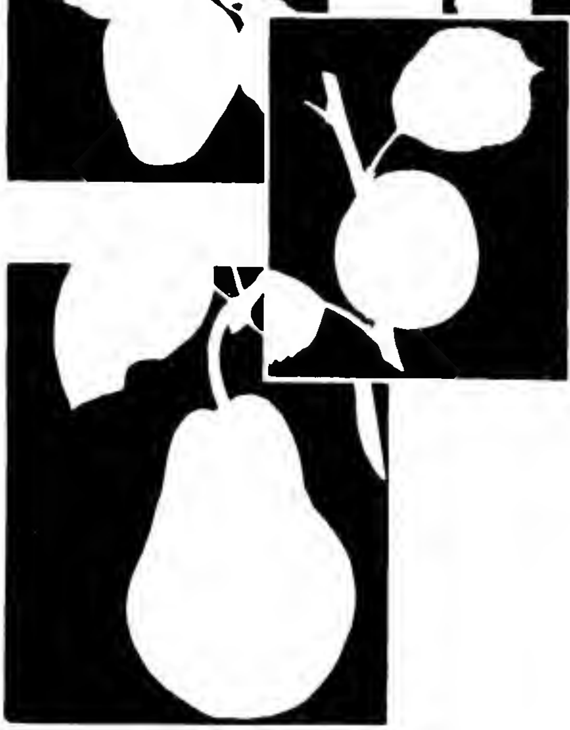
ISSN 0427-6906

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage





Volume 53, Number 3
SUMMER ISSUE, 1988

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

Fruit Notes
Department of Plant & Soil Sciences
205 Bowditch Hall
University of Massachusetts
Amherst, MA 01003

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The Economic Benefits of Summer Pruning

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In previous *Fruit Notes* articles [52(3):7-8 and 53(2):1] Greene and Autio outlined some of the procedures and benefits of summer pruning of McIntosh trees. These benefits included earlier coloring (allowing earlier harvest and lower losses to drop) and a higher percentage of the fruit making the U.S. Extra Fancy grade. In this article we shall detail the economic benefits of summer pruning, to give growers the necessary information to decide whether or not to summer prune.

In 1986 and 1987 summer pruning studies were performed on 25-year-old Rogers McIntosh/M.7 trees at the Horticultural Research Center, Belchertown, MA. These trees can be considered the standard for the industry. Two harvests were made each year. Data were collected on the number of bushels harvested in each picking, the number which were lost to drop, and the percent of a random sample made at the first picking which were U. S. Extra Fancy. Additionally, the fruit were observed after storage and downgrading due to bruising and softening was estimated. Most of these data are reported in the previous 2 articles.

A distribution of the packout was approximated from various observations for the entire yield of trees which were summer pruned and those which were not (Table 1). Grades were divided into 3 groups: Extra Fancy/Fancy, No. 1/Utility, and Processing. Drops were counted separately and assumed to be usable for processing. The per-bushel fruit values used in this study were $10.50 for the Extra Fancy/Fancy, $6.00 for the No. 1/Utility, and $2.00 for the processing. One half bushel per tree was assumed to be lost during the summer pruning activity. Pruning labor was assumed to cost $6.00 per hour.

Summer pruning reduced the losses to drop and downgrading due to bruising and softening, because it allowed an earlier harvest of a larger percentage of the crop. Summer pruning also resulted in more fruit making

Table 1. Comparison of returns and costs for summer pruned and control McIntosh trees.

	Not summer pruned		Summer pruned	
	(bu/acre)	($/acre)	(bu/acre)	($/acre)
A. Crop yields and values:				
Harvested	755		802	
Extra Fancy/Fancy	581	$6101	683	$7172
No. 1/Utility	113	678	63	378
Processing	61	122	56	112
Drop	444	888	360	720
Totals	1199	$7789	1162	$8382
B. Labor costs:				
Summer pruning (hours)	0	$ 0	17	$102
Dormant pruning (hours)	21	126	13	78
Totals	21	$126	30	$180
C. Net value		$7663		$8202

Table 2. Comparison of returns and costs for Alar-treated and summer pruned trees.

	Alar-treated, not summer pruned		Not Alar-treated, summer pruned		Alar-treated, summer pruned	
	(bu/acre)	($/acre)	(bu/acre)	($/acre)	(bu/acre)	($/acre)
A. Crop yields and values:						
Harvested	1019		802		1023	
Extra Fancy/Fancy	815	$8558	683	$7172	871	$9146
No. 1/Utility	153	918	63	378	80	480
Processing	51	102	56	112	72	144
Drop	180	360	360	720	139	278
Totals	1199	$9938	1162	$8382	1162	$10048
B. Labor costs:						
Summer pruning (hours)	0	$ 0	17	$102	17	$102
Dormant pruning (hours)	21	126	13	78	13	78
Totals	21	$126	30	$180	30	$180
C. Alar application		$70		$0		$70
D. Net value		$9742		$8202		$9798

the higher grades on color because of the increase in light penetration into the tree. Summer pruned trees had slightly lower yields, but the overall fruit value was $8382 per acre compared to $7789 for trees that were not summer pruned (Table 1). Seventeen hours of labor per acre were added by summer pruning, but dormant pruning was reduced by 8 hours per acre. Total labor costs were increased by only $54 per acre. Summer pruning resulted in an additional net value of $539 per acre; a value which makes the activity very much worthwhile.

In these 2 years of study only trees which did not receive Alar™ were used, but we have made estimates comparing Alar-treated trees with summer pruned trees which did or did not receive Alar (Table 2). Note that these estimates were approximations based on our experience with Alar and summer pruning. The expected net returns were approximately $1540 higher if Alar were used compared to when summer pruning was practiced without Alar, primarily because of the much lower percentage of fruit lost to premature drop. Obviously, summer pruning cannot compensate completely for not using Alar, but it does reduce the losses by approximately one third. Table 2 also shows an estimate of the costs and returns of Alar-treated trees which were summer pruned, giving a comparable net value to Alar-treated trees which were not summer pruned. These results suggest that it likely would not be beneficial to summer prune if you have already treated with Alar, primarily because Alar would keep fruit on the tree long enough for red color to develop and the fruit to be harvested. However, summer pruning still may be beneficial since earlier coloring would allow earlier harvest, potentially resulting in higher quality fruit for long-term storage.

Summer pruning can be a very beneficial procedure which causes a small increase in pruning costs, but a substantially greater crop value in cases where Alar is not used. Growers should consider summer pruning all McIntosh trees which will not receive Alar. The economic returns speak for themselves.

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Effects of Rootstock and Interstock on the Growth, Productivity, and Anchorage of a Spur and Standard Strain of Delicious

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A number of studies have compared spur and standard apple strains but commonly have not assessed the additional effects of rootstock and interstock. In this study we compared the effects of M.7A, M.26, M.9/MM.111, M.9/MM.106, and MM.111 on the growth, productivity, and anchorage of Starkrimson Delicious (spur strain) and Gardiner Delicious (standard strain) trees.

Trees were planted in the spring of 1981 at the Horticultural Research Center, Belchertown, MA. The experimental design was a randomized complete block with 7 replications. Within each block 4 trees were planted per strain-rootstock-interstock combination, and the two middle trees were used for data collection. All rows were 20 ft apart, but spacing within rows varied with the combination. Starkrimson trees on M.26, M.9/MM.106, and M.9/MM.111 were spaced 12 ft apart, and Starkrimson trees on M.7A and MM.111 and Gardiner trees on M.26, M.9/MM.106, and M.9/MM.111 were spaced 14 ft apart. Gardiner trees on M.7A and MM.111 were spaced 16 ft apart.

In 1983 bloom was assessed, and in 1984 bloom, fruit set, and yield were measured. In 1985 tree height, spread, trunk circumference, and yield were measured. The 1985 tree spread values were used to calculate theoretical tree spacings and theoretical numbers of trees per acre. It was assumed that the optimal distance between trees within a row should be 50% greater than the 1985 tree spread and the distance between rows should be 8 ft greater than the distance between trees within a row. The value of 50% was used because it resulted in approximately the accepted densities for the 2 strains on M.7A, the most tested rootstock in the study. These values were used to calculate the theoretical yield per acre in 1984 and 1985.

In September, 1985 these trees experienced the effects of Hurricane Gloria, which allowed an assessment of tree anchorage of these strains on the various combinations. The angle of lean from the vertical was used to measure anchorage, since poorly anchored trees were partially or completely blown over.

Tree Size

Tree height, spread, and trunk circumference, obtained in November, 1985, are presented in Table 1. For each measurement Gardiner trees were significantly larger than Starkrimson trees. This relationship between a spur and a standard strain has been shown many times. Significant differences also existed among rootstocks within each

Table 1. Height, spread, trunk circumference, and calculated number of trees per acre in 1985 of Gardiner and Starkrimson Delicious trees planted in 1981.

	Height (ft)			Spread (ft)			Trunk circum. (cm)			Trees per acre		
Stock	Gard.		Stark.	Gard.		Stark.	Gard.		Stark.	Gard.		Stark.
M.7A	13.7 b[z]		12.3 a	10.7 a		7.9 a	26.6 a		23.8 a	119 b		191 b
M.26	11.4 d		10.1 b	9.2 b		6.4 b	19.2 d		18.1 bc	153 a		276 a
M.9/MM.111	12.2 c		10.0 b	9.0 b		6.2 b	21.3 c		16.9 d	160 a		291 a
M.9/MM.106	12.6 c		10.8 b	10.5 a		7.8 a	23.4 b		19.5 b	121 b		198 b
MM.111	14.9 a		12.3 a	10.3 a		8.4 a	26.9 a		23.7 a	126 b		175 b
Average	13.0	**[y]	11.1	9.9	**	7.4	23.5	**	20.4	136	**	226

[z]Means within columns not followed by the same letter are significantly different at odds of 19:1.
[y]Gardiner and Starkrimson are different at odds of 99 to 1.

Table 2. Flowering and fruit set of Gardiner Delicious and Starkrimson Delicious trees planted in 1981.

	Number of blossom cluster								
	1983 (/cm trunk circ.)			1984 (/cm limb circ.)			Fruit set 1984 (/cm limb circ.)		
Stock	Gard.		Stark.	Gard.		Stark.	Gard.		Stark.
M.7A	8.3 c[z]		9.9 c	4.0 b		3.5 b	16.8 ab		23.4 ab
M.26	11.8 b		10.6 b	5.6 a		4.3 a	16.6 bc		11.8 bc
M.9/MM.111	10.2 bc		9.2 bc	4.9 a		4.5 a	11.6 c		10.4 c
M.9/MM.106	13.6 a		12.4 a	5.3 a		4.0 a	22.6 a		25.5 a
MM.111	2.0 d		0.8 d	4.0 b		2.9 b	9.6 c		13.4 c
Average	9.2	ns[y]	8.6	4.8	**	3.9	15.4	ns	16.9

[z]Means within columns not followed by the same letter are significantly different at odds of 19 to 1.
[y]If **, then Gardiner and Starkrimson are different at odds of 99 to 1. If ns, then Gardiner and Starkrimson are not significantly different.

Table 3. Yield per tree and theoretical yield per acre for Gardiner and Starkrimson Delicious trees planted in 1981.

	1984			1985			Cumulative		
Stock	Gard.		Stark.	Gard.		Stark.	Gard.		Stark.
A. Yield per tree (bu)									
M.7A	0.4 b[z]		0.3 b	0.6 bc		1.3 bc	1.0 bc		1.6 bc
M.26	0.4 b		0.3 b	0.9 a		1.5 b	1.3 b		1.8 b
M.9/MM.111	0.1 c		0.1 c	0.9 ab		1.0 cd	1.0 c		1.1 c
M.9/MM.106	0.7 a		0.5 a	1.0 a		1.9 a	1.7 a		2.4 a
MM.111	0.1 c		0.1 c	0.4 c		0.8 d	0.5 d		0.9 d
Average	0.3	ns[y]	0.2	0.8	**	1.3	1.1	**	1.6
B. Yield per acre (bu)									
M.7A	47 b		57 b	63 ab		250 b	109 ab		307 b
M.26	49 b		58 b	138 a		385 a	187 a		444 a
M.9/MM.111	20 c		24 c	144 a		312 ab	165 a		336 b
M.9/MM.106	79 a		94 a	123 ab		371 a	202 a		466 a
MM.111	15 c		12 c	42 b		136 c	57 b		147 c
Average	42	ns	49	102	**	290	144	**	340

[z]Means within columns not followed by the same letter are significantly different at odds of 19 to 1.
[y]If **, then Gardiner and Starkrimson are different at odds of 99 to 1. If ns, then Gardiner and Starkrimson are not significantly different.

strain. Gardiner trees were tallest on MM.111, followed by those on M.7A. The two interstem combinations were similar in size, and trees on M.26 were the shortest. Starkrimson trees were tallest on MM.111 and M.7A, and the M.26, M.9/MM.111, and M.9/MM.106 trees were of similar height. Tree spread was greatest for trees on MM.111 and M.7A.

As expected, the size of the spur trees allowed for significantly more trees per acre than for the standard strain (Table 1). For both strains the M.26 and M.9/MM.111 rootstocks resulted in the smallest trees and most trees per acre. The M.7A, M.9/MM.106, and MM.111 trees were of similar tree spread which resulted in similar values for trees per acre. Differences in precocity may cause inaccuracies in determining theoretical densities using these young trees. For instance, the trees on M.9/MM.106 had the highest yields for 1984 and 1985, and as a result their growth rate may have been slower than trees on M.7A. When a similar formula is used to calculate ultimate spread for trees on M.7A and M.9/MM.106, it would be expected that either the density for M.9/MM.106 would be underestimated or that for M.7A would be overestimated. In this case it appears that the theoretical density for trees on M.9/MM.106 may be lower than the ideal density. The situation may be the reverse for trees on MM.111, where the theoretical density was substantially higher than commonly recommended.

Flowering and Fruit Set

Table 2 shows the flowering and fruit set data for 1983 and 1984. No significant differences existed between Gardiner and Starkrimson as to the quantity of bloom in 1983, but in 1984 Gardiner had significantly more bloom than Starkrimson. These trees were in their fourth leaf in 1984 and the greater bloom on Gardiner, the standard strain, may have been due simply to variation in these trees which were just coming into production. In general the interstem trees and trees on M.26 had more blossom clusters than did trees on M.7A or MM.111.

Fruit set in 1984 (Table 2) was similar for the 2 strains, but trees on M.9/MM.106 had the highest set and those on MM.111 and M.9/MM.111 had the lowest.

Yield

Yield per tree and theoretical yield per acre are presented in Table 3. On a per-tree basis the cumulative yield for 1984 and 1985 was significantly higher for the Starkrimson than the Gardiner trees. Some studies have shown a similar relationship, with the spur strain yielding more than the standard strain; however, most studies have shown the reverse. Cases such as this one, where the spur yielded more than the standard strain, may reflect precocity rather than ultimate yield potential. As the standard trees become larger it would be expected that they would yield more than the spur trees.

Theoretical production per acre was significantly higher for Starkrimson. Since the spur strain was smaller and more productive it had a much higher theoretical yield per acre.

Yields per tree for the various rootstocks showed that trees on M.9/MM.106 produced the most fruit, whereas those on MM.111 produced the fewest. The MM.111 root, with or without an M.9 interstock, appeared to confer a low yield potential to the tree, or at least resulted in less precocity. There also was a lower fruit set for trees with these roots. It is particularly interesting to note the difference between the two interstem trees. Trees on M.9/MM.106 had the highest theoretical yield per acre, followed by those on M.26, M.9/MM.111, M.7A, and MM.111. These data suggest that the interstem trees and those on M.26 can result in the highest productivity.

Table 4. Tree lean after Hurricane Gloria, 1985.

	Lean from vertical (°)		
Stock	Gard.		Stark.
M.7A	53 d[z]		33 c
M.26	20 b		19 b
M.9/MM.111	16 b		20 b
M.9/MM.106	34 c		19 b
MM.111	0 a		0 a
Average	25	ns[y]	18

[z]Means within columns not followed by the same letter are significantly different at odds of 19 to 1.
[y]Gardiner and Starkrimson are not significantly different.

Anchorage

Information already presented suggests that MM.111 is a poor rootstock for Delicious, because first of all, it produces the largest tree, and secondly, it has the lowest yield per tree and theoretical yield per acre. However, it is commonly thought to be well anchored. We were able to measure anchorage easily in 1985 because of the effects of Hurricane Gloria. Trees were subjected to winds in excess of 65 miles per hour, and substantial tree movement resulted. After the hurricane, several trees were leaning, and the angle from vertical was measured (Table 4). The poorest anchorage was seen with trees on M.7A roots, where the average angle of lean was 43°. Trees on MM.111

showed no signs of leaning and were by far the best anchored. Granted, the lower fruit load on MM.111 trees may have reduced somewhat the tendency to lean, but they also had the largest leaf surface and above-ground portions, providing a larger area for wind action and more potential for damage.

Trees on MM.111 were undesirable in terms of size and yield but were much better anchored than any other rootstock or rootstock-interstock combination. Under certain conditions the better anchorage would make trees on MM.111 much more desirable than other combinations.

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Prospects for Greater Use of Biological Control Agents Against Pests of Apple in Massachusetts

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A recent publication of the Massachusetts Agricultural Experiment Station, *Opportunities for Increased Use of Biological Control in Massachusetts* by Van Driesche and Carey (Bulletin 718), has reviewed the status of the use of parasites and predators for insect and mite pest control for all major crops in Massachusetts. This report is available through the Bulletin Distribution Center, Cottage A, at the University of Massachusetts at Amherst for $7.00. For apples, several possibilities exist to expand the degree of pest control provided by predators and parasites.

Little to no possibility exists for control of the major apple pests (apple maggot fly, plum curculio, and the tarnished plant bug). These species have few exposed life stages suitable for attack by beneficial insects, and because they are direct pests of the fruit, little tolerance exists for their presence in commercial orchards. Certainly a few parasites of these species do exist, but they offer no reasonable hope for commercially acceptable levels of control. The controls applied for these species do, however, play a key role in regard to the biological control of those species for which effective biological control agents do exist -- namely aphids, scales, white apple leafhopper, mites, and leafminers. All of these groups can come under effective control by predators or parasites given favorable orchard management.

The traditional use of continuous insecticide cover sprays from early season through early to mid-August frequently disrupts the control of these secondary pests. The "Second-stage" IPM program currently being tested at the University of Massachusetts by the tree fruit entomologist, Ronald Prokopy, and the IPM coordinator, William Coli, however, has the potential to change this situation. The strategy replaces insecticidal control of apple maggot fly with a control system based on sanitation and intensive trapping. Second-stage IPM may allow routine, non-fungicidal sprays to be discontinued after the end of May. The termination of these disruptive sprays is expected to result in more mite predators and leafminer parasites in orchards, and these are expected, based on previous studies, to exert commercial-level control of these pests in most orchards. Preliminary results for one field season did show a substantial increase in predator mites when post-May, non-fungicidal sprays were not applied. We are, therefore, very likely to be at a major turning point in orchard pest control, in which the termination of continuous cover sprays (the rule for at least 40 years) will usher in a mixed chemical/biological control strategy in which mite predators and leafminer parasites will provide control of these pests.

There are a number of specific actions or studies that need to be undertaken to reach this goal. The most important is, of course, the second-stage IPM project itself, as it is the foundation on which all else rests. This effort currently is underway with primary funding from the Massachusetts Department of Food & Agriculture and the Massachusetts Society for the Promotion of Agriculture. Other specific actions that will be needed include the following.

Mites. The composition of predacious mite fauna in Massachusetts apple orchards and their response to orchard pesticides is fairly well understood (Hislop & Prokopy, 1981). The goal of increasing predator numbers in orchards to levels high enough to control spider mites can be reached by 1) earlier termination of cover sprays (as in the second-stage IPM strategy); 2) introducing a strain of the main predator, *Amblyseius fallacis*, that has greater resistance to common cover spray insecticides; 3) planting and managing orchard floor vegetation that is most favorable to predator mite survival and reproduction; and 4) avoiding the use of materials such as benomyl and the pyrethroids that do greater damage to predator mites than spider mites. Activity on point one is underway and additional funding for this effort is being sought from the Department of Food & Agriculture under the Department's competitive biological control grants program. A pesticide-resistant strain of *Amblyseius fallacis* does exist and has been established in apple orchards in Quebec where it has provided successful control of European red mite and two-spotted spider mite (Bostanian & Coulombe, 1986). This resistant *A. fallacis* can be introduced in Massachusetts orchards. The role of orchard floor vegetation, the species of plants used and their management, is not well understood. Such vegetation influences winter survival of predators, the timing of their spring movement back into trees, and their rate of reproduction, since plant pollens are used as food sources by the predator. A project to research this topic in Massachusetts has been funded by the Department of Food & Agriculture. Work was initiated in 1987 and will continue this year.

Aphids and San Jose Scale. Generally, existing predators appear to keep the three aphid species in Massachusetts apples under satisfactory control unless disrupted by pesticide use. The cecidomyiid, *Aphidoletis aphidimyza*, is one of the more important aphid predators, but various coccinellids, syrphids, and chamaemyiids also exist in important numbers. The apple aphid is the best studied of the three aphid species, and its control is predominantly by predators. The woolly apple aphid has a specific parasite, *Aphelinus mali*, that is important in regulating that species. Least is known about biological controls of the rosy apple aphid, one of the main aphid pests of apples. San Jose scale is attacked by a specialized parasite, *Prospaltella perniciosi*, of Asian origin, as well as various generalist predators. Future plans for control of all these pest species are based on the judgment that existing parasites and predators do exist that will control these pests in most cases unless disrupted by pesticide applications. As such, the second-stage IPM strategy should improve the degree and reliability of such control in the future.

Leafminers. The apple blotch leafminer is a classic induced pest. In unsprayed areas its densities are kept low by several efficient specialist parasites. In Massachusetts the major species are *Pholetesor (Apanteles) ornigis*, a braconid, and the eulophid, *Sympiesis marylandensis* (Van Driesche & Taub, 1983). Both species feed on older larvae within mines. Under current orchard spray regimes these parasites become common in orchards only late in the season (August through October) after cover sprays are ended. When limited to this short period, parasites cannot suppress leafminers below economic levels. Terminating non-fungicidal cover sprays after the end of May, as envisioned by second-stage IPM, should create an opportunity for substantial increase in control of leafminer populations by parasites. Two additional parasite species have potential for increasing the degree of leafminer control, the braconid, *Apanteles pedias*, from New Zealand and the encyrtid, *Holcothorax testaceipes*, from Japan. Both have been imported successfully into Ontario by fruit entomologists at the University of Guelph and are established in that area. *A. pedias* also has been released in New York state. Dr. Chris Maier of the Connecticut Agricultural Experiment Station recently received funding to import and establish these parasites in New England. Studies in Massachusetts will be needed following releases to determine the degree of control resulting from the introduction of these new species.

In conclusion, biological control, while not applicable for plum curculio, apple maggot fly, or tarnished plant bug, in the future will play the key role in suppressing mites, leafminers, aphids, and San Jose scale. The principal way in which this control will occur will be through better conservation of existing predators and parasites by earlier termination of regular cover sprays. Certain new biological control agents, namely a pesticide-resistant strain of the predator mite, *Amblyseius fallacis*, and two exotic species of leafminer parasites, *Apanteles pedias* and *Holcothorax testaceipes*, should be introduced. As controls become increasingly based on predators and parasites, grower need for information on the recognition and biology of the specific beneficial species involved will increase. To meet this need, new Extension literature discussing the details of biological controls of specific apple pests will be required. Plans to develop such materials exist and are being supported by funds from the Department of Food & Agriculture.

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Peach Brown Rot Fungicides Trial, 1987

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Two of the newer fungicides for peach brown rot control are Ronilan™ (vinclozolin) and Rovral™ (iprodione). These materials are reported to be more effective than most other fungicides on peach brown rot. However, they are also more expensive than other materials.

Ronilan and Rovral are labelled and recommended such that a lower rate may be used under low or moderate brown rot pressure. That means that when the weather is relatively dry, then the lower rate may be used. We tested these materials at the lower label rates (and in one case, below the lowest label rate) in 1987, to see whether or not the low rates would perform as well as a low rate of Funginex™ (triforine), which has been an effective material against brown rot for a number of years. We examined the efficacy of the lower rates and analyzed it with respect to the costs.

Funginex 1.6 EC was used in 1 treatment at the lower end of the standard rate range (12 oz/100 gal), Rovral 50WP was used at 0.25 lb/100 gal (1/2 the standard rate) and Ronilan 50 WP was used in 3 treatments at 0.75 lbs, 0.75 lbs plus the spray adjuvant X-77™, and at 0.5 lbs plus X-77 (standard rate for Ronilan is 1 lb/100 gal). Treatments were scheduled at the discretion of the assistant orchard manager, and were done on the following dates under the weather conditions listed: May 11--late petal fall (70°F, light breeze); May 26--post shuck split (85°F, light breeze); June 22--ripening fruit (85°F, humid, shower); July 6--not Harbinger (75°F, clear, calm); and August 5--Glo Haven only (80°F, clear, calm). Sprays were applied with a high-pressure handgun sprayer at a rate of 250 gal per acre, and trees were sprayed to the drip point.

The block consisted of three cultivars: Harbinger,

Table 1. Treatments and rot ratings for peach brown rot fungicide trial at the University of Massachusetts, 1987.

	Harbinger			Garnet Beauty		Glo Haven		
Treatment	Pre.[z]	Post.[y]	(%)[x]	Pre.	(%)	Pre.	Post.	(%)
Ronilan 0.75 lb + X-77 1% v/v	0.0 a[w]	1.3 a	73	0.1 a	28	0.0 a	0.3 a	13
Ronilan 0.75 lb	0.1 a	1.2 a	70	1.5 d	33	0.4 b	0.3 ab	28
Ronilan 0.5 lb + X-77 1% v/v	0.0 a	1.5 ab	85	0.5 b	39	0.0 a	0.4 b	20
Rovral 0.25 lb	1.0 b	2.4 c	93	1.1 c	22	0.5 b	0.6 d	39
Funginex 12 oz	1.3 b	1.9 bc	82	1.9 d	26	0.5 b	0.4 c	23
Control	3.1 c	3.4 d	100	1.6 d	50	0.8 c	0.9 e	45

[z]Mean number of brown rotted peaches per tree immediately prior to harvest.
[y]Mean rot rating on 0 to 5 scale (0 = no rot, 1 = <10% rot, 2 = 10 to 25%, 3 = 26 to 75%, 4 = 76 to 90%, 5 = >90%) of a random box of approximately 40 fruit after 3 to 4 days at room temperature.
[x]Percent of the harvested fruit showing any rot.
[w]Means in a column not followed by the same letter are significantly different at odds of 19 to 1.

Garnet Beauty and Glo Haven. There were 2 randomly placed blocks of 4 trees of each cultivar in each fungicide treatment, for a total of 8 trees per treatment.

At harvest, fruit on each tree were evaluated for the amount of rot present. All trees were mature (10 years) and were in adjacent rows in a block at the Horticultural Research Center (HRC), Belchertown, MA. Each cultivar was grown in two adjacent rows, 20 ft apart. Peaches were harvested, yield recorded, and a subsample of approximately 40 random, apparently healthy fruit from each treatment were placed in a box and kept at room temperature for 3 to 4 days. The fruit then were rated for the number of peaches which showed rot, and for the average intensity of the rot present, rated on a 0 to 5 scale (0 = no rot, 1 = <10% rot, 2 = 10 to 25%, 3 = 26 to 75%, 4 = 76 to 90%, 5 = >90%). The postharvest ratings for rot intensity were not made on the Garnet Beauty fruit.

All fungicide treatments had significantly less rot than the non-treated controls (Table 1). Harbinger has been particularly susceptible to postharvest brown rot at the HRC, as indicated by the 100% postharvest rot. Even in the treated Harbingers, there was some rot on between 70 and 93% of the peaches. Ronilan treatments at the higher rate, either with or without X-77, significantly reduced rot intensity and preharvest rot. The 0.5 lb rate of Ronilan was slightly better than Funginex at reducing the rot intensity, but not the percent of rotted peaches. The 0.25 lb. rate of Rovral was equivalent to Funginex. Ronilan at either rate was significantly better than Funginex or Rovral at reducing the preharvest rot. There was no difference between Ronilan treatments for preharvest rot on the Harbingers.

In the other two cultivars, adding X-77 to the Ronilan at either the 1/2 rate or 3/4 rate significantly reduced the preharvest rot. Not adding X-77 depressed Ronilan's performance compared to that of Funginex. The 1/2 rate of Rovral was sometimes better and sometimes worse than the standard rate of Funginex.

The best treatment for brown rot in this experiment was generally the 3/4 rate of Ronilan with X-77. The 1/2 rate of Ronilan with X-77 also did reasonably well. The 1/2 rate of Rovral was as good as the standard rate of Funginex.

Does this mean that 3/4 or 1/2 rates of Ronilan may be substituted for other fungicides? Not really. This experiment indicates that in a season with moderate pressure, such as last year, the 3/4 and 1/2 rates of Ronilan or the 1/2 rate of Rovral will work as well as a standard rate of Funginex. The question remains, does Funginex work as well as some of the older materials such as thiram and captan? Research in other states indicates that Funginex is at least as good as either captan or thiram, and that is why we used a Funginex standard. However, without including these materials in the test, we cannot be sure that captan or thiram would not have done better. This year we hope to repeat the test using captan or thiram.

However, if Funginex at 12 oz is a good standard, then the lower rates of Ronilan not only did as well, but usually did better. In that context, reduced rates of Ronilan can do as well as or better than Funginex, and therefore might be considered as an alternative to a full rate of Funginex. However, the economics of the situation do not necessarily favor even the reduced Ronilan, Rovral, or Funginex treatments. For the season (given 3 applications for brown rot), the cost of Ronilan at the low rate was $114.00/acre more than captan; at the 1/2 lb. rate, Ronilan cost $66.00 more than captan (Table 2). Funginex at the 12 oz rate cost $25.50 more than captan. Rovral at the 1/4 lb rate cost $15.00 more than captan. Since 3 applications is a low estimate, the cost difference in many cases would be greater. In short, a full rate of captan is always much less expensive than the newer materials. Among the materials tested, Ronilan is more effective, yet it is also several times

Table 2. List of retail prices for fungicides at recommended and decreased rates (January, 1988).

Material	High rate[z]	Cost per acre[y]	Low rate	Cost per acre	Reduction per acre[x]	Cost comp. to captan
Ronilan 50 W	1 lb	$192.00	3/4 lb	$144.00	$48.00	+$114.00
Ronilan 50 W	1 lb	$192.00	1/2 lb	$96.00	$96.00	+ $66.00
Rovral 50 W	1/2 lb	$90.00	1/4 lb	$45.00	$45.00	+ $15.00
Funginex 1.6 EC	16 oz	$74.25	12 oz	$55.50	$18.75	+ $25.50
Captan 50 W	2 lb	$30.00	2 lb	$30.00	$0.00	+ $0.00

[z]Per 100 gal.
[y]High rate of material in 250 gal, 3 applications; January, 1988 approximate prices from retail source.
[x]Dollars saved by using the reduced rate for 3 applications.

as expensive.

If the increased control can more than pay for itself, it is worthwhile. For example, if the material reduces the number of rotted peaches by 1 peach per tree, it will increase the production of an acre of peaches by approximately 1 bushel. This result will earn an extra $15.00 to $20.00. If the postharvest rot is decreased, extra money and extra customer satisfaction will be added. If this extra money exceeds the extra material cost, obviously the treatment is worthwhile.

By those criteria, our data from last year indicated that the Ronilan treatments were not economically justified. However, it is important to stress that this is only one year, and that we do not know how well captan might have controlled brown rot. In addition, this analysis does not consider what might happen under heavy brown rot pressure.

This year we hope to carry out the economic analysis more completely and include captan treatments for comparison. Only by determining the ultimate financial benefit can we judge whether or not a more effective chemical is indeed a more cost effective fungicide.

* * * * *

Mauget Microinjection for Peach X-Disease Therapy

Julianne Schieffer, Terry A. Tattar, and Daniel R. Cooley
Department of Plant Pathology, University of Massachusetts

Introduction

Since the first report in Connecticut in 1933, X-disease has become a serious disease of peach. Originally thought to be caused by a virus, X-disease was shown to be caused by a mycoplasma-like organism living in the phloem. Infection occurs from chokecherry to peach through transmission by leafhoppers.

An infected tree breaks out of dormancy with healthy foliage and flowers. After seven to eight weeks, sections of the tree begin to show a diffuse yellowing. Soon the leaves become brittle, develop red spots, tatter, and curl upward. Diseased leaves fall, often leaving a rosette of yellowed, dwarfed leaves at the tip of each infected branch. This process produces a "rat tailing" effect as the terminal bud breaks prematurely. Diseased trees have reduced growth and lower yields. Unaffected scaffolds within the same tree may continue to grow and bear, but this fruit often lacks flavor or is bitter. Death of the tree, or winter kill of affected sections, often follows within one to four years.

Attempts to control peach X-disease have had mixed results. Pruning diseased limbs is not successful, as the disease appears on other limbs the following year. Chemotherapy of X-disease with oxytetracycline (OTC) has shown much promise, but traditional injection methods have a number of disadvantages. Injection techniques such as gravity infusion, pneumatic pressure, and pipettes, have proven labor intensive, ineffective, or detrimental to tree health (Lacy, 1982; Rosenberger & Jones, 1977). Mauget microinjection has been used widely to deliver effectively chemicals to shade trees with little injury. The objective of this study was to determine if Mauget microinjection of oxytetracycline could be used in commercial peach orchards for remission of peach X-disease symptoms.

Materials and Methods

The Mauget microinjection system consists of a small disposable capsule. In our research, these capsules contained 4 ml of 4% OTC solution. Each capsule is attached to a beveled feeder tube and pressurized with a mallet to approximately 10 to 12 pounds per square inch. One or more 3/16 inch holes, depending on tree diameter, are drilled approximately 1/2 inch deep at the tree base with a portable drill. The capsules are inserted immediately and tapped with the mallet to break the internal membrane, thereby forcing the OTC solution into the xylem of the tree. The appropriate dose rate is one capsule per two inches of trunk diameter. Most trees in this study received 2 or 3 capsules. The contents of most of the capsules was taken up by the tree within a few hours. Empty capsules were removed within a week.

Four Massachusetts orchards were chosen for injection in September, 1986. Each diseased tree and each healthy control tree was rated with the following scale: 0 = outwardly healthy, 1 = foliar symptoms on 10% or less of the canopy, 2 = symptoms on 10 to 50% or less of the canopy, 3 = 50 to 90% affected, and 4 = over 90% affected or dead. Approximately half the trees in each rating class then were injected after fruit harvest.

Trees were observed throughout the following growing season for symptom remission, yield, and wounding. In September, 1987, every tree was rerated to determine any change due to treatment or to progress of the disease.

Results

As indicated by the rating changes shown in Table 1, most X-disease symptoms on the OTC-treated trees were either absent or less severe. Untreated controls either remained at the same disease level, or grew worse when compared to the previous year's ratings. Of the untreated trees with an initial rating of 0 (healthy), 47% showed an increase in X-disease symptoms. Trees with initial disease ratings of 1 or 2 responded well to the OTC treatments, often bearing as much fruit as healthy trees. The severely diseased trees with ratings 3 and 4 gave variable results. Many treated and untreated trees of the 3 and 4 rating classes became worse or died. Even among those trees responding to the treatment, most had only one or two live scaffolds bearing fruit.

Observations throughout the season showed that most treated trees in rating classes 0 to 2 had good fruit yields. Untreated trees gave a wide range of yields dependent mostly on the extent to which the crown was affected by X-disease.

Some trunk damage associated with the drilled holes was evident a year after treatment. Over 60% of the holes inspected had small cracks or gummosis associated with the injection site. A few trees had extensive cracks (from 6 to 10 inches) and decay. Fourteen percent of the holes had callused over after a year and a half. The injection wound alone did not cause the cracks and gummosis; they were caused by the OTC treatment (Schieffer, unpublished data).

Discussion

Mauget microinjection of OTC appears to be an effective and simple technique for X-disease therapy despite possible long-term drawbacks related to injection wounds. Microinjection is not labor intensive and does not require special equipment. Since most X-infected trees decline quickly and eventually die, treatment of diseased trees may at least prolong their productivity. However, trees not more than half affected responded the most, therefore, Mauget therapy appears to offer limited effectiveness to trees in advanced stages of X-disease. Injections will be most cost-effective where half of the tree or less is affected by foliar symptoms at the time of treatment.

Mauget microinjection may prove especially valuable in delaying symptom development in asymptomatic trees on sites where high disease pressure from infected chokecherries is present. Treatment of healthy trees, on the other hand, may need to be considered carefully because of the possible long-term wound effects from OTC injection.

Research is continuing on the evaluation of risks vs. the benefits of prophylactic use of this method in healthy trees, and to determine how long treated trees remain in symptom remission.

References

Lacy, G.H. 1982. Peach X-disease: Treatment site damage and yield response following antibiotic infusion. *Plant Disease Reptr.* 66:1129-1133.

Table 1. Changes in X-disease ratings following OTC treatment.

Original rating	Treatment	Increase (%)	No change (%)	Decrease (%)
0	OTC	9	91	0
0	Control	47	53	0
1	OTC	5	19	76
1	Control	73	13	13
2	OTC	0	20	80
2	Control	17	75	8
3	OTC	14	7	79
3	Control	10	70	20
4	OTC	0	67	33
4	Control	0	100	0

Rosenberger, D.A. and A.L. Jones. 1977. Symptom remission in X-diseased peach trees as affected by date, method, and rate of application of oxytetracycline-HCL. *Phytopathology* 67:277-282.

Acknowledgements

The authors wish to thank Hamilton Orchards in New Salem, Westward Orchards in Harvard, Bolton Spring Orchards in Bolton, and Green Acres Fruit Farm in Wilbraham for their cooperation during this study. We also thank James Williams and Karen Hauschild for help with injections, and the J. J. Mauget Company for supplying the Mauget OTC capsules.

* * * * *

Reevaluation of NAA as a Preharvest Drop Controlling Chemical for McIntosh

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For the past 20 years Alar™ has been the primary chemical used to control preharvest drop of McIntosh fruit. The superior performance of Alar essentially eliminated the use of those compounds available prior to its registration. However, the registration of Alar is under review and we still do not know what its future will be. More stringent tolerance levels already have been set by the Massachusetts Department of Public Health.

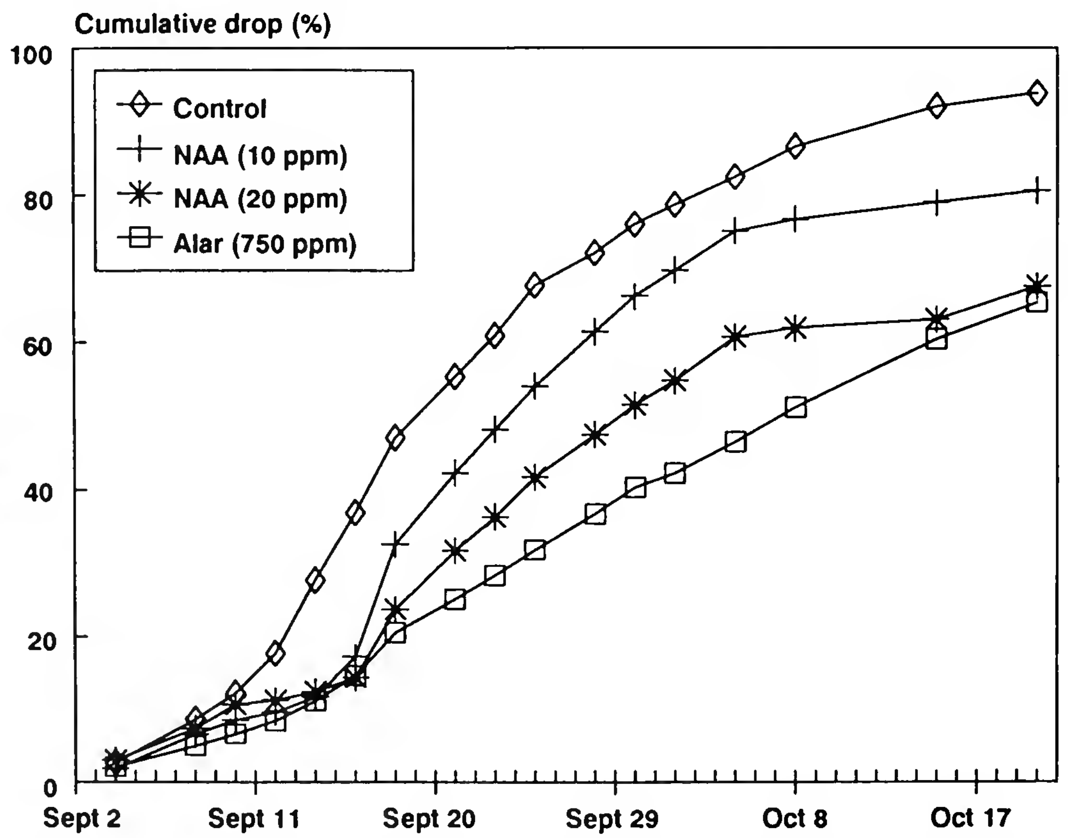

Figure 1. Cumulative drop from trees which received Alar, NAA (10 or 20 ppm on September 8), or no drop-controlling treatment.

The only other drop-controlling chemical that is registered for use on apples is naphthaleneacetic acid (NAA). If growers in Massachusetts must depend on this compound, then a reevaluation of its effectiveness is necessary, since most of the research on NAA was done prior to 1960. Pruning and training systems, pest control programs, rootstocks, orchard management practices, and fruit condition requirements have all undergone significant changes since that time.

A study was initiated in 1987 to answer several specific drop control questions: 1. How effective is NAA at controlling preharvest drop of McIntosh? 2. How long does drop control from NAA last? 3. Can growers first spot pick then effectively control drop with NAA? 4. How much drop occurs as a result of harvesting?

A block of 11-year-old Rogers McIntosh/M.26 were selected and divided into 8 groups of 8 trees each. Two trees in each group were sprayed with 750 ppm Alar (2.25 lbs per acre) on July 17, 1987. When the first sound fruit began to drop on September 8, NAA at 10 and 20 ppm was applied to a tree in each group. This timing is recommended on the NAA label. It was decided that September 14 was the day that a commercial grower would begin spot picking these trees. All fruit that had sufficient color to meet the U.S. Extra Fancy grade were harvested from half of the trees in each block. On September 15 NAA at 10 or 20 ppm was applied to a portion of the trees that were previously spot picked. Drops were removed from under trees prior to and immediately after spot picking. All drops were removed 3 to 4 times weekly from September 1 to October 2 and then twice weekly until the experiment ended on October 20.

The NAA label recommends that application should begin as soon as the first sound, uninjured fruit begin to drop. This timing occurred on September 8. When applied at this time 10 ppm NAA was as effective as Alar at controlling drop for 8 days, and 20 ppm NAA was as effective as Alar for 10 days (Figure 1). After 10 days Alar was clearly the superior drop controlling chemical. Cumulative drop on trees receiving NAA was significantly less than on control trees, even as long as 6 weeks after application. Although fruit quality was not evaluated in this experiment, it was noticed that fruit receiving NAA were noticeably softer and riper at the end of September.

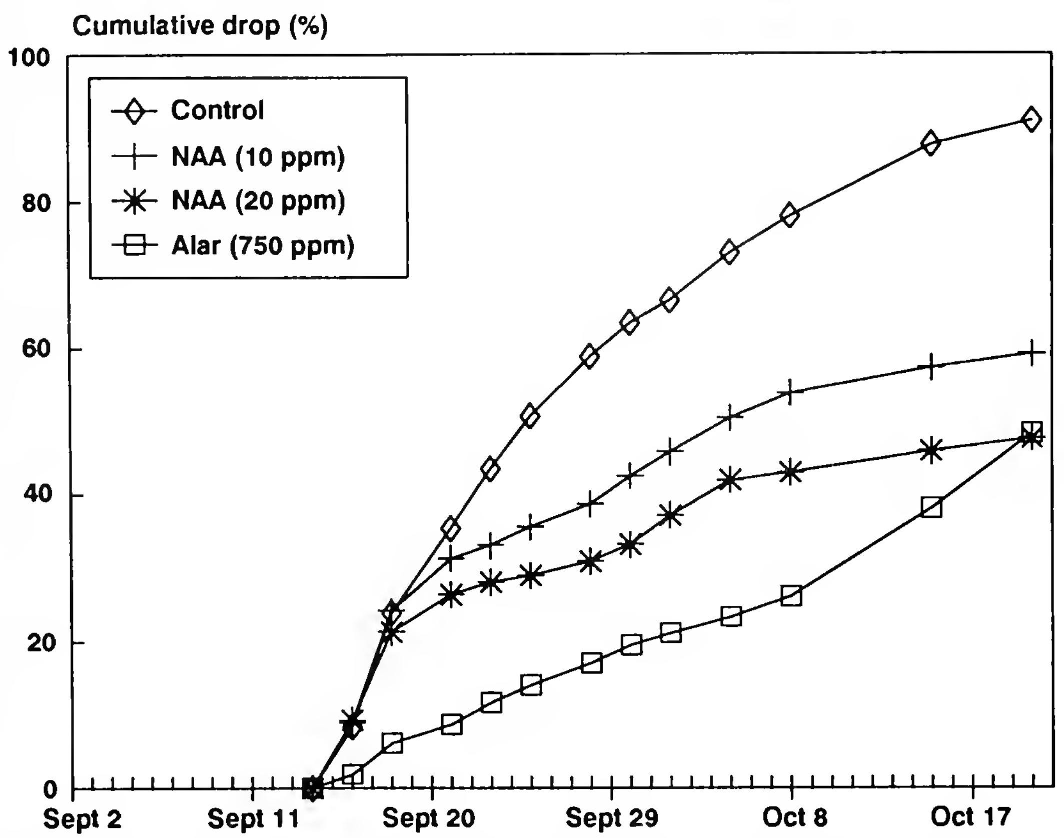

Figure 2. Cumulative drop after spot picking on September 14 from trees which received Alar, NAA (10 or 20 ppm on September 15), or no drop-controlling treatment.

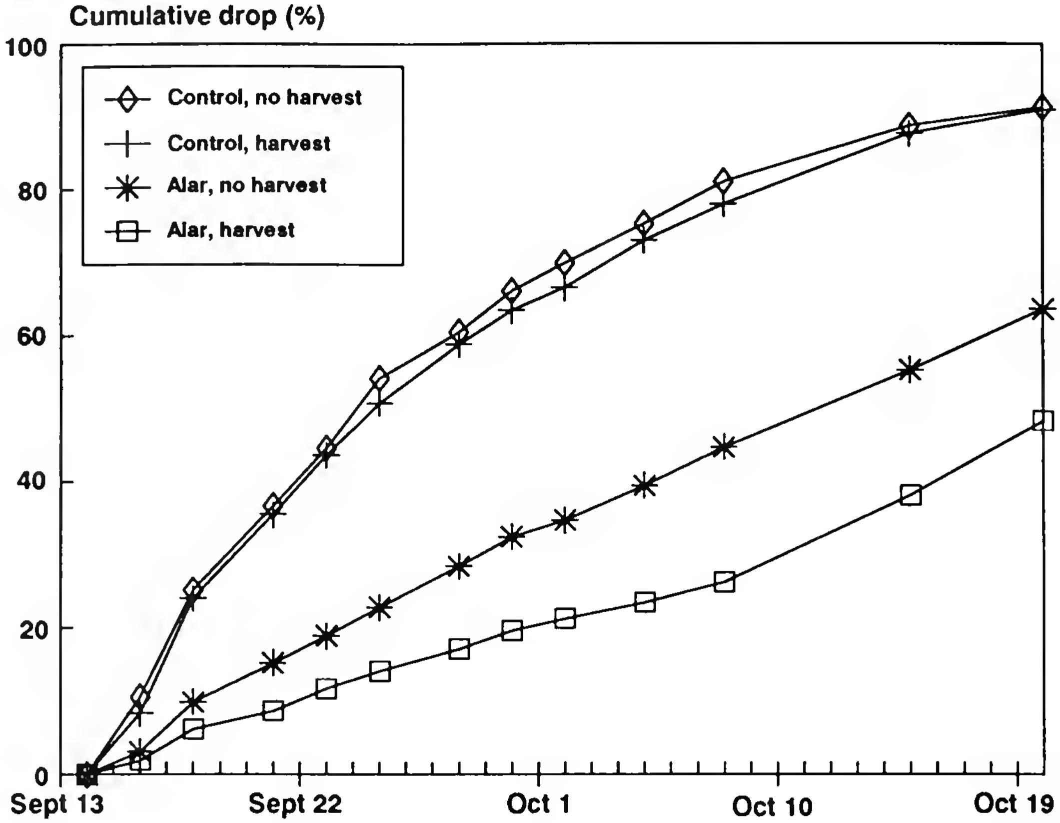

Figure 3. Cumulative drop after September 14 from trees that were or were not spot picked on September 14 and received Alar or no drop controlling-treatment.

Growers may wish to delay the application of NAA until they make their first harvest. This delay will allow the filling of CA storages with fruit that has the potential for long-term storage. When application of NAA was delayed until trees were spot picked (September 14), it took approximately 6 days for drop control to be effective (Figure 2). During this period, over 25% of the fruit on NAA-treated trees dropped. Once drop control was established, NAA retarded drop for a long period of time. The results of this experiment confirm the results of a similar experiment done in 1986. In that study NAA was applied on September 13 when drop exceeded 10%. It required 9 days for NAA to slow drop significantly, and by that time over 20% of the crop had been lost.

Spot picking removed about 39% of the crop. Even though these trees were relatively small and are not difficult to pick, 6% dropped as the result of harvesting process. It has been suggested that partial crop removal may reduce drop. It is reasoned that the more mature fruit that are prone to drop will be removed by spot picking. Also, the snowball effect of one dropping fruit hitting another will be reduced. Harvest did not reduce the amount of drop from untreated trees (Figure 3). However, if trees were previously treated with Alar, crop removal did retard drop. The reason for this is not clear.

Summary. If NAA was applied when the first sound apples started to drop it retarded drop effectively for 7 to 10 days. If NAA application was delayed until trees were spot picked and drop was proceeding, it took up to 6 days to slow drop. Over 25% of the crop was lost before drop control was established.

* * * * *

Postharvest Apple Rots: Dr. Rosenberger's Approach

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Dr. David Rosenberger of the Hudson Valley Lab, Cornell University, has been studying postharvest rots on apples for a number of years. In a recent talk at the University of Massachusetts he discussed some of the key points in the management of these problems, and these points will be outlined in this article. Dr. Rosenberger emphasized that the key to good management was an integration of several techniques:

* Appropriate and sufficient summer fungicide applications;
* Good management of the harvesting process;
* Appropriate postharvest chemical use in the dip tank;
* Good sanitation in the storage facility and harvest process; and
* Intelligent use of storage and marketing options.

Fungicide Applications During the Growing Season

Good storage rot control begins in the field before harvest. For example, last summer the wet harvest temperatures, combined with a tendency to leave fruit on the tree for color development, produced a larger than normal amount of rot in storage. This situation occurred because the wet weather during summer and harvest increased the rot inoculum and unseen fruit infections.

There are a number of diseases, rots and others, which can develop in storage:

Pin-point scab can be a problem. Late-season scab infections on the fruit can go undetected, and develop in storage into visible lesions. The best way to avoid a problem is to maintain good scab management throughout the season.

Sooty blotch and flyspeck are late season problems that may develop if summer weather conditions are humid. Interestingly, the fungi which cause these diseases will not grow at storage temperatures. However, unseen infections on harvested fruit can develop in storage. The fungi grow during the period when the fruit is cooling, before it reaches the storage temperature. In a large storage room, where it may take several days to reach the desired temperature, the fungi grow well for a time. Rapid cooling after harvest would help eliminate this problem.

Moldy core is another disease which develops in the field, and lies undetected until the fruit has been in storage. Moldy core can be caused by a number of fungi, but about 90% of the problems are caused by *Alternaria*. The infections occur during bloom and petal fall. Unfortunately, there do not seem to be any fungicides which control the disease very well. The infections develop inside the fruit, largely protected from fungicides.

Fungicides can help reduce many of the other postharvest rots. A minimum program of 1 application in early July and 1 again in early August should be adequate to control development of most of the late season fungal infections.

Management During Harvest and Packing

Wounded or over-mature fruit are more susceptible to postharvest diseases. For example, a rough orchard road can lead to significant quantities of wounding, which will increase the fruit's susceptibility to rot. Taking the time to smooth the orchard floor can reduce this problem. Avoid storing over-mature fruit. In general, the most mature fruit should be marketed first, and the less mature stored.

As mentioned above, rapid cooling can decrease the time that rot fungi have to develop. In some cases, it will stop development completely, while in others it will slow the process. Rapid cooling slows down fruit ripening, which slows down all forms of fruit rotting since fruit lose their resistance to fungi as they ripen.

Another management practice which affects postharvest rots as well as storability is calcium nutrition. Low calcium in the fruit increases its susceptibility to rot organisms. Perhaps other nutrients, such as potassium also can affect rot susceptibility. Maintaining a calcium nutrition program is advisable.

Sanitation

Attention to sanitation can be beneficial at all points in the postharvest handling process. The basic aim is to keep the inoculum for postharvest rots away from the fruit.

Old bins can contain bits of old, rotten fruit from the previous year. Designating a single bin for culls can reduce the spread of this inoculum. Soaking a bin with bleach solution (10% in water) mixed with either detergent or a standard spreader-sticker, and allowing the bin to air dry also will reduce problems.

Dirt from the orchard floor also can carry inoculum. To counter this problem, keep bins on sod and away from direct soil contact. Do not operate equipment so that it will dig up soil when a bin is lifted. In wet weather, rigging a hose to wash trucks, trailers, and bins will reduce the amount of soil which is carried into the drench solution.

Reducing the inoculum load in the drench solution is very important, since it comes in contact with virtually all the fruit. Besides using an equipment prewash, it is advisable to change the drench solution frequently. Since disposing of the solution is a problem, minimizing the volume of solution used in the drench equipment can contribute to overall efficiency. For example, it would be better to develop a system using 15 gallons of rapidly recirculating drench, and change it daily, than to use a 200 gallon system for weeks.

Given that you have a large volume system, the holding tank should have rounded corners rather than square corners. Square corners are "dead" areas, where fungicide can settle out of solution. Keeping the solution agitated and the chemicals in solution is critical to maintaining proper application rates. Placing rounded baffles in a square tank, or using a rounded tank, can solve the problem.

Fungicides

There are only a few fungicides registered for postharvest use. These include the following materials: Captan 50W™, Captan 80W™, Benlate 50W™, Topsin 70W™, and Mertect 340-F™. Captan is only moderately effective. Benlate, Topsin, and Mertect are very effective, but can become ineffective when fungal resistance develops. Rosenberger observed that these fungicides appeared to control rot better when used in combination with DPA (diphenylamine) than did either the fungicides or the DPA alone. When he tested the fungicides and DPA against benomyl-resistant *Penicillium*, he discovered that DPA inhibited the fungus. However, benomyl-sensitive isolates of *Penicillium* were inhibited only marginally by DPA. Most *Penicillium* isolates were sensitive to either DPA or fungicide. Hence, in a mixed set of resistant and sensitive fungal spores, such as would be expected in natural conditions, the majority of the fungi would be affected. Interestingly, the DPA is effective at low temperature (about 35°F) but not at room temperature.

* * * * *

Electric Lift Trucks in Refrigerated Facilities

James F. Thompson
University of California, Davis

New Battery Designs. Although electric lift trucks cost 60% more than equivalently sized propane-powered lift trucks, many cold storage and precooling operations are buying electric lifts for work inside refrigerated areas. One reason for the switch is that new battery designs allow electric lifts to operate for a full 8-hour shift in these operations. But, more importantly, the savings in energy and maintenance costs will more than pay for the extra cost of an electric lift over its economic life.

Energy Cost. A 5,000 pound capacity lift truck will cost $23,000 if battery-powered (this includes a charger and a battery with a 6,000-hour life). An electric lift uses electricity for battery charging. But an electric lift produces less waste heat than a propane lift, so refrigeration for removing lift truck heat is much less. Seven tons of refrigeration capacity are needed to remove waste heat produced by a propane lift, while only 2.5 tons are needed for electric lifts. In addition, most of the electricity use for electric lifts is at night when electric rates are often lower.

The net effect is that electricity costs are equal for the two types and total energy savings for electric compared with propane are equal to the cost of propane for the propane lift. To estimate propane savings, assume a 5,000 pound lift truck uses about 1 gallon of propane per hour.

Low Maintenance. Electric lifts have much lower maintenance costs than propane lifts. Lift truck manufacturers' estimate maintenance costs for propane powered trucks to be $2.50 per hour of operation, while maintenance costs for electric lifts trucks are an equivalent of only **$1.00** per hour of operation.

For many operations, the energy and maintenance cost savings of electric lifts will more than pay for the higher initial and battery replacement cost of electric lift trucks.

No Ethylene Gas No Carbon Monoxide. An important added benefit of electric lifts is that they do not produce ethylene gas as propane lifts do. Ethylene can cause premature ripening in some crops, and postharvest disorders such as russet-spotting in lettuce. Also, electric lifts do not produce the carbon monoxide which can be a safety concern if a refrigerated, enclosed facility does not have adequate ventilation.

Reprinted from Perishables Handling Newsletter, *Cooperative Extension, University of California. No. 62, October, 1987.*

* * * * *

Potential for Explosions in CA Storage Facilities

Henry Waelti and Eugene M. Kupferman
Washington State University

A certain amount of risk is involved when using combustible gases to generate CA atmospheres. This risk can be minimized if users understand the principles of operation of CA equipment so that they can take the needed precautions.

The common gases used in CA generators are propane and natural gas. Both fuels can be ignited by a spark or flame if they are allowed to accumulate to certain concentrations and if sufficient oxygen is present.

Explosive Limits

The limits of gas-to-air ratios between which explosions can occur are expressed as lower explosive limit (LEL) and upper explosive limit (UEL). Outside of these limits there is no danger of explosion. For propane they are 2.2% (LEL) and 9.5% (UEL). This means that if there is less than 2.2% propane in a room, there is not enough fuel to explode, or if there is above 9.5% propane in a room, there is not enough oxygen present to allow an explosion. (For natural gas, the LEL is 5.3% and the UEL is 14%.) In addition to the gas, a minimum of 11% oxygen is required to create an explosion with propane.

Open Flame Burners

In open flame burners, without catalytic converters, it is essential that the correct amount of gas is used to obtain complete combustion (4.2% propane in normal air). If the ratio of gas to air is lower, or higher, incomplete combustion occurs, resulting in production of carbon monoxide and ethylene gas, which are detrimental to fruit quality. Also, carbon monoxide may leak through walls, accumulate in work areas, and create a health hazard to workers. Fortunately, there are few of these burners left.

Inert Gas Generators

Inert gas generators, such as Tectrol and Isolcell, produce an inert gas by direct and catalytic combustion of fresh air and propane or natural gas. As long as the fuel-air mixture remains at the correct ratio and the catalyst is working properly, complete combustion is assured.

Recirculating

In recirculating systems, such as the catalytic oxygen burners (COB), the fuel is oxidized on a catalytic surface without a flame. As in the open flame burners, enough oxygen must be available to combine with **ALL** the fuel present. Thus, as the oxygen level in a storage decreases, the fuel supply must also be decreased. Although catalytic oxidation of fuel may occur without a flame down to 0.5% oxygen, these burners should not be operated below 3% oxygen. With the proper gas-to-air ratio in the COB, the operating temperature of the catalyst is 1100°F to 1300°F. This temperature range will be maintained as long as the fuel and air flow remain at the proper setting and the catalyst remains functional. A properly designed and operated catalyst allows the fuel to be oxidized completely down to an operating temperature of 1000°F. If a minimum operating temperature of 1000°F cannot be maintained at the recommended fuel and air ratio, then the catalyst may be defective and may need to be replaced.

Accident Prevention

-Purchase a propane/methane monitor. They can be installed on the burner to monitor the effluent stream. Portable units can be used to monitor individual rooms for combustible hydrocarbons and other gases toxic to workers and detrimental to the fruit. It usually is **NOT** possible to detect propane or natural gas by smell.

-In early summer, have a competent technician check out all CA equipment so that there is enough time to make the necessary repairs before the storage season. These tests should include the use of portable gas analyzers to monitor fuel/air ratios and combustion efficiency.

-CA generating equipment must be operated and maintained according to manufacturer's instructions at all times.

-Low temperature fuel cut-offs on recirculating burners should not be set below the manufacturer's recommendations, which is usually 1000°F.

-Check all safety devices at the start of equipment operation, including low and high cutoff thermostats, solenoid valves, fuel regulators, and air pressure switches.

-Do **NOT** turn on the fans and open the door when bringing up the oxygen in a room if there is a suspicion of gas in the room.

-A recommended procedure when opening a room is to scrub out the combustible gases that may be present in the room atmosphere using the COB catalyst. Bring up the oxygen level in the room to 5%. Turn off the fuel supply to the COB and set it on preheat. Run the temperature up to 600°F and recirculate the CA room atmosphere through the generator. The temperature of the catalyst may rise, and it will remain hot until the combustible gas (propane or natural gas) is down to a safe level.

-Some storage operators routinely use a COB to scrub out any combustible gas which may have entered a CA room during pulldown.

It is possible to reduce risks to a minimum. By understanding the principles of CA generator operation, maintaining the equipment and safety devices, and using the available instrumentation, managers can maintain a clean and safe storage atmosphere.

Reprinted from Postharvest Pomology Newsletter, ***Washington State University, March, 1988.***

* * * * *

An "Expert System" for CA Storage of McIntosh Apples

William J. Bramlage
Department of Plant & Soil Sciences, University of Massachusetts

Our recent survey of CA storage operators in Massachusetts indicated that many storages are not being operated at conditions that are most suitable for McIntosh apples. Factors that can contribute to this situation include not recognizing the importance of certain conditions, or overlooking details during the hectic harvest period.

To try to provide easy access for storage operators to critical information, and to create a mechanism for self-evaluation of storage operations, we are developing an "Expert System" for CA storage of McIntosh apples in New England. This system is a series of questions, with answers to be provided by the storage operator, followed by advice about how long the apples reasonably can be expected to retain quality in storage, the potential for storage disorders resulting from some adverse storage condition, and corrections that might be made when an adverse condition is recognized.

This "Expert System" is a computer program on a floppy disk that can be operated on any IBM-compatible personal computer. It will come with directions for activating and operating the program, and will require only the availability of an IBM™-compatible personal computer with 640 kbyte memory capacity, and the rudimentary knowledge for operating the computer.

This system was developed by A. Zubin Varghese, a graduate student in our Department of Food Engineering, through a series of intense interviews with the author. Mr. Varghese worked with Ernest Johnson and Lester Whitney, in the Department of Food Engineering, to convert the information from these interviews into a computer program. This Expert System depicts the author's best judgment of CA storage conditions for McIntosh apples in Massachusetts, but in a broader sense provides information about storage responses of apples to varying conditions. Its format is a series of "If ... Then ..." situations and its primary goal is to provide information to help reduce losses of apples during and following storage.

The questions in this program first attempt to establish the potential of a set of apples for storage based on maturity at harvest, speed of cooling, time required to fill and seal a CA room, and time required to generate the CA atmosphere. Then, the storage operator is questioned about the conditions that are being maintained within the CA room, including unintended deviations from recommendations. Where less-than-desired conditions exist, suggestions for "what might have been" are given. Where risks of physiological disorders are recognizable, these risks are quantified, the potential disorder is described, and possible corrective actions are recommended. The program is accompanied by a printed text describing the kinds of information needed to answer the questions, and the recommended ways of obtaining this information.

This "Expert System" is new and needs testing to see how useful it is and how it might be improved. It is primarily intended as an educational tool, a readily available source of information. We hope to have it available for trial by late summer, and to offer it through the University of Massachusetts Cooperative Extension for a small fee to cover expenses.

We hope that some CA storage operators will be willing to try the system and to help us evaluate its usefulness and possible improvements. If you are interested in obtaining and evaluating this "Expert System" if it is available by late summer, please contact the author or Dr. Wesley Autio, at your earliest convenience.

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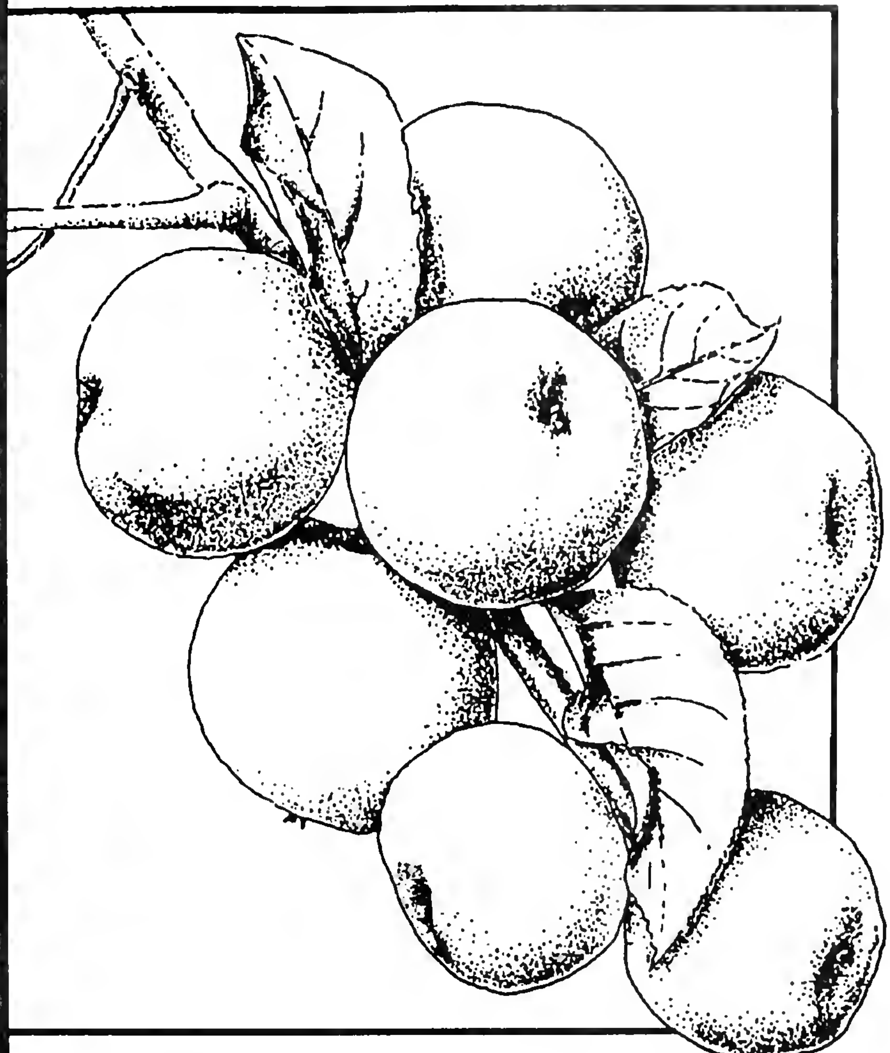
New England Apple Production Guide



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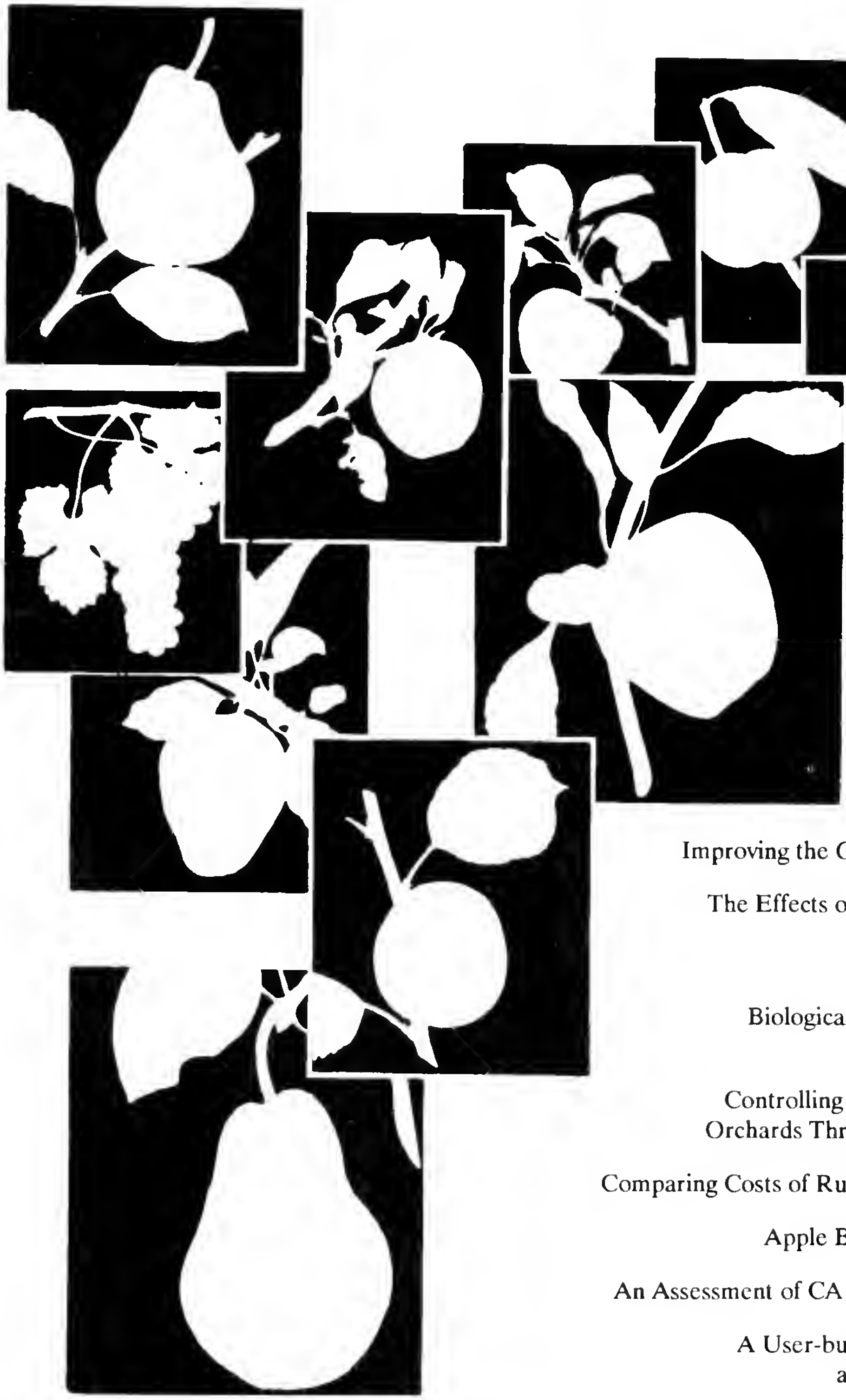
Fruit Notes

ISSN 0427-6906

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage



Volume 53, Number 4
FALL ISSUE, 1988

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

Fruit Notes
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COOPERATIVE EXTENSION POLICY:

Improving the Growth of Newly Planted Apple Trees

Wesley R. Autio and Duane W. Greene
Department of Plant & Soil Sciences, University of Massachusetts
Daniel R. Cooley
Department of Plant Pathology, University of Massachusetts

It is well accepted that to be profitable an orchard enterprise must receive returns from new plantings as early in the life of those trees as possible. Rootstocks and cultivars are major factors determining the age at which an orchard begins to pay for itself. Site preparation and cultural practices prior to, during, and after planting also influence the age at which a tree comes into production.

At the University of Massachusetts Horticultural Research Center in Belchertown we generally do not obtain a desirable amount of growth the year of planting, and it must be recognized that to obtain early returns and maintain high profitability throughout the life of a block it is necessary for the trees to grow well and produce a good fruiting framework in the years just after planting. Site preparation techniques, such as cover cropping, organic matter incorporation, and installation of irrigation or drainage, are known to improve growth. We decided to study planting and post-planting techniques which may offer some benefit to tree growth.

Level of Nitrogen Fertilizer

In 1986 four plantings were established at the Horticultural Research Center. The first planting (Marshall McIntosh/M.9) assessed the effects of different levels of nitrogen fertilizer applied soon after planting. It was postulated that additional growth could be obtained if nitrogen was applied at higher rates than usually recommended. In 1986 individual trees received either 0.5, 1.0, 1.5, or 2.0 pounds of ammonium nitrate in split applications two weeks apart approximately two weeks after planting. Treatments were repeated in 1987; however, the 2.0-pound rate was decreased to 1.5 pounds because of tree injury noticed in 1986. Trunk circumference was measured at planting and after the 1986 and 1987 growing seasons. Total shoot growth was measured after the 1986 and 1987 growing seasons. Data are reported in Table 1.

In 1986, increasing the amount of ammonium nitrate beyond the standard rate of 0.5 pound decreased trunk and shoot growth. Even in 1987, the second leaf, growth was decreased when the rate of application was increased. We can postulate that root injury occurred in 1986 which carried over to 1987, and that we cannot attempt to improve tree growth with increasing nitrogen applications. Furthermore, these results suggest that we should re-examine our present recommendation of 0.5 pound of

Table 1. The effects of different levels of nitrogen fertilization on the growth of Marshall McIntosh/M.9 trees planted in 1986.

Ammonium nitrate 1986/1987 (lbs/tree)	Trunk circumference (cm)			Change in trunk circ. (cm)			Shoot growth (cm)		
	At planting	1986	1987	1986	1987	1986+87	1986	1987	1986+87
0.5/0.5	3.2 *	3.6 **	6.4 **	0.4 **	2.8 **	3.2 **	114 **	649 **	763 **
1.0/1.0	3.3	3.5	5.8	0.2	2.3	2.5	93	524	617
1.5/1.5	3.2	3.3	5.1	0.1	1.8	1.9	78	350	428
2.0/1.5	3.2	3.3	5.1	0.1	1.7	1.9	89	378	467

*No significant differences existed.
**For these measurements there was a significant linear decrease between the 0.5/0.5 and 1.5/1.5 treatments. There was no significant difference between the 1.5/1.5 and the 2.0/1.5 treatments.

Table 2. The effects of urea application technique on the trunk and shoot growth of Summerland Red McIntosh/Mark trees planted in 1986.

Application treatment	Trunk circumference (cm)			Change in trunk circ. (cm)			Shoot growth (cm)		
	At planting	1986	1987	1986	1987	1986+87	1986	1987	1986+87
Dry	3.8 *	4.2 *	7.1 *	0.4 *	2.9 *	3.2 *	117 *	657 *	774 *
Foliar	3.7	4.3	6.9	0.6	2.6	3.2	132	652	784
Drench	3.5	3.9	7.4	0.4	3.5	3.9	108	770	878

*No significant differences existed.

ammonium nitrate and determine if a smaller dose may be appropriate for newly planted trees.

Nitrogen Application Technique

The second planting (Summerland Red McIntosh/Mark) established in 1986 studied the effects of nitrogen application technique the year of planting on tree growth. In 1986 trees all received 0.25 pound of urea, but it was applied either dry to the soil on May 15, in solution as a soil drench on May 8, or in foliar applications on May 25 and June 8. In 1987 all trees received a soil treatment of 1 pound of ammonium nitrate. Tree growth was measured as in the first planting. Data are reported in Table 2, and they showed that application technique did not alter the amount of tree growth during the first or second leaf.

Mulching and Vydate

In the third planting established in 1986 Gala/M.26 trees were either mulched with 0.5 bale of hay after planting, treated with foliar applications of Vydate 2L™ (2 quarts/100 gallons) just after leaf emergence and in mid-July, mulched and treated with Vydate, or not treated. Mulch was reapplied in 1987. Tree growth was measured as in the first planting, and data are reported in Table 3.

Mulch was included in this planting because it often is able to encourage better tree growth, even beyond its weed control abilities. In this experiment weed control was maintained with herbicides. Vydate was used to control nematodes which may reduce growth. Neither mulch nor Vydate treatments affected the growth of these trees. However, mulch significantly increased the quantity of bloom in 1988. It is clear that this response could significantly improve early returns. Additionally, mulched trees are less susceptible to extremes in water availability, so that over a number of years plantings established with mulch would be expected to have better growth even though we did not see it in this planting.

Table 3. The effects of hay mulch and Vydate applications on the trunk, shoot growth, and bloom of Gala/M.26 trees planted in 1986.

Treatment	Trunk circumference (cm)			Change in trunk circ. (cm)			Shoot growth (cm)			1988 Bloom (clusters/ cm^2)
	At planting	1986	1987	1986	1987	1986+87	1986	1987	1986+87	
Control	4.4 *	4.8 *	8.0 *	0.5 *	3.1 *	3.6 *	290 *	906 *	1196 *	8.5 **
Mulch	4.3	4.8	8.3	0.6	3.5	4.0	308	927	1235	20.4
Control	4.3 *	4.8 *	8.1 *	0.5 *	3.2 *	3.7 *	282 *	868 *	1150 *	17.0 *
Vydate	4.3	4.9	8.3	0.5	3.4	3.9	316	962	1278	12.8

*No significant differences existed.
**Significantly different at odds of 99 to 1.

Table 4. The effects of various planting treatments on the trunk and shoot growth of Royal Gala/M.26 trees planted in 1986.

Planting treatment	Trunk circumference (cm)			Change in trunk circ. (cm)			Shoot growth (cm)		
	At planting	1986	1987	1986	1987	1986+87	1986	1987	1986+87
Control	3.8 a*	4.9 bc	8.5 ab	1.1 de	3.6 ab	4.7 ab	321 c	1054 b	1375 b
Topsoil	3.8 a	4.9 bc	9.1 a	1.1 cde	4.1 a	5.2 a	321 c	1509 a	1830 a
Peat	3.8 a	5.4 a	9.2 a	1.6 a	3.8 ab	5.4 a	500 a	1298 ab	1798 a
Manure	3.7 a	5.1 b	8.9 a	1.4 abc	3.8 ab	5.2 a	399 b	1184 ab	1583 ab
Tree planter (TP)	3.8 a	4.7 c	7.9 b	0.9 e	3.2 b	4.1 b	259 c	998 b	1257 b
TP + Aliette (2#)	3.8 a	4.9 bc	8.4 ab	1.2 bcde	3.5 ab	4.6 ab	294 c	1137 b	1431 b
TP + Aliette (4#)	3.7 a	5.1 b	8.4 ab	1.4 ab	3.4 ab	4.8 ab	313 c	1258 ab	1571 ab
TP + Ridomil	3.8 a	5.0 bc	8.6 ab	1.2 bcd	3.6 ab	4.8 ab	328 c	1107 b	1435 b

*Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

Planting Techniques, Hole Treatments, and Root Fungicides

The last planting (Royal Gala/M.26) established in 1986 studied the effects of planting hole treatments, planting techniques, and post-plant root fungicides. In this experiment half of the trees were planted with a tree planter and half were planted into an 2-foot augered hole. The trees in the auger holes either were planted with the soil that was removed from the hole, good topsoil from another site, a mixture of 1:1 peat-to-topsoil, or a mixture of 2:1 composted manure-to-topsoil. Trees planted with a tree planter were either sprayed in 1986 and 1987 to the drip point with Aliette™ (at 2 pounds/100 gallons or 4 pounds/100 gallons) late spring, mid-summer, and early fall; treated with a soil drench in 1986 and 1987 of 1 quart of Ridomil™ (at 1 quart/100 gallons) late spring, mid-summer, and early fall; or were not treated with either root fungicide. Tree growth was measured as in the first planting, and data are reported in Table 4.

In 1986 the most prominent effect was caused by the addition of peat to the planting hole. Peat-treated trees had the largest increase in trunk circumference and the most shoot growth. The addition of composted manure also improved growth but not to the extent of the peat treatment. In 1987 differences in growth rate began to dissipate except for the topsoil treatment. Using good topsoil in the planting hole did not have much effect the first year; however, in 1987 those trees had significantly more shoot growth than the controls. At the end of 1987 the largest trees, in terms of trunk circumference, were those planted with good topsoil, those planted with the addition of peat, and those planted with the addition of manure. Trees planted in an augered hole seemed to grow better than those planted with a tree planter; however, the differences between the two were not statistically significant. These results suggest that the use of some type of planting treatment can significantly improve the growth and development of the trees to be planted. However, it may be difficult to apply these types of treatments in some situations, such as when a tree planter is used. Therefore, at times it may be more practical to use surface applications of organic material or the growing of cover crops with subsequent plowing or tilling under to improve the soil. When the soil has been prepared such as this before planting the effects probably will last longer than if only an augered hole is treated.

The use of root fungicides had only a small effect on tree growth. In 1986 the high level of Aliette and the Ridomil treatment resulted in more trunk growth but no increase in shoot growth. In 1987 no growth differences existed. One could conclude that these root fungicides give little benefit; however, at some sites the pressure of root-attacking fungi may be much greater than at this site at the Horticultural Research Center and the effect may be much greater.

It is clear from the results of these four experiments that cultural treatments performed at planting or to newly planted trees can have significant effects on tree growth. The importance of early tree growth and the establishment of a fruiting framework suggests that growers should carefully prepare a site before planting, and consider the use of some of these treatments during the planting year. We shall continue to study improvements of tree development with cultural techniques.

* * *

The Effects of Travel Speed, Nozzle Arrangement, and Application Volume on Pesticide Distribution in Apple Trees

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Spraying recommendations may seem as though they are based only on common sense rules of thumb, or worse, nothing at all. So it is encouraging when scientific facts are generated that support spraying recommendations.

Dr. Jim Travis and Dr. Turner Sutton, plant pathologists at Pennsylvania State University and North Carolina State University, respectively, recently completed studies on spray deposits in apple trees. The usual recommendation to direct 2/3 of the sprayer output toward the top 1/3 of the tree, and 1/3 of the output at the bottom 2/3 of the tree is based on work done in 1965. Since that time, in spite of the significant changes in tree size and pesticide formulation, that recommendation has continued to be made. Travis and Sutton found that the recommendation is still relatively sound, if trees are of medium size (approximately 13 ft high x 12 ft in diameter). However, as the tree size decreases to 9.5 ft high x 9.5 ft in diameter, a 50:50 ratio (half directed at the top 1/3 and half directed at the bottom 2/3) gives the best deposit throughout the tree, and the lowest variability from one part of the tree to another.

Of course, there are many other factors which affect spray deposition. Of those examined in the recent study, the following were found to optimize spray deposition:
1. A tractor speed of 2 mph was found to be better than 1.5 or 2.5 mph;
2. A rate of 66 gal/acre was better than 40, 100, or 400 gal/acre;
3. Well pruned trees were better than moderately to poorly pruned trees.

Adhering to these guidelines could improve spray deposition and distribution in fruit tree foliage, making pesticide applications more effective and more efficient. It is important to note that the tests were made under a specific set of conditions, which may or may not have relevance to each particular orchard. However, if these practices can be tried, they can help control costs.

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Biological Control of Apple Blotch Leafminers in Massachusetts Apple Orchards

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Introduction

The apple blotch leafminer (ABLM), *Phyllonorycter crataegella* (Clemens) is a small (1/4 inch) moth in the family Gracillariidae that has become a significant pest in Massachusetts apple orchards since the mid 1970's. This problem has occurred due to the development of resistance to common orchard cover spray materials, such as azinphos-methyl (Guthion™), which formerly suppressed populations as a side effect, although there was no conscious effort on the part of the growers to do so.

Following the first detection of resistance in ABLM populations in Massachusetts, resistance spread rapidly throughout the region. Densities of mines rose sharply as the pest was controlled neither by cover sprays (which no longer affected the moth), nor, in commercial orchards, by parasites, which were easily killed by orchard cover sprays.

A broader view shows that this same scenario of pesticide-resistant leafminers and pesticide-susceptible parasites has led to significant pest problems from a number of other *Phyllonorycter* species on apple or other tree fruits in many areas, including *P. blancardella* (F.) in New York, Michigan, and Ontario (Dutcher & Howitt, 1978; Pree et al., 1980; Weires et al., 1980), *P. corylifoliella* (Hubner) in Holland (Van Frankenhuyzen, 1975), *P. elmaella* (Doganlar & Mutuura) in Utah (Barrett & Jorgensen, 1986), and *P. ringoniella* (Matsumura) in Japan (Sekita & Yamada, 1979). This repeated pattern highlights the vulnerability of single-factor chemical controls which, once breached by pest resistance, leave pests free to multiply unrestrained by natural enemies which typically are slower to develop pesticide resistance (if ever) and hence cannot attack the pest in the sprayed environment.

Because high density leafminer populations can adversely affect apple crops by increasing drop and reducing flower bud formation (Reissig et al., 1982) and because *Phyllonorycter* spp. have a high capacity to develop pesticide resistance, it is important that orchardists in Massachusetts broaden control systems immediately to protect and encourage the specialist parasites that attack ABLM. If this is not done, further resistance in the species likely will occur to the specific carbamate and organochlorine materials that are currently effective and used against high density leafminer populations.

Major Parasites of ABLM in Massachusetts

Studies in Massachusetts (Van Driesche & Taub, 1983), Connecticut (Maier, 1984), New York (Weires et al., 1980), and elsewhere have consistently shown that *Phyllonorycter* species attacking apple are themselves extensively attacked by several species of parasites in the absence of interference from pesticide applications. The most important of these in Massachusetts at this time are the braconid, *Pholetesor ornigis* (Weed), and the eulophid, *Sympiesis marylandensis* (Girault) (Van Driesche & Taub, 1983).

P. ornigis is a black species, 1/4 inch long, that attacks tissue feeding host larvae, laying its egg inside the body of the host larva. The mature parasite larvae exits from the host and spins a white cocoon inside the leaf mine. Detection of parasitism by *P. ornigis* is easiest in old mines since parasite cocoons are readily visible to the naked eye and remain present even after the adult parasite has left the mine. Parasite cocoons are easily separated from both live and emerged moth pupae.

S. marylandensis, in contrast, is smaller (1/8 inch), metallic blue-black in color, and attacks tissue stage larvae. Its eggs are laid next to, but outside of, the host larvae and are visible with a hand lens. Parasite larvae develop and feed outside the host larvae and pupate in the mine, with no cocoon. Parasitism by this species can be detected at any time because of its position external to the moth larva. In addition to killing hosts by parasitization, *S. marylandensis* adults directly attack and kill other tissue feeding larvae which they pierce with their ovipositor and then partially consume as a source of protein. Larvae killed in this manner appear dried out and shriveled and are often attached to the mine "skin" at a single point, where the parasite formerly fed.

Other potentially important parasite species, not yet found in Massachusetts, include the braconid, *Pholetesor pedias* (Nixon), and the encyrtid, *Holcothorax testaceipes*, both recently introduced to Ontario (Laing & Heraty, 1981) from New Zealand and Japan, respectively.

Management Options Available to Growers to Promote Biological Control of Apple Blotch Leafminer Populations

The major influence on parasite populations in apple orchards is the pesticide regime, both in terms of its duration and the particular chemicals selected for use. To a lesser extent, proximity of wild or abandoned apple trees, or wild cherry trees where parasite populations will be found attacking various species of leafminers, can also influence events within commercial apple orchards.

Pesticide Management. Attempts have been made to identify pesticides more toxic to the pest leafminer than to their associated parasites (Weires et al., 1982; Van Driesche et al., 1985). While some degree of selectivity has been found (e.g., for oxamyl; Van Driesche et al., 1985), in general all materials which provide effective control of leafminer adults or larvae also seriously harm parasites. Low rates of low-residual materials are the least damaging to parasites. Nevertheless, complete elimination of chemical controls of leafminers in favor of reliance on parasites should be the goal of orchardists trying to establish biological leafminer control systems, as currently available pesticides for leafminer control are relatively incompatible with parasite survival.

In addition to pesticide applications directly targeted against leafminers, cover sprays against other insects also represent a major obstacle to parasite effectiveness within commercial orchards. While parasitism levels on non-sprayed trees are high (often 60% or greater), levels inside blocks sprayed for other insects are typically very low (less than 5%), with some increase in the third leafminer generation in September after cover sprays have ended (Van Driesche and Taub, 1983). It thus appears that the most effective action growers can take to conserve leafminer parasites in commercial orchards is to end regular cover sprays as early in the season as possible, lengthening out the insecticide-free period in which leafminer parasites can increase in numbers. Currently, cover sprays are maintained until mid-August or even into September to protect fruit against apple maggot flies. A "Second-stage IPM" strategy now being tested in Massachusetts may offer a means to extend the length of the insecticide-free period by terminating regular cover sprays at the end of May after the period of plum curculio attack has ended. Control of apple maggot fly in July, August, and September then would be based on intensive trapping using red sticky traps developed by Prokopy and removal of wild or abandoned apple trees adjacent to the orchards. While initial data (1987) show that this system increases numbers of predator mites, data are not yet available as to its effect on leafminer parasites. Such data, however, will be collected in future tests beginning in 1988.

Habitat Management. Abandoned or wild apple trees, or wild cherries in forested areas near orchards typically have *Phyllonorycter* spp. leafminers (including ABLM) that serve as hosts for *P. ornigis* and *S. marylandensis*. Increased parasitism in commercial orchards in late summer and fall results from both within-orchard build up of the parasites that survived early season pesticide applications and perhaps from immigration of parasites into orchards from hosts living on untended trees. The relative importance of these two sources is unknown. Wild hawthorne, wild apple trees, and abandoned apple trees near orchards all serve as sources of apple maggot flies that can enter orchards and hence such trees should be removed. Various species of native cherries also serve as possible breeding sites for ABLM parasites, but are likely to be too few in number to do more than "re-seed" orchards that have lost their leafminer parasites due to extensive pesticide use. The size of mid- to late-season leafminer parasite populations in commercial orchards is therefore less likely to be determined by the habitat outside the orchard than by the pesticide application history in the orchard itself.

State Actions of Potential Value in Promoting Biological Control of the Apple Blotch Leafminer

Existing native parasites of ABLM, while fairly effective, are not necessarily the species with the highest potential to suppress leafminer populations. Because of the problems that have arisen in various regions with other *Phyllonorycter* species, much is known of the parasites attacking a variety of leafminer species. Some species seem to have potential to increase the level of control over that provided by our native parasites. For example in Ontario, the introduced parasite, *Pholetesor pedias*, has produced levels of parasitism 2 1/2 times greater than the native *Pholetesor ornigis* (Laing & Heraty, 1987). This parasite has been established in Ontario and more recently in New York (Weires, personal communication). Another parasite of potential value is the encyrtid, *Holcothorax testaceipes*, which is the major parasite attacking *P. ringoniella* in Japan (Sekita & Yamada, 1979). It has recently been established in Ontario and is becoming the dominant parasite there as well. A recently approved Northeast Regional Apple Project has provided funds to Dr. Chris Maier of the Connecticut Agricultural Experiment Station to introduce both of these parasites to New England.

How to Monitor Parasitism Levels in Your Orchard

Leafminer populations can be monitored either by counts of adult moths caught on red sticky traps, or by counts of mines per leaf for each leafminer generation. Thresholds currently in use in Massachusetts for the second system are 0.13 mine/leaf for the first generation and 1.00 mine/leaf for the second generation. These levels are lower than thresholds currently used in other states to account for compounding effects of mites or drought stress. The use of 0.13 mine/leaf as a treatment threshold is based on the concept that, given the 7 to 8 fold increase typical from the first to the second leafminer generations, more than 0.13 healthy mines in the first generation will result in damaging populations (more than 1.0 mine/leaf) in the second generation. This first generation threshold, however, should be raised if levels of parasitism are high (Figure 1). Parasitism levels can be determined by selecting one hundred old mines at the end of a generation and opening them with needle-nose tweezers. Mines then can easily be classified into ones in which moths have developed, ones in which parasitoids have developed or ones in which the larvae were killed by feeding of adult parasites. Percentage parasitism can then be calculated as number of mines with dead larvae plus the number with parasitized larvae or parasite pupae or cast parasite pupal skins divided by the total number of leaf mines sampled. Levels of parasitism can be taken into consideration only if leafminer levels are assessed in the first generation and required treatments are then made in the next generation against leafminer adults. This strategy currently has the drawback that available materials for killing leafminers tend to make mite control problems worse. This effect becomes increasingly more severe as the season progresses, and thus, given existing pesticides, treatments made early against first generation leafminer larvae are less disruptive to mite population dynamics than treatments made for second generation leafminer adults. Unfortunately, treatments targeted against first generation leafminer larvae cannot use thresholds modified by levels of parasitism because parasitism occurs late in the leafminer larval stage. If the insect growth regulator diflubenzuron (Dimilin™) is registered for leafminer control, it will be easier to utilize a strategy based on assessing first generation mine numbers and levels of parasitism at that time and then treating second genera-

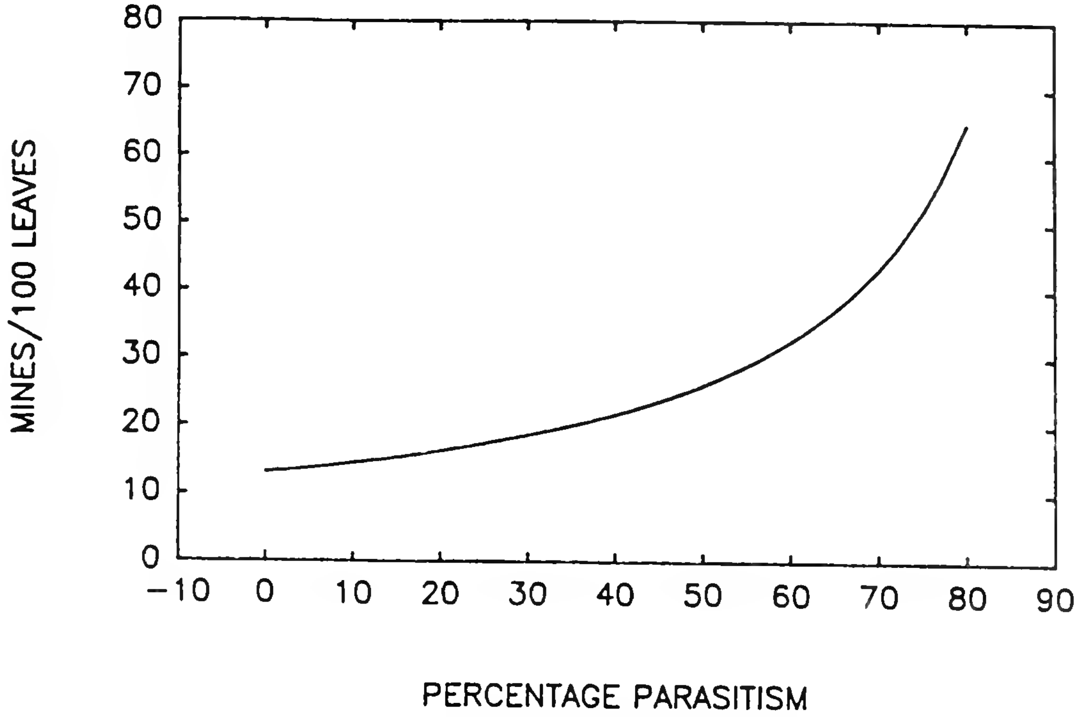

Figure 1. Treatment thresholds for apple blotch leafminer.

tion leafminer adults if needed, because diflurbenzuron is not disruptive to biological mite control.

Converting From Pesticide Management to Biological Control of Apple Leafminers

Conversion from pesticide management of apple leafminers to management based largely on conservation of parasites is essential if growers are to reduce pest management costs and the threat of ever increasing pesticide resistance in leafminer populations. This goal can be reached only as part of an integrated reduction in orchard pesticide use to increase, to the greatest extent possible, the insecticide-free period from mid- to late season. Recognition of the principal parasite species and the ability to tell a leaf mine that produced a parasite from one that produced a moth are essential. Sharp tweezers and a hand lens are the required tools for this determination. Training can be obtained from regional fruit extension agents. Regular assessment of proportions of mines parasitized can help growers remain aware of the status of leafminer populations in their orchards and can be used to modify recommended chemical control thresholds.

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Controlling Spider Mites in Massachusetts Apple Orchards Through Conservation of Predator Mites

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Introduction

Spider mites (European red mite, *Panonychus ulmi* (Koch), and two-spotted spider mite, *Tetranychus urticae* Koch) have become increasingly significant pests in apple orchards due to destruction of predator mite populations and development of resistance to some major miticides. While spider mites are not direct pests of the fruit itself, the cost of their control has increased relative to control costs of other pests. Efforts to reduce production costs therefore must include less expensive alternatives for spider mite control. This article discusses how the strategy of predator conservation may be employed by growers to reduce their mite control costs.

The Predators

In New England the most important mite predator is the phytoseiid mite, *Amblyseius fallacis* (Garman) (Table 1). A second species of importance is the stigmaeid mite, *Zetzellia mali* (Ewing). In Western New York, *Typhlodromus pyri* (Scheuten) rather than *A. fallacis* is the major phytoseiid predator and in Pennsylvania and New Jersey, the coccinellid *Stethorus punctum* (LeConte) is important. *S. punctum* is most often seen as a predator attacking high density mite populations (15 or more mites/leaf); whereas, *A. fallacis* does well moderate mite densities (4 to 7/leaf). *T. pyri* and *Z. mali* are able to persist at very low mite levels (under 3/leaf) because of their abilities to utilize various alternative food sources such as rust mites, pollens, and fungi. Predator mite biology for each species must be understood if management practices are to be effective. For example, whereas *T. pyri* spends the entire year in apple trees, *A. fallacis* overwinters in the orchard groundcover. Management of orchard groundcover thus influences both *A. fallacis* survival and the timing of its recolonization of apple trees the following season.

Table 1. Major species of mite predators on apples in the Northeastern United States.

Area	Species	Family
New England	*Amblyseius fallacis* (Garman)	Phytoseiidae
	Zetzellia mali (Ewing)	Stigmaeidae
New York	*Typhlodromus pyri* (Scheuten)	Phytoseiidae
	Zetzellia mali (Ewing)	Stigmaeidae
	Stethorus punctum (LeConte)	Coccinellidae
Pennsylvania	*Stethorus punctum* (LeConte)	Coccinellidae

Conservation Methods Available to Growers

Pesticidal chemicals, nitrogen, and orchard groundcovers are the three orchard components that can be manipulated to promote biological mite control.

Pesticide Management. Growers can create an orchard environment more favorable for predator mite survival and reproduction by 1) selecting pesticides that are as safe as possible to predator mites and 2) ending orchard cover sprays as early in the growing season as possible. Relatively safe pesticides that may be used without damaging greatly predators do exist (Table 2). In part, the relative safety of some materials, such as azinphos-methyl (Guthion™), is due to a natural evolution of pesticide resistance in predators such as *A. fallacis*, subject over many years to the use of these pesticides as orchard cover sprays. The relative safety of oil to predator mites is due to selective timing, in that *A. fallacis* is not on the tree at the time that early season applications are made to kill European red mite eggs. All classes of pesticides, including herbicides, fungicides, and plant growth regulators as well as insecticides and miticides, should be reviewed as to their harmfulness to mite predators prior to use. For example, both lime sulfur and benomyl are very harmful to *A. fallacis*, but for very different reasons. Lime sulfur is directly toxic. Benomyl induces sterility in female predator mites (Hislop & Prokopy, 1981) and thus, when used from June onward, destroys the potential for the population to persist and grow. Miticides,

Table 2. Relative harmfulness of orchard pesticides other than acaricides to predator mites in apple.[z]

Very harmful	Moderately harmful	Relatively safe
chlorpyrifos[y]	phosphamidon	oil[x]
methomyl	karathane	malathion
carbaryl	amitraz	phosmet
oxamyl	difolatan	azinphos-methyl
phosalone	dinocap	endosulfan
diazinon	dikar	methoxychlor
demeton		glyodin
dimethoate		dodine
permethrin		maneb
fenvalerate		thiram
ammonium sulfate		dichlone
paraquat		captan
glyphosate		ferbam
benomyl[w]		simazine
lime sulfur		dalapon
		NAA

[z]Data from Hislop & Prokopy (1981) and Butkewich & Prokopy (1985) using *A. fallacis* as test species.
[y]At low dosage, this material may be relatively safe.
[x]Oil does not affect *A. fallacis* because this predator overwinters off the tree in the groundcover and hence is not contacted by oil applications made in the very early periods of the growing season.
[w]Harmful because it sterilizes female predator mites.

although by definition directly toxic to mites, still offer a spectrum of safety to predator mites, ranging from dormant oil that is relatively safe to *A. fallacis*, to formetanate hydrochloride (Carzol™) which is extremely damaging to predator mites. Miticides in current use are arranged in terms of relative safety to *A. fallacis*, the major mite predator in Massachusetts, in Table 3.

Second-stage IPM, currently being developed in Massachusetts apple orchards, provides another approach to pesticide management that aids in conserving mite predators. Under this management strategy, regular cover sprays are used only in the early portion of the growing season (to approximately the end of May). After this period only fungicide applications are made. Apple maggot fly damage is prevented after termination of cover sprays by intensive trapping (using red sticky spheres) and removal of wild or abandoned apple and hawthorne trees. Preliminary data on this strategy from 1987 tests show an improvement of predator:prey mite ratios from 1:9 in grower-sprayed control blocks to 1:5 in second-stage IPM blocks. At the 1:5 ratio predator mites can be relied on to maintain spider mites under commercially acceptable control in most cases.

Nitrogen Management. Apple foliage with elevated nitrogen levels is a more nutritious food for spider mites, resulting in more rapid development and a larger number of eggs laid per female mite (van DeVrie & Boersma, 1970). This more rapid build up of spider mite populations makes control by any existing level of predator mites more difficult. Nitrogen levels thus should be kept at the lowest levels consistent with healthy tree growth. Nitrogen may become available to trees either directly, in the form of fertilizer applications, or indirectly from nutrients released from groundcovers killed by herbicide application or plowing. Growers should monitor actual nitrogen levels in leaves and adjust their fertilization practices accordingly.

Groundcover Management. Over and above the indirect effects of orchard floor vegetation management through leaf nitrogen levels, groundcover management directly influences predator numbers. Because *A. fallacis* overwinters off the tree, groundcovers can influence the numbers of predators that survive, and can affect the timing in the following growing season of predator movement back into the trees. The timing of predator re-entry into trees depends in part on the availability of two-spotted spider mites and other food sources in the groundcover. The ideal groundcover species and management practices are not known, but are currently the subject of research in both Massachusetts and New York. In addition, herbicides are sometimes used to kill strips of orchard floor vegetation. Certain of these (e.g., glyphosate, paraquat, and ammonium sulfamate, see Table 2) are highly toxic to predator mites.

Other actions that growers can take to promote biological mite control include encouraging development of apple rust mite populations. These mites make apple leaves less favorable for spider mites and serve as food for predator mites when spider mites are scarce. Alternate food sources moderate predator mite population declines when primary prey species are low in number with the result that more predators remain in the orchard to suppress spider mite populations when their numbers begin to increase.

Table 3. Impact of orchard acaricides on predator mites.

Material	Trade name	Overall impact[z]	Comments
oil	---	5	Use split application (half at half inch green and half at tight cluster or early pink)
propargite	(Omite™)	4	
fenbutatin-oxide	(Vendex™)	4	
clofentezine	(Apollo™)	4	
hexythiazox	(Savey™)	4	
oxythioquinox	(Morestan™)	3	For pre-bloom use only, do not combine with oil
dicofol	(Kelthane™)	2	Very hard on predators
formetanate hydrochloride	(Carzol™)	1	Very hard on predators

[z]Safety index, with 1 being most harmful and 5 being safest on A. fallacis.

In addition, growers whose orchards have few predator mites (due to factors such as past pesticide use practices) can "re-seed" their orchards by purchasing predators, such as *A. fallacis*, from commercial sources and releasing them on orchard trees to induce a more rapid increase in predator numbers, which must then be conserved by altered (i.e. reduced pesticide) management. In some cases such purchased predators may possess higher levels of pesticide resistance than is common in native predator mite populations. Such resistance will promote better predator mite survival and reproduction for populations subjected to pesticide use.

State Programs to Enhance Biological Mite Control

Most of the decisions that influence biological mite control in apples are made by growers. Two areas exist however where state (or University) programs could contribute to this process: introduction to Massachusetts of more highly pesticide-resistant strains of existing predator mite species and introduction of new species of predator mites not currently found in Massachusetts. Higher levels of pesticide-resistance than exist in field populations have been induced in *A. fallacis* and other species of phytoseiid predator mites. Such a pesticide-resistant strain of *A. fallacis* has been released and established in apples in Quebec with good results (Bostanian & Coulombe, 1986).

Existing native species of mite predators in Massachusetts (*A. fallacis* etc.) are not necessarily the most effective possible predator species. Some success has occurred in establishing exotic predator mites in other regions. For example, *T. pyri* has been moved successfully to Australia for control of European red mite (Thwaite & Bower, 1980). Examples listed by McMurtry (1982) of species that are of value against spider mites in apples in other regions of the world include *Amblyseius potentillae* (Garman) from Europe and *Typhlodromus arboreus* (Chant) from Oregon, among others. Attempts to establish exotic mite predators on outdoor crops generally have been inhibited by the widespread belief among research acarologists that locally existing native species likely are to be superior due to better adaptation to the local conditions. However, given that apples, European red mite and two-spotted spider mites all are recent introductions in Massachusetts (i.e. a few hundred years at most), there is little reason to hold this view. Successes in other areas argue for trials of exotic species to test whether or not more effective mite predators might not be obtainable.

Assessing Predator Levels in Your Orchard

Decisions to apply or not apply miticides are made based on evaluations of numbers of prey mites (not counting eggs) per leaf in light of numbers of predators (either per leaf or per prey mite) and the point in the growing season. The simplest assessment system is a fixed predator:prey ratio. For example if on 50 leaves 50 predators and 500 prey are found, you have a 1:10 predator: prey ratio, or 10 prey per leaf and only 1 predator per leaf. Massachusetts makes miticide recommendations based on a threshold than varies with the season (i.e. spray if there are 2 to 3 mites/leaf in June, but 3 to 5/leaf in July and 5 to 15/leaf in August). New York recommends miticide applications if there are more than 5 prey mites/leaf unless predators are numerous (1 or more per leaf). In general a 1:5 predator:prey ratio seems to indicate good prospects for biological mite control. A 1:10 ratio indicates less prospect for control (but still possible). Ratios smaller than 1:10 indicate biological mite control is unlikely to occur.

Actually counting all the mites on each of 40 or so leaves can be a difficult task. To simplify the process, New York has developed a sequential sampling scheme in which leaves are picked one after another and then each leaf is classified as either having or lacking spider mites and having or lacking predators. A chart with curves then allows the sampler to determine if predator:prey ratios are such that biocontrol is likely to occur, if miticide applications are needed, or if more leaves should be examined (Nyrop, 1987). This scheme has been developed for *T. pyri* in New York. No similar scheme has been developed yet for *A. fallacis* in Massachusetts.

In Pennsylvania, a more elaborate decision making process in the form of a question and answer "expert system" has been developed that growers can use on home computers. No similar system exists in Massachusetts.

Regardless of the exact thresholds used, growers who wish to monitor predator:prey ratios in their orchards must learn to recognize predator mites as distinct from prey mites (i.e. spider mites). A hand lens is sufficient for this task and training can be requested from the regional fruit extension agents.

How to Convert From a Pesticide Mite Control Program to a Biological Control Program

Growers who wish to change management strategies from chemical to biological mite control should begin by requesting an evaluation of their mite control situation from an IPM specialist or extension representative. Factors to consider include past and current pesticide use (both amounts and specific types), orchard floor vegetation management, nitrogen management, and current spider mite and predator densities. IPM scouts can assess probable influences of various actions on mite populations and recommend specific actions to promote mite biological control. Regular monitoring for the first season is essential to determine if mites are responding as desired, and to determine timing and choice of any supplemental mite control treatments that may prove necessary. A period of several years may be required to convert from an intensive chemical control program to one based on conservation of mite predators, as predator populations will require time to increase in numbers. This process may be shortened by purchasing and releasing predator mites into orchards lacking predators after predator conservation practices have been established (see, for example, Field et al., 1979).

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Comparing Costs of Rubigan™ and Conventional Fungicides

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One of the most appealing features of the ergosterol biosynthesis inhibiting fungicides (SI's) is that they offer longer periods between applications than do conventional fungicides. Rubigan 1 EC™ at 6 oz/acre, when combined with a half-rate of Dithane M45 80W™ (0.75 lbs/100 gal), has performed well when used at 10 day intervals in tests at the Horticultural Research Center, Belchertown, MA (Table 1). It should be noted that the performance of Rubigan at the 4-oz rate plus the half-rate of Dithane is not as good, and generally would not be acceptable, at the 10-day intervals. After looking at efficacy, we then examined the economics of a complete-season Rubigan program.

At 10-day intervals, 6 Rubigan/Dithane applications were used in primary scab season last year (Table 2). At 7-day intervals, 9 standard applications would have been necessary. Looking at fungicide costs, using retail cost estimates, we found that the Rubigan/Dithane program was more expensive than a standard program (Tables 2 and 3). (The standard program used was 1.5 lbs/100 gal in all applications, plus 2 applications containing 3/8 lb/100 gal Cyprex 65W.)

However, fungicides themselves are only part of the costs. Application costs, such as gasoline, equipment wear, and labor, must also be considered. Since the Rubigan/Dithane program requires fewer applications, then such costs over a season will be lower. Estimates for application costs vary: in Massachusetts they are estimated at approximately $5.50/acre/application, while in New York they are estimated at $16.00/acre/application. When the non-fungicide costs were varied, and applied to different types of seasons, the following results were obtained (Table 4).

In a season similar to last season (9 standard sprays vs.

Table 1. Scab incidence under 10-day Rubigan/Dithane programs at two rates, 1987.

Fungicide & Rate	Percent scab incidence		
	Cluster	Terminals	Fruit
Rubigan 1EC 4 oz plus Dithane M45 80W 2.25 lbs	0.7 a[z]	0.3 a	1.7 a
Rubigan 1EC 6 oz plus Dithane M45 80 W 2.25 lbs	2.9 a	0.5 a	4.7 b
Dithane M45 80 W 2.25 lbs	13.1 b	1.5 b	5.7 b
Non-sprayed control	23.6 c	4.4 c	23.0 c

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

Table 2. Comparison of actual 10-day SI spray applications with a theoretical 7-day program (based on Horticultural Research Center data, 1987).

Infection period	Growth stage	Mill's scab infection period and severety	Standard	Rubigan/Dithane
April 16 - 18	1/4 to 1/2"	light	yes(4/15)	yes(4/19)
April 20 - 21	early TC	light	no	no
April 25	TC	none	yes(4/25)	no
May 2	late TC	none	no	yes(5/2)
May 7 - 9	pink to bloom	heavy	yes(5/5)	yes(5/12)
May 16 - 17	petal fall	heavy	yes(5/12)	no
May 21 - 22	late PF, set	heavy	yes(5/19)	yes(5/22)
May 22 - 23	late PF, set	heavy	no	no
May 27 - 28	set	heavy	yes(5/26)	no
May 30 - 31	1/4" fruit	moderate	no	no
June 2 - 3	1/4" fruit	heavy	yes(6/1)	yes(6/1)
June 4 - 5	1/4" fruit	heavy	no	no
June 12 - 13	3/4" fruit	heavy	yes(6/8)	yes(6/11)
June 13 - 14	3/4" fruit	heavy	yes(6/15)	no
Totals		12	9	6
Cost			$76.07[z]	$79.40[y]

[z]Dithane M45 80W, 1.5 lbs/100 gal, 4.5 to 3.6 lbs/A plus 2 applications in combination with Cyprex 65W, 3/8 lb/100 gal., 1.13 to 0.9 lbs/A.
[y]Rubigan 1 EC 6 oz/A in combination with Dithane M45 80W, 0.75 to 0.6 lbs/A.

6 Rubigan/Dithane), if application costs exceed $13.00, it would be less expensive to apply Rubigan/Dithane than a standard treatment. If Rubigan is used at the 4 oz rate, then application costs need to exceed only $6.00 for economy. (Note, however, that our results with this rate may not be commercially acceptable.)

When 6 standard sprays are needed versus 4 Rubigan/Dithane sprays, the break-even points for application costs are the same: $13.00 at the 6 oz Rubigan rate and $6.00 at the 4 oz rate. If the season is such that the numbers of standard and Rubigan/Dithane applications are similar, the break-even points increase. So, at 7 standard vs. 6 Rubigan/Dithane applications, application costs need to exceed $30.00 (unlikely) for economy.

Table 3. Estimates of retail prices used in the cost comparisons.

Material	Rate per acre[z]	Cost	Cost per acre per application
Rubigan 1 EC	6 oz	$1.99/oz	$11.94
Dithane M45 80W	4.5 lbs	$1.74/lb	$7.84
Rubigan/Dithane	6 oz/4.5 lbs	---	$15.86
Cyprex 65W	1.13 lbs	$2.49/lb	$2.81

[z]Dilute rate, assuming 300 gal per acre required.

Table 4. Break-even point for non-fungicide application costs under different types of seasons and varying numbers of applications.

Type of season (Mills period)	Number of standard applications	Number of Rubigan/Dithane applications	Break-even point[z] 6 oz	Break-even point[z] 4 oz
Heavy	10	7	$16.00	$8.00
Moderate - Heavy	9	6	$13.00	$6.00
Average	6	4	$13.00	$6.00
Light	4	3	$22.00	$10.00
Light	4	4	none	none

[z]If application costs are above the figure, the 10-day program is less expensive; if application costs are below the figure, the standard program is less expensive.

In fact, it is more likely that the Rubigan/Dithane applications will save 2 or 3 sprays, and that the number of applications will be 9 vs. 6, or 6 vs. 4, or some combination in between. The IPM block at the Horticultural Research Center has received an average of 8.5 dosage equivalents of fungicide in each of the past 8 years, with a range of from 6 to 11 applications. (Last year was the only year in which 6 dosage equivalents were used, largely because Rubigan was used for the first time in the block.) Similarly, Dr. Robin Spitko of New England Fruit Consultants reports an average of 8.3 dosage equivalents in orchards that they scout, with a range of 6 to 11. In view of that, it may be important to calculate application costs, in order to determine whether a 10-day program would be cost-effective under a given farm's conditions.

Of course, the convenience of a 10-day program also should be considered. And, there may be additional cost efficiency when a 10-day schedule allows an insecticide to be applied with a fungicide, but a standard program would not. A 10 day schedule offers considerable flexibility, and does not appear to cost a great deal, if any, more than a conventional program, even without considering possible convenience and additional savings.

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Apple Bruising. I. Evaluating Grading Lines

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Bruising is responsible for downgrading large quantities of apples and other fruit. A single bruise larger than 5/8 inch in diameter, or several smaller bruises with an aggregate area of more than 1/2 inch diameter will eliminate an apple from the U.S. Extra Fancy grade. Some bruising may occur before harvest, but the great majority of it occurs during harvest, transport to the packing house, grading and packing, transport to the retail outlet, and during retail marketing. A great deal of this bruising is caused by the harvesting and packing operations, and is largely preventable. While any knowledgeable fruit grower knows that a ripe apple is easily bruised and can identify some obvious sources of bruising, many sources are difficult to identify and thus to remedy.

Personnel at the U.S. Department of Agriculture, Agricultural Research Service and at Michigan State University have been conducting cooperative research on the sources and consequences of apple bruising, and have published a series of reports on their findings that are very helpful in identifying and correcting sources of bruising. This article is the first in a series of articles in *Fruit Notes* on their findings about this extremely important subject.

Apple packing lines offer many opportunities for bruising, but identifying trouble spots is not always easy. In a paper presented at the December 15-18, 1987 meeting of the American Society of Agricultural Engineers, G. K. Brown, C. L. Burton, S. A. Sargent, N. L. Schulte Pason, E. J. Timm, and B. E. Marshall addressed this problem. Their paper, entitled "Apple Packing Line Damage Assessment," examined bruise, cut, and puncture damage incurred by Golden Delicious apples as they moved through typical mechanical packing and grading lines. Eight different packing lines were tested, representing the widely-used equipment and the range of daily capacity of commercial packing houses in Michigan. The lines were all evaluated twice: mid-September to mid-October (freshly harvested apples), and early-January to early-February (ripe air-stored fruit).

Apples were sampled at 4 locations: input to the washer, output from the dryer (after waxing), on the sizer, and on the packing table. Additional samples were taken after bagging. Bruises were all rated according to size (diameter): "A" = 1/4 to 1/2 inch; "B" = 1/2 to 3/4 inch; "C" = 3/4 to 7/8 inch; "D" = 7/8 to 1 1/4 inch; "E" = more than 1 1/4 inch.

Sampling at the washer input measured bruising that occurred in the flotation tank, the undersize eliminator, and the inspection belt. Two-thirds of the apples sustained bruises in these operations. Sampling at the dryer measured damage from the washer, dewaterer, waxer, and dryer. More damage occurred in these operations than anywhere else on the line. Sampling on the sizer showed damage from the singulator and from transfer to the sizer, and this was the second-most source of fruit damage on the line. Sampling at the packing table showed damage that occurred from the sizer, and the conveyor, and here the least amount of damage occurred. By the time the fruit reached the packing table, 99% of them had been bruised in the packing line. To evaluate damage in the bagging operation, bruise-free fruit were bagged. This step was the most damaging of all, bruising 91% of the apples.

These results are depicted in Figure 1, showing the average number of bruises per fruit incurred in each of these operations, for each of the 8 packing lines. The data shown are for the late test.

Up to the bagging operation, over 90% of the bruises were of the "A" size, less than 1/2 inch in diameter, and less than 5% of the fruit were cut or punctured. However, during bagging the damage was more severe; 20 to 25% of the bruises were 1/2 to 3/4 inch in diameter, and 4 to 5% of the fruit were cut or punctured.

There were few differences in results between the fall and winter tests, meaning that ripening had little effect when compared with the operations of the packing lines. One difference that did exist was that freshly harvested fruit were more likely to be cut or punctured than were fruit out of storage.

As you might expect, there were great differences in damage among the different packing lines, indicating that much of this damage is under the control of the packing line operator, and thus is correctable. This was demonstrated clearly in that total number of bruises was reduced by 50% in the late test, after operators saw the results of the early test and began taking corrective actions.

The authors summarized their assessments of the causes of damage as follows.

Sampling Point A:

1. Rolling fruit hit steel chains, rollers, plates, and other fruit.

Sampling Point B:

1. High washer or waxer brush speed resulted in bouncing and stacking of fruit.

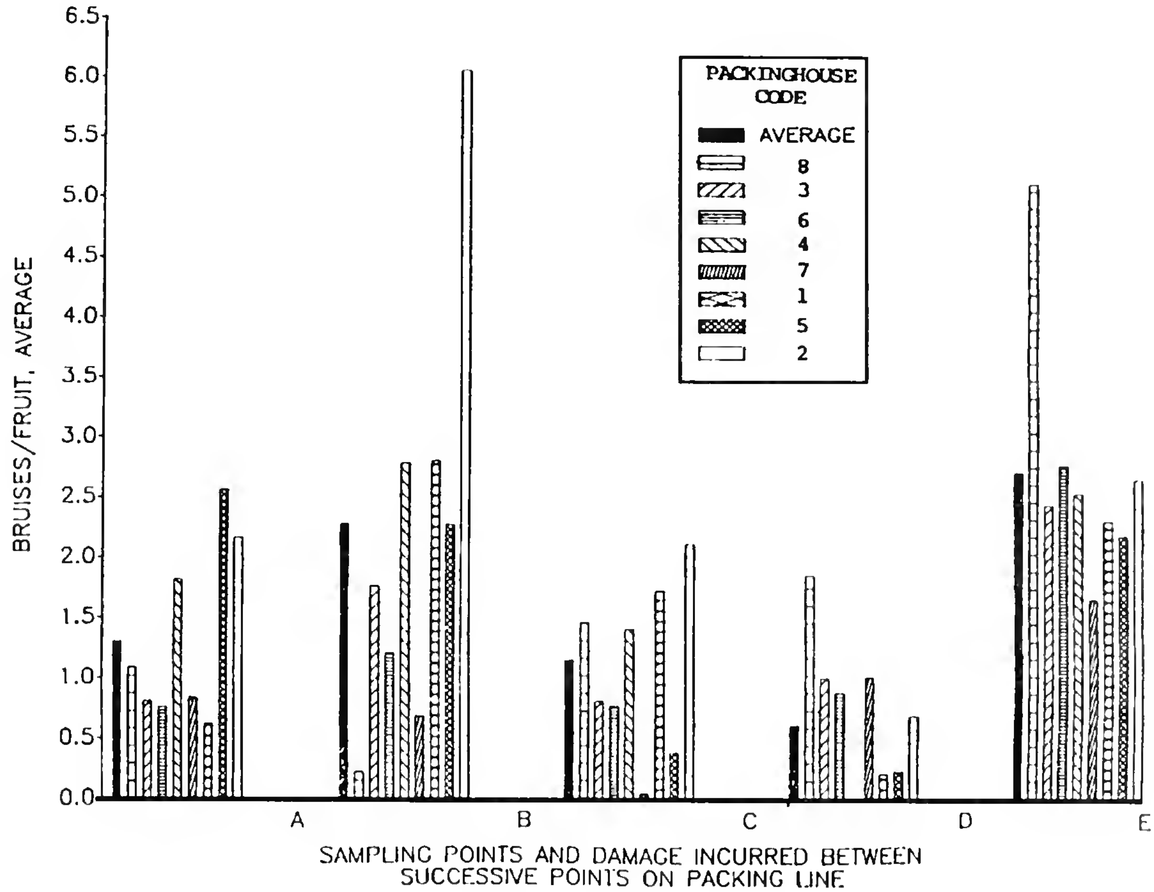

Figure 1. Average number of bruises to Golden Delicious apples incurred between points on eight grading lines. A = at input to the washer. B = output from the dryer. C = on the sizer. D = on the packing table. E = bagging operation.

2. Unpadded or poorly padded braces and guides. Obstructions in the line.

3. Mismatched transfers from washer to dewaterer/waxer.

4. Fruit to fruit contact or impact required for fruit flow.

5. No partitioning between parallel-flow brushes.

6. Long resistance time in washer, dewaterer, and waxer (low slope angle, fruit contact required for flow).

7. Fruit hit dryer rollers too fast after leaving the waxer.

Sampling Point C:

1. Unpadded plates and rollers.

2. Dried wax on padded surfaces caused surfaces to be rough and hard.

3. Mistimed singulator to sizer transfer (fruit hit cup or bounced).

4. No timing for transfer of fruit from singulator to sizer.

5. No transfer plate at singulator-to-sizer transfer.

6. Fruit-to-fruit impact.

7. Excess fruit on singulator fell onto hard surfaces in recycling line.

8. Hard cup surfaces on the sizer.

Sampling Point D:

1. Excessive belt speeds or sizing cone speeds in sizer.

2. Excessive drop distance from sizer cup to cross conveyor.

3. Fruit-to-fruit impact.

4. No decelerator strips.

5. No padding in sizer.

6. Hard surface on sizing cones (metal, rubber).

7. Excessive recycling on the accumulation tables due to fruit volume exceeding packing capacity.

Sampling Point E:

1. Fruit-to-fruit contact on the bagger feed-rolls.

2. Fruit-to-fruit contact as apples drop into the bags.

3. Excessive vertical drop height from the weight tray to the bag.

4. Excessive fruit size for the bagger.

5. Dropping bagged fruit onto the conveyor.

6. Top apples in bags getting hit at the bag closer machine.

7. Bag tumbling at conveyor transfer corners and drops.

These findings show that many surfaces impacted by apples should be padded, that fruit velocity (primarily as they roll down transfer ramps) should be slowed, and that drop angles (especially in the sizers and baggers) should be reduced. Knowing what to look for should help the operators of packing lines identify and correct problems, thereby substantially reducing fruit bruising during the packing operations.

In subsequent articles based on these Michigan State studies, we shall describe other sources of fruit bruising and some of its consequences.

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An Assessment of CA Storage Operations in Massachusetts

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Development of controlled atmosphere (CA) storage in the 1940's and 1950's revolutionized the McIntosh apple industry. This apple has an inherently short life in air storage that is made worse by its susceptibility to brown core development at temperatures below 37°F. In air storage, its quality cannot be maintained beyond 3 or 4 months. However, in CA, it can be kept at a temperature high enough to avoid brown core and, under proper CA conditions, retain good quality for up to 8 or 9 months. Thus, when done properly, CA can triple the length of the marketing season for McIntosh.

Current CA recommendations for McIntosh in Massachusetts are 3% O_2, 2 to 3% CO_2 for the first month and then 5% CO_2, and 37°F. Some researchers have shown that McIntosh can be stored safely at much less than 3% O_2 if the CO_2 is also kept very low, but we have never succeeded with low O_2 storage for our McIntosh and do not recommend low-O_2 storage in Massachusetts. The risk of injury to the fruit is too high.

Every year we receive a number of samples of apples showing symptoms after storage that strongly indicate that storage operation was not correct. These symptoms include soft and broken-down apples due to over-ripeness, O_2 or CO_2 injury due to an incorrect atmosphere composition, and core browning or freeze damage due to too low a temperature.

To better understand why these problems occur, and to help us in advising CA operators on how to do a better job of managing their storages so as to maintain high quality of fruit, we conducted a survey of CA operations for McIntosh during the 1986-87 season. A detailed questionnaire was sent to each of the 28 CA operators licensed by the Massachusetts Department of Food and Agriculture, and all of them responded to our request. From their responses we can construct a reliable profile of CA operations for McIntosh in Massachusetts. This information is summarized and evaluated below.

Survey Results

Size of Facilities. The 28 CA facilities have a total of 83 CA rooms with a total capacity of about 590,000 bushels.

The average operation stored 21,000 bushels, but 50% of the operators have a capacity of 15,000 bushels or less. The average CA room size was 7,100 bushels, but the capacities ranged from 600 to 33,000 bushels per room. Thirteen of the CA storages have only 1 or 2 rooms, while 10 have 3 or 4 rooms, 4 have 5 rooms, and 1 has 7 rooms. All but 4 operators stored only their own fruit, yet 84% of the fruit was destined for the wholesale market. McIntosh comprised 77% of the stored fruit. These members all show clearly that the CA industry in McIntosh is dominated by small storages where the operator stores only his own fruit.

Room Maintenance Characteristics. About two-thirds of the rooms use freon as refrigerant, and the remainder use ammonia. Only about two-thirds of the operators test the rooms for leaks annually, a serious oversight by the remaining operators. For pressure relief in the room, 82% use breather bags, 21% use U-tubes, but 7% apparently lack a designed relief system. (Percentages may exceed 100% because some operators have different equipment on different rooms.) In only two-thirds of the rooms are floors covered with water before sealing, and only 4 operators attempt to measure humidity in the rooms. About 75% of the rooms use lime boxes to scrub CO_2 from the atmosphere.

Establishing CA Conditions. During precooling, only one-fifth of the operators actually measure fruit temperatures. Only 39% of the respondents typically fill a room within 1 week, and 50% require 1 to 2 weeks for filling. (When rooms are opened, 21% typically are emptied in 2 to 4 weeks, while another 21% require 8 to 12 weeks.) Liquid nitrogen was used in 43% of the rooms to generate an atmosphere, in most of which 5% O_2 was reached within 3 days. However, one-third of the rooms utilize only fruit respiration to generate the atmosphere, which requires more than 7 days for 5% O_2 to be reached.

Monitoring the Storage Atmosphere. In about one-third of the storages, thermocouples or thermistors are used to monitor temperature, and more than 2 locations per room are monitored in one fourth of the storages. However, nearly 50% of the rooms have only a thermometer at the door for measuring temperature. Three-fourths of the respondents calibrate their temperature-monitoring devices annually.

All storages monitor O_2 and CO_2 with an Orsat. Only 8 storages use a pump to draw air from the room to the Orsat. Only 7 storages monitor the atmosphere more than once per day, and 3 reported monitoring it less than once per day.

Desired storage conditions for McIntosh varied widely. Half of the operators did not state their desired temperature, and of those who did, two-thirds set the temperature at less than 37°F. For O_2 levels, less than half of the respondents try to keep the room at 3%. Eleven operators try to keep O_2 between 3 and 4%, and 5 try to maintain O_2 at 4 to 5% O_2. Six operators run rooms at less than 3% O_2, but no one tries to go below 2%. Half of the storage operators try to maintain 5% CO_2, and nearly half try to keep CO_2 at less than 5%.

Atmosphere Variations. Operators were asked to identify typical atmosphere fluctuations in "good" rooms and in "difficult" rooms. In good rooms, about half reported temperature variations of no more than 1°F from the set point, and about one-third reported that it varied no more than 2°F. For O_2, about half reported variation of no more than 0.5%, but 6 said that it typically fluctuated more than 1% from the desired value. For CO_2, responses were almost identical to those for O_2.

One quarter of the operators reported no "difficult" rooms. Of those who have such rooms, wide variations in O_2 or CO_2 were more common than in temperature. When asked what condition was most difficult to maintain in their storage, half of the operators noted O_2 and none noted temperature, while one-fourth said there was no real difference. When asked what kind of atmosphere injury to fruit was most frequent for fruit in their storages, 7 identified freezing, 6 identified brown core, 2 identified CO_2 injury, and 1 identified low-O_2 injury.

An Evaluation

This survey clearly show that some of the difficulties with fruit quality that CA operators experience when the fruit come from storage arise from the sizes of the operations. To optimize the benefits from CA, a room should be at atmosphere within 7 to 10 days after the first fruit in the room were picked.

Since half of the CA storages in Massachusetts consist of only one or two rooms, and half require more than 1 week to fill a room, it appears that many operators lack the volume to fill quickly enough to achieve full benefits of CA. How much benefit these operators lose depends on how ripe the apples become, how long it actually takes to achieve CA conditions, and how well the storage operates. Their problems are also compounded by slow pack-out rates. Once the CA condition is broken, fruit begin to ripen faster, and when 21% of the storages require 8 to 12 weeks for pack-out, much ripening occurs after breaking the CA seal. These operations may benefit substantially from division of the rooms, so that they can be both filled and emptied faster.

Once a room is filled, it is critically important that it be sealed and brought to atmosphere quickly. One-third of the CA rooms still employ only fruit respiration to achieve atmosphere pull-down, which takes more than a week. Fruit condition is lost during this time --- needlessly. Liquid nitrogen is easy to use to generate rapidly a low-O_2 atmosphere, and is especially applicable to small storages. No storage should use fruit respiration to generate a CA atmosphere with the technology that is readily available today.

We recommend CA conditions of 3% O_2, 5% CO_2, and 37°F for McIntosh in Massachusetts. Many storages are operated under conditions different from these.

Most operators set temperatures lower than 37°F, thus risking brown core development in the fruit. Although operators indicated that they thought temperature was the easiest condition to maintain in CA, low-temperature disorders were the most frequently observed problems they reported. In part, these problems stem from too many operators relying on a single thermometer on the door to monitor temperature, but in part they also result from deliberately operating at too low a temperature.

Over half of the storages operate at too high an O_2 level. The recommended 3% O_2 level is a very conservative value, intended to allow for some difficulties in maintaining control. When operators deliberately maintain O_2 above 3%, they are wasting fruit condition needlessly. The same can be said for CO_2 levels. About half of the operators deliberately maintain CO_2 below 5%, often well below it. In part this may be due to the practice of placing lime in the room. However, when CO_2 is less than 5% after the first month of storage, fruit condition is being wasted.

Perhaps the wariness about maintaining recommended O_2 and CO_2 levels arises from distrust of Orsat readings. There is always some risk in relying on readings from a stationary Orsat. These readings should be checked weekly against readings at the door and or readings with another instrument. We believe that Orsats served their purpose in the past, but that it is time to replace them with better equipment that is now available. Electronic O_2 and CO_2 monitors offer many advantages over the Orsat, and should instill more confidence in the readings obtained.

Some fluctuations in the storage atmosphere are inevitable, but they need not be large. Large fluctuations carry two risks: when O_2 is too high or CO_2 is too low, fruit condition is lost, and when O_2 goes too low or CO_2 goes too high, there may be a risk of fruit injury. It is difficult to evaluate how big this problem is in Massachusetts CA storages, because our questions and many of the responses were somewhat ambiguous. Yet, it is obvious that atmospheres in many storages fluctuate excessively, and this fluctuation too may be responsible for many of the storage operators being too conservative in their desired O_2 and CO_2 levels.

Excessive fluctuations can arise from many sources. One is leakiness of the room, and all rooms should be tested and leaks patched annually before filling. Another source is infrequent sampling. Atmospheres should be monitored once a day at a minimum, but more frequent sampling is highly desirable. Another source is improper means for adjusting the atmosphere. Letting in too much air or using excessive scrubbing rates or times are two examples of this problem.

Much can be done to improve maintenance of the storage atmosphere. At the Horticultural Research Center in Belchertown we established an automated system of sampling and controlling the storage atmosphere. This system is described briefly in an accompanying article. The system provides improved atmosphere maintenance, and results in conditions that better maintain fruit quality and avoid injurious situations.

This survey of CA operations was of great value toward an understanding of the problems that CA operators face. We are most grateful to all of our operators for providing us with this information. The results of the survey illustrate many different sources of fruit losses, and hopefully they will be a great help in identifying and correcting problems in CA operations that are causing serious economic losses to many storage operators.

* * *

A User-build System for Automated Monitoring and Controlling of CA Apple Storages

William J. Bramlage
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The Orsat gas analyzer is used almost exclusively in New England to determine the concentration of O_2 and CO_2 in controlled atmosphere storages. Adjustments of the O_2 and the CO_2 levels are then performed manually by the storage operator. Use of the Orsat is subject to considerable operation error. It also is time-consuming, resulting in atmosphere sampling no more often than once a day in most storages, which in turn can result in significant atmosphere fluctuations, or in problems going unnoticed or uncontrolled for some time. Probably for these reasons, CA operators tend to be very conservative in their desired O_2 and CO_2 levels, thus forfeiting some of the potential benefits to the fruit from the CA atmosphere.

To try to improve on CA management in New England we have developed a demonstration system at the Horticultural Research Center, Belchertown, that automates the CA control procedure. This idea is not new. Numerous automatic control systems have been developed in other areas, and some excellent systems are commercially available.

Our approach was to try to develop a system at minimal cost to the storage operator, since many New England storages are small and the operators are short on investment capital. It is a system using off-the-shelf components, in which the storage operator is involved from the outset in developing a system to meet his or her specific conditions and needs.

Our system was developed by Katrin Kaminsky, as part of her M.S. thesis, in cooperation with personnel in the Department of Food Engineering who have expertise and experience in control systems and computer technology. The project was funded by a grant from the Massachusetts Society for Promoting Agriculture, with supplemental funding from the Massachusetts Agricultural Experiment Station.

The system is designed as a working demonstration of automated sampling and control of a CA atmosphere. It is in ongoing use at the Horticultural Research Center. To provide storage operators with ready access to information about the system, a University of Massachusetts Cooperative Extension Publication has been prepared and is now available. The publication provides a step-by-step description of the system we have developed, and a complete listing of supplies and costs that were involved.

The publication, entitled, "A User-built System for Automated Monitoring and Controlling of CA Apple Storages," publication C-197, is available from William Bramlage or Wesley Autio, Department of Plant & Soil Sciences, Bowditch Hall, University of Massachusetts, Amherst, MA 01003. We sincerely hope that CA operators will obtain a copy and carefully evaluate the application of this system to their operation. We hope that many operators will take the appropriate steps to upgrade their storage operations with the technology that is now in hand.

* * *

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ISSN 0427-6906

Fruit Notes

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage

Volume 54, Number 1
WINTER ISSUE, 1989

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

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205 Bowditch Hall
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Results of the Second Year of Second-stage Apple IPM Practices

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In a previous issue of *Fruit Notes* [53(2):8-11], we reported on results in 1987 from the first year of our second-stage IPM program in commercial orchards. Second-stage IPM employs behavioral, ecological, and biological approaches to pest management as a substitute for all insecticide and miticide treatments after the last spray against plum curculio in early June. The intent of second-stage practices is not only to provide an environmentally safe, cost-effective approach to controlling summer pests that directly attack apple fruit (apple maggot, codling moth, summer leafrollers) but also to alleviate insecticide toxicity to beneficial predators/parasites of important foliar pests such as mites, aphids, and leafminers. Allowing more natural enemies of foliar pests to flourish reduces the need for pesticide treatment against foliar pests and thereby lessens the rate (currently very high) at which several of these pests are developing resistance to pesticides. To emphasize further this latter goal, a major facet of second-stage IPM is use during April, May, and early June of pesticides least likely to be harmful to beneficial predators and parasites.

In the 1987 second-stage IPM tests, we compared 3 types of non-pesticidal approaches to intercepting apple maggot flies before flies penetrated the orchard interior. These approaches were: (1) placing synthetic apple odor-baited sticky red sphere traps every 10 yards in the woods immediately surrounding a block of apple trees; (2) placing such spheres every 10 yards on perimeter apple trees themselves; and (3) spraying perimeter (border row) apple trees every 3 weeks from late June through August. In all cases, abandoned apple trees within 100 yards of the orchard block perimeter were removed to preclude immigration of codling moths and summer leafrollers.

In 1988, we repeated the second and third approaches in the same blocks as in 1987. The first approach (placing spheres in woods) failed to control apple maggot flies to an acceptable level. It was replaced in a different set of blocks by a treatment that received border row sprays every 3 weeks from late June onward and that also received releases of mite predators into the block interior. Each of the 3 approaches used in 1988 was carried out on 6 test blocks averaging 2 to 4 acres. Each test block was matched with a nearby block of comparable size that received a normal amount of spraying during June, July, and August.

Apple Maggot Fly Interception Traps on Perimeter Trees

In 1988 we doubled the density of odor-baited sticky red sphere traps in perimeter apple trees from 1 trap every 10 yards to 1 trap every 5 yards. Results (Table 1) show that average apple maggot fly captures per block in 1988 were about 50% greater than captures in 1987 (compare 3201 in 1988 with 2054 in 1987). Non-baited sticky red monitoring spheres were placed in the interior of each test block and grower-sprayed block to provide an estimate of maggot fly populations in the block interior. In 1987, 40% more maggot flies were caught on monitoring traps in test blocks than in grower-sprayed blocks. In 1988, only 11% more were caught in the test blocks than in the grower-sprayed blocks, reflecting the greater effectiveness of the higher density of interception traps in 1988. This greater effectiveness is also borne out by the low amount of maggot injury to fruit in 1988 (0.5% in test blocks vs. 0.2% in grower-sprayed blocks). In sum, the higher density of interception traps in 1988 did a very good job of preventing apple maggot flies from penetrating the block interior.

Fruit injury by all other pests active after mid-June (codling moth, red-banded leafroller, other leafrollers, scale insects) was essentially the same (no greater than 0.2%) in test and grower-sprayed blocks in both 1987 and 1988. This result demonstrates the effectiveness of removing apple trees within 100 yards of the orchard perimeter as a method of preventing movement of codling moths and summer leafrollers into orchards (apple maggot flies move over much longer distances and are little affected by the tree removal method).

In both 1987 and 1988, total *Amblyseius fallacis* and yellow mite predators were about double in frequency in the test blocks compared with the grower-sprayed blocks. In 1988, pest mites in the test blocks were effectively held in check by predatory mites despite no use of miticide other than pre-bloom oil. In the grower-sprayed blocks, where miticide was usually used in addition to oil, there was a much less favorable pest-to-predator mite ratio. A similar pattern held true for aphid predators in 1988: nearly double the frequency in the test blocks. Together, the results point out the predator-fostering value of complete elimination of insecticide and miticide use after the

Table 1. Effects from using AMF interception traps on perimeter trees.

Year	Block	No.	Avg. no. AMF/block: Interception traps	Avg. no. AMF/block: Interior monitoring traps	Avg. % fruit injury by insect pests active after mid-June[z,y]: AMF	CM	RBLR	Other
1987	Trapped	6	2054	123	1.4	0.0	0.1	0.0
	Grower-sprayed	6	---	84	0.5	0.0	0.1	0.1
1988	Trapped	6	3201	117	0.5	0.0	0.1	0.0
	Grower-sprayed	6	---	105	0.2	0.0	0.2	0.0

Avg. % leaves (or terminals) infested/block[y,x]

Year	Block	No.	ERM TSM	AF	YM	Ratio of pest to predatory mites	WAA	WAL	PL	LM	GAA	GAAP
1987	Trapped	6	20	4.0	3.2	2.8:1	2	9	17	10	-	-
	Grower-sprayed	6	13	1.5	2.3	3.4:1	2	5	10	14	-	-
1988	Trapped	6	12	1.3	1.2	4.7:1	3	27	3	11	14	6.7
	Grower-sprayed	6	11	1.1	0.1	9.3:1	4	18	2	11	16	3.7

[z]500 on-tree fruit/block sampled during July, August, and September.
[y]AMF = apple maggot fly, CM = codling moth, RBLR = redbanded leaf roller, ERM = European red mites, TSM = two spotted mites, AF = Amblyseius fallacis, YM = predatory yellow mites, WAA = woolly apple aphid, WAL = white apple leafhopper, PL = potato leafhopper, LM = leafminer, GAA = green apple aphid, GAAP = green apple aphid predators: cecidomyiids and syrphids.
[x]400 leaves (or terminals) sampled/block during July, August, and September.

last curculio spray in early June.

Woolly aphid and leafminer populations were similar in abundance (both low) in test and grower-sprayed blocks in both 1987 and 1988. However, both white apple leafhopper and potato leafhopper populations were greater in the test blocks than the grower-sprayed blocks each year. This result causes us concern. It indicates we must consider applying pesticides specifically against leafhopper nymphs in test blocks in early- or mid-June.

We are most encouraged by the results of using apple maggot fly traps on perimeter apple trees. No grower will want to hang hundreds of sticky spheres around his orchard each year and clean the spheres of maggot flies every month or so. We have in mind a substitute plan whereby a grower might purchase several hundred larger spheres (5 to 6 inches or so in diameter) which could be more attractive than the current 3-inch spheres. These larger spheres could be hung in a permanent position on perimeter trees for perhaps 10 years. Only tree pruning would necessitate repositioning. In July, each sphere would be sprayed with or dipped in a solution containing a long-residual pesticide, a feeding stimulant for arriving maggot flies, and an agent that would greatly lengthen pesticide residual activity. Odor attractants would be affixed on a nearby twig. Under this plan, there would be no sticky and there would be minimal handling of the spheres. We are trying to obtain grant funds to pursue this idea.

Border Row Sprays Without Predator Releases

As in 1987, test blocks in 1988 received a spray of Guthion™ or Imidan™ applied only to perimeter apple trees every 3 weeks from mid-June through August. The interior of the block remained free of insecticide or miticide during this time.

As shown in Table 2, in both 1987 and 1988, there was little fruit injury caused by apple maggots, codling moths, summer leafrollers, or other insects active after mid-June in either border-row-sprayed blocks or the fully-sprayed

Table 2. Effects of applying border row sprays without mite predator releases in apple orchard blocks.

Year	Block	No.	Avg. no. AMF on interior monitoring traps	Avg. % fruit injury by insect pests active after mid-June[z,y]: AMF	CM	RBLR	Other
1987	Brd-row-sprayed	6	104	0.6	0	0.1	0.2
	Fully-sprayed	6	63	0.8	0	0.1	0.1
1988	Brd-row-sprayed	6	101	0.3	0	0.1	0
	Fully-sprayed	6	53	0.2	0	0	0

Avg. % leaves (or terminals) infested/block[y,x]

Year	Block	No.	ERM TSM	AF	YM	Ratio of pest to predatory mites	WAA	WAL	PL	LM	GAA	GAAP
1987	Brd-row-sprayed	6	24	1.2	0.1	19:1	5	0	9	5	-	-
	Fully-sprayed	6	16	0.3	0	48:1	5	1	10	4	-	-
1988	Brd-row-sprayed	5[w]	12	0.1	0.1	61:1	5	8	2	4	31	10.7
	Fully-sprayed	5	9	0.5	0.1	16:1	5	6	2	6	23	8.2

[z]500 on-tree fruit/block sampled during July, August, and September.
[y]AMF = apple maggot fly, CM = codling moth, RBLR = redbanded leaf roller, ERM = European red mites, TSM = two spotted mites, AF = Amblyseius fallacis, YM = predatory yellow mites, WAA = woolly apple aphid, WAL= white apple leafhopper, PL= potato leafhopper, LM= leafminer, GAA= green apple aphid, GAAP= green apple aphid predators: cecidomyiids and syrphids.
[x]400 leaves (or terminals) sampled/block during July, August, and September.
[w]Owing to a mistake on our part, data on foliar pests in one orchard had to be omitted.

blocks. This result demonstrates the effectiveness of border row sprays in preventing penetration of these fruit-injuring pests into the block interior.

Unfortunately, mite predators were low in frequency in border-row-sprayed blocks in 1988, as they were in 1987. Indeed, in neither year in neither type of block was the ratio of leaves with predators to leaves with pest mites better than 1 to 15. This result suggests a very low probability of achieving effective biological control via buildup of predatory mites in border-row-sprayed blocks (assuming the 6 blocks in which our tests were conducted are representative). From recent work in our department on the in-

Table 3. Effects from using border row sprays with mite predators releases.

				Avg. % fruit injury by insect pests active after mid-June[z,y]			
Year	Block	No.	Avg. no. AMF on interior monitoring traps	AMF	CM	RBLR	Other
1988	Brd-row-sprayed	6	135	0.4	0	0	0.1
	Fully-sprayed	6	104	0.2	0	0	0.1

			Avg. % leaves (or terminals) infested/block[y,x]									
Year	Block	No.	ERM TSM	AF	YM	Ratio of pest to predatory mites	WAA	WAL	PL	LM	GAA	GAAP
1988	Brd-row-sprayed	6	25	2.2	0.6	9.0:1	4	20	3	23	9	3.0
	Fully-sprayed	6	20	2.5	1.6	4.9:1	4	20	2	21	6	1.8

			Avg. % leaves/orchard with		
Tree sampled	predators released under these trees	Avg. no. trees per orchard	ERM&TSM	AF	YM
July	Yes	14	32	5.5	0.3
	No	14	35	3.1	0.2
August	Yes	14	19	4.5	1.2
	No	14	18	3.1	0.8
September	Yes	14	7	1.4	0.3
	No	14	9	1.1	0.6

[z]500 on-tree fruit/block sampled during July, August, and September.

[y]AMF = apple maggot fly, CM = codling moth, RBLR = redbanded leaf roller, ERM = European red mites, TSM = two spotted mites, AF = Amblyseius fallacis, YM = predatory yellow mites, WAA = woolly apple aphid, WAL= white apple leafhopper, PL= potato leafhopper, LM= leafminer, GAA= green apple aphid, GAAP= green apple aphid predators: cecidomyiids and syrphids.

[x]400 leaves (or terminals) sampled/block during July, August, and September.

fluence of ground cover and orchard border area composition on mite predator abundance, it appears that a substantial number of predatory mites may be wind-blown into orchards from plants surrounding the orchard. Possibly such predators are being killed as they contact the sprayed border row apple trees. Further work is planned to evaluate this possibility.

All other foliage-injuring pests (woolly aphids, leafhoppers, leafminers) were fairly low in abundance in both 1987 and 1988 in both border-row sprayed blocks and fully-sprayed blocks.

In sum, we are pleased with the results of the border-row spray program in virtually every respect except the failure of predatory mites to build to effective numbers.

Border Row Sprays With Predator Releases

In 1988 6 border-row-sprayed blocks and 6 fully-sprayed blocks were established in which *Amblyseius fallacis* mite predators were released at the rate of 500 to 1000 predator eggs, nymphs, or adults under each of 6 to 7 trees per block (every 4th tree of the block interior) in July.

As in the border-row-sprayed blocks without mite predator releases, there was little difference between border-row sprayed and fully-sprayed blocks in the amount of fruit injury by apple maggots, codling moths, or summer leafrollers or in populations of woolly aphids, leafhoppers, or leafminers (Table 3).

Of prime interest is the result of the mite predator releases. *Amblyseius fallacis* were about equally abundant in both the border-row-sprayed and the fully-sprayed blocks and were far more abundant in both than in comparable blocks (Table 2) where no predators were released. The released predators had genotypes largely resistant to Guthion and Imidan. This situation may explain the much greater abundance of this species in the blocks where they were released than in border-row-sprayed and fully-sprayed blocks where they were not released. These results are encouraging in terms of released predator survival during summer in sprayed blocks. We collected data in each block on the abundance of pest mites and *Amblyseius fallacis* on trees where the latter were released vs. immediately adjacent trees where they were not released. These data (Table 3) suggest that the numbers of released predators were too few to have affected populations of pest mites on the trees and that released predators were rather slow to move away from the trees under which they were released. This result suggests that in the future, much greater numbers of predator mites should be released on a greater proportion of trees in the orchard if such releases are to provide meaningful biological control of mites.

Conclusion

In conclusion, we are highly encouraged by most of the results of these past 2 years of second-stage IPM experimentation. We have a few "bugs" to iron out to render the second-stage approach more cost-effective and labor-appealing (especially development of a system to replace sticky as a method of killing apple maggot flies that arrive on spheres). Presently, we see 2 alternative routes to achieving potential second-stage IPM success on a practical level: (1) no insecticide or miticide used after early June, employing baited, pesticide-treated, non-sticky spheres around the orchard perimeter to intercept and kill apple maggot flies, removing all apple trees within 100 yards or so of the orchard perimeter, and allowing mite and aphid predators to immigrate into and build up in such blocks in a pesticide-free atmosphere; or (2) using border row sprays as a substitute for employing maggot fly spheres and releasing very large numbers of pesticide-resistant mite predators (possibly on an annual basis) on a high proportion of trees.

Acknowledgements

We thank the Massachusetts Society for the Promotion of Agriculture, the USDA Israel Binational Agricultural Research and Development Fund (BARD) under grant US-807-84, and the Northeast Regional Project on Integrated Management of Apple Pests (NE-156) for supporting our work on second-stage apple IPM. Special thanks to Betsy Frederick, Esther Ruiz, Phuong Nguyen, and Joseph Shepherd, who worked on the 1988 studies. Bill Coli, Kathleen Leahy, and Bill Pyne also participated in this program.

* * * * *

Apple Bruising. II. A "Mechanical Apple" Measures Fruit Impact During Packing and Transport

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A series of recent reports from Michigan State University describe results of an intense study of causes of apple bruising. This research was cooperative between personnel of the U.S. Dept. of Agriculture, Agriculture Research Service, and the Agricultural Engineering Department at Michigan State University. In the previous article [*Fruit Notes* 53(4):15-17], we summarized their study of bruising of Golden Delicious apples on commercial grading and packing lines. Here we shall describe a companion study of this situation that gives new insight into the problems.

This study was reported in a paper entitled, "Bruising Impact Data Acquisition and Analysis in Apple Packing and Handling Systems, Utilizing the Instrument Sphere (IS)." The paper was presented to the American Society of Agricultural Engineers on June 26-29, 1988, by B. R. Tennes, H. R. Zapp, D. E. Marshall, and P. R. Armstrong.

The "Instrument Sphere" used in this study is an ingenious device designed to simulate an apple and to record impacts it experiences as it passes through typical commercial operations. It is the size of an apple and is a battery-powered computer that senses impacts and records them over times.

This device was passed 3 times through 5 different packing lines along with the apples being graded on those lines. Results are summarized in Figure 1, in which maximum acceleration on any run is shown at 19 positions on a generic packing line.

As acceleration increases above about 50 g's, the risk of apple bruising increases. In Figure 1 it can be seen that high acceleration rates (rates of impact) occurred at many points, especially from the initial water dumping through the singulator after waxing, and in the automatic bagging operation. These results generally substantiate the visually

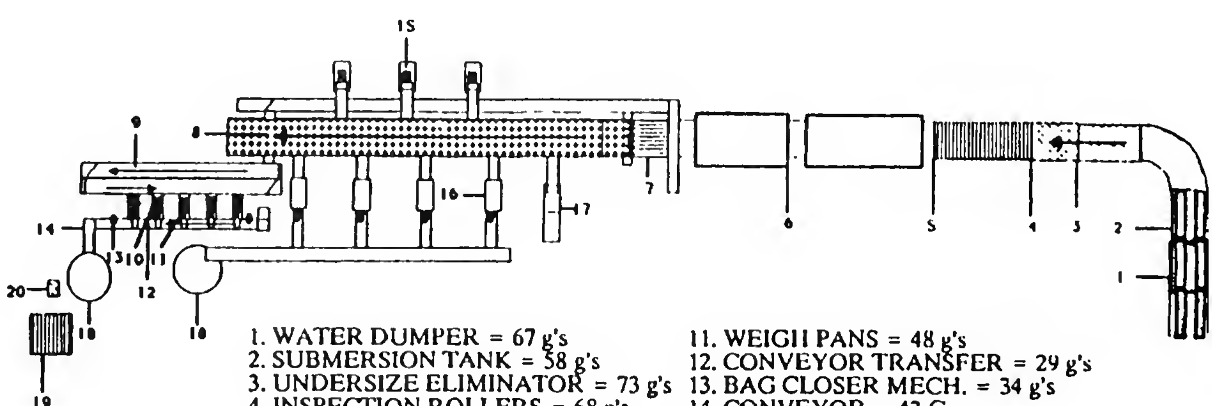

Figure 1. A schematic drawing of a generic apple packing line, with points of fruit transfer numbered consecutively from input to the water dumper (1) to putting bags into cartons (20). The maximum acceleration (g's) of the Instrument sphere is shown at each transfer point during 3 runs on each of 5 different packing lines.

determined bruising of Golden Delicious apples during grading and packing that we described earlier.

The bagging operation is a point of special concern, since it causes so much impact bruising. The high impacts (Figure 1) resulted from bags being dropped onto a conveyor in front of the closing machine, the snapping action of the bag-closing mechanism, the transfer points on the conveyors leading, and the hand placing of bags into shipping cartons.

Much of this impact bruising during bagging can be eliminated. The authors clearly showed this when they placed a piece of shag carpet (facing up) between a conveyor belt, onto which the bagged apples fell, and its steel backing. The Instrument Sphere was dropped different distances onto the belt, with and without the carpet backing, and the padding reduced impact of the instrument by nearly 75%.

Instrument Spheres were also used in a transportation study. They were placed in the top tray of a tray-pack carton, and into 3-lb. bags in a carton. The cartons were transported from the packing house to a distribution center, and then to a retailer, by a commercial semi-trailer. As the trailer passed over bridges under repair, impacts were 3-times greater (54 vs. 17 g's) in the trays than in the bags. Apparently, the tight fit in the bags provides protection to the fruit during rough transit. Note, however, that velocities of these impacts during transport were much lower than many of those experienced by apples on the grading line (Figure 1).

The Instrument Sphere developed by these researchers appears to have much value in assessing the sources of impact bruising on harvested fruit. This particular study re-emphasizes the high potential for bruising apples during the mechanical grading and packing processes, and the fact that much of this bruising need not occur. We urge readers to review the causes of fruit damaged outlined in the previous article evaluate their own packing lines for sources of impact bruising, and take corrective actions. Bruising is preventable.

* * * * *

Apple Bruising. III. Impact Bruising Leads to Fruit Rotting

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In previous articles [*Fruit Notes* 53(4):15-17 and this issue pp. 6-7], we have examined findings on sources of bruising to apples from studies conducted at Michigan State University. Here, we shall use their findings to show a consequence of this bruising - - - fruit rotting after packaging.

This study was reported by C. L. Burton, Nancy L. Schulte Pason, G. K. Brown, and E. J. Timm in a paper entitled, "The Effect of Impact Bruising on Apples and Subsequent Decay Development," presented to the American Society of Agricultural Engineers on December 15-18, 1987. The authors are researchers in the Agricultural Engineering Department and the U.S. Department of Agriculture, Agricultural Research Service, at Michigan State University, East Lansing.

Blue mold, caused by *Penicillium expansum* Lk. ex Thom, is responsible for 80 to 95% of the rotting of apples that is seen in commercial markets in the U.S. Contamination with spores of this fungus can occur in the orchard, but most of it probably arises in the packing house, especially in water dumps and on grading and packing equipment. Fruit contaminated during these operations may rot quickly if the spores are able to penetrate the fruit surface. Earlier studies showed that bruises can allow this penetration even though the skin is not broken. The study reported here was conducted to see how blue mold rotting related to impact bruising on apples. The authors conducted a series of laboratory tests using McIntosh, Delicious, and Golden Delicious apples that were bruised on surfaces contaminated with blue mold spores.

Fruit were carefully picked and handled so as to minimize pre-storage injury, stored at 34°F for 0, 2, or 4 months, and warmed to room temperature before bruising. They were bruised by being dropped onto a steel plate from different heights, which caused impact bruising of different severities. The surface of the steel plate was covered with blue mold spores to inoculate fruit as they impacted on it. Following bruising, the apples were kept in

Table 1. Effects of drop height on average bruise diameter on McIntosh, Golden Delicious, and Delicious apples after 0, 2, or 4 months of storage at 34°F.

Drop height (cm)	Average bruise diameter (mm) months in storage 0	2	4	Avg.
5	16	18	17	17
10	21	21	20	21
20	26	21	26	24
30	29	28	27	28
40	31	32	30	31
50	30	31	32	31
75	38	35	36	36
100	40	39	39	39
Avg.	29	28	28	

moist plastic containers at 75°F for 5 to 7 days and then inspected for rots.

Increasing drop height increased the average size of impact bruises (Table 1). However, bruising was not increased by storage time, even though the apples softened during storage. Also, cultivar did not greatly influence bruise size from a fall of a given height, so the data in Table 1 are the average values for the 3 cultivars.

Bruising greatly affected the amount of rotting that occurred on these apples, as shown in Figure 1. Bruising at harvest (0 months of storage) resulted in very little rot, regardless of bruise size or cultivar. However, after 2 or 4 months of storage, bruising led to much rotting, and the amount was greater for the apples stored for a longer time before bruising.

Rotting increased as drop height (and bruise size, Table 1) increased. A given drop height caused much more rotting of Golden Delicious than of the other cultivars, and more on McIntosh than on Red Delicious, even though bruise size from a fall of a given height was about the same for all 3 cultivars.

Since damage to the fruit from a given impact did not increase with storage time, but subsequent rotting increased greatly (Figure 1), the difference must be due to ripening changes inside the fruit. It is well known that as

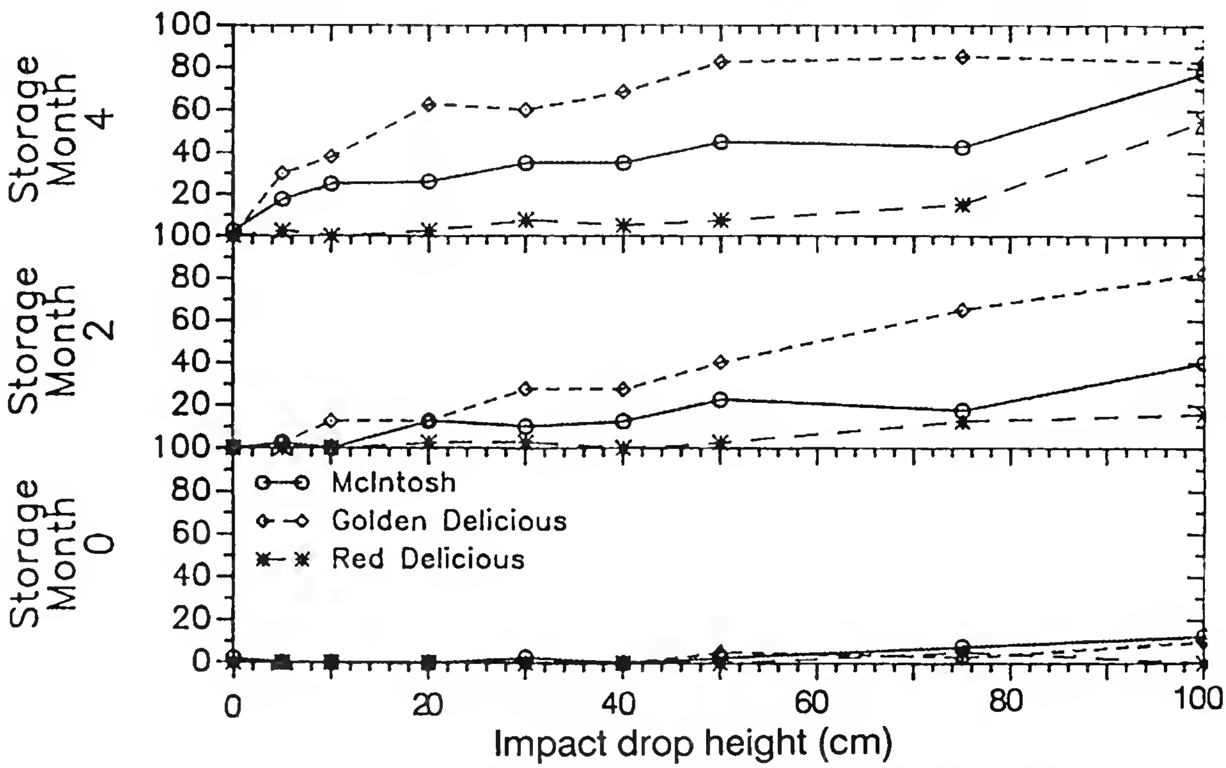

Figure 1. Percent blue mold rotting that developed on 3 cultivars of apples dropped different heights onto a contaminated metal plate after 0, 2, or 4 months of storage at 34°F. After bruising, the apples were kept in a moist environment for 5 to 7 days at 75°F.

they ripen, fruit lose their ability to fight-off invading pathogens. Bruising, then, must in some way help the fungus enter the fruit, and then advancing ripeness allows that fungus to more easily rot the apples. Figure 1 shows dramatically how the consequences of bruising worsen as the bruising occurs on progressively riper fruit.

In earlier articles [*Fruit Notes* 53(4):15-17 and this issue pp. 6-7], results of packing-line studies of bruising were reported. In the study reported here, the authors projected the amount of rot that likely would result from the bruising incurred by Golden Delicious apples passing through commercial packing lines.

They conclude that bruising of ripe apples on a contaminated packing line (and they all are contaminated) would directly lead to 4 to 8% of the tray-packed apples rotting within 5 days at 75°F, and that less ripe apples and cultivars other than Golden Delicious probably would not rot as badly. However, the projections of the authors show what can happen and may help explain why some lots of apples are rejected because of excessive rotting. Clearly, bruising during the grading and packing operations can lead to substantial rotting as well as to the direct quality loss caused by appearance of the bruises themselves.

In their earlier studies [*Fruit Notes* 53(4):15-17 and this issue pp. 6-7], the authors showed that much of this bruising is preventable, and they described what packing-line operators should be looking for, and gave some suggestions for alleviating the problem.

The results described here also re-emphasize the importance of practices to reduce build-up of fungal spores on and around fruit. A recent article [*Fruit Notes* 53(3):15-16] examined this problem and offered suggestions for controlling apple rotting.

* * * * *

Blueberry Nutrition

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For high yields, blueberry bushes must be vigorous, making at least 12 to 18 inches of new growth per year. The most productive shoots are those with 15 to 20 leaves. Low vigor can be the result of improper or no pruning, dry or wet soil conditions, incorrect soil pH, or lack of nutrients.

Pruning must be done annually in late winter or early spring. Mulching with sawdust or wood chips is ideal for conserving soil moisture and preventing drought stress. Many growers, particularly on light, sandy soils, are using trickle irrigation to supply moisture during drought periods. Wet soil conditions can be corrected by soil drainage in some cases.

Soil Acidity

Blueberries require an acid soil, the ideal pH being between 4.5 and 5.5. If the pH is below 4.5, dolomitic or high magnesium limestone should be applied to raise the pH, while sulfur may be used to lower the pH. In addition, fertilizers having an acid reaction should be used, such as most complete fertilizers (10-10-10, etc.), ammonium sulphate, and ammonium nitrate. Do not use fertilizers having an alkaline reaction, such as sodium nitrate, calcium nitrate, cyanamide, bone meal, and wood ashes, unless the pH is 4.6 or lower.

Nutrients

It is generally agreed that nitrogen is the most important of the major elements required by blueberries, the ammonium form being preferred to the nitrate form. Little or no response has been observed to phosphorus or potassium applications although one Massachusetts grower reports improved growth and production from application of superphosphate. In the field, the only deficiency symptoms observed are those of nitrogen, iron, and magnesium. Symptoms of nitrogen deficiency include stunted growth, yellowing, and, under severe deficiency, reddening of older leaves. Iron deficiency appears on the new growth with the leaves becoming bright yellow, while magnesium deficiency usually becomes apparent at harvest as yellowing between the veins and of leaf margins of older leaves while veins remain green. Both iron and magnesium deficiencies are usually corrected by adjusting pH to the optimum range. Environmental factors that can be confused with nutrient deficiency symptoms include drought stress, poor drainage, cool weather during the growing season, insect or disease injury, fertilizer burn, and injury from pesticides and herbicides. Therefore, a soil test or leaf tissue analysis is advisable if a nutrient deficiency is suspected. Soil samples should be taken in the fall while leaf samples should be taken from July 15 to August 15.

Fertilizer is usually applied in a ring around the bush or in broad bands on both sides of the row. On newly-set, young bushes a 6-inch ring around the bush 12 inches from the crown is recommended when new growth starts. A second application may be made in late June or early July and a third in late November before the ground freezes.

On newly set plants the recommended amount of fertilizer is 1 ounce of 10-10-10 or its equivalent. This amount may be doubled each year to a maximum of 1 pound per bush at 5 years. Bushes low in vigor may be fertilized again with 1/2 pound in late November. Fertilizer rates may be increased up to twice the recommended amount where bushes are heavily mulched. Higher rates are needed on sandy soils since nitrogen leaches readily, especially in the nitrate form. Lower rates at frequent intervals help to minimize leaching. Fertilizers containing muriate of potash (potassium chloride) are not advisable since the chlorine may be injurious, particularly to young bushes. Well rotted manures may be applied in late fall or early spring using half as much poultry as cow or horse manure.

* * * * *

Red Fuji is a Promising New Apple Cultivar

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There is increasing interest on a world-wide basis in identifying and evaluating new apple cultivars. Significant shifts are occurring, particularly in places such as The Netherlands, New Zealand, China, and Japan, from the traditional cultivars toward those that have better taste and storage characteristics. Of the new cultivars, one of the most promising is Fuji, a cross between Ralls Janet and Delicious. It is a medium-sized apple that is green with a dull pink or red stripe or blush over a yellow-green ground color. Red strains show considerably more, but not outstanding, red color. The flesh is yellowish green, dense, crisp, and sweet. Fuji is a high quality apple! Several red coloring strains have been identified, and they are sold by various nurseries. It is the most popular apple in Japan, where 44 % of the production is Fuji (including its red coloring strains). It is the most widely planted cultivar in China and the most talked-about apple in California. Growers in the Pacific Northwest also are giving Fuji considerable attention.

At the University of Massachusetts Horticultural Research Center, Belchertown, we propagated and planted a strain of Red Fuji obtained from Roger Way at the New York Agricultural Experiment Station in Geneva. The first fruit from these trees were harvested this fall. Here we report briefly on the first year's results with this strain of Red Fuji.

Tree Characteristics

Fuji is a moderate- to high-vigor, non-spur tree. It is easily trained to a central leader, and has scaffold branches that appear to require no spreading. The tree may have some blind wood at the base of 2-year-old wood, similar to that of nonspur Delicious (one of its parents). It blooms mid- to late-season. It is a diploid and thus should have viable pollen capable of pollinating other cultivars blooming in the same season. In 1988 it set more fruit in our planting than similar Marshall McIntosh trees. Because it blooms and sets fruit at an early age, control of growth in the orchard should not be difficult. Reports from elsewhere suggest that it is susceptible to fire blight but may have some resistance to apple scab.

Fruit Characteristics

Harvests of Red Fuji were made on October 20 and 24, 1988. At this time seeds were brown, and severe watercore had developed in some fruit. Consequently, we feel that the fruit could have been harvested some time prior to October 20. Harvest was delayed because of the persistence of a dark-green ground color. Fruit weight averaged about 7 ounces. Because the trees are young, one could expect fruit size on older trees to be smaller. Flesh firmness was 18.5 pounds. Soluble solids (sugar) was over 15%, which is the highest that we have recorded for any cultivar evaluated at the Horticultural Research Center. The taste was sweet, fruity, slightly aromatic, subacid, and pleasant. The fruit surface was slightly rough with raised lenticels. The overall exterior appearance was very similar to a well-colored Baldwin. We would rate the overall quality of Red Fuji to be good but not exceptional. However, it is reported that Fuji does not produce a high quality fruit on young trees. Fruit is now in air storage for periodic evaluation of its storage potential.

We believe that Red Fuji is worthy of trial in Massachusetts. Anyone who can mature Rome should be able to mature Fuji. Based upon reports from other parts of the country and from Australia, we believe that fruit color and possibly taste of Fuji grown in Massachusetts may be as good as, if not superior to, those fruit grown in other regions. If the potential for Fuji is greater than that for Granny Smith, as some have suggested, then Red Fuji is a cultivar that growers in Massachusetts should be watching very carefully.

* * * * *

Apple Rootstocks for the 1990's

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The ideal apple tree is determined by fitting the rootstock with the cultivar, site, training system, and the orchardist's perception of what makes a good tree. The introduction of a number of new rootstocks presents fruit growers with many options for the future. Many of these rootstocks are not tested, although research is being conducted around the world to evaluate them. The purpose of this article is to report on the results of 2 NC-140 Rootstock Research Committee plantings in Massachusetts that contain some of the most promising new rootstocks.

The most thorough and extensive evaluation of rootstocks in North America is carried out through the NC-140 Rootstock Research Committee. This committee is a group of approximately 50 pomologists from the U.S. and Canada. Each year the group meets to share data and observations on present plantings and to plan future, cooperative, uniform plantings. At present 2 apple rootstock plantings are in the ground, and 2 new plantings are scheduled for 1990. The oldest of the two plantings was

Table 1. Trunk circumference, yield, yield efficiency, and fruit weight of Starkspur Supreme Delicious on various rootstocks planted in 1980 and 1981. Cumulative yields and yield efficiencies represent data from 1983 and 1984 through 1988 for the 1980 and 1981 plantings, respectively.

Rootstock	Trunk circumference (in)	Yield per tree (bu) 1988	Yield per tree (bu) Cumulative	Yield efficiency (kg/cm²) 1988	Yield efficiency (kg/cm²) Cumulative	Fruit weight (oz)
1980 Planting:						
Ott.3	8.1 bc[z]	1.2 bc	7.6 b	0.68 a	4.15 bc	8.0 ab
M.7 EMLA	11.9 a	3.6 a	12.5 a	0.95 a	3.27 c	7.1 bc
M.9 EMLA	6.4 cd	1.0 bc	6.0 bc	0.83 a	5.32 a	8.5 ab
M.26 EMLA	9.3 b	1.8 b	8.9 b	0.76 a	3.80 bc	8.1 ab
M.27 EMLA	3.5 e	0.3 c	1.4 d	0.68 a	3.95 bc	7.4 abc
M.9	4.7 de	0.3 c	2.6 cd	0.47 a	4.23 abc	7.9 ab
MAC 9	8.4 b	1.0 bc	9.0 ab	0.49 a	4.54 ab	9.1 a
OAR 1	9.6 b	1.2 bc	3.8 cd	0.46 a	1.51 d	5.8 c
1981 Planting:						
Ott.3	7.2 bcd	1.5 ab	6.8 ab	1.15 abc	4.73 ab	8.4 ab
M.7 EMLA	9.9 a	2.1 a	7.6 a	0.81 abc	2.85 cd	7.8 ab
M.9 EMLA	6.4 cd	1.6 ab	6.1 abc	1.45 a	5.38 a	8.5 ab
M.26 EMLA	8.3 abc	2.3 a	7.5 a	1.22 ab	3.98 abc	7.9 ab
M.27 EMLA	5.2 e	0.2 c	0.8 d	1.14 abc	3.45 bc	7.2 ab
M.9	6.8 d	0.4 bc	3.0 cd	0.48 bc	3.93 abc	8.7 ab
MAC 9	6.8 cd	0.4 bc	5.3 abc	0.33 c	4.15 abc	9.6 a
OAR 1	9.0 ab	1.4 abc	3.4 bcd	0.61 bc	1.49 d	6.5 b

[z]Means within plantings and columns not followed by the same letter are significantly different at odds of 19 to 1.

established at 27 locations in 1980 and 1981 and includes Starkspur Supreme Delicious on M.7 EMLA, M.9 EMLA, M.26 EMLA, M.27 EMLA, M.9, OAR 1, Ottawa 3, and MAC 9 (the virus-indexed version of which is now being sold as "Mark"). This planting was established as a randomized complete block with 10 replications. Trees in half of the replications (those planted in 1981) were staked at planting, while trees in the other half (those planted in 1980) were staked only when they leaned more than 45° from vertical. Each year the height, spread, trunk circumference, and yield from each tree is measured.

The younger NC-140 planting was established in 1984 and includes Starkspur Supreme Delicious on Bud.9, Bud.490, P.1, P.2, P.16, P.18, P.22, MAC 1, MAC 39, CG-10, CG-24, M.4, M.7 EMLA, M.26 EMLA, C.6, Ant.313, and domestic seedling in a randomized complete block design with 10 replications. Trees have been staked only when they have leaned more than 45° from vertical.

Table 1 presents the trunk circumference and yield data from the 1980 and 1981 plantings. The discussion here will focus on the 3 most interesting rootstocks in the 1980/81 planting: M.9 EMLA, Ott.3, and MAC 9 (Mark).

The EMLA designation refers to those rootstocks derived from clones which have had the latent viruses removed. They were developed by a cooperative effort of the East Malling and Long Ashton Research Stations in England. In general, the EMLA series rootstocks are very similar to the rootstock from which they were derived, e.g., M.7 EMLA is very similar to M.7 or M.7A. In some cases vigor may be slightly greater for the EMLA version; however, M.9 EMLA is considerably more vigorous and productive that M.9 (Figure 1). M.9 EMLA actually was derived from a different strain of M.9 than we commonly use. The trunk circumference after the 1988 growing season of trees on M.9 EMLA was 28% greater than those on M.9. The 1988 yield per tree was 308% larger, and the cumulative yield per tree from 1983 through 1988 was 118% greater. Another way to look at yield is in terms of yield efficiency (Table 1), which is given as yield per unit of trunk cross-sectional area. This term accurately relates tree size and yield per tree and allows a comparison of potential productivity. On a cumulative basis through 1988 the trees on M.9 EMLA were 30% more yield efficient than those on M.9.

In general, M.9 EMLA may result in a tree which is too vigorous for a trellis; however, trees on M.9 EMLA may be a superior tree on a post trained to a slender spindle or a similar system. It is necessary to consider cultivar when choosing between M.9 and M.9 EMLA and among the various training systems. These observations are based primarily on a low-vigor cultivar: Starkspur Supreme Delicious. With a vigorous scion M.9 may produce an excellent posted tree, and M.9 EMLA may result in a tree too large for a high density planting. With a low-vigor cultivar the vigor induced by M.9 EMLA may be necessary to allow the development of even an adequate trellised

Figure 1. Starkspur Supreme Delicious on M.9 EMLA (left) and M.9 (right) after 8 growing seasons (1981 planting).

tree.

Ottawa 3 (Figure 2) is a hardy rootstock which may hold a great deal of promise. It results in a tree similar in size to M.26 EMLA with a similar yielding potential. On a cumulative basis through 1988 the yield efficiency (Table 1) of trees on Ott.3 was second only to those on M.9 EMLA. Trees on Ottawa 3 appear to be slightly better anchored than those on M.26 EMLA but in most cases will require support. Ripening studies (data not shown) suggest that Ott.3 may advance ripening.

Figure 2. Starkspur Supreme Delicious on Ott.3 after 9 growing seasons (1980 planting).

MAC 9 (Mark) (Figure 3) is probably the most interesting rootstock in the study. Tree size after the 1988 growing season was similar to that of trees on M.26 and Ott.3 (Table 1), and it has been one of the most productive trees in the planting. On a cumulative basis through 1988 trees on MAC 9 were 12% more yield efficient than trees on M.26 EMLA. An inherently high level of precocity can be a problem with MAC 9, especially with weak cultivars. Excessive fruiting can result in very little growth and "runting out" of the trees. Once growth has stopped due to excessive cropping it is difficult to get trees to grow again. Because of the limits of the uniform planting we did not thin the fruit in 1987 when the crop was excessive, thus fruit size and growth were reduced significantly in 1987 and the crop was very light in 1988. Trees on MAC 9 (Mark) in a commercial planting must be thinned early in their life to maintain good growth and fruit size. Our observations suggest that MAC 9 is only somewhat better anchored than M.26 EMLA, so we feel that in most cases it will benefit from support, at least during the first 5 years in the ground when tree structure is being established. Ripening studies (data not shown) suggest that MAC 9 delays ripening, which may be a very useful tool for expanding the harvest

Figure 3. Starkspur Supreme Delicious on MAC 9 (Mark) (left) and M.26 EMLA (right) after 8 growing seasons (1981 planting).

season of a single cultivar in commercial settings.

The 1984 NC-140 planting is at this time too young to make any accurate statement about specific rootstocks. However, data on tree size and yield are presented in Table 2, and this information can be used to get some idea of the basic relationships among these rootstocks. After the 1988 growing season the smallest trees were on P.16 and P.22, and the largest were on P.18, CG-10, Ant.313, and domestic seedling. On a cumulative basis the most efficient trees were on P.2, P.16, Bud.9, C.6, and P.22. The rootstocks with the most promise are Bud.9, P.2, and C.6. All are between M.9 and M.26 in their size controlling properties, and all trees on these rootstocks will need support. Representative trees on these rootstocks are pictured in Figures 4, 5, and 6. We will be observing this planting for the next 5 years to see where some of these new rootstocks might fit into our production systems.

The next plantings of the NC-140 Rootstock Research Committee are scheduled for 1990. One planting will look at the interaction of rootstock and training system and the second will study the interaction of rootstock and cultivar. In the rootstock/cultivar planting we are trying to eliminate the problem of evaluating a rootstock based

Figure 4. Starkspur Supreme Delicious on Bud.9 after 5 growing seasons (1984 planting).

Table 2. Suckering, trunk circumference, yield, yield efficiency, and fruit weight of Starkspur Supreme Delicious on various rootstocks planted in 1984. Cumulative yields and yield efficiencies represent data from 1987 through 1988.

Rootstock	Root suckers per tree (1984-88)	Trunk circumference (in)	Yield per tree (bu) 1988	Yield per tree (bu) Cumulative	Yield efficiency (kg/cm^2) 1988	Yield efficiency (kg/cm^2) Cumulative	Fruit weight (oz)
Bud.9	0.0 c	4.7 efg	0.8 abc	1.2 abc	1.31 ab	2.04 ab	7.1 abc
MAC 1	3.9 abc	7.2 bc	0.4 def	0.5 f	0.28 f	0.32 d	7.3 abc
MAC 39	0.0 c	4.7 efg	0.7 bcde	0.8 cdef	1.08 abcd	1.34 bc	8.2 a
P.1	0.7 bc	6.8 bcd	1.1 a	1.6 a	0.91 cd	1.31 bc	7.7 ab
P.22	0.7 bc	3.0 h	0.3 f	0.5 ef	1.02 bcd	1.98 ab	6.8 bc
Seedling	7.0 abc	8.4 ab	0.5 cdef	0.6 ef	0.25 f	0.31 d	7.1 abc
CG-10	9.2 a	8.1 ab	0.4 ef	0.4 f	0.28 f	0.34 d	7.2 abc
CG-24	3.9 abc	7.2 bc	0.5 cdef	0.6 def	0.39 ef	0.44 d	6.8 bc
M.4	0.8 bc	7.2 bc	0.6 bcdef	0.8 cdef	0.48 ef	0.62 cd	7.1 abc
M.7 EMLA	0.4 bc	6.3 cde	0.8 abc	1.1 abcd	0.74 de	0.96 cd	7.5 abc
M.26 EMLA	3.3 abc	5.3 def	0.8 abcd	1.0 bcde	1.00 bcd	1.37 bc	7.7 ab
Bud.490	1.0 abc	7.5 abc	0.7 bcde	0.8 cdef	0.46 ef	0.55 d	7.6 ab
P.2	0.0 c	4.1 fgh	0.7 bcde	1.0 bcde	1.53 a	2.18 a	7.0 abc
P.16	0.6 bc	3.4 gh	0.3 ef	0.6 ef	1.21 abc	2.20 a	6.3 c
P.18	0.8 abc	8.1 ab	0.7 bcde	0.8 cdef	0.38 ef	0.46 d	7.9 ab
C.6	0.5 bc	5.3 def	0.9 ab	1.4 ab	1.15 abc	1.83 ab	8.3 a
Ant.313	7.3 ab	8.4 ab	0.6 bcdef	0.8 cdef	0.37 ef	0.48 d	7.7 ab

[z]Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

Figure 5. Starkspur Supreme Delicious on P.2 after 5 growing seasons (1984 planting).

solely on data from one cultivar. It will contain 4 cultivars (Golden Delicious, Jonagold, Empire, and Law Rome) and 5 rootstocks (M.26 EMLA, M.9 EMLA, Mark, Ott.3, and Bud.9) at all cooperator locations. Cultivars to be planted at some locations include Marshall McIntosh, Stayman, Red Yorking, Liberty, Jonathan, Chieftain, Mutsu, Gala, and Granny Smith. Rootstocks which will be planted at some locations include P.22 and M.27 EMLA. With this planting we hope to evaluate cultivars of different basic growth types on the most promising rootstocks to give a better idea of how these rootstocks will perform.

Proper selection of a rootstock will be a significant factor in apple production in the future. The choice of the most appropriate rootstock will depend on a number of factors including cultivar, training system, soil, and time of ripening. An unprecedented number of new rootstocks presently are under intensive evaluation. The prominent rootstocks of the future likely are among those being tested.

Figure 6. Starkspur Supreme Delicious on C.6 (left) and M.26 EMLA (right) after 5 growing seasons (1984 planting).

* * * * *

Apple IPM Program: Delivery and Observations in 1988

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Our thanks to the following cooperating growers in the IPM monitoring program this year: Charlie and Alex Dowse, Ed Jensen, Tony Lincoln, Tony Rossi, Don Schlicke, Steve Smedberg, Mike and Tim Smith, Mike Smolak, and Denis Wagner. Special thanks to Sue Butkewich for technical assistance.

Overview of the Program

The 1988 Massachusetts Apple Integrated Pest Management (IPM) Program was a mixture of "old" and new approaches to orchard pest management. As always, we monitored commercial blocks for insect and disease activity and reported the information to the state's growers, via newsletters, recorded Code-A-Phone messages, and direct grower access of INFONET, our computerized bulletin board system. Some pesticide trials and other related research was conducted at the University of Massachusetts Horticultural Research Center, Belchertown. In addition to these activities, however, we are now working toward melding our more-proven, first-stage-IPM pesticide-reduction practices with some of the more-radical practices involved in second-stage IPM into a unified "third stage" of greatly reduced pesticide use without loss of crop quality or profitability.

Monitored blocks (7 out of 9 blocks reporting pesticide records) received an average of 4.3 dosage equivalents (full-rate equivalents) of insecticide this year, 0.9 DE's of miticide, and 8.5 DE's (range of 5.4 to 12) of fungicide. This reduction in overall pesticide use did not result in any loss of crop quality, premature fruit drop, or other problems in these blocks. One spray-related problem was brought to our attention which had appeared in some locations: a russetted ring toward the low-hanging end of the fruit. This injury was tentatively attributed to Captan applied on a hot (88°F) day under poor drying conditions.

Insects and Diseases in 1988

European Apple Sawfly. Captures were quite high in blocks where sawfly was not well controlled last year; one block even exceeded our record high trap captures of 1987 with an average of 73 per trap and a maximum of 126! Trap captures were moderate in most blocks; however, sawflies entered in such a way that many growers were unable to protect earlier cultivars when later cultivars were still in bloom. Sawfly damage was seen in blocks where prebloom sprays were applied as well as where such sprays were withheld.

Plum Curculio. Curculio activity also occurred in a very concentrated period at bloom and petal fall. Injury was exceptionally high in some blocks where controls could not be applied in time. Very little fresh injury was seen or reported in the 9 regular monitoring blocks after 2 to 3 weeks past petal fall. Some growers, particularly those who often experience late curculio injury, did, however, report serious problems with late curculio activity this summer.

Pear Thrips. This insect became a major problem in at least 3 orchards in western Massachusetts as well as in Vermont, causing poor fruit set in infested blocks (approximately 75% yield reduction in one case). Thrips have been present in low-spray orchards in this area since 1985, but this year was their first major appearance in commercial blocks in Massachusetts.

Leafminers. This year was another unusual year for leafminer activity. Spring emergence seemed fairly stable and predictable (unlike that of 1987, when cold and snow made emergence highly erratic), and growers who had leafminer problems, for the most part, were able to time their sprays well. However, the second and third generations increased to unexpectedly high levels, even where the first generation appeared to be adequately controlled, or where first-generation mines indicated that populations were too low to worry about. Premature drop did not appear to be a problem in any infested block, however.

Larvae of the apple-and-thorn skeletonizer (*Anthophila pariana*) were present in one orchard in fairly high numbers, but were completely controlled by an insecticide directed against apple maggot fly in early August. Apple leafminer (*Lyonetia speculella*) was also found in a few locations this year, but no problems were observed.

Tarnished Plant Bug. Plant bug captures on white rectangle traps were unusually low throughout the prebloom period, not reaching either the tight cluster or pink threshold in any monitored block. For this reason, some growers were able to withhold insecticides directed against plant bug this year. Plant bug damage at harvest was less than in previous years; of the injury that did appear, much could have been either sawfly (calyx stings) or green fruitworm/oblique-banded leafroller (large russetted dimples) injury.

Leafrollers. More oblique-banded leafroller injury was seen than is usual this year in monitored, first- and second-stage IPM blocks, but still did not appear to be at a level of concern. Early-season leafroller damage was found in some blocks, especially low-spray blocks; this type of injury is unusual in Massachusetts. Apparently the small window of sawfly/curculio activity and control gave the leafrollers a chance to move in after petal fall. Pesticide resistance on the part of oblique-banded leafroller is also a possibility, although damage was more notable in lightly-sprayed blocks than in heavily-sprayed blocks. Overall leafroller injury remained very low, however, amounting to less than 0.2% of surveyed fruit.

Apple Maggot Fly. Overall maggot fly pressure was low, and very little damage was found. There did not appear to be a late-season flush of apple maggot fly activity, as there has been for the last few years.

Aphids. Aphids were eventually controlled by predators, but populations tended to hang on longer than usual, especially on water sprouts, where they could be found until mid-July in some blocks. This delayed effect could have been due to the presence of spiraea aphids in addition to green apple aphids, or to some other factor. No honeydew problems were seen in any monitored block. As in 1987, cecidomyiid midge larvae were the predominant predator, ably assisted by syrphid fly and camaemyiid fly larvae, minute pirate bugs, ambush bugs, and ladybird beetles.

Ladybird Beetles. Populations of ladybird beetles were noticeably higher statewide this year than in previous years.

Mites/Predators. Mite activity appeared to level off in late summer; some growers who had originally planned to treat decided to wait, and ultimately did not need a miticide at all, or were able to use a low rate or spot treatment. Once again, dormant oil appeared to be a highly effective method of preventing mite buildup. Miticide use averaged close to 1 DE in 9 commercial blocks, down from the usual average of 2 DE of miticide (not including dormant oil). Summer oil at 1 quart/100 gallons was used successfully in one monitored block, with no apparent ill effect on fruit or foliage. Predators continue to build in commercial orchards; *Amblyseius fallacis* and *Zetzellia mali* built up later than usual, and were lower in number than in 1987, but were still of value in several blocks. Rain in late summer probably also helped wash mites off leaves.

Leafhoppers. Potato leafhopper was not much in evidence this year, except in one low-spray block of young trees, where it disappeared entirely after an organophosphate insecticide was applied. White apple leafhopper was at a problem level in one first-stage and a few second-stage IPM blocks, but overall it did not present a major problem this year.

Catfacing Insects. Activity was very low to moderate in peach blocks this year. Many growers reduced insecticide use with no noticeable ill effects.

Earwigs. Several instances of earwig injury to apples in commercial orchards occurred, especially on Cortland fruit. Injury was most often in the stem end and took the form of chewing as well as substantial frass accumulation. It was not possible to tell whether the earwigs had initiated the injury or only moved in later and enlarged previous wounds.

Scab. There were only 5 or 6 (depending on location) actual scab infection periods, though the length of these generally exceeded 36 hours. Frequent wetting periods, which were not Mill's periods, occurred during primary season. The timing of sprays was difficult due to the length of the wetting periods, and windy weather. Growers who missed a spray, or even missed a few trees, had some trouble for the rest of the season which would have been worse except for the dry summer weather. The average fruit scab injury for IPM monitoring blocks was generally low (0.47%) except for one block where mechanical breakdowns interfered with the scab spray schedule, and injury was 5.5%.

Sooty Blotch and Flyspeck. These problems were evident in a number of blocks, especially on Golden Delicious apples.

Calyx End Rot, Black Rot, etc. Very little of any of these problems were noted in monitored blocks, especially when compared to the levels reported in previous years. There were some instances of *Botrytis*-induced end rot

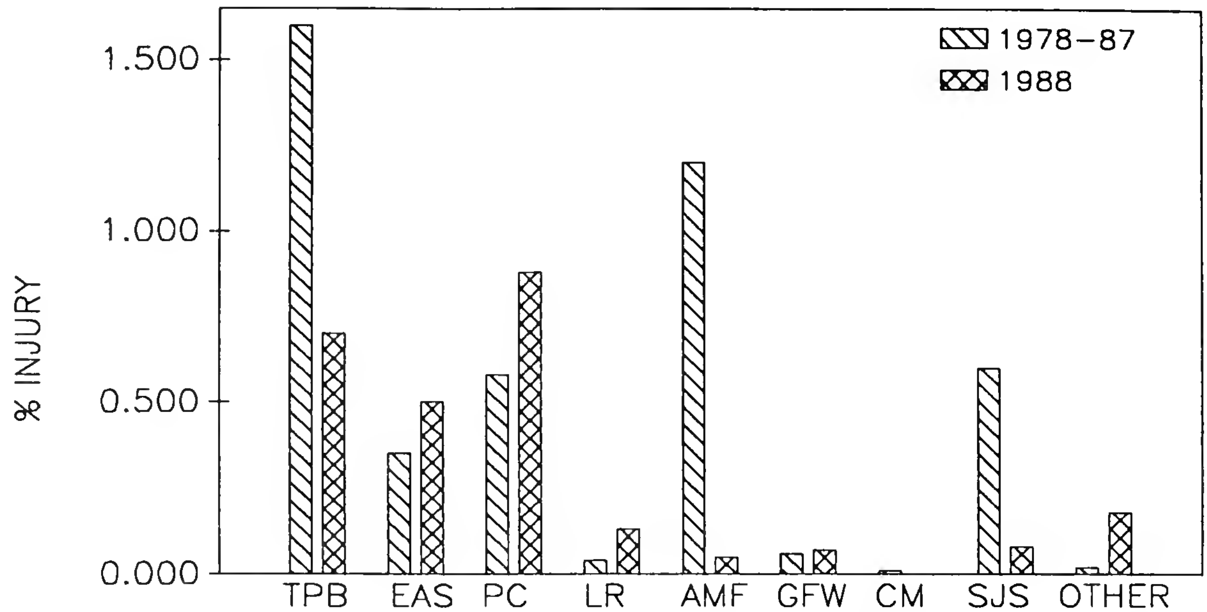

Figure 1. Insect injury on fruit in 1988 (percent of 8000 fruit evaluated) compared with 1978-87. (TPB = tarnished plant bug, EAS = European apple sawfly, PC = plum curculio, LR = leafroller, AMF = apple maggot fly, GFW = green fruitworm, CM = codling moth, SJS = San Jose scale.)

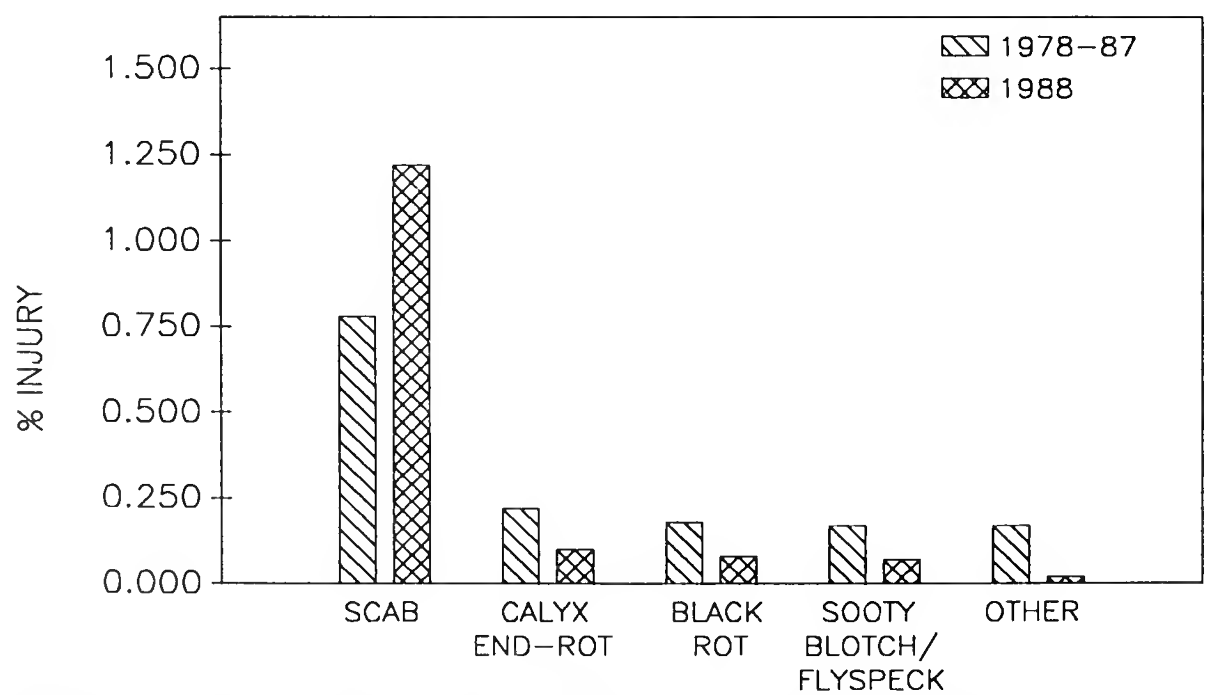

Figure 2. Disease injury on fruit in 1988 (percent of 8000 fruit evaluated) compared with 1978-87.

which did not progress into the apple.

Fire Blight. Except for a limited occurrence on young Gala and a block of exotic (British cider) cultivars, fire blight was not a major problem on apples in 1988. This observation was interesting, since 2 pear blocks had very heavy fire blight damage, and other pear growers had limited problems. Possibly growers are regularly using dormant materials on apples but not on pears. Of course, pears generally are more susceptible, but have not had more fire blight than apples in recent years.

Bitter Rot. Isolated incidence of bitter rot at economic levels (>5%) occurred in one Massachusetts orchard. This outbreak was probably related to the unusual heat and humidity. Also, drops had not been removed from the block for 2 years.

Figures 1 and 2 show the insect- and disease-related fruit injury which occurred in 1988 compared with 1978-87.

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Fruit Notes

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage

Volume 54, Number 2
SPRING ISSUE, 1989

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

Fruit Notes
Department of Plant & Soil Sciences
205 Bowditch Hall
University of Massachusetts
Amherst, MA 01003

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Life Without Alar

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In August, 1985 the controversy began regarding the safety of Alar™ residues on apples. Since that time many discussions and arguments have occurred. A recent "60 Minutes" program fueled the controversy by presenting claims made by the Natural Resources Defense Council that Alar is a potent carcinogen. The scientific data available certainly do not support that view; however, the widespread publicity likely will eliminate Alar-use as a horticultural practice. Apple growers must look toward a future without Alar. In this article I shall present some of the ways that may help reduce the need for Alar.

Before discussing specific activities, we must be clear on what benefits are received from Alar. The first and foremost function of Alar is to act as a "stop-drop." This function allows a grower to harvest most of his crop before it drops to the ground. By allowing fruit to remain on the tree longer they are able to color more fully, giving higher grade fruit. One reason why fruit stay on the tree longer is that Alar delays the beginning of fruit ripening, which results in less-ripe fruit for storage, which then allows the fruit to retain high quality for a longer time. In particular, the apples stay firm for a longer period of time.

Alternative approaches to the use of Alar must address these benefits that Alar provides. Approaches will be divided into two types: short-term practices and long-term changes. Short-term practices include several activities, but in general these are practices which may be undertaken this season to reduce the losses associated with the non-use of Alar. Long-term changes require more time and capital to implement. It must be understood that Alar provided a great deal of benefit, and no practices are real alternatives: they only assist in reducing the losses associated with non-use of Alar.

Short-Term Practices

Pruning

Several *Fruit Notes* articles [52(3):7-8; 53(1):12-13; 53(2):1; and 53(3):1-2] have discussed the effects of pruning, particularly summer pruning, on the production of high quality fruit. Removal of upright, hanging, and shade-causing wood in the summer can result in a dramatic increase in light penetration, fruit coloration, and packout. Additionally, it causes earlier coloration and thus allows earlier harvest, hopefully reducing some of the need for Alar while not reducing average fruit quality. Dormant pruning also is important, specifically in improving light penetration to the fruit. For more specific information about summer pruning practices, see *Fruit Notes* 53(2):1, and for more information about dormant pruning to improve packout, see *Fruit Notes* 53(1):12-13.

Chemical Treatments

There are no chemical alternatives to Alar. However, there are two chemicals that can be used to expand the harvest season: Ethrel and NAA. The problem with both chemicals is that they may render the fruit unusable for long-term storage by advancing ripening. Ethrel is used to advance the harvest season by breaking down to ethylene and triggering ripening. Treatment with Ethrel results in marketable fruit early in the season, but also fruit that probably must be consumed immediately, because they are too ripe to store. NAA is a "stop drop." It will significantly delay premature fruit drop, but it also advances fruit ripening. NAA can expand the season, but treated fruit must be sold relatively quickly. Details on the use of both of these chemicals are given in the *New England Apple Spray Guide*.

Harvest and Storage Management

Without Alar the fruit in storage probably will be riper than what growers are used to. To maintain fruit quality throughout the storage period, the fruit must be handled with greater attention to details than if they had been treated with Alar. This additional care includes more accurate attention to cooling and to the rapid establishment and maintenance of optimal temperature and atmosphere conditions, as well as to application of the appropriate postharvest chemical treatments. No longer will sloppy storage management be acceptable, since the fruit will show the quality of storage management more readily than before. In addition to storage management, the intensity of harvest management must be increased. Growers must accurately manage their harvest so that the most appropriate fruit are placed in long-term storage. This practice may include the more frequent use of the starch-iodine test for maturity assessment.

Increased Labor

Increasing harvest labor so that more fruit can be picked in a shorter period of time is one way to reduce the impact of the non-use of Alar; however, growers must be able to handle the increased quantity of fruit. Specifically, the orchard operation must be able to move the fruit quickly from the orchard to the storage, stack them in the storage, cool them quickly, and seal the storage (if CA is used) if the increased labor is going to pay off. Beside the availability of additional labor, one problem which may prevent this practice from being feasible is the size of the refrigeration plant. If there is not adequate refrigeration to cool the high quantity of fruit being placed in the storage per day then the additional labor is not truly reducing the impact of the non-use of Alar.

Long-term Changes

Changes in Cultivars

One of the characteristics of the New England apple industry which has increased the problems related to the loss of Alar is the large proportion (60 %) of the production devoted to McIntosh. A relatively simple way of reducing the need for Alar is to replace McIntosh with other cultivars which allow an expansion of the harvest season or do not require a chemical "stop-drop." Several cultivars have potential in New England, such as Gala, Mutsu, Liberty, Jonagold, and Red Fuji. Older cultivars like Cortland and Macoun also may deserve a greater role in the industry. Obviously, several years are required to change cultivars, and several years are required to develop markets for new cultivars.

Changes in Strains

Several McIntosh strains are now available. Marshall McIntosh has been the most planted strain over the last few years, primarily because of its higher coloring potential. Additional benefits which come from Marshall McIntosh are given by its earlier coloring and earlier ripening. It colors approximately 10 days prior to Rogers McIntosh and ripens approximately a week earlier. These two differences allow an advancement of the McIntosh harvest season without the kind of quality loss found with the use of a chemical such as Ethrel. However, planting entirely to Marshall McIntosh will not reduce the losses associated with the non-use of Alar, because the entire harvest season will be earlier and just as concentrated as with a standard strain of McIntosh. Future orchards should have a mix of Marshall McIntosh with other strains to allow the maximum expansion of the harvest season.

Pioneer Mac (recently named by Adams County Nursery) technically is not a strain of McIntosh but actually is a seedling of McIntosh and thus a new cultivar; however, its fruit are virtually indistinguishable from McIntosh and undoubtedly will be accepted as McIntosh. Its reported advantage over standard McIntosh is that it ripens 2 weeks later. In 1988 at the University of Massachusetts Horticultural Research Center we established a replicated trial to compare Pioneer Mac to Marshall McIntosh and Rogers McIntosh. When information is available it will be reported through *Fruit Notes*. The benefits of Pioneer Mac may be great, but as with Marshall McIntosh it will be necessary to include earlier-ripening strains of McIntosh to provide a true expansion of the harvest season.

Rootstocks

Changes in rootstocks must occur to give benefits in two areas. First, more dwarfing rootstocks must be used. Large plantings of McIntosh as semi-dwarf trees will not be feasible to maintain without Alar. Growers must consider moving into the dwarf category, using M.9, M.9 EMLA, M.26, Mark, and possibly Ott.3 as rootstocks. Trees on these rootstocks are much easier to prune, require less spray material, and most importantly, in the context of this article, are much easier to harvest than are semi-dwarf or standard trees. Nearly all the fruit are harvestable from the ground, and the harvesting process can be done more rapidly. Because of high light penetration into the canopy, more of the fruit are highly colored, making selective harvesting less of a priority while improving packout. For more general information on these dwarfing rootstocks see *Fruit Notes* [51(4):22-24; 52(1):1-4; 53(1):4-7; 53(3):3-6; and 54(1):11-15].

The second potential benefit of a change in rootstocks is their effect on ripening. For three years we have been conducting research at the University of Massachusetts Horticultural Research Center on the effects of rootstocks on apple fruit quality and ripening [see *Fruit Notes* 52(2):5-10], and have found that Mark can delay ripening of Delicious and McIntosh fruit by as much as 5 days when compared to fruit from trees on M.26 EMLA and Ott.3. The use of rootstock to expand the harvest season should complement the use of different strains to expand further the McIntosh harvest season.

Conclusions

We do not have any easy answers to the question of what an apple grower can do to reduce the losses associated with the non-use of Alar. Short-term approaches, obviously, are stop-gap measures which may somewhat reduce the losses. The long-term changes will take time and capital to implement but should go far to eliminate the need for Alar. The New England apple industry has rough seas ahead, but if growers look to the future and begin to make some changes, it should be able to weather this storm.

* * * * *

Apple Bruising. IV. Injury Occurring During Harvest and Transport to the Packinghouse

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This is the fourth in a series of articles reporting findings of a research group at Michigan State University on the causes and consequences of bruising to apples. The previous articles examined bruising during packing, grading, and subsequent transport [*Fruit Notes* 53(4):15-17, 54(1):6-7, and 54(1):7-9]. Here we summarize a report in which sources of bruising during harvest and transport to the packing house are examined.

This report is entitled, "Damage Assessment for

Table 1. Damage incurred during hand-harvest of McIntosh apples for 6 Michigan orchards. Average damage for all orchards, and range of damage among the 6 orchards, are shown.

	Location in bin					
	Bottom		Top		Total bin	
	Avg.	Range	Avg.	Range	Avg.	Range
A. Fruit damage, %						
Undamaged	14	5 to 24	23	7 to 41	18	6 to 29
Bruised	86	76 to 95	77	59 to 92	81	71 to 94
Cut	2	0 to 5	1	0 to 1	1	0 to 3
Punctured	4	2 to 7	3	1 to 4	3	1 to 5
B. Bruise frequency, %						
Bruise diameter (inches)						
1/4 to 1/2	86	74 to 93	89	81 to 94	87	77 to 93
1/2 to 3/4	13	7 to 24	11	6 to 18	12	7 to 21
3/4 to 7/8	1	0 to 1	1	0 to 1	1	0 to 1

Table 2. Cumulative damage to McIntosh apples incurred during harvest and transport to packing houses for 6 Michigan orchards.

	Average	Range
A. Total damage in bin, %		
Undamaged	6	0 to 11
Bruised	93	88 to 100
Cut	1	0 to 3
Punctured	4	2 to 8
B. Bruise frequency, %		
1/4 to 1/2 inch	91	88 to 95
1/2 to 3/4 inch	8	5 to 11
3/4 to 7/8 inch	1	0 to 1

C. Characteristics of orchard transport

Orchard	In the orchard	Orchard to packing house
1	Fork lift	Truck, 4 mi. gravel road
2	Fork lift; bin trailer	Truck, 6 mi. paved road
3	Fork lift; bin trailer	Truck, 3 mi. paved road
4	Double fork lift	Fork lift, 0.3 mile lane
5	Fork lift; bin trailer	Semi-trailer, 65 mile paved road
6	Fork lift	5th wheel trailer, 1.5 mile gravel and paved roads

Apple Harvest and Transport," and was presented by S. A. Sargent, G. K. Brown, C. L. Burton, N. L. Schutte Pason, E. J. Timm, and D. E. Marshall to the American Society of Agricultural Engineers December 15-18, 1987. It was a cooperative study by the U.S. Dept. of Agriculture, Agricultural Research Service, and the Agricultural Engineering Department, at East Lansing, Michigan.

This study examined damage to McIntosh apples in 6 commercial hand-harvested orchards in Michigan. Fruit were sampled from bins when they had 2 or 3 layers of fruit in the bottom, and again when they were full. Fruit in these bins were again sampled at the packing houses as they were floated by water from the bins, to assess damage that had occurred during bin transfer operations.

All fruit were visually evaluated for bruises, which were rated for size (diameter) as "A" = 1/4 to 1/2 inch, "B" = 1/2 to 3/4 inch, "C" = 3/4 to 7/8 inch, "D" = 7/8 to 1 1/4 inch, and "E" = greater than 1 1/4 inch. Cut or punctured fruit were also recorded.

Overall, only 18% of the fruit in the bins in the orchard were uninjured (Table 1). Eighty one percent of them were bruised, 1% were cut, and 3% were punctured. As expected, however, injury was more prevalent in the bottom than on the top of the bins. Most (87%) of the bruises were less than 1/2 inch in diameter, and bruise size was about the same for fruit in the bottom and at the top of the bin, indicating that drop distance was about the same in both locations, since bruise size increases with drop height.

In all orchards, bins were transported by tractor-mounted fork lifts. In some cases, bins were moved to other parts of the orchard for filling, and 1 orchard used a double fork-lift to transport bins from the orchard to the packing house. Three operators used self-loading bin trailers with low-pressure balloon tires for transport to roadside. Various trucks and trailers were used to transport bins from roadside to packinghouse. Most roads were paved, and distances ranged from 1/4 to 7 miles.

Following harvest and transport, only 6% of the

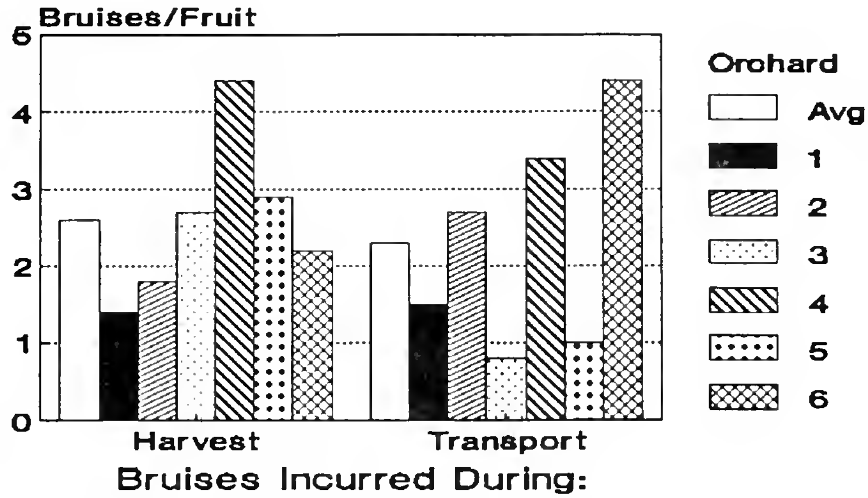

Figure 1. Average number of bruises incurred during harvest and transport of McIntosh apples in 6 Michigan orchards. See Table 2 for descriptions of transport methods among the 6 orchards.

fruit were undamaged. Most of the increase in damage during transport was from bruising, with very little cutting or puncturing occurring after the harvest operation. Most of the bruises incurred during transit were the small, class A type. A high percentage of these bruises appeared to be due to repeated vibrations from trucks or trailers with "stiff" suspensions.

The relationships of orchard operation to bruising can be seen in Table 2 and Figure 1. Orchard 4 had by far the most bruising during harvest, an indication of poor instruction and/or supervision of pickers. Orchard 6 produced the most bruising during transport. Here, a trailer with "stiff" suspension was used to transport bins from the orchard to the packing house, a distance of about 1.5 miles over some gravel and some paved roads.

The striking feature in Figure 1 is the relatively low amount of bruising during transport in Orchards 2, 3, and 5, all of which used bin-loading trailers to move bins out of the orchard to the roadside.

Care in bin handling by fork-lift operators can greatly reduce the amount of damage incurred when setting bins on trailers and floors. In several operations fork lifts had short tines which did not extend under the entire bin bottom. This caused the bottom boards to spring upward during transport, which can bruise apples in the bottoms of the bins.

The authors conclude by recommending (a) gentle harvest and placement of apples in bins; (b) careful lifting, movement, and setting of bins during transport; (c) a minimal number of handling steps, and (d) use of appropriate equipment. They recommend use of long tines on fork lifts, soft tires, and soft suspensions on transport vehicles. Bin-loading trailers were of considerable benefit in avoiding bruising.

Figure 1 clearly shows that much bruising during harvest and transport is avoidable. The information provided in this study should help growers to carefully evaluate their operations to identify problems, and help to correct them. This can substantially improve fruit quality and pack-out.

* * * * *

The Effects of Summer Pruning on Insect and Mite Populations in Apple Trees

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Summer pruning is one way to reduce setbacks in apple production caused by the elimination of Alar™ from a grower's spray program. Without Alar, fruit may drop before they become red enough to yield a high market value. In previous issues of *Fruit Notes* [52(3):7-8, 53(2):1, 53(3):1-2] the benefits derived from summer pruning of McIntosh trees were illustrated. An increase in light penetration into the tree from summer pruning resulted in 1) earlier coloring of fruit, 2) a higher percentage of fruit making the U. S. Extra Fancy grade, 3) earlier harvesting of fruit, and 4) production of more fruit with a potential for long term storage.

Little is known about the effects of summer pruning on apple arthropod pests and predators. Pruning of vegetative sprouts may remove a resource for pests that prefer to feed on young succulent tissue (e.g., green apple aphid and spirea aphid), but wound exudate from pruning cuts may offer direct nutrient benefits to pests like wooly apple aphid. Summer pruning may also trigger a change in the level of tree nutrients or defense compounds, and subsequently influence phytophagous arthropod populations this way.

Two pruning experiments were conducted in 1988 on M.7 McIntosh trees at the University of Massachusetts Horticultural Research Center, Belchertown. These studies were undertaken initially to determine the effect of summer pruning on fruit production. However, data on fruit yield and quality will be reported in a future issue of *Fruit Notes*. Here, only data on arthropod pest and predator levels are reported.

On August 26, 10 fruit cluster leaves and 10 non-cluster leaves were sampled from the interior of each tree at about head height. Within a cluster, the third to the fifth leaf out was sampled. Non-cluster leaves were picked from the interior part of a branch (not the branch terminal) and were equivalent in size to cluster leaves. The underside midrib area of each leaf was evaluated for presence or abscence of European red mites (ERM) and two-spotted spider mites (TSSM), and also for presence or absence of the predatory mites *Amblyseius fallacis* (AF) and *Zetzelia mali* (ZM). These leaves were also evaluated for white apple leafhopper (WALH) damage and apple blotch leafminer (ABLM) damage (sap and tissue feeders). In addition, 10 pruning cuts on the tree interior were sampled for the presence of wooly apple aphid (WAA). In control (non-pruned) trees, 10 pruning cuts from the previous year were examined.

Experiment 1 was aimed at determining benefits of summer pruning at various times after June. Three rows of trees were randomly divided to accommodate 8 replications of 6 treatments. The treatments consisted of trees pruned on July 1, July 15, August 1, August 15, and September 1 and a control tree that was not pruned.

Experiment 2 was conducted to determine effects of summer pruning in combination with stop-drop applications. In the same rows as Experiment 1, additional trees were chosen to provide 7 replications of these treatments: 1) summer pruning, 2) summer pruning plus NAA, 3) summer pruning plus Alar, 4) NAA, 5) Alar, and 6) a control that received no treatment. In this experiment all summer pruning occurred on August 1. Alar was applied on July 15. NAA was applied on September 18, after the first harvest (September 16). Note that NAA was applied after the arthropod sample date. Data from treatments 2 and 4 thus will be excluded.

Results from both experiments revealed that population levels of WALH, TSSM, and the predator mites ZM and AF were extremely low and not significantly different among treatments. Low populations of ZM and AF are typical of orchards where predator-harsh pesticides have been used. Populations of TSSM are often low in situations where ERM may have outcompeted them.

Population levels of other insects and mites surveyed in Experiment 1 varied among treatments (Table 1). On most sampling dates, more ERM were found on fruit cluster leaves than on non-cluster leaves. There were no trends that may have suggested that pruning

Table 1. Effects of summer pruning of McIntosh apple trees on European red mite (ERM) and apple blotch leafminer (ABLM) populations on leaves, and on wooly apple aphid (WAA) populations around pruning cuts.

Pruning Date	Percent leaves with ERM		Number of ABLM mines/leaf		Percent cuts with WAA
	Cluster	Non-cluster	Cluster	Non-cluster	
Control	71	69	1.0	0.66	10
July 1	67	61	0.63	0.30	9
July 15	74	71	0.75	0.46	14
August 1	51	71	0.78	0.69	1
August 15	70	70	0.70	0.60	3
September 1	71	64	0.70	0.53	15

Table 2. Effects of summer pruning on August 1 and of Alar application on European red mite (ERM) and apple blotch leafminer (ABLM) populations on leaves, and on wooly apple aphid (WAA) populations around pruning cuts.

Treatments	Percent leaves with ERM		Number of ABLM mines/leaf		Percent cuts with WAA
	Cluster	Non-cluster	Cluster	Non-cluster	
Control	27	17	0.44	0.31	16
Alar	26	26	0.51	0.40	11
Summmer pruning	34	31	0.40	0.41	19
Summer pruning + Alar	30	29	0.51	0.36	16

date had any substantial impact on ERM abundance. Mines from ABLM likewise were more abundant on fruit cluster leaves than on non-cluster leaves. In this case, the fewest ABLM mines on both cluster and non-cluster leaves were found on trees pruned on July 1. Perhaps pruning on this date eliminated leaves that otherwise would have been utilzed by second generation ABLM ovipositing at that time. The lowest WAA populations were found on trees pruned on August 1 and August 15. Summer pruning on any date did not appear to lead to buildup of either ERM or ABLM compared with populations on non-pruned trees, altough WAA on trees pruned July 15 and September 1 were slightly greater than populations on non-pruned trees.

In Experiment 2 (Table 2), there were no apparent differences in the numbers of ERM, WAA, or ABLM mines among treatments. However, there did tend to be more ERM and more ABLM mines on cluster leaves than on non-cluster leaves.

These data are preliminary and should be combined with results on fruit production to make sound decisions about summer pruning. While further research is needed to determine the influence of summer pruning on pest and predator populations throughout the summer, the results presented here do not suggest that summer pruning has a major impact on foliar pest populations.

* * * * *

New Trap-capture Thresholds for Tarnished Plant Bug and European Apple Sawfly in Massachusetts Apple Orchards

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Department of Entomology, University of Massachusetts

IPM trap-capture thresholds for tarnished plant bug (TPB) and European apple sawfly (EAS) originally were developed in 1980. Changes in input costs and produce prices have reduced the reliability of these thresholds. In this article we are presenting new threshold values as well as a general format for establishing a trap-capture threshold. With this format growers could use their own price and production figures to calculate appropriate thresholds and update them as their data change.

The new trap capture thresholds are as follows:

Fruit market	TPB, silver tip to: Tight cluster	Pink	EAS (all)
Wholesale	3.5	5.5	9.0
Retail	5.4	7.7	9.0

The actual mechanics of how the new thresholds were determined can be seen in the Table 1. Clearly, a number of assumptions needed to be made about per-acre fruit production, types and costs of chemicals used, etc. Some of the assumptions used were:

- 15 minutes to spray one acre
- labor cost = $7/hr
- equipment cost = $8.68/hr, developed from publications by New York agricultural economists, updated by W. R. Autio
- use of an organophosphate insecticide
- per-acre production = 500 bushels
- average 80% Extra-Fancy packout
- fruit values = $15/bu U. S. Extra Fancy, $9/bu U. S. Number 1, $7.50/bu Utility, $2/bu Processing

In all cases, where a choice of assumptions was possible, we used the more conservative figure.

One obvious fact that emerged in calculating these new thresholds was that the intended market for the fruit made a difference in how much injury a grower could tolerate. A grower selling fruit through a farmstand, or who could otherwise market fruit graded less than U. S. Fancy, can afford more injury than a grower for whom any fruit that does not meet the U.S. Fancy grade will be priced as processing fruit. Thus, we found that wholesale growers need to be considerably more conservative in their pest management decision-making than retail growers, a fact that probably will not surprise most growers. In response to this situation, we developed separate thresholds for the two situations.

Thus, we considered two possibilities for downgraded fruit: first, U. S. Extra Fancy downgraded to a mix of U. S. Number 1, Utility, and processing (20, 70, and 10 %, respectively, of those fruit downgraded); and second, U. S. Extra Fancy downgraded to processing only (100 % of those fruit downgraded). We also used data from a number of packout studies (e.g., Morin and Bahn, *Fruit Notes* 1981) showing that only about 10% of plant bug injury actually is downgraded at all, since it tends to occur in the calyx of the fruit, hidden from view.

Mostly what these new thresholds demonstrate is that some growers can tolerate more, and even a good deal more, tarnished plant bug injury than had previously been assumed. In the case of sawfly, the tolerable threshold likewise is slightly higher. But we do not expect that growers will be able to save many sprays for sawfly, since a petal fall insecticide would usually be necessary for plum curculio or other insects even if sawfly were not a problem. In certain years when curculio adults begin attacking apples later than normal (e.g., a week after petal fall), sawfly trap captures can indicate whether sawflies are sufficiently abundant to spray at petal fall or not.

Table 1. Calculating the trap-capture thresholds for tarnished plant bug (TPB) and European apple sawfly (EAS) in retail and wholesale apple orchards.

I. The "break-even" level of injury is calculated related to the cost of the injury and the cost of the treatment.

$$B = \frac{E + L + C}{(P)(XF/100)[\$XF-(\$NO)(NO/100)-(\$U)(U/100)-(\$P)(P/100)]}$$

where:

B	=	"Break-even" proportion of injury
E	=	Equipment cost per acre
L	=	Labor costs per acre
C	=	Chemical costs per acre
P	=	Total production per acre
XF	=	% U. S. Extra Fancy if no injury was to occur
$XF	=	Value of 1 bushel of U. S. Extra Fancy grade fruit
$NO	=	Value of 1 bushel of U. S. Number 1 grade fruit
NO	=	% of injured fruit downgraded to U. S. Number 1 grade
$U	=	Value of 1 bushel of Utility grade fruit
U	=	% of injured fruit downgraded to Utility grade
$P	=	Value of 1 bushel of Processing grade fruit
P	=	% of injured fruit downgraded to Processing grade

The following calculations were made with the assumptions used in this article.

For TPB in a retail operation:

B(retail--TPB) =

$$\frac{\$2.17 + \$1.75 + \$8.55}{(500\ bu)(80\%/100)[\$15 - (\$9)(20\%/100) - (\$7.50)(70\%/100) - (\$2)(10\%/100)]}$$

$= 0.004 = 0.4\ \%$

Table 1, continued.

For TPB in a wholesale operation and EAS:

$$B(wholesale\text{--}TPB) = B(EAS) = \frac{\$2.17 + \$1.75 + \$8.55}{(500\ bu)(80\%/100)[\$15-(\$2)(100\%/100)]}$$

$$= 0.0024 = 0.24\ \%$$

II. Some damage will occur regardless of treatment. For TPB 0.05 % should be added to B, and for EAS 0.1 % should be added to B.

$$T = B + A$$

where:

T = Total % injury
A = % injury even with a well-timed insecticide treatment

With the assumptions used in this article:

$$T(retail\text{--}TPB) = 0.4\% + 0.05\% = 0.45\%$$

$$T(wholesale\text{--}TPB) = 0.24\% + 0.05\% = 0.29\%$$

$$T(EAS) = 0.24\% + 0.1\% = 0.34\%$$

III. A portion of the total TPB injury is not downgraded. Data suggest that only 10 % of the TPB injury actually is downgraded; whereas 100 % of the EAS injury is down graded.

$$EIL = T/(D/100)$$

where:

EIL = Economic injury level
D = % of injury actually downgraded

Table 1, continued.

With the assumptions used in this article:

EIL(retail--TPB) = 0.45%/(10%/100) = 4.5%

EIL(wholesale--TPB) = 0.29%/(10%/100) = 2.9%

EIL(EAS) = 0.34%/(100%/100) = 0.34%

IV. The trap-capture threshold (TC) can be calculated from the EIL using relationships presented by Coli et al. (1985) Agriculture, Ecosystems and the Environment 14:251-265.

TC(TPB--before tight cluster) = (EIL + 0.0774)/0.8507

TC(TPB--before pink) = (EIL + 0.9981)/0.7107

TC(EAS) = (EIL + 0.3438)/0.0757

With the assumptions used in this article:

TPB before tight cluster

TC(retail) = (4.5 + 0.0774)/0.8507 = 5.4 TPB/trap

TC(wholesale) = (2.9 + 0.0774)/0.8507 = 3.5 TPB/trap

TPB before pink

TC(retail) = (4.5 + 0.9981)/0.7107 = 7.7 TPB/trap

TC(wholesale) = (2.9 + 0.9981)/0.7107 = 5.5 TPB/trap

EAS

TC = (0.34 + 0.3438)/0.0757 = 9.0 EAS/trap

* * * * *

Diagnosing Leaf Injury Symptoms

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Growers often are faced with individual trees or groups of trees that show unusual leaf symptoms -- either color changes, shape or size differences, or in some situations, leaves "just don't look right." It is relatively easy to rule out insect and disease problems, but often it is much more difficult to diagnose nutritional or weather-related foliar damage. The purpose of this article is to help growers determine the cause of non-pest related foliar damage.

Herbicide injury is often confused with, or hard to distinguish from, nutritional deficiency symptoms. The best clue to herbicide injury is your knowledge of application -- how and when each herbicide was applied. Proper sprayer calibration, attention to label directions, and attention to weather conditions when applying materials all will help to minimize herbicide damage.

Common Herbicide Injuries and Their Symptoms

Terbicil (Sinbar™) -- Injury results in pronounced differentiation of green and yellow areas of leaves. Leaves also may appear deformed. Leaf veins may be greener than normal.

Dichlobenil (Casoron™) -- Injury results in yellowing of the leaf margins. Leaves may be deformed.

Diuron (Karmex™) -- Injury is similar to calcium chloride injury and moisture stress. It is characterized by browning of leaf margins that eventually progresses throughout the leaf.

Simazine (Princep™) -- Injury develops as necrosis of the leaf margins, with a quick onset of necrosis of the entire leaf. Leaves also may appear blotchy. With more severe damage, leaves tear and veins become more pronounced.

Weather-related Injuries

Drought -- Symptoms originate at leaf tips, and margins then become necrotic. These symptoms usually follow a period of dry weather.

Frost injury -- Injury shows as a whitening of leaves. Leaves become parchment-like in appearance. Symptoms are often confined to lower limbs.

Nutritional Deficiency Symptoms

Nitrogen (N) -- The primary expression of deficiency is the yellowing of leaves. Leaves also may be tinged with red and the coloration may progress to orange-red with time. Leaves also can be small and deformed and may abscise.

Potassium (K) -- Deficiency is most often a problem on young, fruiting trees. It starts as a loss of green color followed by a water-soaked appearance in the older leaves and progresses to leaf scorch.

Magnesium (Mg) -- Older leaves are affected first. Areas between leaf veins become yellow, and with time become necrotic. By late summer, shoots may defoliate, leaving tufts of green leaves at tips.

Manganese (Mn) -- Deficiency appears first on older leaves and is seen as fading of leaf margins. This fading is inward progressing toward the leaf midrib. Green veins may be sharply defined with white-yellow coloration between them.

Zinc (Zn) -- Deficiency may appear as rosettes of leaves in early spring (dense cluster of narrow leaves above, or at the end of, an otherwise leafless twig). It also may show as short, lateral spurs, or marginal interveinal yellowing.

Although it often is difficult to diagnose the cause of leaf injuries, knowledge of local weather patterns and accurate, up-to-date herbicide and fertilizer application records will help you make an accurate diagnosis. Where one or more nutritional deficiencies is suspected, foliar tissue analysis can confirm your diagnosis. When leaf symptoms occur, the above symptom descriptions should help you determine the tree's particular problem. Remember, however, that more than one problem could be present, and that often one symptom can mask another.

* * * * *

Integrated Pest Management for Commercial Strawberry Growers in Massachusetts

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The strawberry IPM program began in 1987 with 4 cooperating growers. This number expanded to 14 in 1988. This expansion provided a better sample of grower practices and improved overall contact with Massachusetts growers. We also expanded the geographic base of the program to include a wider area of the state. Cooperating growers were chosen from among those who had responded positively to a question on the 1987 grower survey asking if they would like to become involved in the IPM program.

Fields were scouted for tarnished plant bug, strawberry bud weevil (clipper), and two-spotted mite. Recommendations were also made for Botrytis gray mold management. The sampling methods used for monitoring insect populations were those generally used by other IPM programs in New York and New England. Relative yield impact due to pest injury was monitored and comparisons were made between areas under IPM management and ones under conventional management.

Tarnished Plant Bug

For this insect, two scouting methods were combined. It has been asserted that the immature stages are the form of this insect that cause economic injury to strawberries (Schaefers, 1980). Adults are present, but in lesser numbers than nymphs, and are considered less of a threat. Nymphs are said to hatch around bloom, the growth stage most susceptible to TPB injury. White sticky traps were used for an indication of adult activity (Coli, 1985). Thresholds are not available for this method, because trap catches do not correlate with resulting injury levels. However, traps can determine when adult tarnished plant bugs become active. We are developing a database of trap catches over several years to be used to develope thresholds. The main sampling method used for making management recommendations has been to assess nymph populations. This sampling is done by shaking flower trusses and counting the number of nymphs that fall out. A threshold number of 1 nymph per 25 flower trusses was developed in New York (Schaefers, 1980) and has been used by our program for two years. Additional information suggests that the threshold perhaps can be raised substantially to 1 nymph per flower truss (Mailloux and Bostanian, 1988).

The situation is somewhat confounded by reports that suggest that both nymphs and adults are causing economic injury to strawberries in Massachusetts. Adult insects cause much damage to strawberry production in Maine and New Hampshire, but are considered to be of little consequence in New York. New York researchers consider nymphs to be the primary problem. Massachusetts may be at the interface of two ecological regions, which suggests the need for further research.

Among our cooperating growers the average number of insecticide applications for tarnished plant bug control in 1987 was 1.8 sprays per season. Under IPM practices, these same growers made 0.9 insecticide applications in 1988, a 50 % savings. This level can also be compared to non-IPM areas on the same farms this year where 1.4 insecticide applications were made. Here, IPM recommendations resulted in a 35% savings (Schloemann and Cooley, 1988). No significant differences in injury to fruit were observed.

Strawberry Bud Weevil

Strawberry bud weevil is an insect which destroys individual buds before the strawberries can form. This pest is of great consequence in mid-western states and is becoming of greater concern in New England. Of the 14 cooperating growers in 1988, 11 sampled positive for the presence of strawberry bud weevil (clipper). Only 4 of these growers had levels of clipper high enough for concern, though 8 typically spray for them. The sampling method for clipper involved counting the number of clipped buds per foot of row. A threshold of 0.6 clipped buds per foot was used (Schaefers, 1972). The problem with this method is that it evaluates damage after the fact. Work has begun in New York to evaluate the efficacy of boll weevil traps for clipper. This trapping may be a valuable innovation for the future.

Two-spotted Mite

Two-spotted mites provided a very interesting case for the strawberry IPM program this year. Late in the 1987 season, strawberry growers saw the removal of cyhexetin (Plictran™) from use for mite control. This loss left very few materials available to growers. Mite infestations were early and heavy in some locations in 1988. Ordinarily, high mite levels do not occur before mid-June. This time is approaching harvest which makes spraying difficult due to harvest interval restrictions. This year, with such high levels early in the season, growers were concerned. The use of predators for the control of two-spotted mites has been studied (Croft et al., 1976; Penman et al., 1979; Waite, 1988). These predators feed on all stages of two-spotted mite, disperse rapidly in strawberry fields, and are indigenous to the Northeast. In many cases, the natural populations are sufficient and appeared to be effective in keeping two-spotted mite population levels low. Releases of artificially reared populations can also be made in locations where the natural populations are insufficient for control. A local business, Biokon, has emerged for the distribution of the predator *Amblysieus fallacis*. In cooperation with Biokon, the strawberry IPM program monitored population levels of pest and predator mites prior to and after releases of the predators were made. The results were impressive. In most cases the predators "cleaned up" the two-spotted mites within 2 to 3 weeks, a result difficult to achieve with miticide applications. Data in Table 1 illustrate these results.

Table 1. Two-spotted spider mite populations per strawberry leaf at first occurrence of the predator mite *Amblysieus fallacis*, and for 3 weeks following its appearance. No miticide applications were made.

	Average TSM population per leaf			
Grower	Weeks after 1st occurrence of *A. fallacis*			
site	0	1	2	3
1	0.5	0.5	2.0	2.2
2	0.9	0.4	1.5	0.4
3	3.2	1.1	6.5	0.3
4	33.8	12.5	30.0	1.6
5	16.2	2.5	1.0	0.2
6	5.3	21.6	13.6	1.8
7	0.4	1.0	27.5	0.2
8	1.9	13.0	7.5	0.2
Mean	7.8	6.6	11.2	0.9

Table 2. Mean numbers of fungicide applications and percent injured fruit at harvest for IPM and non-IPM blocks in 1988.

Treatment	Number of fungicide applications	Injured fruit at harvest (%)
IPM	1.1 b*	5.6 a
Non-IPM	3.8 a	6.3 a

*Means within columns not followed by the same letter are significantly different at odds of 20 to 1.

Botrytis Gray Mold

Strawberry growers make more pesticide applications to control *Botrytis cinerea*, the fungus which causes gray mold, than for any other single problem in commercial strawberry production in Massachusetts (Schloemann and Cooley, 1987). In 1987 Massachusetts growers applied an average of 5.6 fungicide sprays, ranging from 0 to 15. These applications cost growers about $140 per acre. Studies have shown that the most susceptible growth stage for the infection of Botrytis is bloom, when the fungus infects the tender blossom tissue (Devaux, 1987; Grove et al., 1985). The infection remains latent until conditions of fruit development and favorable weather conditions coincide. Therefore, the IPM program in Massachusetts targets bloom to prevent infection. Many growers have had great success with this program of bloom sprays and have saved several spray applications later in the season. Table 2 shows that under IPM recommendations in 1988, cooperating growers made an average of 1.1 fungicide applications this year, compared to 3.8 in non-IPM blocks on the same farms, a 70% savings. Incidence of Botrytis in IPM vs. non-IPM fields was not significantly different. However, disease pressure was light this year. The program's goal is to keep Botrytis sprays to an average of 3 or less.

Inoculum causing blossom infections comes from overwintering Botrytis in the live leaf tissue of strawberries protected under the mulch (Braun and Sutton, 1986; Braun and Sutton, 1987; Sutton and Braun, 1987; Sutton, 1988). These leaves are infected in the fall. As they senesce in the spring, they produce spores. Efforts are underway to develop ways to inhibit the ability of Botrytis spores to penetrate the leaf surface successfully in the fall, thereby reducing the initial inoculum available for infection in the spring. This information is being incorporated into research efforts to be conducted in the future.

Applied Studies

The strawberry IPM program has secured 2 acres of land at the University research farm in South Deerfield for applied studies of pest management practices. Currently, studies of fumigation materials at different rates and non-fumigant cultural practices are in progress. There is little doubt that fumigation provides tremendous production benefits. However, its economic and ecological costs are generally high. Alternatively, certain cover corps have allelopathic qualities which reduce pathogens, nematodes, and the viability of weed seeds. They might also have some direct economic value to the grower, as with Sudex (a Sudan x sorghum hybrid which is now used by some growers as winter mulch) or pumpkins (which have been studied for their allelopathic qualities related to black root rot control in strawberries). This work illustrates the value of cultural practices in IPM systems. Additional studies for improved and innovative management of Botrytis gray mold, tarnished plant bug, and two-spotted spider mites are planned for 1989.

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From the editors:

The following is the first in a series of reprinted articles from Fruit Notes *of 50 years ago. This discussion by Professor Van Meter was first published in the February, 1939 issue.*

Planting Orchards in Massachusetts

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The average rainfall in Massachusetts is about 43 inches. This is more than the important competing apple regions get. We get our heaviest precipitation in July and August when we need it most. Our climate gives a finish to apples that has long been famous, and its very severity holds insects like codling moth in check to such an extent that we have less trouble with them than any important competing section.

In the past 10 years Virginia has averaged about 45% of a crop each year. New York has averaged 53%, New England 63%, and the Northwest about 70%. The Northwest stands highest in average % of a crop and New England comes next. The dependable cropping of New England orchards is a real advantage. We are rapidly becoming a one-variety section and that is a disadvantage. McIntosh is the most popular apple on the market and we would not trade it for any or all the others grown elsewhere, but we do need a good, high quality variety to grow with it. McIntosh probably is the most difficult apple to handle that is grown anywhere and we still have much to learn about placing it on the market in good condition.

We have some excellent orchard sites and soils, many of which are not now utilized for orcharding. Recent studies of the relation of subsoils to root development have added much to our knowledge of what soils to select.

Here in the Northeast we have a densely populated area characterized by a high concentration of wealth. This makes the best market on the continent. Its nearness makes marketing costs very low and affords advantages that many sections can never offset. This is all reflected in the average per bushel price received by Massachusetts growers. Table 1 will make this clear.

Table 1. Average farm price paid for apples.

	1934	1935	1936	1937
Massachusetts	$1.26	$1.02	$1.35	$0.90
Virginia, etc.	0.89	0.72	0.99	0.60
Northwest	0.73	0.60	0.96	0.69
United States	0.88	0.71	1.05	0.70

The decline in the per capita consumption of apples is not necessarily a calamity for the apple grower. The per capita consumption is arrived at by dividing the total crop (150,000,000 bu.) by the population (125,000,000) to get the average consumed by each individual (1 1/5 bu.). This is lower than it was a few years ago--not because people refuse to eat apples for they eat all you grow, but because fewer apples are produced. Why are fewer apples produced? Cold winters have destroyed millions of apples trees; increasing difficulties in controlling pests have driven many thousands of small orchards out of business, and commercial orchards have not been planted fast enough to take up the slack. Prices have not been high enough to encourage large-scale planting--that is where the decline in consumption operates.

People have not turned away from apples. In the last 5 years they have eaten 3 times as many apples as oranges and 6 times as many apples as grapefruit. If we do plant more orchards in New England we shall not wreck the market, for prices are affected by the supply of all fruits in the country. We grow but about 5% of the total apple crop. The last census showed about 6,000,000 apple trees in New England. If all these trees lived 50 years we would have to plant 120,000 more trees per year in New England in order to maintain the number of trees. We haven't been doing that. The man who knows his business should plant in the right places making a careful choice of varieties and plant acreage enough to give him a satisfactory living. There is still a chance for apple growing in New England as a sound conservative industry.

* * * * *

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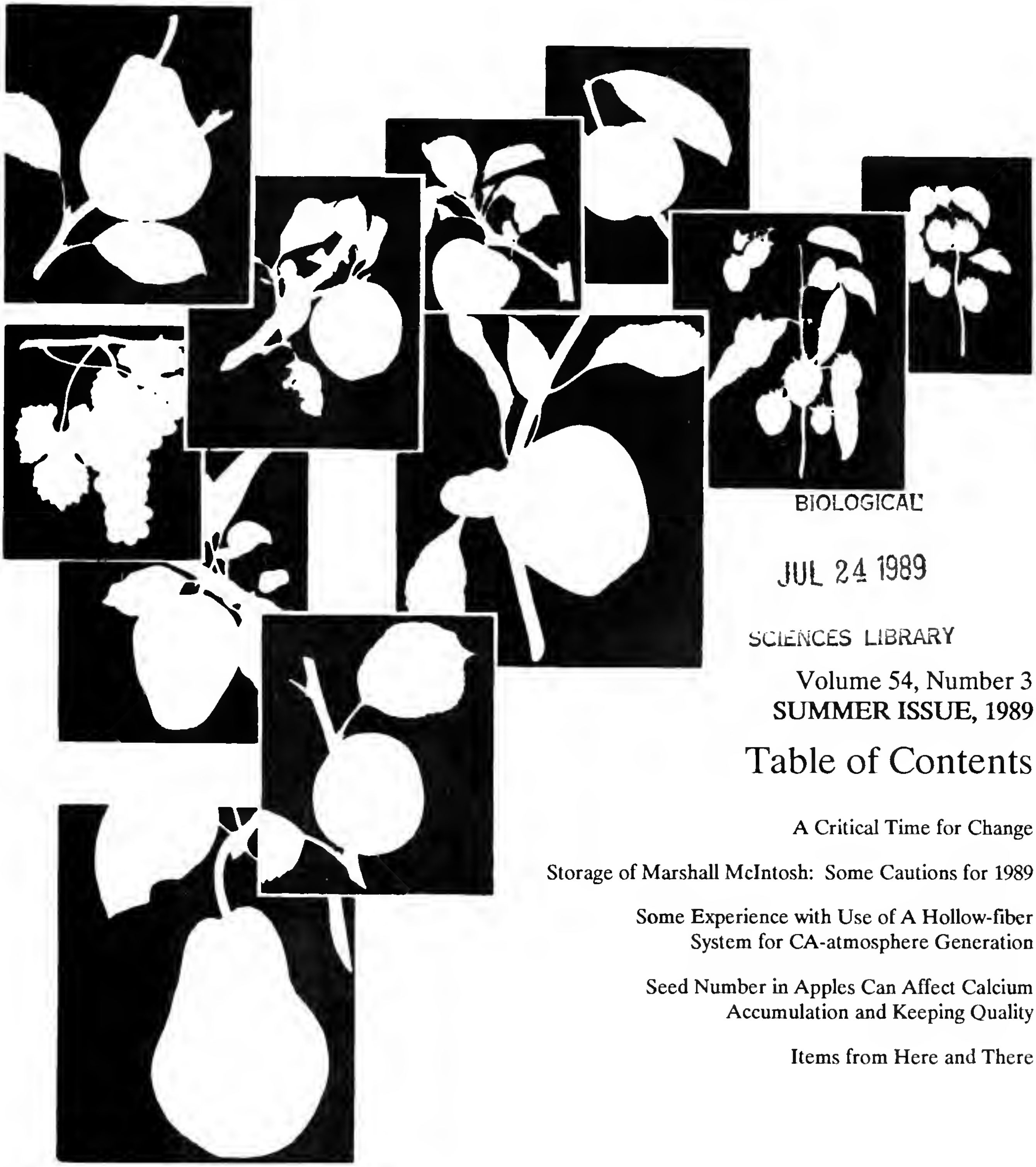
Fruit Notes

ISSN 0427-6906

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage



Volume 54, Number 3
SUMMER ISSUE, 1989

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

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A Critical Time for Change

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Renewed adverse publicity has increased the likelihood that Alar™ will not be available for orchard use in the future. Even if results of current tests show that Alar is a safe chemical, registration may be cancelled because of public pressure. The loss of Alar will influence growers of McIntosh and Stayman most, so these growers must not waste time in making the long-term decisions required to cope with growing apples without Alar. In a previous *Fruits Notes* article [54(2):1-3] a number of options were put forth as alternatives to using Alar. The option that we will discuss here is the replacement of McIntosh with different cultivars.

There are many new, excellent-quality apple cultivars now available, and many others are in the early stages of evaluation. The loss of Alar may be a blessing in disguise since there is now incentive to plant new and better-tasting cultivars. Selection of the cultivars to plant may be the most important management decision growers will make in the 1990's. Consistent and sustained increased per capita consumption of apples will not occur with continued planting of McIntosh, Delicious, and Golden Delicious. It will only occur when we provide consumers with a wider choice of better-tasting apples that have a longer shelf life than is presently available. In this article we will describe the most viable alternatives to growing McIntosh.

Cultivars of Proven Superior Quality Where New England Growers May Have a Competitive Advantage

Gala

Gala is an apple cultivar introduced in New Zealand in 1962 by Dr. Donald McKenzie. We previously reported that this cultivar showed promise in New England [*Fruit Notes* 51(1):12-14]. The planting of Gala is no longer a gamble but a good business decision. It is being planted extensively in the Pacific Northwest and in many other areas in the country. It is estimated that nearly 25% of all apple trees planted in Washington in 1990 will be Gala. In Massachusetts the fruit characteristics and storage potential of Gala were evaluated and compared to McIntosh in 1988. Taste panelists consistently preferred Gala over McIntosh.

Gala is precocious and has shown early, heavy production. Trees at the University of Massachusetts Horticultural Research Center (Belchertown) on M.26 yielded over 8 bu/tree in their 7th leaf. Based on a 12- x 22-foot plant spacing there was a potential yield of 1386 bu/acre in the 7th leaf with a cumulative yield of about 3150 bu/acre. Gala is a "grower-friendly" tree with few cultural problems. Limb spreading is probably not necessary. However, thinning is necessary since Gala fruit size is not large, but trees have not had any apparent tendency toward biennial bearing.

There are several red-coloring strains of Gala available, and they are described below. Replicated strain trials were established in 1988 at the Horticultural Research Center and at Honeypot Hill Orchard (Stowe, MA). We will be reporting on these studies as soon as the trees come into production.

<u>Kidd's D-8</u>. This strain is the original one released in New Zealand in 1962. Based on grower comments from other parts of the country, the flavor of this strain may be better than that of other red-coloring strains. Kidd's D-8 colors well in New England. In our 1988 trials it developed red color on up to 80% of the surface. Unlike other cultivars, the nonred portion of Gala turns from green to yellow and finally to a very attractive orange-yellow color, providing a striking feature for customer identification. Based on its appearance from Australia, Italy, and other portions of the USA, we believe that New England may produce the reddest and most attractive Kidd's D-8 Gala. We may have a distinct advantage in growing this strain.

<u>Royal Gala</u>. This strain is the most widely planted, red-coloring strain of Gala. We fruited Royal Gala at the Horticultural Research Center in 1988. It has a distinct red stripe and is much redder than Kidd's D-8. The yellow-orange background color is lacking on this strain. Only time will tell what strain the consumer or marketing chain buyers will prefer. In our estimation the quality and taste of Royal Gala was at least comparable to that of Kidd's D-8 in 1988.

<u>Regal Gala</u>. This strain is a blush type. It has been suggested, but not confirmed, that Regal Gala is more vigorous than Kidd's D-8 and may have superior color, larger fruit size, better flavor, and less firm fruit [*Good Fruit Grower* 40(7):7, 1989].

<u>Imperial Gala</u>. This striped strain is very similar to Royal Gala in fruit appearance.

Scarlet Gala. This strain produces a striped red fruit that may have better flavor than other red-coloring strains.

Spur Gala-Go-Red. This striped strain is the only spur-type Gala that has been identified. It is reported that Spur-Gala-Go-Red may produce larger, earlier-coloring, and brighter fruit than Royal Gala. This strain is not included in our trial but it is on order for delivery in 1990.

Galaxy. It is a well-colored, solid-blush strain with a dark overstripe. Trees of this strain are not presently available.

Jonagold

This cultivar was released in 1968 by the New York Agricultural Experiment Station in Geneva and is a cross between Golden Delicious and Jonathan. It has become very popular in Europe, especially in Belgium and Holland. Jonagold consistently receives high ratings for flavor. Last year Jonagold was the best tasting (except maybe for Gala) of all apples evaluated at the Horticultural Research Center. However, it may not have a long storage life. By the end of November acid levels had declined to the point where the taste was bland. Previous to that point, it was a superior and outstanding apple.

Jonagold is a large yellow apple with a red blush or cheek. It requires at least as much if not more direct sunlight for red color to develop than McIntosh. It is reported to ripen with Golden Delicious. We feel that it should have been harvested between October 4 and 8 at the Horticultural Research Center. It is a triploid, so the trees are vigorous and cannot be used as pollinizers for other cultivars. There are many red-coloring strains of Jonagold, but these have not been evaluated extensively.

There was intense interest in Jonagold in the Pacific Northwest until recently. However, two abnormally warm growing seasons exposed the susceptibility of Jonagold to sunscald and reduced fruit quality. Consequently, Jonagold probably will be grown only in the cooler areas in the Northwest. The cool nights and sunny days in September and early October, climatic conditions which make New England an ideal place to grow McIntosh, may also make New England the best place in the United States to grow Jonagold. The quality of this apple is excellent at harvest. The biggest question about Jonagold is how long can it be kept in storage before becoming bland and unappealing.

A number of red-coloring strains of Jonagold have been identified, but few are presently available. We will attempt to keep growers in New England updated as these strains become available and reliable information is generated.

Cultivars That Show Considerable Promise That Are Worthy of at Least Limited Planting

Red Fuji

We reported in an earlier article [*Fruit Notes* 54(1):10] on the Red Fuji apples grown at the Horticultural Research Center. We have observed some of these fruit periodically from regular storage. Of the apples that we grow, these fruit appear to maintain flavor and firmness in regular storage much longer than any other. Pressure tests made on March 28, 1989 after 22 weeks in regular storage, revealed that flesh firmness averaged over 16 lbs. Fruit harvested with a green ground color averaged over 18 lbs and their flavor was still very good. Fruit that were harvested with a yellowish-green ground color were somewhat bland and flesh firmness averaged about 14.5 lbs.

This cultivar is being planted extensively in California and the Pacific Northwest. Fuji normally has a red or pink cheek on a greenish yellow ground color. Even the red-coloring strains do not develop the intense red color characteristic of red-coloring strains of other apple cultivars. However, growers in the Northeast may have an advantage growing it since red color and desirable acid levels should develop more in our climate. In 1988 it ripened at about the same time as Rome Beauty. It is a vigorous tree and we feel that it should be grown on rootstocks no more vigorous than M.26.

There are several red-coloring strains available but all are largely untested in this country. We currently have 4 strains of Red Fuji under evaluation at the Horticultural Research Center.

Liberty

Of the disease-resistant cultivars available, Liberty is clearly the one with the highest fruit quality. However, Liberty should not be considered as a specialty cultivar to be grown only in situations where no fungicides are used. Liberty is an apple that should be grown on its own merits. In taste tests conducted in Oregon and Washington and reported by Bob Stebbins at the most recent New England Fruit Meetings, Liberty was rated equal to or higher than Empire. It is a medium-sized, oblate fruit with red color over a yellow ground color, very similar in appearance to Empire. It is crisp and juicy, and qualities of one of its parents, Macoun, are quite apparent. It ripens with Empire. Trees are semivigorous and productive. It is likely that Liberty trees will require thinning to the same degree as Empire to obtain adequate fruit size.

Cultivars That May Be Worthy But Further Testing Is Required.

Braeburn

Braeburn is a chance seedling that originated in New Zealand. It is firm, crisp, very juicy, sweet, and aromatic with light-green flesh and oval shape. Fruit are medium to large in size and green overlaid with red. Fruit are not attractive; however, the eating quality of this apple has been rated excellent. Probably the biggest question about Braeburn is whether or not our season is long enough to mature it. The maturity date of Braeburn has been compared to that of Granny Smith. However, the 1988 Apple Variety Progress report from Oregon State University by Bob Stebbins et al. indicates that Braeburn ripens a week later than Delicious and a week before Fuji. Braeburn appears to store well. The tree is moderately vigorous, precocious, and has a standard type growth habit. It appears to be a "grower-friendly" tree [*Pacific Northwest Fruit Tester's Association (PNFTA) Fact Sheet*, James K. Ballard, 1101 West Orchard Street, Selah, WA 98942].

Criterion

This cultivar originated as a chance seedling in an orchard near Parker, Washington. Criterion is a yellow apple with a shape similar to Delicious. Like Golden Delicious, color is determined largely by the nitrogen status of the tree. It is a firm, sweet, aromatic apple with creamy flesh and excellent flavor. Criterion bruises easily. It is not prone to russet, and near harvest it develops a red cheek. Its storage potential is good. It is reported to ripens with Rome Beauty, although there are indications that it may not mature properly in western Washington and in British Columbia. It is a very vigorous tree which may not be as precocious as other cultivars (*PNFTA Fact Sheet*).

Elstar

This cultivar is one of the most attractive and promising of the new cultivars available. It is also one of the most heavily planted cultivars in Northern Europe. Elstar resulted from a cross between Golden Delicious and Ingrid Marie (a seedling of Cox's Orange Pippin) made at the Institute for Horticultural Plant Breeding at Wageningen, Holland. It is medium to large in size and round to conical in shape, with white flesh. It is a firm and somewhat-tart, yellow apple with a very attractive orange-red stripe that matures in late September. It may require a period of storage to develop acceptable flavor (*PNFTA Fact Sheet*).

Acey Mac

Acey Mac is a selection from trees vegetatively propagated from a seedling tree discovered over 20 years ago by Art Burrill in the Champlain Valley of New York. It is very similar to McIntosh in appearance, taste, shape, flesh color, and flesh texture. It is reported that Acey Mac is larger and firmer, has less preharvest drop, and ripens about 5 days later than Rogers McIntosh. Red color development appears to be better than Rogers McIntosh, and it may be comparable to Marshall McIntosh. Acey Mac is a nonspur tree with growth and bearing characteristics similar to McIntosh. Nine-year-old trees of Acey Mac are growing in the orchard of Bob Sodoma, Brockport, New York (Carl Perleberg, Columbia Basin Nursery, Quincy, WA and Dick Norton, Spencerport, NY).

Buhr McIntosh (Wafler Nurseries, Wolcott, NY) was originally propagated from the same tree as Acey Mac. We are unsure at this time if there are distinguishable differences between Acey Mac and Buhr McIntosh.

Pioneer Mac

Pioneer Mac is very promising, McIntosh-type cultivar. It was discovered as an open pollinated seedling of McIntosh at Ernest Greiner's farm in Marlboro, New York. It appears to have fruit characteristics very similar to those of McIntosh, although it is reported to have better color than the Roger's strain. Taste and external appearance are close if not identical to McIntosh. Preharvest drop does not appear to be a problem. It is a nonspur tree that may be less vigorous than Roger's McIntosh (Phillip Baugher and Tom Callahan, Adams County Nursery, Inc., Aspers, PA).

Cultivars of High Quality That May Have Local or National Market Acceptance

Akane

Akane ripens 7 to 10 days before the start of McIntosh harvest. The fruit are firm, medium sized, and red with white, dense flesh. Fruit hang on the tree for an extended period of time without dropping or losing appreciable fruit quality. It has a distinctive spicy flavor. It appears to hold up better in storage than other late-summer apples. It has been reported to be somewhat resistant to scab. The largest fault that we find with Akane is that fruit set may be light. It is one of the shyest producers that we have at the Horticultural Research Center.

Paulared

This cultivar is one of the most attractive and best tasting apples that ripens before McIntosh. Fruit size, red color, and productivity have been very good at the Horticultural Research Center. It can be stored for several weeks without excessive softening. Since it is an attractive and early-coloring apple, the tendency is to harvest this cultivar too early, before its true flavor develops. Sufficient Paulareds should be planted so that they can be harvested at the appropriate time and sold with the fine flavor and quality that Paulared is capable of developing.

Empire

The popularity of this apple is increasing, especially where it is difficult to color McIntosh adequately. It is a high-quality, firm, red apple that stores exceptionally well. In our estimation it is only rivaled by Mutsu for its ability to store in CA. It has not developed the popularity in New England that many thought that it would. Since it ripens between McIntosh and Delicious, it is not always harvested at the proper time. Although its storage capability is exceptional, once removed from CA it appears to soften more rapidly than other cultivars. There does not appear to be the customer acceptance of a moderately soft Empire as there is with other cultivars with similar firmness. It may be difficult to obtain good fruit size in all areas, and it appears to be particularly difficult to size Empire in colder areas (a characteristic that it may have inherited from Delicious).

Macoun

The popularity of this old and difficult-to-grow apple appears to be increasing. The flavor and crispness of Macoun is exceptional and makes this fruit a much sought after apple in the fall. Its many faults make it unpopular to grow. It may be very biennial, and hand thinning is frequently required. Red color may develop slowly, and preharvest drop may occur before adequate color. Fruit lose firmness rapidly in storage although they will store well in CA. This apple is not for everyone, but for those who can grow it, there is good customer demand.

Mutsu (Crispin)

The quality of Mutsu is among the highest of the apples that we can grow here in New England. It is a firm, juicy, and very large, yellowish-green apple that matures after Golden Delicious. It holds up very well in regular storage, but its regular storage potential is not exceptional. However, in CA storage fruit come out in almost identical conditions to that when they were placed in storage. Mutsu has not developed the popularity that its quality and CA potential warrant. It is susceptible to *Pseudomonas* or blister spot, and unless this problem is controlled, packout will be poor. We have found that 3 weekly sprays of Polyram™, starting at bloom, control most of the blister spot. Mutsu is also very susceptible to excess nitrogen. Mutsu is a yellow and not a green apple and frequently is picked too early. Like Granny Smith, if it is picked too early it will have only mediocre flavor. For people who have roadside stands, this apple should attract considerable return business if grown properly and harvested at the time that will assure the quality that Mutsu is capable of developing.

Melrose (and its red strains)

This cultivar is the result of a Jonathan x Delicious cross. Fruit are large, firm, crisp, juicy, and red with a yellow background. It is a high quality apple that ripens with Golden Delicious and keeps well in storage. It is a very popular apple in Ohio.

Idared

Idared has been planted extensively in New York where it is suitable for fresh market or processing. It is a very easy tree to grow and maintain. It is a medium-sized red apple with good flavor. Idared ripens after Golden Delicious and it benefits from a period of storage following harvest. Although the quality of Idared is not as high as that of some of the other cultivars mentioned, its regular and CA storage potential are excellent. Long after other cultivars have lost firmness and flavor, Idared remains a good and saleable apple. People who grow this apple will have quality apples to sell from regular storage, prior to opening of CA storages, and at the end of the apple marketing season.

Growing of new, superior-quality apples will be successful only if the apples can be grown and sold at a profit high enough to stay in business. Growers who sell directly to the public through roadside stands have a distinct advantage since they can introduce to customers specific cultivars at the appropriate time to provide the customer with the best possible product.

Growers who wholesale market their product will have a more difficult time but it is not impossible.

1. Growers must insist and ensure that their product is sold at the proper stage of maturity. For example, Granny Smith is a high-quality apple that at proper maturity is yellowish green. Unfortunately, it is nearly impossible to buy a good Granny Smith in the grocery

stores, because all were harvested when still too green, before proper flavor developed. Idared has been sold for the past 2 seasons by local grocery chains in mid-September, fully 3 weeks before it should be harvested. It seem ludicrous to harvest an apple so early that you unjustifiably tarnish the name of that apple and also jeopardize sales of other apples.

2. Grower groups may volunteer time to pass out apple samples in the grocery stores. Anyone who has shopped recently has been offered free samples of pizza, hotdogs, and cheese. Why not apples?

3. In a recent address to the Washington State Horticulture Society, Frieda Caplan, Chairman of the Board of Frieda's Finest Produce Specialties, Inc., made several suggestions to Washington State Growers to increase sales of their apples. She suggested that refrigeration of apples in grocery stores should be the growers' number one imperative. Taste, appearance, storage life, more rapid rotation, and increased sales would all be improved. It is time that we communicated to the public the conditions under which apples should be stored.

4. There is a need for growers to become involved with cultivar testing. Jim Ballard, a prominent Washington State pomologist and former Washington State University Extension specialist, has organized the Pacific Northwest Fruit Testers Association. This group is comprised of growers and nurserymen who have agreed to test and share results and observations of new apple cultivars with other members. Although the membership is changing rapidly, in December, 1988, there were 180 members in 22 states and 12 countries. This organization is providing an invaluable service to the industry by speeding up the testing process and providing the most current information on appropriate cultivars, especially those adapted to growing conditions in the Pacific Northwest. Recent evaluations emphasize that environment plays a dominant role in determining the suitability of a cultivar for a particular location. Evaluations conducted in the Pacific Northwest provide a good first screening. However, they provide only rough indications of suitability for the Northeast.

Is it time to establish an evaluation organization in the Northeast? If you feel that this approach is appropriate contact Duane Greene (413-545-4733) or Wesley Autio (413-545-2963).

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Storage of Marshall McIntosh: Some Cautions for 1989

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Marshall McIntosh is presently the most widely planted strain of McIntosh in the Northeast. In a previous issue of *Fruit Notes* [52(4):1-5] we reported on tree, fruit, and storage characteristics of Marshall in comparison with 6 other strains. Marshall trees were similar in size to Morspur, Imperial, Macspur, Gatzke, and Rogers trees and yielded similar amounts. Marshall fruit colored earlier and to a higher degree than other strains, and Marshall fruit ripened 3 to 5 days earlier than the other strains. Marshall trees produced relatively small fruit, but in most years they were not significantly smaller than Rogers fruit.

We also evaluated the storage potential of Marshall and found no consistent differences between it and other strains with regard to softening or the development of storage disorders in refrigerated (32°F) or controlled atmosphere (CA) (37°F, 3% O_2, 5% CO_2) storage. However, when commercial CA's were opened in 1988 a number of growers reported off-flavors and other injuries only with Marshall, which suggested that Marshall may be more sensitive to low O_2 levels than other strains. To test these observations, we harvested 2 bushels of fruit from each of 8 Rogers and 8 Marshall trees (planted in 1979 in a replicated trial). One bushel from each tree was kept in 3% O_2 and 5% CO_2, and the other bushel was kept at 2.25% O_2 and 5% CO_2. After 6 months of CA, 1 month of refrigerated storage, and 6 days at room temperature, the incidence of low-O_2 injury was assessed.

Low-O_2 injury can manifest itself in a number of ways including presence of off-flavors, purpling of the skin, and development of brown sunken patches on the surface. The most common symptom noted in this study was internal browning as shown in Figure 1. The

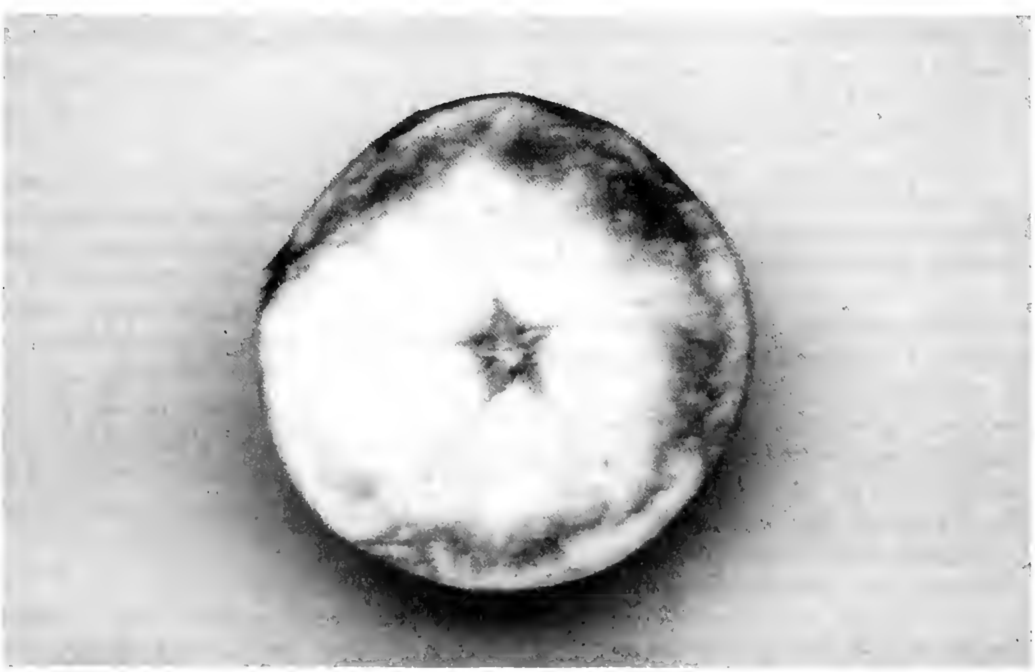

Figure 1. Internal low-O_2 injury in McIntosh apples.

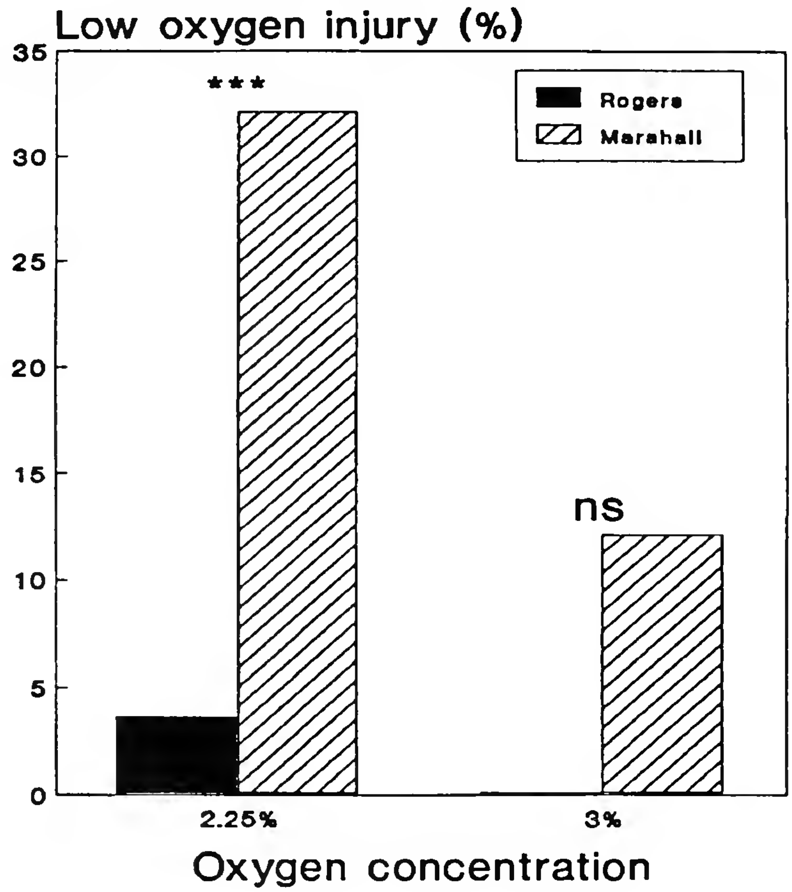

Figure 2. The incidence of low-O_2 injury in Marshall and Rogers McIntosh fruit stored at 3% and 2.25 % O_2 after the 1988 harvest.

flesh browning characteristic of low-O_2 injury has a rim of normal, white tissue outside of the browned tissue and under the skin. With further development, this white rim disappears.

Figure 2 shows the levels of low-O_2 injury found in Marshall and Rogers fruit. Even at 3% O_2 (the recommended level for CA storage of McIntosh in New England) Marshall fruit developed some internal low-O_2 injury. At 2.25% O_2, 32% of the Marshall fruit exhibited internal low-O_2 injury, while only 4% of the Rogers fruit were damaged. This increased level of damage would represent a significant loss by a storage operator. Storage operators must monitor their O_2 concentrations carefully and not allow O_2 to drop below the recommended value if they are storing Marshall McIntosh fruit.

Because of its early coloring and ripening, Marshall McIntosh will undoubtedly be of great value to the New England McIntosh industry if Alar™ is not used in the future. However, we stress that it is not safe to store Marshall fruit in CA with O_2 concentrations below 3%.

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Some Experience with Use of A Hollow-fiber System for CA-atmosphere Generation

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Controlled atmosphere (CA) storage of apples requires a method of reducing oxygen (O_2) concentration in the storage atmosphere from that of air (21%) to the level desired for apple storage (usually 3% or less). Originally, the process used fruit respiration to "pull down" the O_2, but at low storage temperatures this reduction usually requires 14 to 21 days or more. We now recognize that this length of time results in significant loss of fruit quality, and recommend that the atmosphere be pulled down to 5% in no more than 3 days after sealing the room. This reduction cannot be done by fruit respiration alone.

Rapid pull-down can be achieved by either displacing most of the storage air with nitrogen (N_2), as tank gas or as liquid N_2, or by using an external generator to create a low-O_2 atmosphere that is piped into the room. Several types of generators were developed that mixed propane gas with air to produce carbon dioxide (CO_2) and water either by open-flame burning or by catalytic chemical reaction. However, a series of storage explosions have made both storage operators and generator manufacturers wary about using these machines, and they rapidly are becoming obsolete.

In New England, many CA storage operators recently have adopted use of liquid N_2 for CA pull-down, a practice that we have advocated (Proc. 92nd Annu. Meet. Mass. Fruit Growers' Assoc. 1986:102-105), because it requires little capital investment and achieves a CA atmosphere rapidly and without buildup of CO_2, which would have to be removed. Liquid N_2 also provides some cooling in the CA room. However, use of liquid N_2 is not problem-free. Some freezing of fruit near the manifold outlets often occurs, and some storage operators have difficulty obtaining timely de-

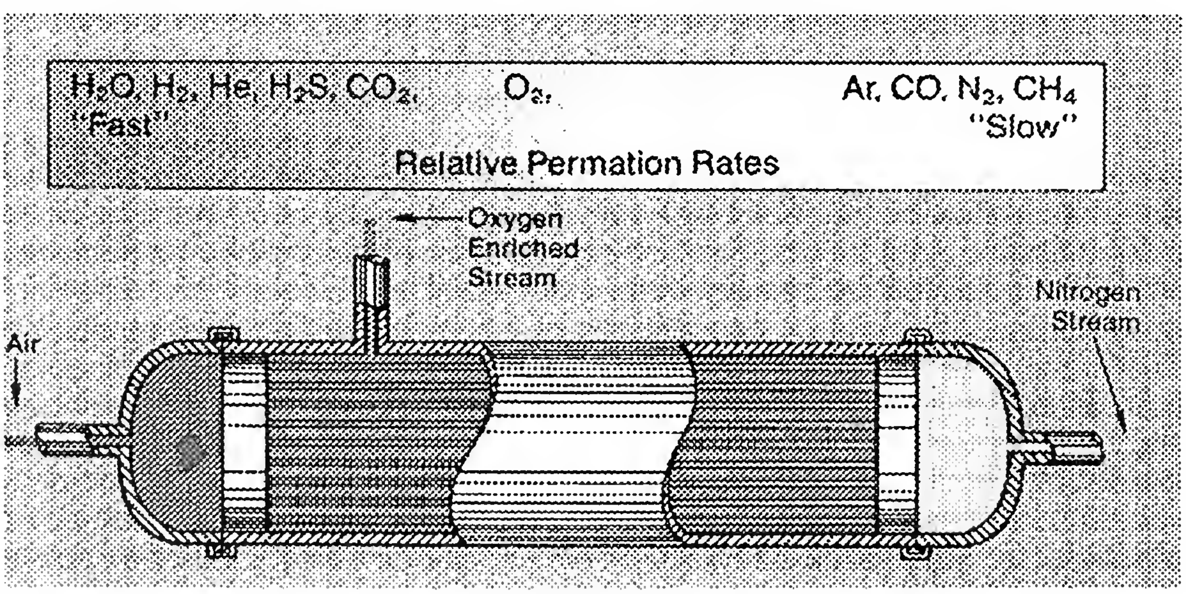

Figure 1. Relative permeation rates for the Prism Alpha™ hollow-fiber system.

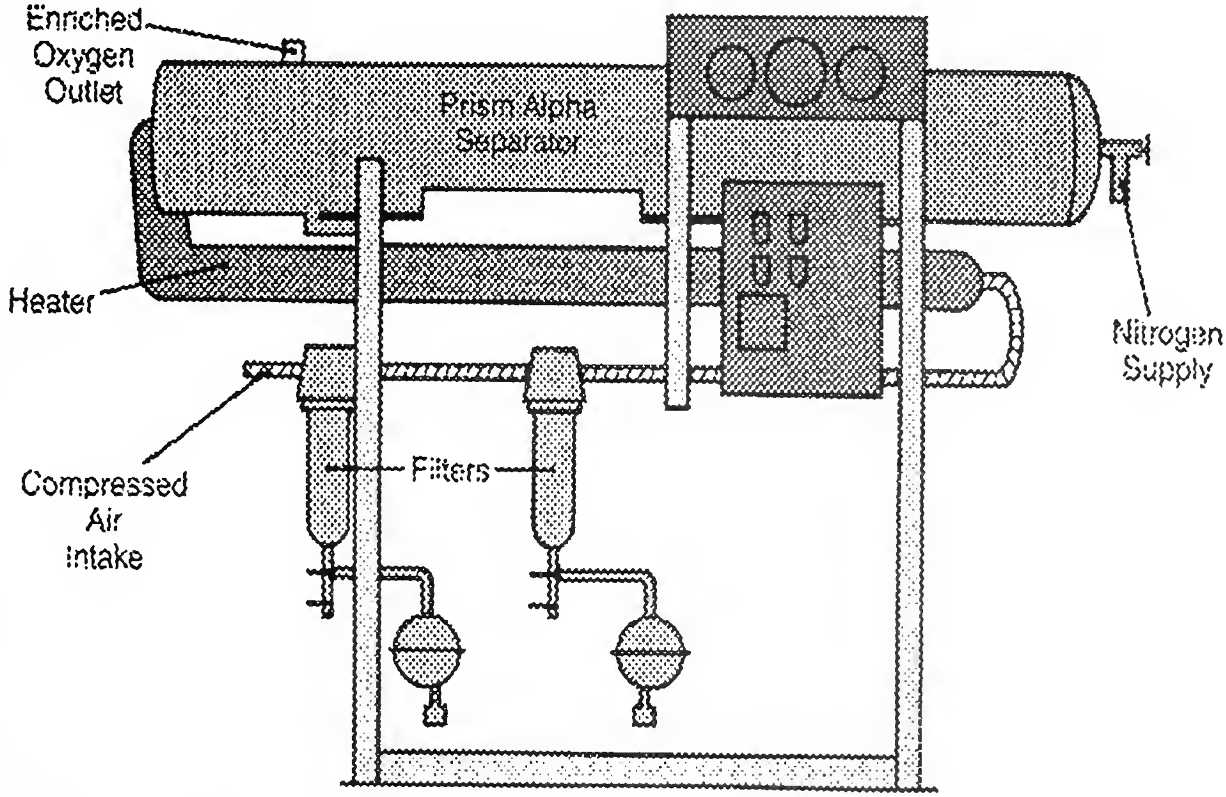

Figure 2. A schematic representation of the hollow-fiber system used at the HRC.

livery of liquid N_2. Also, cost of liquid N_2 to different operators can vary considerably.

We are interested, therefore, in the development of new types of atmosphere generators which remove the O_2 from air in ways other than by using propane. Two types of these "air separator" generators now are available commercially: "pressure-swing" units that remove O_2 by adsorption, and "hollow fiber" systems that remove it by diffusion.

Pressure-swing adsorption binds O_2, water, and some other gases onto a Carbon Molecular Sieve (CMS), leaving nearly-pure N_2 that then enters the CA room. It is called "pressure-swing" because (a) the air entering the unit must be under high pressure, and (b) it consists of two columns of CMS, and alternates ("swings") between them . . . the column not adsorbing gases is being regenerated so that it can be used again.

The hollow-fiber membrane system is a unit filled with tiny plastic tubes, through which air is forced under pressure. The plastic is much more permeable to some gases, such as O_2, CO_2, water, and ethylene, than to others such as N_2. Thus, as the air passes through the long tubes, the more permeable gases pass out through the plastic, and at the exit port the remaining gas is mostly N_2, which then enters the CA storage.

Through a lease agreement with Permea, Inc., a subsidiary of Monsanto Company and manufacturer of a hollow fiber system (Prism Alpha™), we obtained a unit in September, 1987, for use at the University of Massachusetts Horticultural Research Center (HRC), Belchertown. This unit was designed to generate an atmosphere of 2 to 8% O_2 and 98 to 92% N_2 at a flow rate of 125 to 535 standard cu. ft. per hour, at a pressure of 150 PSI.

We immediately encountered a major problem. We had been assured that the 5 horsepower (HP) air compressor at the HRC would adequately power the unit, but it did not. Through aging it was inadequate, ran constantly, and overheated. As a result, we were unable to use the N_2 generator to pull down our CA rooms.

In January, 1988, we rented a 15 HP air compressor (which was oversized but available) so that we could use the N_2 generator to regenerate a CA atmosphere in a room that had been opened, partially emptied, and re-sealed. We were pleased with its operation, so in August, 1988, we purchased a new 5 HP generator. Later, it was attached to operate in tandem with the existing compressor to provide the pressure and volume of air needed to operator the N_2 generator efficiently.

In September, 1988, two 600-bushel CA rooms filled with McIntosh apples were sealed. One was pulled down with liquid N_2, and the other one was pulled down with the N_2 generator. With liquid N_2 the room was at 3% O_2 in 1 hour. With the generator, the other room reached 5% O_2 in 26 hours, although at that time the unit was being powered by only the new air compressor.

After the two air compressors were operating together, the N_2 generator was used to pull down a 2500-bushel CA room filled with a mixture of "hard" cultivars. The generator pulled the room down to 13% O_2 in 6 hours, and to 3% O_2 in a total of 30 hours.

At various times, the generator was used to purge O_2 from the storage atmosphere, to observe its operation. For example, at one point it reduced O_2 from 3.7% to 3.4% in 4 hours. The unit is effective for scrubbing CO_2, since CO_2 diffuses rapidly through the plastic tubes, but in our system we maintain constant CO_2 levels by adjusting continual flow through lime boxes, so we did not use the generator for CO_2 scrubbing.

In January, 1989, the 2500-bu room was opened, 800 bushels were removed, the room was resealed, and the generator was used to pull down O_2. In this partly empty room, the unit required 24 hours to reduce O_2 to 11%, and a total of 48 hours to reduce it to 7%. It then took an additional 48 hours to reach 3% O_2.

The hollow-fiber N_2 generator exhibited a number of attractive features during these operations. Once the operator becomes familiar with its operation, the unit requires little "tinkering" and does not have to be watched, so the operator is free to attend to other duties. The unit has no moving parts, so it should require very little maintenance and have a very long operating life. It can maintain both O_2 and CO_2 in an atmosphere as well as generate an atmosphere, although we chose to use it for little more than generation. Also, it will combine with a computer-operated CA system very easily, although we chose not to do this due to other research objectives.

The two problems we encountered were first, the high initial cost of the unit, and second, the absolute need for adequate air compressor capacity. Operating costs are limited to the power needed to operate the compressor and to maintain the temperature of the generator at 110°F.

The hollow-fiber generator will not pull down a CA room as fast as can be done with liquid N_2. However, the pull-down rate is sufficient to optimize CA conditions for apples, and the fact that the unit is always ready to operate as soon as the room is sealed may save time that would be spent obtaining liquid N_2 or preparing for its use. In the short-run, use of liquid N_2 is the less expensive method, but since the N_2 generator should have a long, trouble-free life, in the long-run the costs may be comparable.

In summary, while our experience with the hollow-fiber, N_2-generating system is not extensive, it has been very positive. These units should have a secure place in CA storage operations. While we have had no experience with a pressure-swing adsorption unit, a number of these are in use throughout the United States and in other countries, and experiences with them also have been positive. Thus, it appears that CA storage operators have a number of effective options for achieving CA atmospheres rapidly. The choice from among these options will depend on personal and local considerations.

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Seed Number in Apples Can Affect Calcium Accumulation and Keeping Quality

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Apple growers are well aware of the importance of pollination and seed development for fruit set. However, the importance of seeds continues throughout fruit development, affecting not just the fruit but also the tree. During experiments designed to test other questions, we have observed some of these relationships between seed number and fruit quality, which we shall describe briefly here.

In a study of effects of growth regulators on McIntosh apples, we found that with increasing concentrations of gibberellins A_{4+7} and benzyladenine, an increasing number of seedless fruit remained on the trees and ripened. However, during and after storage the amount of senescent breakdown that occurred increased as growth regulator concentration that had been applied to the fruit increased. When the fruit were examined and analyzed, we found that the senescent breakdown was mostly in seedless fruit, and that the treatments were depressing fruit calcium concentration at the same rate that they were increasing the numbers of seedless fruit that matured. This result suggested that calcium was much lower in seedless fruit than in ones with seeds.

In a later study of effects of growth regulators on Delicious apples, we again noticed large differences in seed numbers among fruit, so samples from all of the treatments were examined for size, seed number, and mineral composition. The results are summarized in Table 1.

There was a significant linear relationship between seed number and fruit diameter: the more seeds in the apple, the larger the apple. This relationship has been seen before with a number of different kinds of fruit, so one effect of abundant seed development appears to be larger fruit size.

It is well known that increasing fruit size reduces the amount of calcium in apples, yet as can be seen in Table 1 there was a significant increase in fruit calcium with increasing seed number. Thus, the extra calcium drawn into the apple as a result of increased seed number was greater than the dilution effect that the increased size had on fruit calcium concentration. The end result was larger fruit with more calcium in them. In the case of magnesium, the data on Table 1 show that it was reduced by seed number, but statistical analysis showed that this reduction was merely the dilution effect of larger fruit size. For potassium, seed number had no effect. Therefore, the effect of seed number was specific to calcium --- increased seed number attracted extra calcium into the fruit.

Table 1. Relationships of seed number per fruit in Delicious apples to fruit size (diameter) and mineral concentrations.

Seed number per fruit	Average diameter (mm)	Mineral concentration[z]		
		Calcium	Magnesium	Potassium
0-1	67	174	284	6700
2-3	70	208	278	6600
4-5	71	215	279	6600
More than 5	72	223	280	6600
Significance[y]	**	**	**	ns

[z]Parts per million dry weight in outer cortical tissue.
[y]**,significantly different at odds of 99:1; ns, not significantly different.

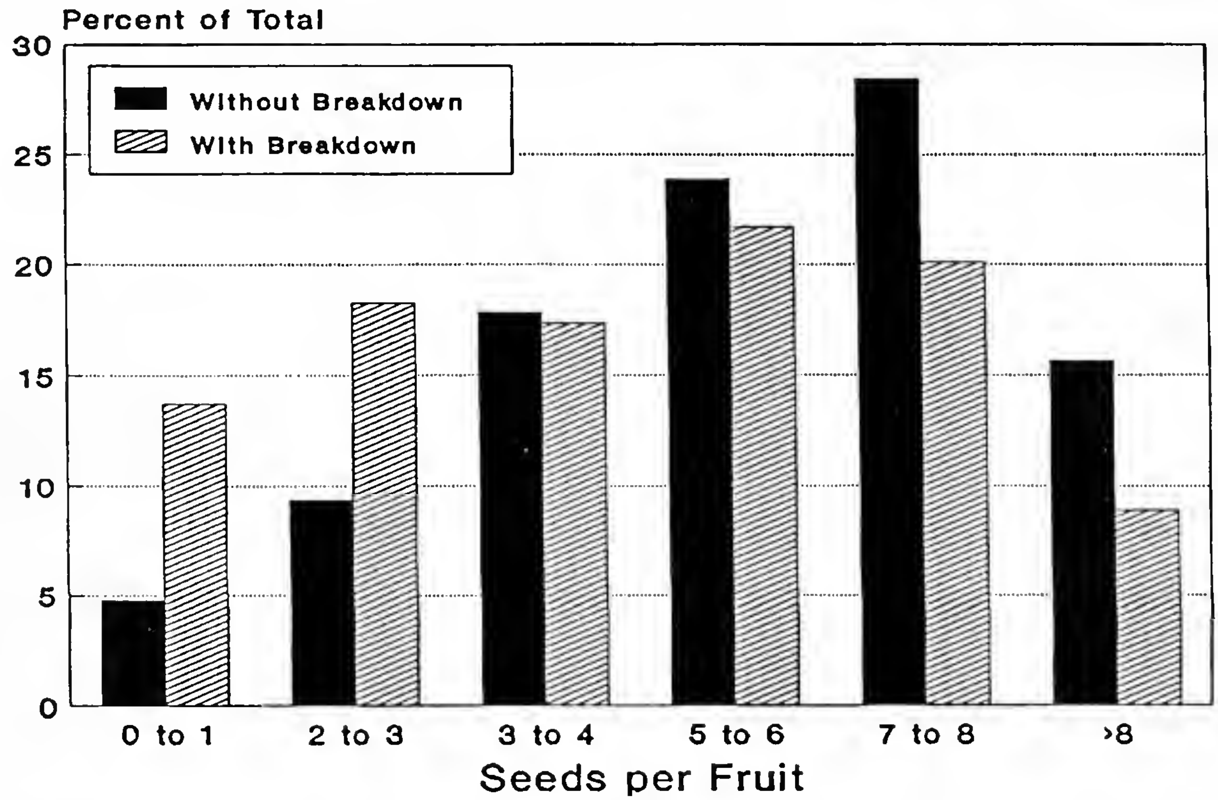

Figure 1. Seed numbers for McIntosh apples that did or did not develop senescent breakdown after 6 months of storage in 32°F air plus 1 week at room temperature. "Percent of total" is for each population --- those that developed breakdown, and those that did not develop the disorder.

In this experiment we did not determine the occurrence of disorders after storage of fruit, because there were not enough fruit for a meaningful test. However, in another experiment we had the opportunity to relate seed number to keeping quality.

Bushel samples of McIntosh apples had been collected from 50 different blocks in commercial orchards, and all had been stored at 32°F in air at the Horticultural Research Center for 6 months. They were then kept at room temperature for 1 week, and each fruit was cut open, its seed number counted, and it was recorded as to whether or not senescent breakdown had developed.

The results are shown in Figure 1. We examined the results as two populations of fruit --- those that had breakdown and those that did not have it. In the population that developed breakdown, a high proportion of the fruit had 3 seeds or less. In the population that did not develop breakdown, most of the fruit had 5 or more seeds. A statistical analysis showed that a real difference in seed number did exist between the two populations. Thus, in these McIntosh from commercial orchards throughout Massachusetts, low seed number appeared to be a contributing factor (though certainly not the only factor) in development of senescent breakdown, a disorder caused by calcium deficiency.

These results demonstrate that low seed number probably contributes to low calcium concentrations in McIntosh and Delicious apples, and also contributes to calcium-related disorders during and following storage. This means that one approach to maintaining adequate calcium levels in apples is to pay careful attention to pollination conditions in orchards. Seeds are important contributors to fruit quality.

* * * * *

The following "Items from Here and There" are reprinted from *Fruit Notes*, June and August, 1939.

Items From Here and There

William H. Ties
Department of Pomology, Massachusetts State College

Granville Grower Solves Deer Problem

Karl Hanson, who owns an orchard in the town of Granville, has constructed a wire fence which seems to exclude deer in a section where much damage has been done in previous years. Mr. Hanson had to replace many of the trees in his orchard and found it impossible to get satisfactory tree growth before the deer were fenced out. The construction is briefly as follows. A barbed wire is stretched along the ground to prevent deer from getting underneath, and about 4 inches above that is stretched a section of woven wire, 39 inches high. The top and bottom strands are number 10 wire and the rest number 13. Above the top of the woven wire are 4 strands of heavy wire such as is used in growing covered tobacco, these strands being spaced as follows. The first, 8 inches above the top of the woven wire, the others 10, 12, and 14 inches, respectively. This makes a fence about 7 feet high. Mr. Hanson has found no evidence of deer jumping such a fence, although other growers have reported them jumping as high as 8 or 9 feet. There are still plenty of deer in that locality, although this orchard has been unmolested since the fence was built 4 years ago.

Two Interesting Gadgets

Yankee ingenuity is still fairly common in Massachusetts. Lee Rice of Wilbraham has devised a spray tank filler by mounting a small pump, similar to that used by the telephone company, on the front bumper of his truck which carries a supply tank. The pump is attached to the truck motor and makes possible the filling of the tank from a brook or pond in short order. Raymond Fiske of Lunenburg, instead of using a wooden frame or barrel for support in spraying from the top of the tank, has mounted an automobile tire at that point, thus providing a rubber bumper effect for weary bones.

A Square Deal Without "Square Apples"

A campaign is underway in the Wenatchee district to do away with "unnecessary and unwarranted mashing of apples in the packing shed." An attempt is being made to prevent a higher and higher bulge as the fruit leaves the packing house. The contention is made that there isn't the slightest reason for putting 45 lbs. of apples into a box and then stamping them with a 40 lb. stamp. Very often apples are not of uniform firmness and when they are squeezed together in the lidding process, the harder ones make virtually square apples out of the softer ones.

McIntosh Color Requirements are Too Low

The color requirements for McIntosh are too low, according to Cornell Memoir 220, "Joint Correlation Applied to the Quality and Price of McIntosh Apples," published in March, 1939. After a detailed study of the various factors which surround a McIntosh apple and of their relation to market price, the author, J. R. Raeburn, says, "The relationships of color to price indicated that apples with less than 67% of their skin a good red characteristic of the variety should not be permitted in the United States Extra Fancy grade, and those with less than 33% should not be permitted in the United States No. 1 grade."

Red Sports are Often Picked Too Early

W. E. Piper reports a well known Boston dealer as saying "A green Red Grav is worse than a green Green one." This seems to suggest a tendency among growers to pick red sports too early. If we harvest a Red Grav, Richared or other red sport as soon as it takes on a red color, we are sure to have a less edible apple than the color would indicate and about the only thing worth less than an immature, rubbery apple is two such apples.

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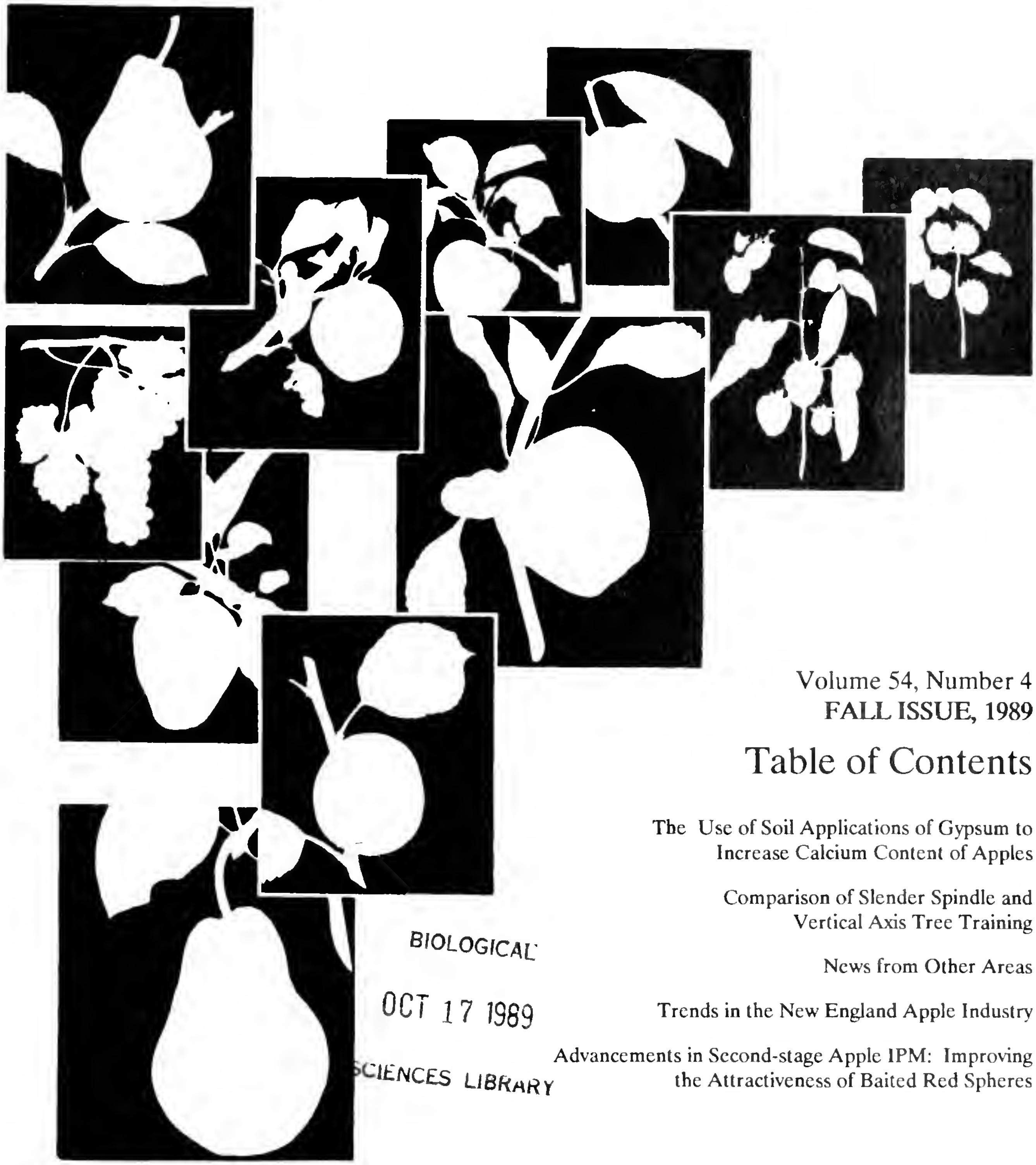
Fruit Notes

Prepared by the Department of Plant & Soil Sciences.

University of Massachusetts Cooperative Extension,
United States Department of Agriculture, and Massachusetts Counties Cooperating.

Editors: Wesley R. Autio and William J. Bramlage



Volume 54, Number 4
FALL ISSUE, 1989

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Fruit Notes

Publication Information:

Fruit Notes (ISSN 0427-6906) is published the first day of January, April, July, and October by the Department of Plant & Soil Sciences, University of Massachusetts.

The costs of subscriptions to *Fruit Notes* are $4.00 for United States addresses and $6.00 for foreign addresses. Each one-year subscription begins January 1 and ends December 31. Some back issues are available for $1.00 (United States addresses) and $1.50 (foreign addresses). Payments must be in United States currency and should be made to the University of Massachusetts.

Correspondence should be sent to:

Fruit Notes
Department of Plant & Soil Sciences
205 Bowditch Hall
University of Massachusetts
Amherst, MA 01003

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The Use of Soil Applications of Gypsum to Increase Calcium Content of Apples

William J. Bramlage, Sarah A. Weis, and John H. Baker
Department of Plant & Soil Sciences, University of Massachusetts

The problem of calcium (Ca) deficiency in apples is well known to our readers, as is the fact that we have researched various ways of alleviating this problem for many years.

There are four ways of improving Ca content of apples:

1. Orchard practices to reduce competition between leaves and fruit for available Ca.
2. Soil applications of materials to increase uptake of Ca by apple tree roots.
3. Foliar sprays of Ca-containing materials.
4. Postharvest treatments with Ca-containing materials.

In general, soil treatments have been the least effective method of improving fruit Ca levels, because apple roots are very poor at absorbing Ca, which is one of the most abundant minerals in soil. This problem is increased by the very slow movement of Ca in an apple tree, resulting in slow and perhaps diluted responses to whatever improvement in Ca uptake that may have been achieved.

Despite these problems, we have found that soil applications of gypsum (hydrated calcium sulfate) can increase apple fruit Ca levels. An experiment begun by Mack Drake and John Baker in 1976 first showed these benefits, and another one begun by Bill Lord in 1980 expanded on those findings. Since the retirements of Dr. Drake and Dr. Lord, we have assumed these experiments and established a series of new ones designed to answer questions raised by results from the original experiments.

Research with soil treatments to influence apple nutrition progresses very slowly. First, trees respond slowly to soil treatments, and second, the soil is a very complicated system and when you change it, you must look at long-term effects of these changes. In 1987, we reported the promising results from the studies of Dr. Drake and Dr. Lord, and described some of the questions that needed to be answered (*Fruit Notes* 52(2):1-4). Here, we have updated those earlier findings with what we have recorded during the past two years.

In our 1987 article, we showed that 8 years of annual gypsum treatments to soil beneath mature, seedling-rooted Cortland trees had raised fruit and leaf Ca levels, decreased fruit and leaf Mg levels, and had no effect on fruit and leaf K levels. The treatments had no effect on fruit firmness at harvest or after storage, but reduced the occurrences of bitter pit and senescent breakdown after storage. A second experiment applied to young Delicious trees also showed that gypsum increased Ca, decreased Mg, and had no effect on K, but no consistent effects on fruit quality were yet apparent at that time. We pointed out that we did not know what effects the treatments were having on soil properties, that we did not know what the optimum application rate was, and that we did not know the economics of gypsum treatments.

Currently, we have three long-term gypsum experiments in progress. The first is a continuation of the experiment begun by Dr. Lord in 1980, using a block of Sturdeespur Delicious trees on MM.106 planted in 1972. Trees in this block were given 0, 50, or 100 lbs. of gypsum (0, 0.3, and 0.6 lbs. per sq. ft.) each April through 1985, with the gypsum spread beneath the tree canopy. By 1985, it was apparent that both 50-lb. and 100-lb. application rates were having the same effect, so the 100-lb. rate was discontinued to determine how long effects would last after a gypsum treatment was ended.

The second experiment was established in a block of mature Cortland trees on M.7 rootstock planted about 1962. These trees have a severe Ca deficiency, and their fruit always develop high rates of bitter pit and senescent breakdown. The objective was to see what role gypsum treatments might play in trying to control a chronic Ca-deficiency situation. Annual applications of 0, 40, or 80 lbs. of gypsum (0, 0.25, and 0.5 lbs. per sq. ft.) beneath the tree canopy are made in April or May. The experiment was begun in 1986 and thus is in its fourth year.

The third experiment was established in 1987 in a block of Cortland trees on M.7a rootstock planted in 1981. Trees received applications of 0, 8, 16, 24, 32, 40, or 48 lbs. of gypsum (0, 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 lbs. per sq. ft.) in April, in an attempt to learn the optimum rate of application.

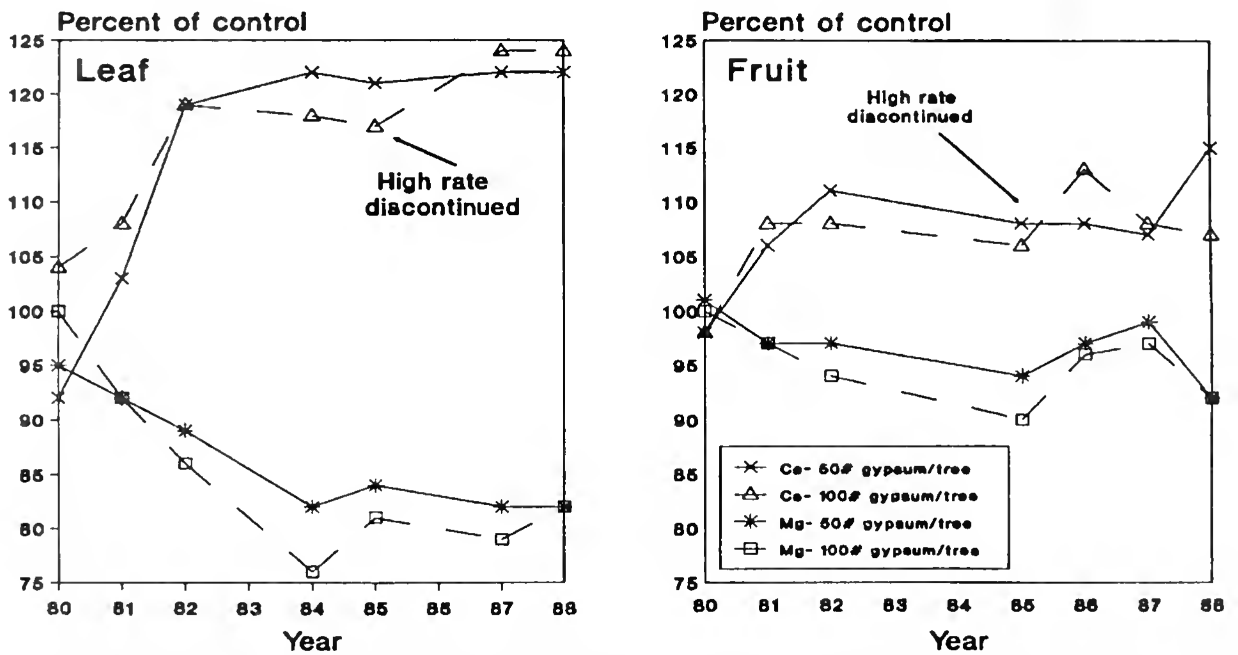


Figure 1. Effects of low (50 lbs./tree) and high (100 lbs./tree) rates of gypsum, applied annually, on leaf and fruit mineral composition of Delicious. The high rate was discontinued after 1985.

The soil type in these blocks is generally a Scituate fine sandy loam, although depth to hardpan and specific soil characteristics varies somewhat among the blocks.

Effects on Leaves and Fruit

In the Delicious experiment, we continue to see the effects of gypsum on leaf and fruit mineral composition that we reported earlier, that is, gypsum significantly increases leaf and fruit Ca and decreases leaf and fruit Mg (Figure 1), but has no effect on leaf and fruit K (data not shown). The effects were quite consistent from year to year, with about a 20% increase in leaf Ca and a 10% increase in fruit Ca, and a 20% decrease in leaf Mg and a 5% decrease in fruit Mg each year after responses were established. This means that the response is very reliable, and also that you can get only so much response from a gypsum treatment: once the response is established, it does not get bigger as you continue to apply gypsum from year to year. It is also clear that it takes time for the tree to respond to gypsum treatments ---in this case, it took 3 years after treatments began before the responses were established.

In the trees where gypsum applications were discontinued in 1985, it can be seen that levels of leaf and fruit Ca and Mg continued to show the gypsum effect for at least two years. In 1988, the third year, it appeared that levels might be starting to change, but we should have a much better picture of this after the 1989 analyses are completed. It may be that 3 years represents the time needed for Ca to move from the roots to the fruit in these trees, since it took this long to see benefits of gypsum treatments, and perhaps this long to see any result of ending the treatment.

The gypsum treatments had a very consistent effect on the occurrence of bitter pit in these fruit (Figure 2). Once the treatment effects were established, 5 to 10% less of the crop has developed bitter pit after storage in the samples taken from gypsum-treated trees, except in 1986 when no bitter pit developed in any fruit. Again, as with the mineral analyses, it is clear that only so much could be done to alleviate Ca deficiency through gypsum treatments. They did not work magic!

In the experiment with mature, Ca-deficient Cortland trees, leaf Ca was increased and leaf Mg was decreased in the third year of treatment (Figure 3), as with the Delicious. However, there was no effect on fruit Ca or Mg, or on fruit quality, during the first three years. Since these trees were larger than the Delicious trees at the time their experiments were established, it may be taking longer for the Ca to travel from root to

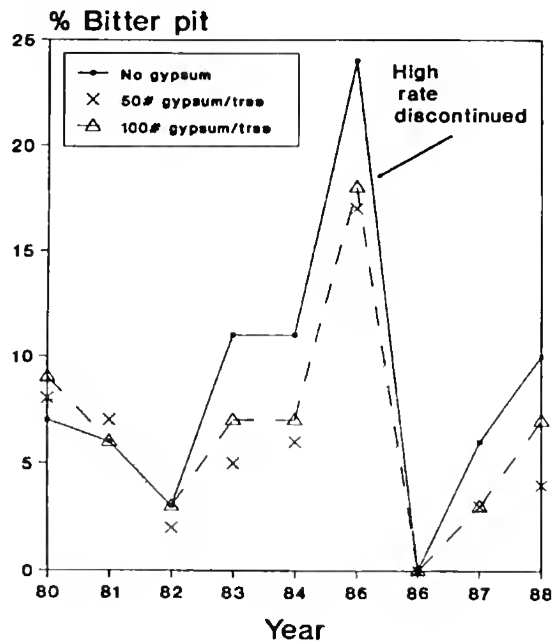


Figure 2. Effects of annual applications of gypsum on the percent of fruit having bitter pit after 6 months of storage in air at 32°F. Effects were significant in 1985, 1987, and 1988.

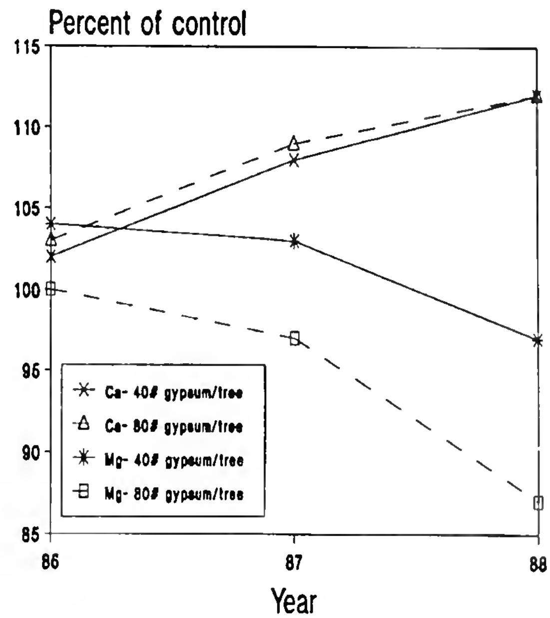


Figure 3. Effects of low (40 lbs./tree) and high (80 lbs./tree) rates of gypsum applications on leaf mineral composition of Cortland. There were no significant effects on fruit mineral composition.

Table 1. Effects of different rates of gypsum application on leaf and fruit mineral analyses. 1988. Treatments were begun in 1987 beneath 6-year-old Cortland trees on M.7a rootstock.

Treatment	Leaf			Fruit		
(lbs./tree)	Ca (%)	Mg (%)	K (%)	Ca (ppm)	Mg (ppm)	K (%)
0	1.23	0.26	1.34	122	388	0.54
8	1.32	0.25	1.28	138	320	0.51
16	1.40	0.25	1.40	147	334	0.55
24	1.35	0.22	1.34	142	313	0.50
32	1.46	0.25	1.30	155	337	0.53
40	1.46	0.24	1.31	144	330	0.52
48	1.43	0.23	1.34	147	325	0.52
Significance	***	*	ns	*	ns	ns

Significance: ***, odds of 999:1; *, odds of 95:1; ns, not significant.

fruit in these larger trees. We should have a better picture of effects when 1989 samples are analyzed.

A key experiment for us is the one in which different rates of gypsum are being applied, as it will help considerably in determining practical treatments. In only the second year of application to these young trees, results have begun to emerge (Table 1). Both leaf and fruit Ca levels were higher in the gypsum treatments than in the controls, with the hint that 16 lbs. per tree might be as effective as 48 lbs. per tree. Both leaf and fruit Mg were suppressed by gypsum, and neither leaf nor fruit K was affected by it. It will require several more years of data to establish response levels, but these results suggest that much lower rates of gypsum application than we have used in our previous experiments may be just as effective. These results also add to our view that tree size influences response time: fruit on these small trees responded in two years, while on the large Cortland trees, fruit did not respond in even the third year of treatment.

Effects on Soil Properties

It is important to know what effects the treatments are having on soil properties in order to judge long-term effects of gypsum applications.

In 1988, we analyzed soil samples taken to hardpan in April in both the Delicious block and the mature Cortland block. Only the results for the Delicious block are presented here (Figure 4), since the results from the mature Cortland block were nearly identical.

Gypsum greatly increased the exchangeable Ca in the soil throughout the entire soil profile. Thus, a huge reservoir of exchangeable Ca has been created on the treated soil. However, a shocking reduction of exchangeable Mg and K also occurred. It is surprising that the suppression of leaf and fruit Mg has been so small (Figure 1), and even more surprising that neither leaf nor fruit K has been affected by gypsum treatments. Apparently, in this soil, before treatment there was much more exchangeable Mg and K than was needed to feed the apple roots, but less Ca than is desirable for optimum Ca uptake.

There was no consistent effect of gypsum treatments on soil pH beneath the Delicious trees (Table 2). Similarly, there was no effect on pH beneath the mature Cortland trees (data not shown).

Discussion

In 1987 we cautiously concluded that gypsum treatments could improve fruit Ca levels and fruit quality. Two more years of data remove some of the caution from our conclusions.

It is evident that under our soil conditions, gypsum

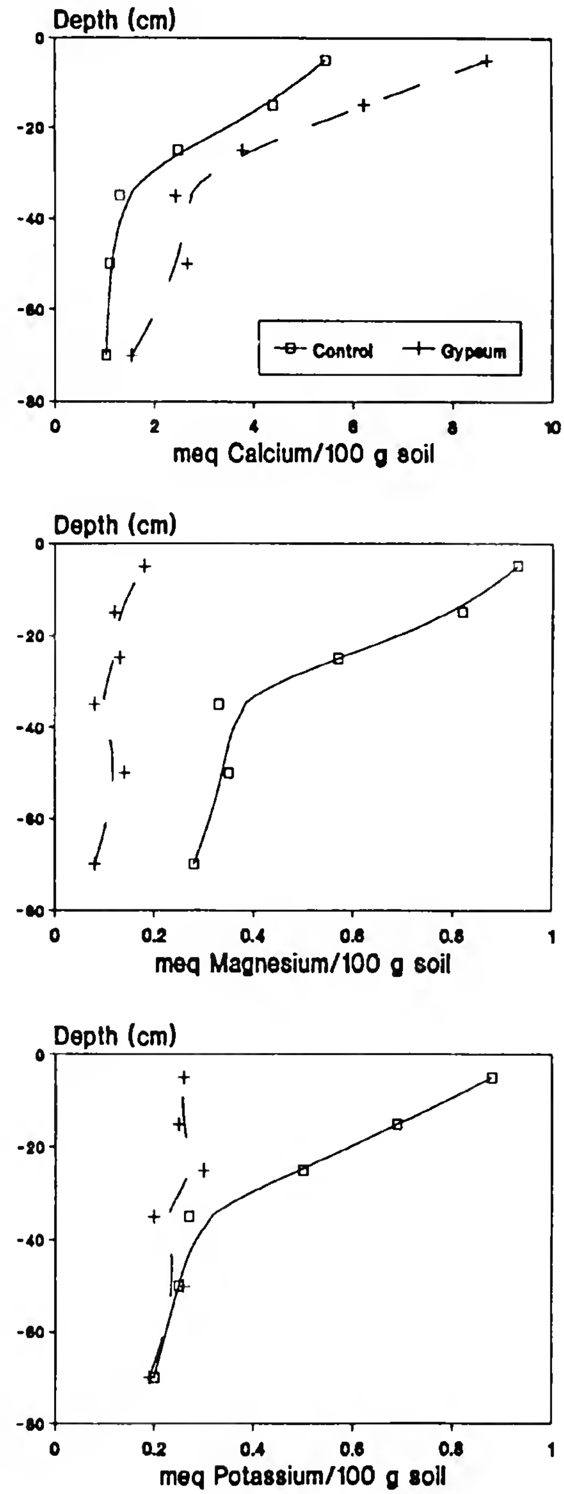


Figure 4. Effects of 8 years of annual applications of gypsum (50 lbs./tree) on exchangeable Ca, Mg, and K at different depths of Scituate fine sandy loam soil.

Table 2. Effects of eight years of annual applications of gypsum (50 lbs./tree) on pH of soil at different depths beneath Delicious apple trees.

Depth (cm)	Control	Gypsum
0-10	5.4	5.8
10-20	5.4	5.5
20-30	5.4	5.4
30-40	5.5	5.4
40-60	5.3	5.3
60-80	5.2	5.2
Mean	5.3	5.4

treatments can improve fruit Ca levels and fruit quality. It is also clear, however, that benefits are limited. Figures 1 and 2 convincingly demonstrate that only a relatively modest improvement can be achieved, but these Figures also show that a fruit grower can count on this level of benefit once treatment responses are established. Thus, it appears that gypsum treatments have a role in trying to control Ca deficiency in apples, but they are not a solution to Ca deficiency, a problem that is a part of modern apple production.

We are still far from knowing what is the optimum treatment of gypsum. It appears that we have applied much higher rates than needed in our experiments to date, but several more years of data will be needed to clarify this. Likewise, we cannot tell yet whether or not annual treatments are needed. Even though treatments greatly increased exchangeable Ca in the soil, one cannot assume that trees can continue to benefit from this after annual treatment ceases.

It is clear from these data that there is a long delay after gypsum is applied until the fruit begin to show increased Ca levels and improved quality. Results presented here suggest that at least two years are required, and that in large trees even three years may not be a long enough time. Responses of fruit to gypsum come slowly!

It is also clear that a price is to be paid for improved Ca levels in fruit: the reduction in leaf Mg. In the results shown here, the reduction was small and did not increase over time, although in Dr. Drake's original gypsum experiment, the reduction in leaf Mg became greater each year of treatment. The severe reduction in soil exchangeable K is also troubling. Perhaps in other orchards, leaf K might be reduced. There is also the possibility that some other element, such as manganese might be influenced by such large effects on soil chemistry. Thus, it is imperative that an orchardist who tries gypsum treatments employ a careful leaf analysis program to monitor the mineral nutrition of the trees.

It should be noted that gypsum is well known to improve the physical properties of soil, and in particular to improve water penetration. Thus, gypsum may help maintain good soil properties, especially in herbicide strips where soils can lose their structure over time.

It should be pointed out also that gypsum is not a substitute for lime, and vice versa. As seen in Table 2, gypsum did not change pH, so it did not change the liming needs of the soil. Gypsum is much more water soluble than lime, and quickly penetrates through the soil profile (Figure 4). Lime, in contrast, quickly affects only the soil area where it was applied, moving only very slowly down through the soil. If an orchardist is using gypsum, then liming should be done with only dolomitic limestone, to help offset the loss of soil Mg due to gypsum (Figure 4).

We cannot judge the economics of gypsum treatments from our experiments. At this point, we do not know what is the optimum rate of application, or whether or not annual treatment is required. Also, we do not know what is the most economical material to apply.

In our experiments, we have used mined, ground white gypsum, which is relatively expensive. There are other grades of mined gypsum, which, because they are not white, cannot be used in wallboard and thus are less expensive. Also, there are vast quantities of materials available at many power plants that are the result of purging smokestacks of sulfur emissions. A series of studies have suggested that these materials may be as effective as mined gypsum when applied to the soils. We have not used any of these materials, but they may be available at little or no cost other than transportation. Indeed, use in orchards may be a desirable way of disposing of such waste materials.

Clearly, many questions about use of gypsum or gypsum-like materials to improve fruit Ca levels remain to be answered. However, our results strongly suggest that treatments can produce consistent, albeit modest, improvements in fruit Ca and quality. Such treatments will not solve the Ca-problem in apples, but may be a part of the program needed to cope with Ca deficiency, which is such a general part of modern apple production.

Acknowledgement

We wish to thank Agway, Inc., Syracuse, New York, for their financial support during the course of these experiment.

* * * * *

Comparison of Slender Spindle and Vertical Axis Tree Training

Kathleen Williams
Washington State University

As the Pacific Northwest tree fruit industry moves into the 21st century, there will increasingly be an emphasis on improving orchard labor efficiency and fruit quality, as well as promoting early production. Labor for pruning and harvesting operations is, and will continue to be, the most expensive aspect of producing fruit. Improved labor efficiency depends on improved orchard design.

Large trees of the Pacific Northwest (PNW) central leader system pose significant problems in terms of orchard labor efficiency and fruit quality. We as an industry are looking to other orchard systems, primarily from western Europe, to improve our orchard efficiency.

Two promising systems, the slender spindle from the Netherlands and the vertical axis from France, are currently under test in Washington State. Both of these systems use a central leader tree with a supporting framework of laterals.

However, there are significant differences in pruning and training techniques for producing trees in either of these orchard systems in comparison with the PNW central leader system.

Slender Spindle

The slender spindle orchard system was developed in the Netherlands in the mid 1960's and has been refined throughout the past 20 years. The system was developed to optimize light interception and distribution throughout the tree canopy under the low-light conditions in the Netherlands. Furthermore, the trees had to be physically easy to train, prune, and maintain, because the Dutch labor supply depends on the local people. The trees also had to begin producing early to repay the high initial capital expenditure required and allow growers the option of replanting their orchards to newer, more profitable cultivars.

The slender spindle and vertical axis systems were developed and continue to be utilized primarily in the management of non-spur cultivars such as Golden Delicious.

The slender spindle tree is a pyramid-shaped tree that is always planted on a dwarfing rootstock, mainly M.9. Trees are supported with either a post or stake. Tree height is maintained at 6 to 7 feet, and tree spread is generally restricted to 3 to 3.5 feet in a single row design. Tree density is 1,000 trees or more per acre, depending on the tree spacing. (See Table 1.)

Training the Slender Spindle Tree

Year 1 – At Planting

A branched or "feathered" nursery tree is always preferable to a non-branched "whip" as planting stock, because production will occur at least one year earlier. The branched tree is headed 10 to 15 inches above the highest retained branch. If there are upright branches present which cannot be trained to a more horizontal angle, they are removed. Branches below 18 inches above the soil line are removed, because they will interfere with herbicide applications, and the fruit will be too low for convenient and clean harvest. If a whip is planted, it is headed 33 to 30 inches above the soil line.

Year 1 - Summer (First Leaf)

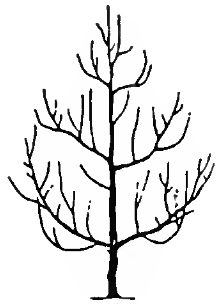
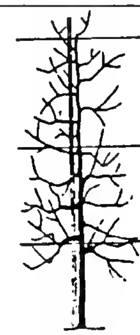
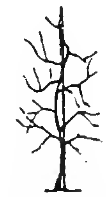
Vigorous branches are tied or weighted down to the horizontal with non-spur cultivars. For spur types, a less extreme horizontal angle is appropriate, e.g., 45 to 60 degrees. It is important with spur types not to train weak branches to a horizontal angle; the branches will be devigorated by fruiting and will eventually "runt out".

The optimum time for limb positioning, if tying or weighing down, is mid July to mid August. However, earlier improvement of branch angles with young shoots three to six inches in length can be achieved with clothespins or toothpicks.

Care must be taken to keep the terminal ends of the branches at a horizontal or slightly vertical angle; they should not be allowed to bend down, as this can cause excessive vigor in the lower portions of the branch. On spur types, extreme downward bending can be too devigorating.

The first summer is when most of the pruning is conducted on the young slender spindle tree. Vigorous

Table 1. Comparison of central leader training systems for non-spur apple cultivars (after Barritt, 1984).

	 PNW Head & Spread	 Vertical Axis	 Slender Spindle
Tree height	10-15 feet	10-14 feet	7-8 feet
Tree spread	7-10 feet	4-6 feet	4-6 feet
Spacing of single rows	16-20 feet	13-16 feet	10-12 feet
Tree density	200-400 trees/acre	450-800 trees/acre	700-1100 trees/acre
Rootstocks	M.26, M.7, MM.106 MM.111, seedling	M.9, M.26, M.7	M.9, Mark
Tree support	None	Pole & wires	Post or stake
At planting head the tree	Yes	Yes	Yes
Select 3-5 permanent lower scaffolds	Yes	Yes	Yes
Head leader in dormant season	Yes	No	No
Pruning of central leader after year 1	Head into 1-yr-old wood. To maintain height, cut to lateral.	No heading. To maintain height, cut to replacement leader.	Head to competing lateral on older wood.
Remove central leader to weaker side shoot in each dormant season	Yes	No	No
Head scaffolds in dormant season	Yes	No	No
Spread or tie down branches	Yes, 45°	Yes	Yes, to horizontal
Control limb length by cutting back into older wood	Yes	Yes	Yes, lower tier
Control limb length by removal to trunk	No	Yes, upper limbs, leaving a stub.	Yes, upper limbs, leaving a stub.

upright branches which compete with the leader are removed. The desirable branches to leave are weak and horizontal.

Year 2 – Dormant Pruning (First Dormant Season)

If summer training and pruning operations were conducted during the first growing season, very little dormant pruning is required. However, if vigorous branches or upright growth were not removed, now is the time to do this operation.

Vigorous growth should not be allowed to remain for two seasons; the growth and vigor of the leader and other lateral branches will be unbalanced.

The central leader is removed by heading into two-year-old wood to a competing lateral. An alternative method of central leader vigor control is to bend over the central leader the previous summer, then return the leader to the other side of the supporting post the following spring (May or June).

In this method, no heading cuts are made during the second winter. The leader of a non-spur cultivar should not be headed into one-year-old wood.

The scaffold branches for the lower permanent tier are selected; there are generally three to five permanent lower branches. Scaffold branches are NEVER headed into one-year-old wood, as this type of pruning cut is too invigorating. Also, heading cuts into one-year-old wood delay fruiting.

Year 2 – Summer Training and Pruning

As in year 1, limb positioning of lateral branches should be continued and undesirable growth removed. Proper limb positioning is critical for flower bud initiation and development. Growth which competes with the leader or is excessively vigorous should not be allowed to develop during the growing season.

Timing and techniques for training and pruning are the same as those for year 1 summer.

Year 3

The tree should be in commercial production by year 3 (third leaf), if a branched nursery tree was planted. Dormant and summer pruning utilize the same techniques as employed in the first growing seasons.

However, lower scaffolds will need to be shortened with the use of stubbing cuts into two-year-old wood. The leader will continue to be pruned to a replacement lateral or tied over as in previous years.

Continued pruning of the central leader to a competing lateral, which is then trained upwards results in a central leader with a zigzag shape. This zigzag configuration helps to reduce excessive growth in the top of the tree as the tree matures.

Year 4

By the fourth leaf, maintenance pruning is conducted. There are three major steps to remember:

1. Renew upper scaffolds: after a branch has fruited, it is generally removed completely, leaving a short stub.
2. Shorten lower scaffolds: head to a weak lateral on older wood. This is used to restrict the tree to its allotted space.
3. Control central leader growth: use either replacement pruning or tying down. After year 5, the central leader is generally controlled by cutting to a competing lateral on two-, three-, or four-year-old wood. Bending over the leader is not recommended.

The same principles as outlined above are employed throughout the life of the mature slender spindle orchard. Special caution is advised concerning the vigor of the tree, particularly at the top of the canopy. The growth **MUST** remain weak and must be continually renewed after fruiting.

If the top is allowed to become vigorous and dominant, the fruiting portion of the lower third of the tree is eliminated. All parts of the tree must receive light. Shading also reduces fruit quality.

The slender spindle system as described above is the "pure" system. Modifications will be devised to fit Pacific Northwest growing conditions. The higher light incidence and longer growing season in a desert climate, as compared to the Netherlands where the system was developed, will certainly mean that we must adapt the slender spindle tree for our needs and purposes. A taller slender spindle tree (eight feet) would utilize light efficiency under Pacific Northwest growing conditions.

It may be necessary to use more heading into one-year-old wood than the original slender spindle system allows. Treatment of the leader may be modified to light tipping on varieties such as Granny Smith, which may require more feathery growth at the top of the canopy, and tying, rather than heading, for devigoration.

Vertical Axis

The "axe centrale" or vertical axis tree training system was developed by Lespinasse in the 1970's. It is a central leader tree trained to a three- or four-wire trellis. Modifications of the trellis have been successfully employed, such as a one-wire trellis with bamboo stakes for individual tree support.

Generally, trees are 10 to 14 feet high, depending on the rootstock used, and about five to six feet wide. Rootstocks range from M.9 to MM.111 under French conditions, with MM.111 recommended for severe replant sites. Tree density ranges from 500 to 600 trees per acre.

Trees are usually planted in single rows, as opposed to the multi-row bed system used frequently with the slender spindle. The tree has a narrow pyramid shape, with an open (sparse) top. (See Table 1.)

Training The Vertical Axis Tree

Year 1 – At Planting

If unbranched trees ("whips") are planted, it is advisable to head the tree 30 to 33 inches above the ground to force lateral branching. Preferably, branched or feathered trees are utilized. As originally described, heading of the central leader is not done. It may be advisable to head the leader 10 to 12 inches above the highest retained branch. This type of heading cut encourages the development of a strong, permanent lower tier of branches. As with the slender spindle, branches that have poor angles, or that are lower than 18 inches above the soil line, are removed.

Year 1 – Summer

Limb positioning is an important aspect of tree training for the vertical axis. Weights and strings are most commonly used. In a non-spur cultivar, branches can be trained to the horizontal. For a spur type, a more moderate branch angle, i.e. 45 to 60 degrees, is advised.

Early summer pruning is an essential part of tree training. Branches that are overly vigorous with narrow angles are completely removed (thinning cuts) in May and June, when three to six inches long. In fact, if rigorous summer pruning is conducted, little or no dormant pruning is required the subsequent winter. (See Figure 1.)

The leader must be supported by tying it to the supporting pole. Plastic tubing and tape are commonly used. Nylon string is not advised, because of risks of girdling the leader.

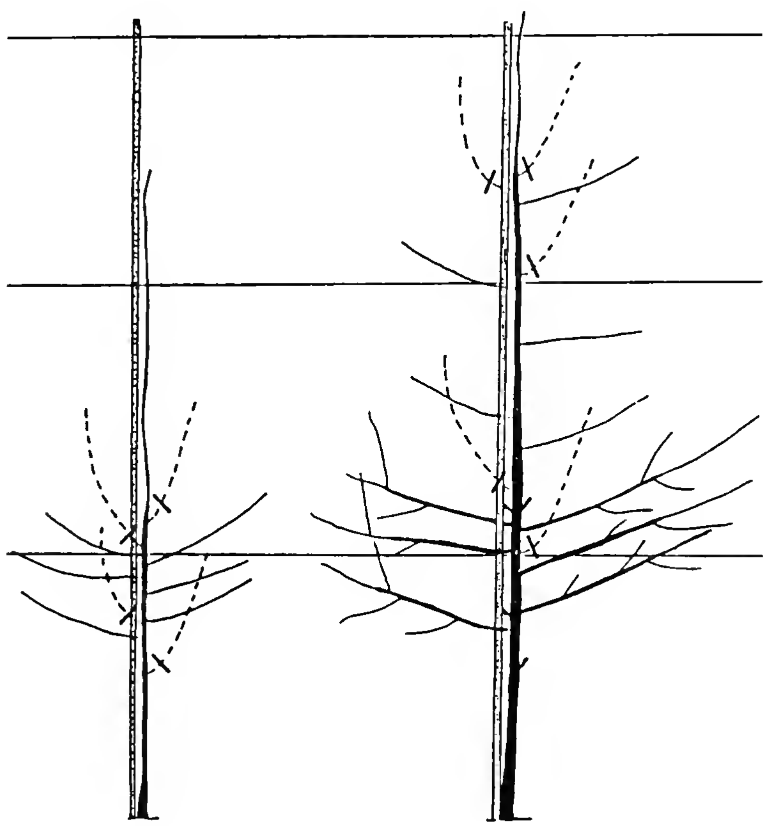


Figure 1. Do not allow vigorous growth to remain on the vertical axis tree. The most desirable wood to retain is weak and horizontal.

Year 2 – Dormant Pruning

No dormant pruning is required if summer pruning has been utilized. If no summer pruning was done, remove competing laterals, vigorous upright growth, low branches, and poorly placed growth. Do not head the leader.

Year 2 – Summer Training and Pruning

Tree training and pruning techniques are identical to those used for year 1. Caution: do not allow vigorous growth to remain on the tree. (See Figure 1.) The most desirable wood to be retained is weak horizontal growth.

Year 3 – Dormant Pruning

Remove uprights and vigorous branches. Do not head the leader. Very little pruning is required.

Year 3 – Summer Training and Pruning

As in the previous two summers, special attention must be paid to eliminate overly vigorous fruiting branches. In addition, the vigor of the top of the tree must be controlled. One of the easiest methods of controlling top vigor is to let the leader bend over above the point of central leader support with the weight of cropping. Later, the portion of the central leader above the support that has become pendulant is removed entirely. This process will likely be repeated in subsequent years. It is important to remove strong upright growth at the top of the tree; this growth can interfere with fruit bud formation in the bottom portion of the tree.

Year 4 – Dormant Pruning

The lower scaffolds are permanent branches and must eventually be shortened. Shortening to lateral branches is used to contain the lower scaffold branches to their allotted space. Also, the weight of the crop bends the branches downward, and so branches are pruned to promote a more horizontal growth habit. (See Figure 2.)

Vigorous growth is removed and replacement branches selected in the upper portion of the tree. If a branch has been fruited and requires replacement, an angled stub is made. (See Figure 2.) A new branch will emerge from adventitious buds and can then replace the old branch.

Pruning the mature vertical axis tree employs the same techniques as that of the slender spindle:

1. The lower permanent scaffold branches are shortened to weak lateral branches (preferably, fruiting laterals) to contain their length.
2. The upper two-thirds of the canopy receive renewal pruning. Fruiting laterals are not allowed to remain in the tree for more than three or four years. Constant renewal of the fruiting wood is critical to keep the mature vertical axis tree productive.
3. Light must reach every portion of the tree. If light is limiting, production will be affected. Special care must be taken to keep the top of the tree weak to prevent shading in the bottom section of the tree.

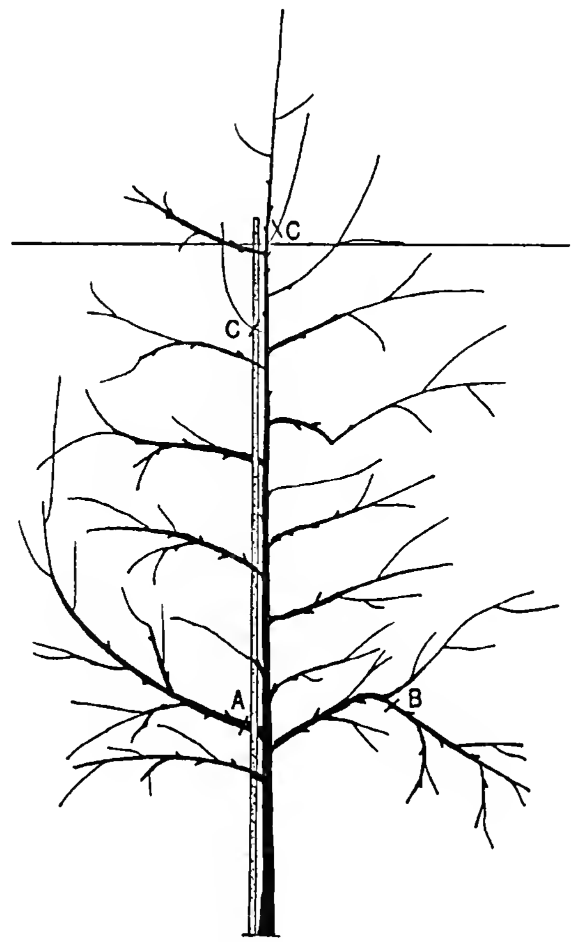


Figure 2. Vigorous growth is removed and replacement branches are selected in the upper portion of the vertical axis tree.

Summary

Both the slender spindle and the vertical axis training systems are central leader systems. There is a dependence on summer pruning for tree training (limb positioning) and a lack of heading into one-year-old wood. Renewal pruning and limb shortening are critical to the success of these systems.

The systems differ in how the central leader is handled. With the slender spindle tree, the central leader is headed into two-year-old wood (or older) to a replacement lateral which is tied upward to continue the central leader. In contrast, the vertical axis leader is never headed, except at planting.

Both the slender spindle and vertical axis systems will produce more quickly - if handled correctly - than the traditional PNW central leader system. In addition to earlier production, there is the advantage of improved labor efficiency.

Changing to high density systems in the Pacific Northwest will not be a matter of "if," but "when."

This article was reprinted from **Good Fruit Grower,** *June, 1989.*

* * * * *

News from Other Areas

Editors' Note: The following two items are reprinted from "Garden," *the Journal of the Royal Horticultural Society, London, England in their August, 1989, issue.*

Hope for National Fruit Collection

There is now more than a glimmer of hope about the future of the National Fruit Collection at the Brogdale Research Station in Kent, which is under threat from Government cutbacks. Having held the collection in the past, the Royal Horticultural Society is deeply concerned that the threatened closure of Brogdale may mean the loss of the world's largest collection of apple cultivars - an incomparable treasure trove of genetic material for breeders and nurserymen the world over.

Government ministers have now given a commitment to secure the future of the collection for a few years. What this entails is still uncertain and it is likely that the Collection will need to be moved over the next five years.

The Royal Horticulture Society was approached by the Ministry of Agriculture, Fisheries and Food to consider housing the Collection (apple cultivars in particular) at the Wisley RHS Garden in Surrey, and indicated that "it would be prepared to do this if the source of funding for the maintenance was secured." The Society already has 700 apple cultivars in cultivation at Wisley - a third of the Brogdale Collection.

Wye College, in Kent, offers another possible site and the College is keen to take responsibility for the National Fruit Collection - again provided adequate funding is available. Wye is remarkably well placed for the purpose. It is in the right location, has appropriate soils and has the space and expertise to maintain the Collection. The RHS would be happy to support the College in its application.

There remains the problem of raising the one million pound (about $1.5 million) endowment fund estimated to be required to safeguard the future maintenance of the Collection. It is vital to the future of the fruit-growing industry that this unique collection of world-wide importance is saved.

Survey of Old Apple Cultivars

The National Council for the Conservation of Plants and Gardens (NCCPG) is making a survey of old cultivars held in small collections and as individual trees in private gardens.

When completed it will be possible to assess which cultivars are in the greatest danger of becoming lost and where the greatest effort must be made to save them.

Initially all culinary and dessert cultivars (not cider) produced before 1900 are being listed. This list will be extended if necessary.

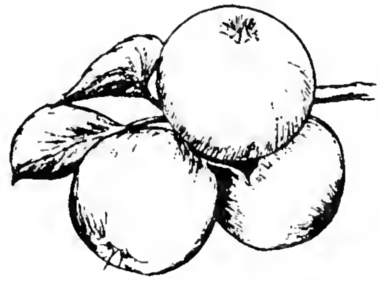
The NCCPG is asking for information from anyone who grows old cultivars. The information they need is:

1. The names and numbers of each cultivar held in collections or as individual trees.
2. Their approximate age.
3. The location.

If 'local' names only are known, please give these with a brief description of the fruit and its season of ripening.

As the Council anticipates a large number of replies it regrets that letters cannot be answered. However, if the survey reveals that certain cultivars are in a parlous state, the owners will be contacted with a view to providing propagating material.

Please send details to: Mr. S. F. Baldock, Fruit Collator for the NCCPG, Costrels, Eaton Bishop, Hereford. HR2 9QW. England.



Trends in the New England Apple Industry

Wesley R. Autio
Department of Plant & Soil Sciences, University of Massachusetts

New England fruit growers produce 7.8 million bushels of apples on 24,000 acres of land. Figure 1 shows the acreage planted to apples in each of the New England states. The size of individual orchards is generally larger in northern New England (ME, NH, VT) than in southern New England (MA, RI, CT) (Figure 2). In northern New England 75% of the crop is grown for a wholesale market; whereas, only 47% of the southern New England crop is sold wholesale (Figure 3).

In 1989 a survey was conducted to study the New England planting trends. (RI data are not included due to insufficient returns.) Figure 4 shows the percentage of each state's 1989 acreage planted before 1980, between 1980 and 1984, and between 1985 and 1989. The least planting has been done in Maine, with only 18% of

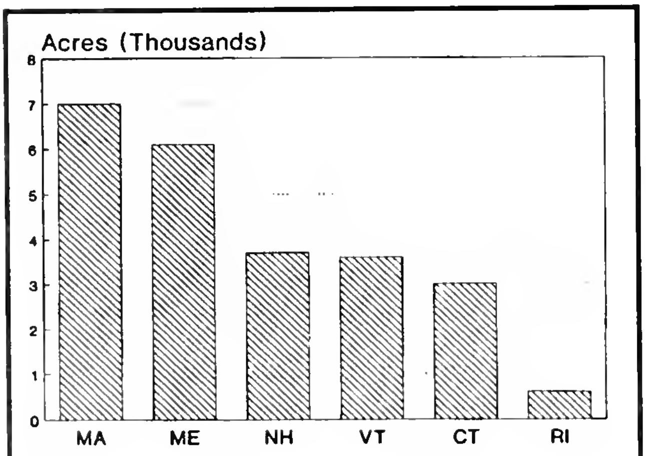


Figure 1. Total acreage of apple production in each New England state.

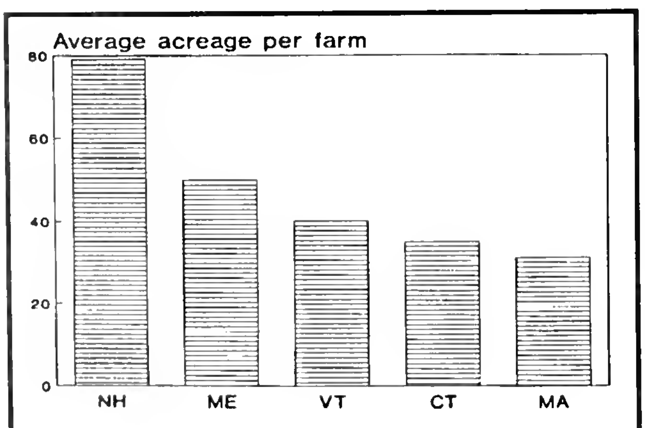


Figure 2. Average acreage per farm in apple production.

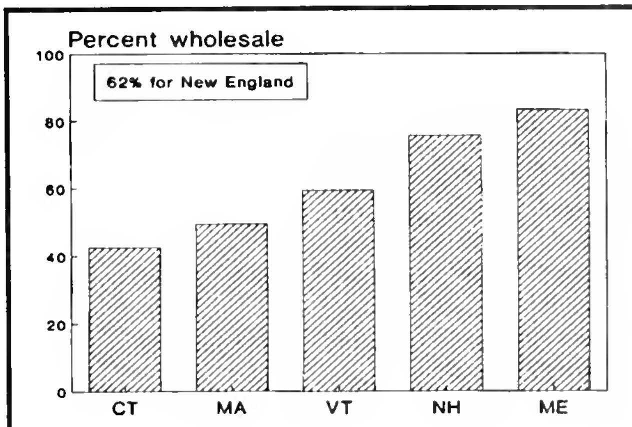


Figure 3. Percent of the annual production sold in a wholesale market.

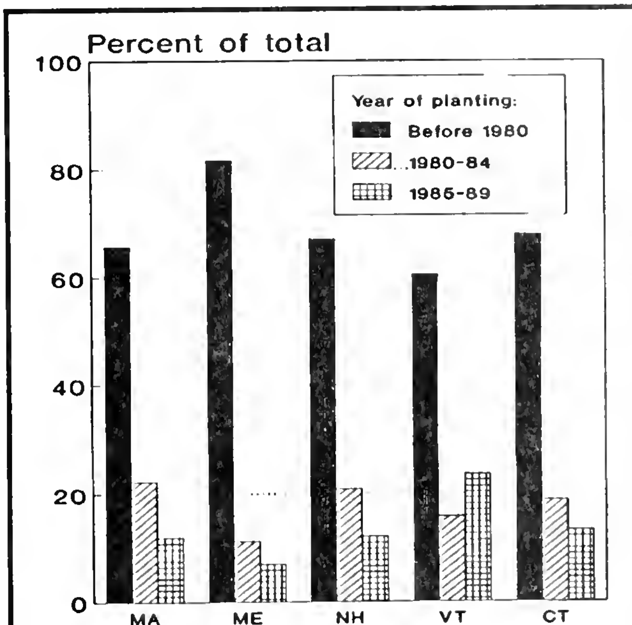


Figure 4. Percent of each state's total apple acreage planted before 1980, between 1980 and 1984, and between 1985 and 1989.

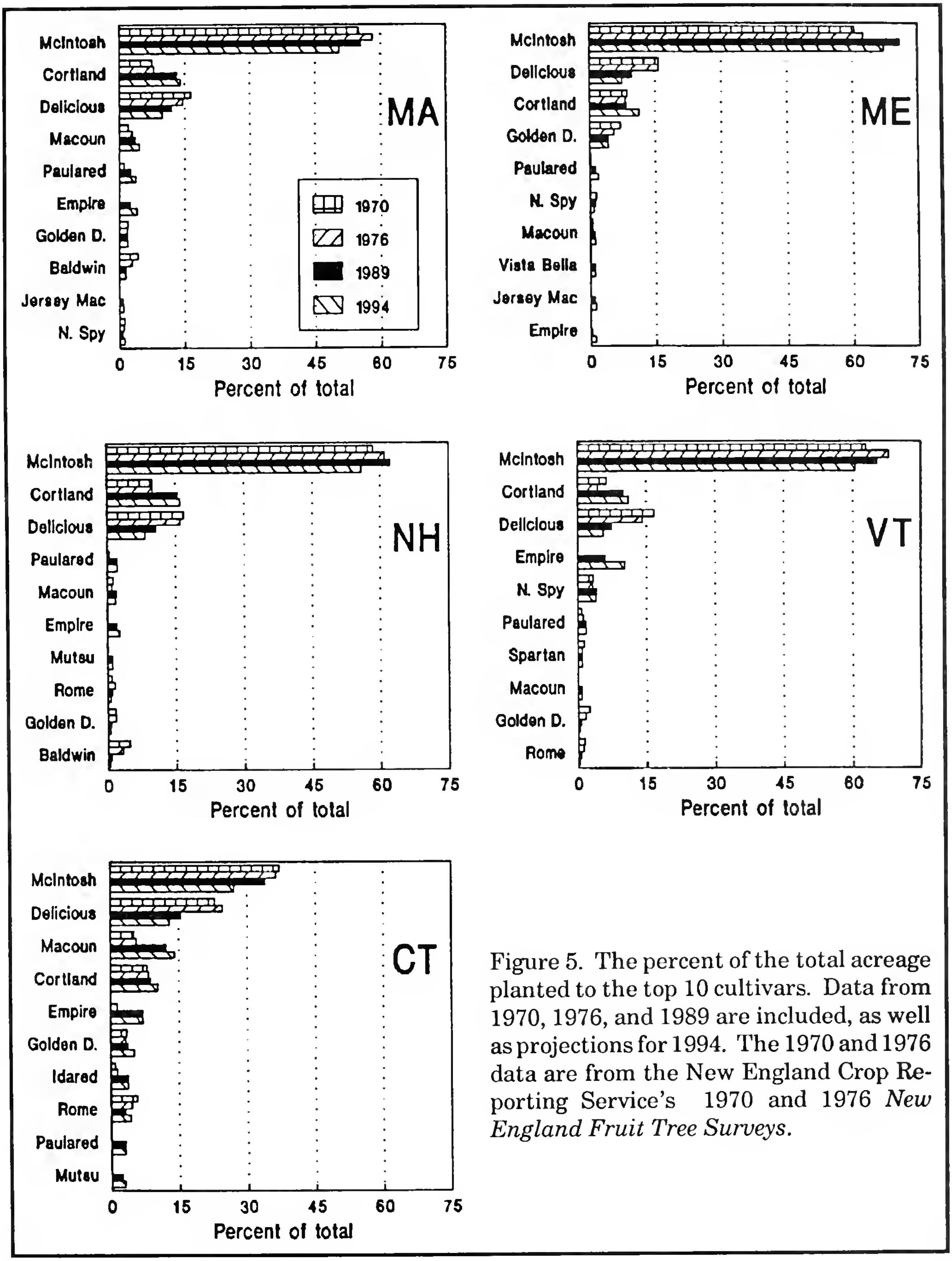


Figure 5. The percent of the total acreage planted to the top 10 cultivars. Data from 1970, 1976, and 1989 are included, as well as projections for 1994. The 1970 and 1976 data are from the New England Crop Reporting Service's 1970 and 1976 *New England Fruit Tree Surveys*.

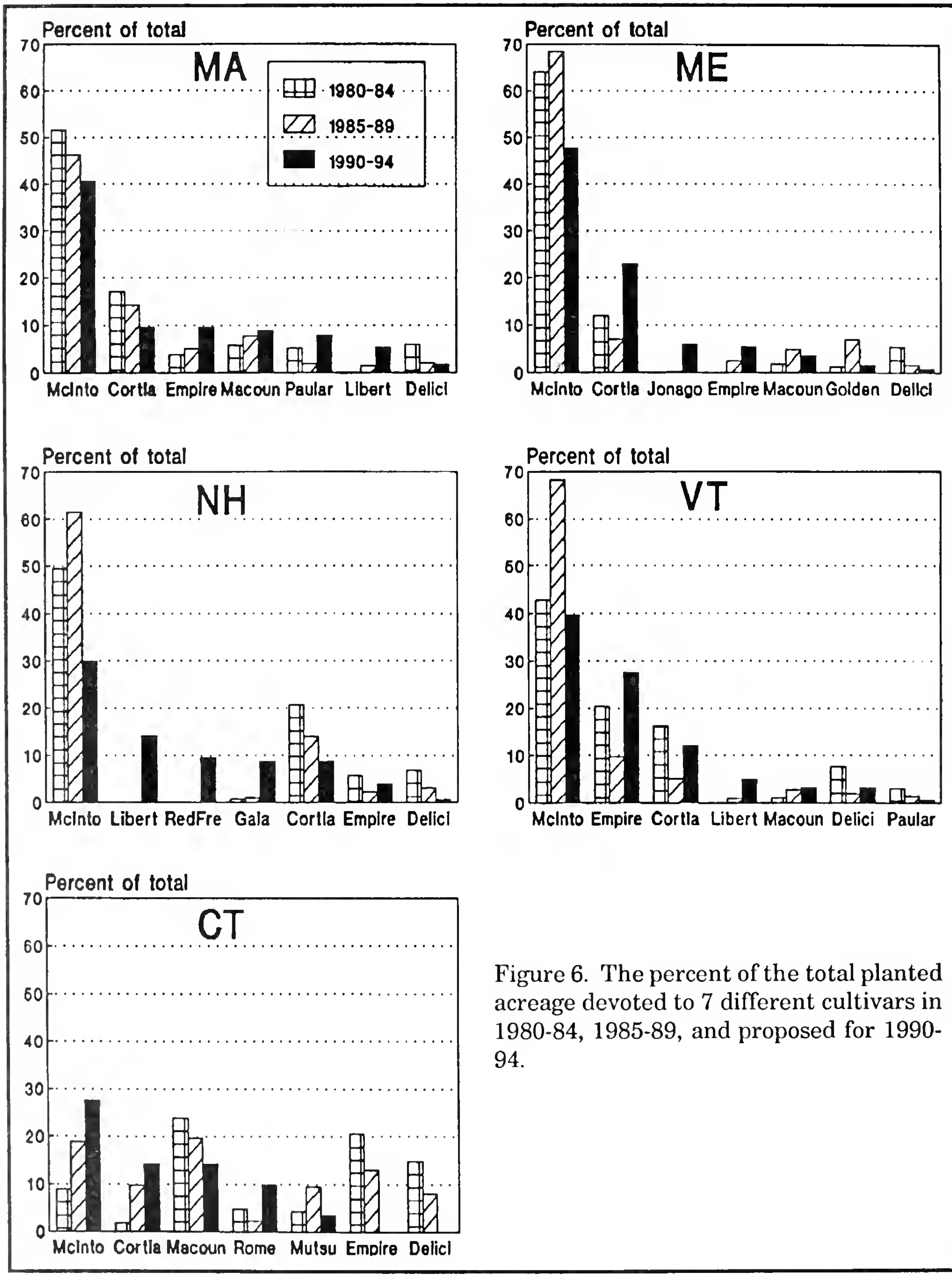
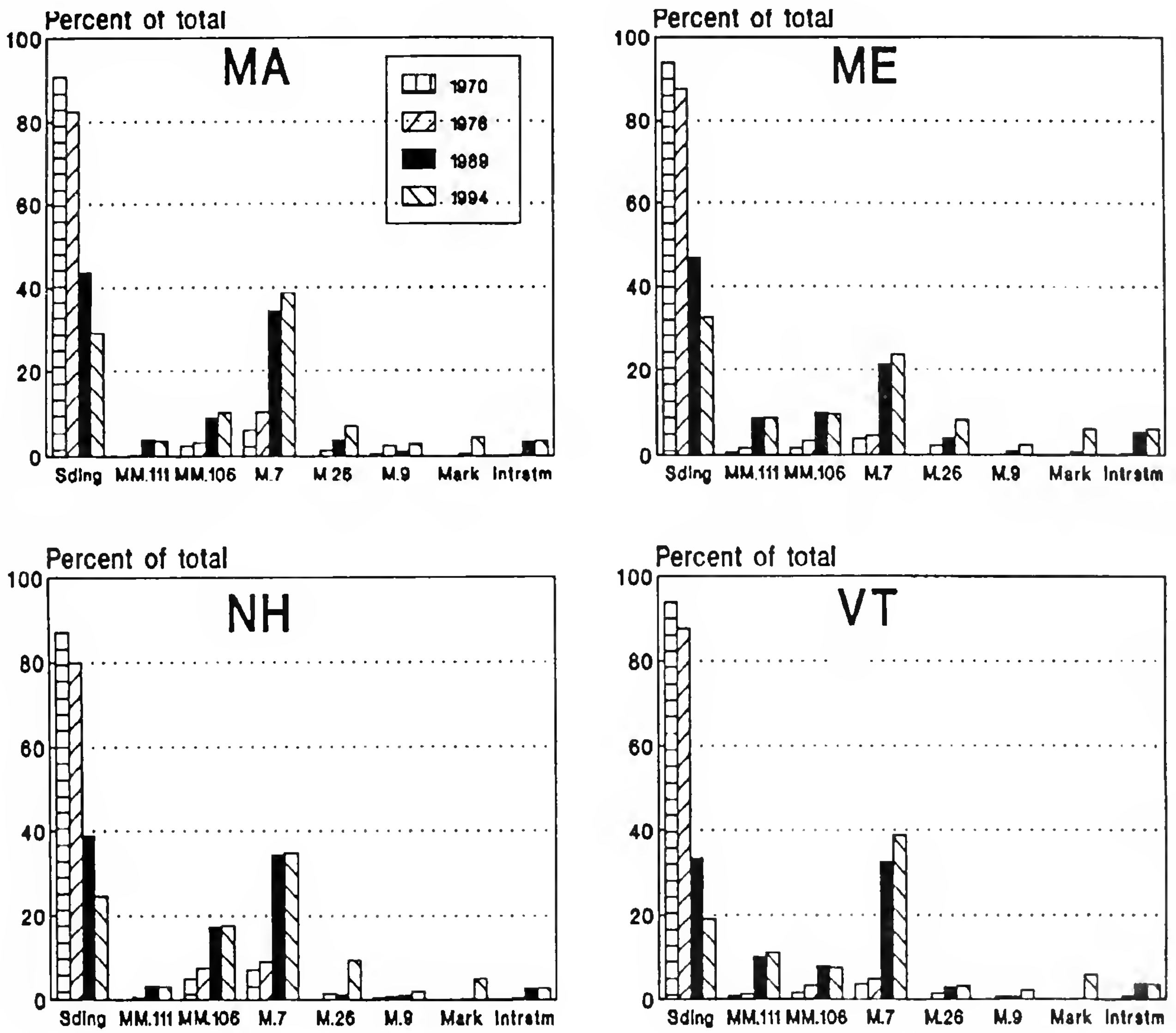


Figure 6. The percent of the total planted acreage devoted to 7 different cultivars in 1980-84, 1985-89, and proposed for 1990-94.



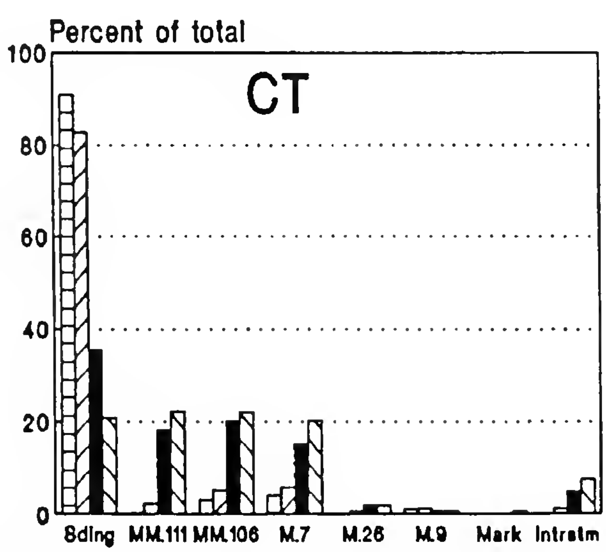


Figure 7. The percent of the total acreage planted to various rootstocks. Data from 1970, 1976, and 1989 are included, as well as projections for 1994. The 1970 and 1976 data are from the New England Crop Reporting Service's 1970 and 1976 *New England Tree Fruit Surveys*.

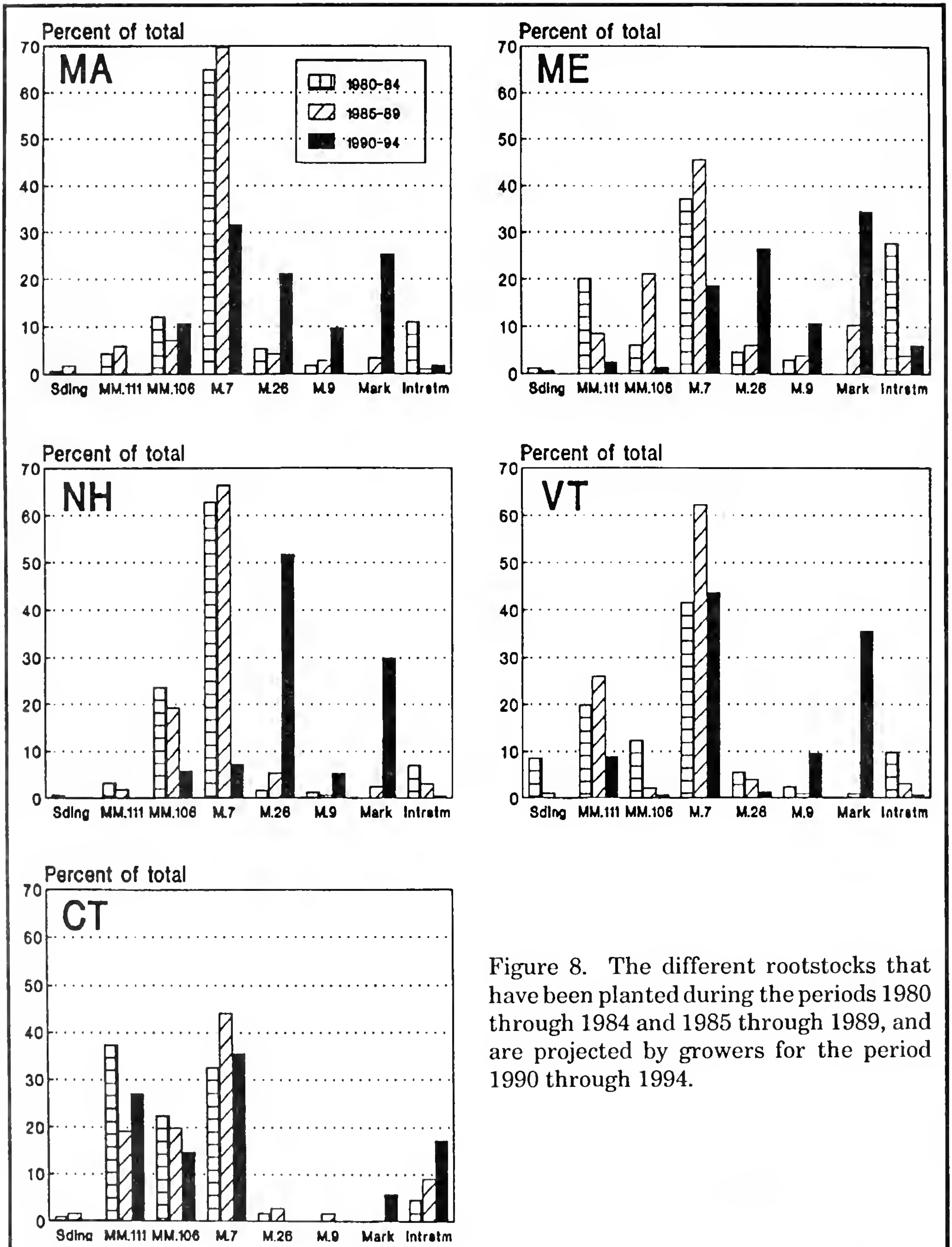


Figure 8. The different rootstocks that have been planted during the periods 1980 through 1984 and 1985 through 1989, and are projected by growers for the period 1990 through 1994.

the acreage less than 10 years old. Vermont, on the other hand, has 39% of its acreage less than 10 years old. Based on the intent of growers, as expressed in the survey, it is estimated that 16% of the acreage will be replanted in the next 5 years.

The primary intent of the survey was to determine cultivar trends. Figure 5 presents the top 10 cultivars in 1989 for each state. Also included are data for 1970 and 1976. A projection for 1994 is given, assuming that 70% of the trees removed will be McIntosh, 15% will be Delicious, 5% will be Cortland, and the remaining 10% will be small amounts of various other cultivars.

McIntosh alone accounts for about 58% of the acreage in New England and will continue to be the primary cultivar; however, it is likely that the acreage of McIntosh will decline in the next 5 years. Other important trends in these data are the dramatic decline of Delicious that has occurred and will continue to occur, and the increases of Cortland, Macoun, Empire, and Paulared.

Since a relatively small portion of the total acreage is planted each year, the data presented in Figure 5 do not give an accurate estimate of trends. Figure 6 gives the planting which occurred during the last two 5-year periods and is projected to occur during the next 5-year period. It is clear that in all but Connecticut the percentage of trees planted which are McIntosh will decline over the next 5 years. Delicious has declined dramatically as a percent of the total planting and will continue to decline. Liberty, Jonagold, Redfree, and Gala planting will increase substantially in the next 5 years. The disease-resistant cultivars alone will account for 10% of the planting during this time.

The percentages of the acreage planted to trees on various rootstocks are presented in Figure 7. In 1970 approximately 90% of all of the trees in New England were on seedling rootstocks. Now only 42% are on seedling roots, with M.7, MM.106, and MM.111 accounting for 47% of the acreage. The 1994 levels were projected assuming that 90, 2, 3, 4, and 1% of the trees removed in the next 5 years will be on seedling, MM.111, MM.106, M.7, and interstems, respectively. The amount of the acreage devoted to trees on seedling rootstocks will continue to decline, and the full dwarfing rootstocks (M.26, M.9, Mark, etc.) will account for significant portions of the acreage by 1994.

As with cultivars, overall levels do not give an accurate picture of trends, since only small portions of the acreage are replanted each year. Figure 8 shows the planting which has occurred over the last two 5-year periods and will occur over the next 5-year period. Since 1980, most trees have been on M.7, MM.106, and MM.111, accounting for 82% of the total. However, a dramatic change will occur during the next 5 years, with dwarfing rootstocks accounting for 62% of the planting. Mark and M.26 will account for 28 and 22% of the total, respectively.

The New England apple industry is experiencing a great deal of change. The decline in McIntosh and increase in other cultivars is certainly related to the loss of Alar™. An increase in the planting of disease-resistant cultivars is likely related to the broader concern about pesticides. The increased use of dwarfing rootstocks is somewhat due to the loss of Alar, but also may be related to an increasing interest in a smaller tree with the potential for higher profitability. It is clear that the New England apple industry is bracing for the future with these important and necessary changes.

* * * * *

Fruit Notes Founder Dies

Wilbur H. Thies, Professor Emeritus, University of Massachusetts, died July 29, 1989. He was born in Leland, Michigan, October 24, 1892. He graduated with a B.S. degree in 1919 and a M.S. degree in 1925 from Michigan Agricultural College (now Michigan State University). In 1924 he joined the Horticulture Department at Massachusetts Agricultural College (now University of Massachusetts) as Extension Horticulturalist. In July, 1935 he founded *Fruit Notes* and continued to write for and edit it until his retirement from the University on February 1, 1955. Memorial services were held September 30, 1989 at the North Congregational Church of Amherst, Memorial gifts may be made to one's favorite charity.

Advancements in Second-stage Apple IPM: Improving the Attractiveness of Baited Red Spheres

Ronald J. Prokopy, Jian Jun Duan, Patricia Powers, and Max P. Prokopy
Department of Entomology, University of Massachusetts

We previously reported [*Fruit Notes* 54(1):1-5] on results of the second year of our pilot second-stage apple IPM program in Massachusetts commercial orchards. One of the major elements in second-stage IPM is the use of red spheres baited with synthetic apple odor for intercepting immigrating apple maggot flies at the orchard perimeter. We concluded that before such an interception system for maggot fly control could become broadly successful on a commercial level, some improvements would be needed. One improvement might be enhancing the attractiveness of spheres to apple maggot females, to ensure better capture of a high proportion of females flying from border areas onto apple trees at the orchard perimeter. Here, we describe results of 2 studies conducted in 1989 toward this goal.

The first study involved evaluating different sizes of unbaited red spheres. More than a decade ago [*Fruit Notes* 41(6):6-9], we found that spherical shape (mimicking apple shape) was more attractive to maggot flies than cubical, cylindrical, or rectangular shape. We also discovered that red and black spheres were equally attractive as colors and more attractive than green, orange, yellow, or white spheres. We chose to use red spheres over black ones to permit better vision of a captured maggot fly. Finally, we found that 8-cm-diameter red spheres were more attractive than spheres of 4,6,15,23,30, or 45 cm in diameter. Here, we wondered if there were any sphere size between 8 and 15 cm that might be more attractive than the 8 cm size.

We purchased softballs (10 cm), toy balls (14 and 18 cm), and volleyballs (23 cm), painted them the same red color as our standard 8 cm croquet balls, coated them with sticky, and hung them in non-sprayed fruiting apple trees harboring a low population of apple maggot flies. Foliage and fruit within 10 cm of the sphere surface were removed. Periodically, the spheres were rotated to provide equal time for each size at each position.

Although the low fly population precluded substantial fly captures, the results (Table 1) do nonetheless indicate a consistent pattern of greater captures of females on 8 cm spheres than on spheres 10 cm or larger in size. Other recent studies we have carried out indicate that apple maggot female response to fruit of different sizes is partly under genetic control and partly a learned response based on recent experience with fruit of a particular size. From our results here, it appears that if an apple or a red sphere mimicking an apple is larger than 8 cm, neither genetic-based nor learned behavior of females confers strong attraction.

Table 1. Total apple maggot females captured on unbaited sticky red spheres of different sizes hung in unsprayed fruiting apple trees (July 27-August 8, 1989).

Size of sphere (cm)*	Experiment 1	Experiment 2	Experiment 3
8	7 a	9 a	11 a
10	0 b	7 ab	8 a
14	1 b	3 b	-
18	1 b	-	-
23	0 b	-	-

*No. replicates per experiment: Expt. 1 = 5; Expt. 2 = 8; Expt. 3 = 8. Values not followed by the same letter are significantly different at odds of 19 to 1.

Perhaps apples and red spheres increasingly larger than 8 cm decreasingly have the appearance of fruit in the eyes of flies whose native host is hawthorn fruit, which are only 1.5 to 2.0 cm in diameter.

The second study involved evaluation of different numbers of vials containing synthetic apple odor placed at different distances from 8 cm sticky red spheres. At the New York Agricultural Experiment Station in Geneva, where Anne Averill, Harvey Reissig, Wendell Roelofs, and others showed butyl hexanoate to be the principal component of apple odor attraction to apple maggot flies, liquid butyl hexanoate has been used to monitor fly populations by putting it into small (2-dram) polyethylene vials seated in wells drilled into 8 cm red spheres. The liquid is absorbed by the wall of the vial, which then releases about 700 apple equivalents of the odor per hour. In the first 2 years of our pilot second-stage apple IPM program, we placed such a polyethylene vial containing butyl hexanoate about 15 cm to the side of each 8 cm sticky red sphere hung on perimeter apple trees. However, recent research conducted by graduate student Martin Aluja of our laboratory suggested that a polyethylene vial releasing 700 apple equivalents of butyl hexanoate per hour may arrest or even repel apple maggot flies that move too close to the vial. We were therefore interested in determining the optimum density and distribution of polyethylene vials (containing butyl hexanoate) that would confer high fly attraction to the vicinity of a red sphere but not adversely affect the propensity of an arriving female to alight on the sphere.

Our test was carried out in Clarkdale Orchard, West Deerfield, MA, which harbored a moderate population of apple maggot flies on a mixture of Early McIntosh and Gravenstein test trees. We placed no more than 1 sphere in each tree. Using wire, we positioned either 0,1,2, or 4 2-dram polyethylene vials of butyl hexanoate 15,30, or 60 cm to the side of a sphere. Where more than 1 vial per sphere was used, vials were distributed evenly around the sphere. Periodically, the vials were rotated from tree to tree to provide equal time for each treatment at each position.

The results (Table 2) indicate that 2 vials of odor placed 30 cm to the side of a red sphere gave rise to a 50% greater capture of apple maggot females than vials at any other density or distribution. Use of 2 or 4 vials per sphere invariably led to greater female captures than 0 vials or 1 vial at an equivalent distance. Thus, butyl hexanoate used in conjunction with red spheres led to increased capture of apple maggot females, but too great an amount too close to a sphere reduced fly captures, possibly through arresting or repelling effects.

For future employment of red spheres to intercept apple maggot flies on perimeter apple trees under second-stage IPM, we will continue to use 8 cm spheres but will now bait each sphere with two 2-dram polyetheylene vials of butyl hexanoate 30 cm from (and on opposite sides of) each sphere, instead of a single vial 15 cm from a sphere.

Table 2. Total apple maggot females captured on 8 cm sticky red spheres hung in fruiting apple trees in a commercial orchard and baited with different numbers of 2-dram polyethylene vials containing attractive apple odor (butyl hexanoate) at different distances from the side of a sphere (July 21 - August 3, 1989).

Distance of vials from sphere (cm)*	Number of vials around each sphere: 0	1	2	4
15	47 b	70 b	92 b	78 b
30	67 b	66 b	149 a	92 b
60	70 b	83 b	96 b	101 b

* Four replicates per treatment type. Values not followed by the same letter are significantly different at odds of 19 to 1.

ACKNOWLEDGMENT. We thank the Northeast Regional Project on Integrated Management of Apple Pests (NE-156) for supporting this work.

* * * * *

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