A Note from the Editors

Fruit Notes has been published for 63 years by pomologists at the University of Massachusetts (actually at the Massachusetts Agricultural College in the beginning). During these years, it has evolved considerably but always has focused on issues of importance to fruit growers. Today's subscribers live primarily in New England, but many are from other tree-fruit-producing states and several other countries.

With this issue, the first of its sixty-fourth year, *Fruit Notes* is embarking on new and exciting changes. First, the cover is redesigned, but most importantly it is becoming *Fruit Notes of New England*. We hope to have regular contributions from individuals in the other New England states.

Within the articles, the first evidence of this change is the discussion written by Jan Nyrop on the use of mite predators. This paper, although not written by a New England author, was presented at the 1999 Annual Meeting of the Maine State Pomological Society. In fact, *Fruit Notes* subscription will be a benefit of membership in the Maine State Pomological Society, and *Fruit Notes* will publish papers presented at meetings of the Society.

The editors are excited about these changes and hope that they result in a significant improvement in the quality of this publication. If you have any questions or comments, please contact us at the address provided inside the cover.

Making Integrated Mite Control Work in Northeast Apple Orchards

Jan P. Nyrop
Department of Entomology, Cornell University, NYSAES, Geneva, New York

European red mites (ERM), *Panonychus ulmi*, feed on leaves of apple trees and thereby interfere with photosynthesis and production of carbohydrates. At high levels, ERM damage to apple leaves reduces fruit yield and quality. As a general rule, keeping ERM numbers below 2.5 per leaf before July, below 5 per leaf during July, and below 7.5 per leaf in August will prevent economic losses from this pest.

Three strategies can be used to control ERM in apple orchards. First, protectant miticides (e.g., dormant oil or an ovicide) can be applied early in the growing season. Second, pest mite numbers can be monitored and miticides applied if densities exceed threshold levels. Third, natural enemies that feed on ERM can be encouraged and managed to constrain pest mite numbers. Strategies based solely on miticides are relatively expensive and eventually lead to the development of resistance by ERM to the miticides. With the help of natural enemies, the cost of managing ERM in apples can be greatly reduced and resistance delayed.

Insect and mite predators, including several species of phytoseiid mites, stigmaeid mites such as *Zetzellia mali*, and ladybird beetles, feed on ERM. Phytoseiid mites are the most effective of these predators in the Northeast. Several species of phytoseiid mites, including *Amblyseius fallacis, Typhlodromus pyri, T. occidentalis, T. vulgaris,* and *A. cucumeris*, can be found in commercial orchards. Species cannot be identified in the field because they are so similar in appearance. They are only distinguishable through microscopic examination of the arrangement of the setae (hairs) on their bodies. *T. pyri* and *A. fallacis* are the two most common species in Northeast orchards. Of the two, *T. pyri* is better able to regulate ERM populations. This is the species that should be established and maintained for biological mite control in Northeast orchards. In this article I answer three questions: First, why is it that *T. pyri* is such an effective predator? Second, is *T. pyri* an effective predator throughout the northeast? Third, how can you make use of this natural enemy to provide cost-free mite control?

Why is *Typhlodromus pyri* such an effective predator? For many years *A. fallacis* was promoted as an effective biological control agent for ERM. In truth, *A. fallacis* gives sporadic and unreliable ERM control, while *T. pyri* is highly effective in this capacity. Differences in effectiveness of *T. pyri* and *A. fallacis* as biological control agents are rooted in their biologies.

T. pyri require approximately 32 days to complete a generation, and have three to four generations per year. They overwinter as mated adult females on trees wherever they can find a protective site (e.g., bark crevices, branches, spurs). Adult females emerge from overwintering sites on warm spring days before budbreak. The adults live about 20 days and lay an average of 20 eggs starting as early as tight cluster or pink bud growth stages. Eggs are usually laid on the undersides of leaves along the midrib. The eggs hatch in 1-3 days and resulting immatures are nearly transparent and look like smaller versions of the adults. Immatures and adults feed on a wide variety of food sources, including pollen and rust mites, along with ERM and two-spotted spider mites (*Tetranychus urticae*). An adult female will consume one to two ERM adults or three to four ERM nymphs per day. These predators do not concentrate on leaves with large numbers of ERM, unlike some other phytoseiids (e.g., *A. fallacis*). *T. pyri* are relatively winter hardy and remain in the tree even when ERM are scarce, feeding on alternative food sources.

A. fallacis require 16 days for each generation, with four to six generations per year. These phytoseiids may also overwinter as adults in trees if prey are available to feed on in late summer and early fall; otherwise, they disperse from the trees and overwinter in the ground cover. Occasionally, they can be found in trees when ERM eggs start to hatch just before bloom, but are usually scarce until mid-July because of high winter mortality or lack of ERM as a food source before bloom. Adult *A. fallacis* lay twice as many eggs as *T. pyri*, immatures and adults consume nearly a third more ERM per day than *T. pyri,* and immatures develop into adults in a third of the time required by *T. pyri*. *A. fallacis* feed mainly on spider mites. Therefore, when prey mite numbers are low in the trees, *A. fallacis* will disperse out of the trees to locate another food source, possibly in the ground cover. *A. fallacis* are more effective at reducing high red mite populations than *T. pyri*, but this is often after ERM have done considerable damage to the leaves.

Based on generation time, oviposition rate, and prey consumption, it would appear that *T. pyri* is a less effective biological control agent than *A. fallacis*. But the advantages *T. pyri* has over *A. fallacis* are its greater winter hardiness, its use of alternative food sources when ERM are not present, and its tendency to remain in trees when ERM are scarce. When ERM numbers are low, *T. pyri* will stay in the tree canopy feeding on pollen and rust mites, and will continue to be a presence as ERM numbers start to rise.

Because *A. fallacis* are often absent from trees or are in very low numbers in trees in early spring, ERM often build to damaging levels before *A. fallacis* exercise control. *T. pyri* will consistently maintain ERM populations at low levels provided these predators are conserved. *T. pyri* usually cannot control ERM populations in excess of five to seven per leaf, and it can take 2-3 years for sufficient numbers of *T. pyri* to build in an orchard to realize biological control. Once predators are established, the benefits are great as the need for miticides can be eliminated.

Data from an orchard at the New York State Agricultural Experiment Station into which *T. pyri* were released into two blocks of Delicious trees will serve to illustrate the effectiveness of this predator. In this orchard, no miticides were used since 1991, fungicides have consisted of captan and Nova, and pesticides have been restricted to Imidan, Sevin, Bt, and Provado. Dynamics between *T. pyri* and ERM were measured between 1992 and 1997. Results are summarized in Table 1. Since 1992 ERM numbers have been kept well below threshold levels (500 mite days) and predator numbers have steadily increased. Averages shown here are the average of temporal counts from June 1 to September 1.

Is *Typhlodromus pyri* an effective predator throughout the northeast? Yes! Until recently, *T. pyri* was thought to be common in eastern north America only in central and western New York and Nova Scotia. Therefore, in 1996 we embarked on a project with cooperators in all the New England states to introduce and establish *T. pyri* throughout this region. There is no apparent reason why *T. pyri* should not survive and thrive

Table 1. Summary statistics for European red mite (ERM) and *Typhlodromus pyri* in two orchard blocks at Geneva, NY. Numbers are density per leaf.

Parameter	1992	1993	1994	1995	1996	1997
Maximum ERM	2.1	0.2	3.6	1.8	1.9	1.53
Mite days[a]	68	7	63	25	30	39
Average ERM	0.8	0.08	0.7	0.3	0.3	0.5
Minimum *T. pyri*	<0.1	0.2	0.1	0.3	0.1	0.1
Maximum *T. pyri*	0.1	0.9	0.6	1.4	1.9	2.8
Average *T. pyri*	0.02	0.5	0.3	0.9	1	1.3

[a] Mite days is the cumulative density of mites. The damage threshold is 500 mite days.

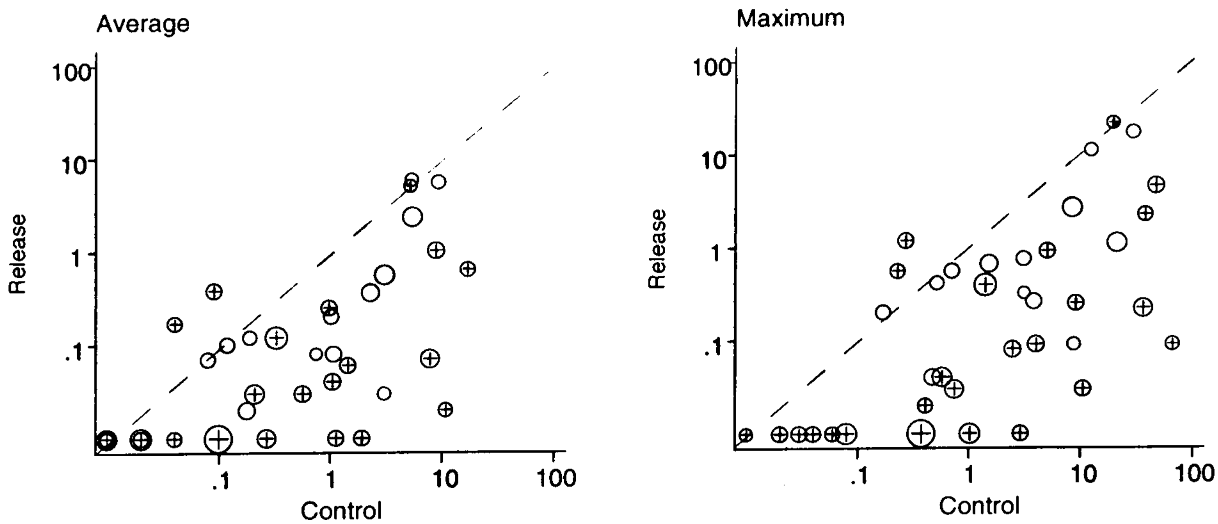


Figure 1. Average and maximum European red mite densities in 1998 in plots where *T. pyri* were released in 1996 and in control plots where *T. pyri* were not released

throughout the northeast. Possible abiotic limits are winter cold, summer heat, and low moisture during the summer. However, a review of historic climatic data raises no red flags. *T. pyri* aggregate in flowers in the spring to feed on pollen. Therefore, to collect predators for release, we collected flower clusters from an orchard at the Experiment Station and shipped these clusters with predators within to cooperators who then affixed the clusters to recipient trees. Each release site consisted of a plot of six trees into which the predators were placed and a plot of six control trees. In early July we also shipped leaves with predators on them from the same orchard. These leaves were affixed to the target trees. To measure the effectiveness of the releases, leaves were collected from the release and control sites and shipped to Geneva. There, predators were collected from the leaves and identified. In 1996 releases were made at 40 locations.

In 1996 *T. pyri* were recovered from 38 of the release plots and 16 control plots. In 1997 these numbers had changed to 36 and 19. In 1997, releases were made at two additional sites. In 1998, *T. pyri* were recovered from 38 of 38 release plots and from 33 of 38 control plots! The number of control sites where *T. pyri* were found was surprising. In both 1996 and 1997 the average number of *T. pyri* in the control plots was more than 10-fold lower than in the release plots. In 1998, this difference had to changed to only two-fold lower in the control plots. These results indicate that *T. pyri* can persist throughout the northeast and are likely indigenous.

Of course the most important question is whether these predators had any impact on ERM numbers. Shown in Figure 1 are the average and maximum ERM densities in the control and release plots 1998. The average density is the average over the sampling period which generally ran from late May to mid August. The size of the symbols in these figures represent average *T. pyri* densities and data points with a cross hatch represent sites where we predicted biological control would occur. These predictions were based on *T. pyri* and ERM densities in 1997. Where biological control was predicted to occur, no oil or ovicide was applied in 1998 for ERM control in the release plots. The dashed lines in the two graphs indicate where the data points should lie if there were no differences between ERM densities in control and release plots. European red mite were generally much more abundant in the control plots than in the release plots. Of the

26 sites where biological control was predicted to occur, at only one site was this prediction in error and this occurred because *T. pyri* were inexplicably low in number for much of the growing season.

How can *T. pyri* be used to provide cost-free mite control? Achieving biological mite control using *T. pyri* is minimally a one-step process and may require two steps. First, an environment must be established in the orchard that will allow *T. pyri* to survive and flourish. This requires that pesticides that are toxic to these beneficial mites not be used. Second, if *T. pyri* are not already present in the orchard, they must be introduced.

<u>An environment conducive to *T. pyri*</u> *T. pyri* have acquired resistance to some chemical pesticides used in commercial orchards and are innately tolerant of others. However, some pesticides are quite toxic to *T. pyri*. If biological mite control is to be achieved using this predator, these toxic materials must be avoided. Because *T. pyri* are resident in trees year round, and because these predators have a relatively slow growth rate, pesticides toxic to *T. pyri* cannot be used even intermittently (e.g., every other year) without serious disruption to biological control. A list of pesticides that can be used to control insects and diseases of apple while conserving *T. pyri* is provided in Table 2. Be advised that estimates of toxicity to *T. pyri* were obtained using predators from western NY, and there may be differences in susceptibility among predator populations indigenous to other regions of the Northeast.

<u>Introducing *T. pyri* into an orchard</u> There are situations where *T. pyri* might not be present in an orchard or where they are very scarce. This deficiency can be overcome by moving predators from an orchard where they are known to occur to a recipient site. Because phytoseiid species cannot be identified in the field, it is important that you be sure the source predators are, in fact, *T. pyri*. The best way of ensuring this is to have someone identify them for you. If this is not possible, you can be reasonably sure the predators are *T. pyri* if either of the following conditions are met: 1) The predators can be found in the trees either before or just after bloom and the predators are easily found even when ERM are scarce. 2) The predators in the source orchard were themselves introduced as *T. pyri* one or more years ago, and no pesticides harmful to *T. pyri* have been used since the introduction.

T. pyri can be moved from a source orchard to a recipient orchard in one of four ways, each of which is described below. It is best to concentrate inoculation material in the recipient orchard rather than spreading it thinly over a site. If the predators are spread thinly, few animals may be introduced into each tree, which may allow for extinction of the populations. Once *T. pyri* are established in the receiver trees, they can be spread further in subsequent years. While *T. pyri* do disperse by themselves, assisting this process will hasten biological control throughout the planting.

The first method of moving *T. pyri* from one orchard block to another is to place wood pruned from a source orchard in winter or early spring into a recipient orchard. Because *T. pyri* overwinter as adult females, prunings harbor predators, although numbers in each section of pruning are highly variable. We suggest placing all the prunings from one tree into another tree. It is probably not effective to simply spread the prunings beneath recipient trees. Pruned wood need not be placed in the recipient trees immediately after pruning, but should be placed there before or just when trees begin to produce green tissue the following spring.

The second method consists of transferring flower clusters from a source orchard to a recipient site. *T. pyri* move into flower clusters at tight cluster and remain there through bloom, probably to feed on apple pollen. As many as two to three predators can be found in each flower cluster and surrounding leaves. To transfer predators in this manner, at least 20 flower clusters (and associated wood and leaves) should be placed in each recipient tree. The flower clusters are easily attached with paper clips, staples, or twist ties. Flower clusters may be stored for several days in a cooler before being affixed to receiver trees.

The third method of transferring *T. pyri* consists of collecting leaves during the summer from trees where *T. pyri* are abundant, and placing them into recipient trees. Leaves are easily affixed to the target sites using staples. The number of leaves to use depends on the density of *T. pyri* in the source orchard. As a guide, at least 50

Table 2. Relative toxicity of pesticides[1] to the mite predator, *Typhlodromus pyri*. Materials with a low toxicity can be used when needed. Pesticides with moderate toxicity should be used sparingly. Those with high toxicity must be avoided.

Pest	**Low toxicity**	**Moderate toxicity**	**High toxicity**
Apple scab	Nova, Rubigan, or Procure in combination with captan	mancozeb or metiram (EBDC fungicides), or Ziram before bloom	mancozeb or metiram (EBDC fungicides), or Ziram after bloom
Powdery mildew	Nova, Rubigan, Procure, Bayleton, sulfur		
Fire blight	Fixed copper, streptomycin		
Black rot	captan, benomyl or Topsin M	mancozeb or metiram before bloom	mancozeb or metiram after bloom
Sooty blotch and fly speck	benomyl, Topsin M, captan		mancozeb, metiram or Ziram after bloom
Rust disease	Nova, Rubigan, Procure, or Bayleton	mancozeb or metiram before bloom	mancozeb or metiram after bloom
Rosy apple aphid	Thiodan or Provado	Lorsban	Lannate, Vydate, dimethoate
Tarnished plant bug			pyrethroids
Spotted tentiform leafminer	Provado		pyrethroids, Vydate, Lannate
Codling moth	azinphos-methyl, Imidan, Penncap M, B.t.	Lorsban	Lannate, dimethoate
Green fruitworm	Thiodan	Lorsban	pyrethroids, Lannate
Obliquebanded leafroller	B.t., Confirm, spinosad, Penncap M	Lorsban	Lannate, pyrethroids
Plum curculio	azinphos-methyl Imidan, Penncap M, carbaryl	Lorsban	pyrethroids
leafhoppers	Provado, Thiodan, Sevin		Lannate, dimethoate, Carzol, Vydate
Apple aphids, spirea aphids	Provado, Thiodan	Lorsban	dimethoate, Lannate, Vydate
Apple maggot	azinphos-methyl, Imidan, Penncap M	Lorsban	Lannate, dimethoate
European red mite	prebloom oil, Savey, Apollo, Pyramite, Vendex	Agri-mek, summer oil, Kelthane	Carzol

[1] Check EPA and state registration status by contacting local Cooperative Extension representative. Registration status is changing annually and is not universal across all state lines. Use of product names does not imply endorsement of particular products. Read all labels for rates and timing.

predators should be released in each target tree.

The fourth method of transferring *T. pyri* is perhaps the easiest and does not carry the risks of also moving unwanted pests that the three prior methods have. Artificial overwintering sites for *T. pyri* can be created by gluing burlap to the inside of tree wrap. These composite bands, approximately 12 to 16 inches in length, are then placed on source trees in early to mid-September by stapling them around the tree bole and/or large scaffold branches. In early December, these bands should be collected, tightly rolled with a rubber band used to hold them so, and placed in a sealed plastic bag with a bit (ca. 1 in^3) of wet cotton. The bag should be placed in an insulated storage container, which in turn should be placed in a cold, though protected, environment that will buffer large temperature fluctuations. Ideally, temperatures should be maintained right at the freezing point. The following spring, the burlap bands should be placed around recipient trees at around the half-inch green bud growth stage. While the number of predators that overwinter in bands is variable, as many as 400 predators can be transferred in each band. We suggest placing a single band on each recipient tree if the bands were collected from trees that harbored moderate to high numbers of *T. pyri* (1-2 per leaf) the prior fall, and two bands in each tree otherwise.

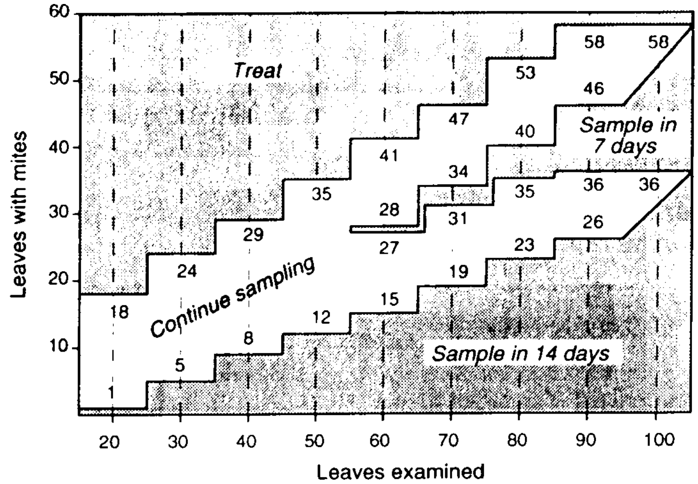
After a receiver orchard is inoculated with *T. pyri*, it often takes 2 to 3 years for the predator population to become abundant enough to regulate ERM without the need for any miticides. During this time, additional control measures are often needed to keep ERM below damaging levels. There are two key aspects to any strategy designed to do so. First, early season dormant oil sprays should be used to reduce ERM populations in the spring. These oil applications have no deleterious effect on *T. pyri*. Second, ERM numbers should be monitored, and if densities exceed threshold levels, a miticide that is not toxic to *T. pyri* should be used to control the pest mites. Note that it is actually desirable to have some pest mites in the trees after inoculation with *T. pyri* because these plant-feeding mites provide a food source for the predators and foster faster predator population growth.

A commonly asked question is, "How do you know when there are enough *T. pyri* to effect biological control?" This question is difficult to answer. While predators can be seen in the field, they are easy to miss, especially at low densities, and their impact on ERM is dependent on which species they are. Guidelines have been provided for the ratio of predators to ERM needed to achieve biological control; however, estimating these ratios is not practical. Fortunately, all that is required to determine if biological control is working is to note whether pest mites remain below threshold levels. This can be determined without regard to predator abundance. A procedure for determining whether ERM exceed threshold levels is described in the appendix. If pesticide regimes for all orchard pests can be followed that allow *T. pyri* to survive, these predators will become abundant enough to make miticide applications unnecessary.

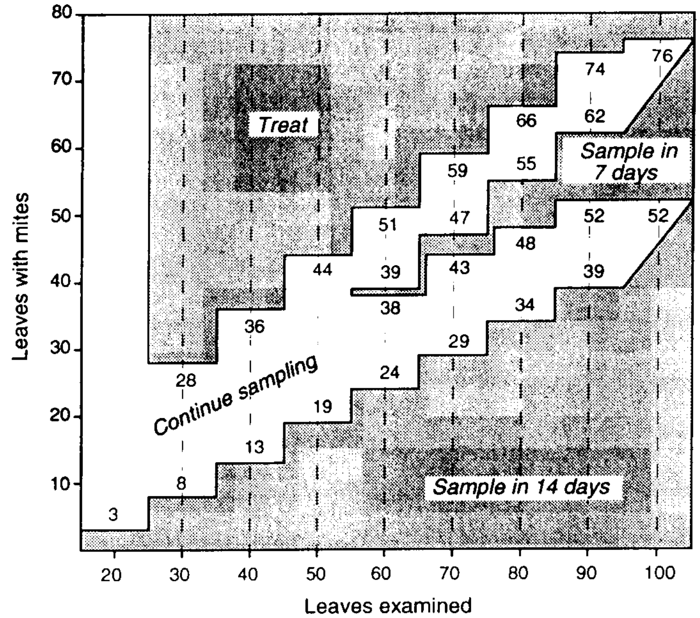
Appendix - Monitoring European Red Mite in Apple Orchards

Damage by European red mites (ERM) to apple leaves is best related to cumulative mite density, which is measured as mite-days. Apple trees with a normal crop load can tolerate approximately 500 mite-days before reductions in fruit yield or quality occur. Therefore, one goal of any mite monitoring program is to ensure that miticide treatments are recommended so as to prevent 500 mite-days from occurring. Another goal of a mite monitoring program is to allow biological control to take its course when mite natural enemies (phytoseiid mites) are present. So, a mite monitoring program should not recommend intervention with pesticides when treatments are not necessary. A final goal of a mite monitoring program is to indicate when the pest population should again be sampled to determine its status. If, at the time of sampling, mite densities are very low, then it is not necessary to sample the population again in a short period of time. On the other hand, if densities are currently close to but not greater than a treatment threshold, the population should

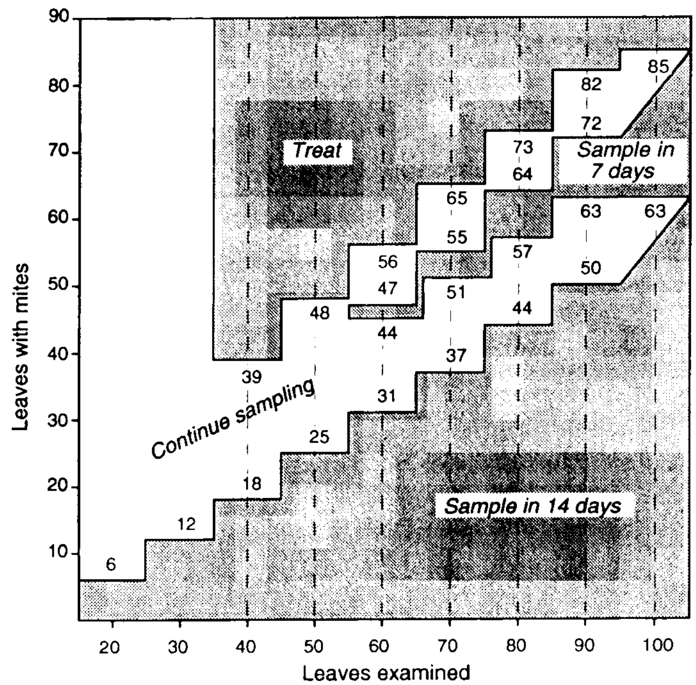
Use this sampling guide during June



Use this sampling guide during July



Use this sampling guide during August



be assessed again in a short period of time. The monitoring program described here meets these goals.

This monitoring procedure classifies ERM density into one of three categories: 1) greater than treatment threshold, indicating application of a miticide is necessary, 2) less than treatment threshold, but requiring assessment again in about 7 days, and 3) much less than a treatment threshold and not requiring assessment again for 14 days.

ERM are small and often numerous. This makes counting these pests a tedious and often difficult task. For monitoring purposes, it is only necessary to record the number of leaves infested with one or more motile mites. A mathematical relationship between the proportion of infested leaves and actual density can then be used to classify mite density. Because higher mite numbers can be tolerated as the season progresses, three sampling procedures are used at different times of the growing season; one each for June, July, and August with treatment thresholds of 2.5, 5, and 7.5 mites per leaf , respectively.

The sampling guides are used as follows:

1. Sampling trees from throughout the orchard block, collect five intermediate aged leaves from each of four trees. To make sure the leaves are of an intermediate age, pick them from the middle of the fruit cluster before July and from the middle of fruit clusters or terminals thereafter.

2. Using a magnifier, examine the top and bottom surface of each leaf for motile mites (anything but eggs), and keep track of the number of leaves with mites on them.

3. When all 20 leaves have been examined, compare this number with the numbers on the decision guide. When the counts fall into any of the shaded regions, sampling is terminated and a decision to either "Treat", "Sample in 7 days," or "Sample in 14 days" is made. If the counts fall in the region labeled "Continue sampling" collect and examine groups of 10 leaves until the counts fall into one of the shaded regions. If the number of leaves with mites is equal to the values on the guide, use the decision indicated by the value minus one (e.g., for the June chart, if 18 leaves have ERM after examining 20 leaves, use 17 leaves with mites and make a decision to "Continue sampling").

Establishment and Spread of Released *Typhlodromus pyri* Predator Mites in Apple Orchard Blocks of Different Tree Size: 1998 Results

Ronald Prokopy, Starker Wright, and Jonathan Black
Department of Entomology, University of Massachusetts

Jan Nyrop, Karen Wentworth, and Carol Herring
Department of Entomology, Cornell University, NYSAES, Geneva, New York

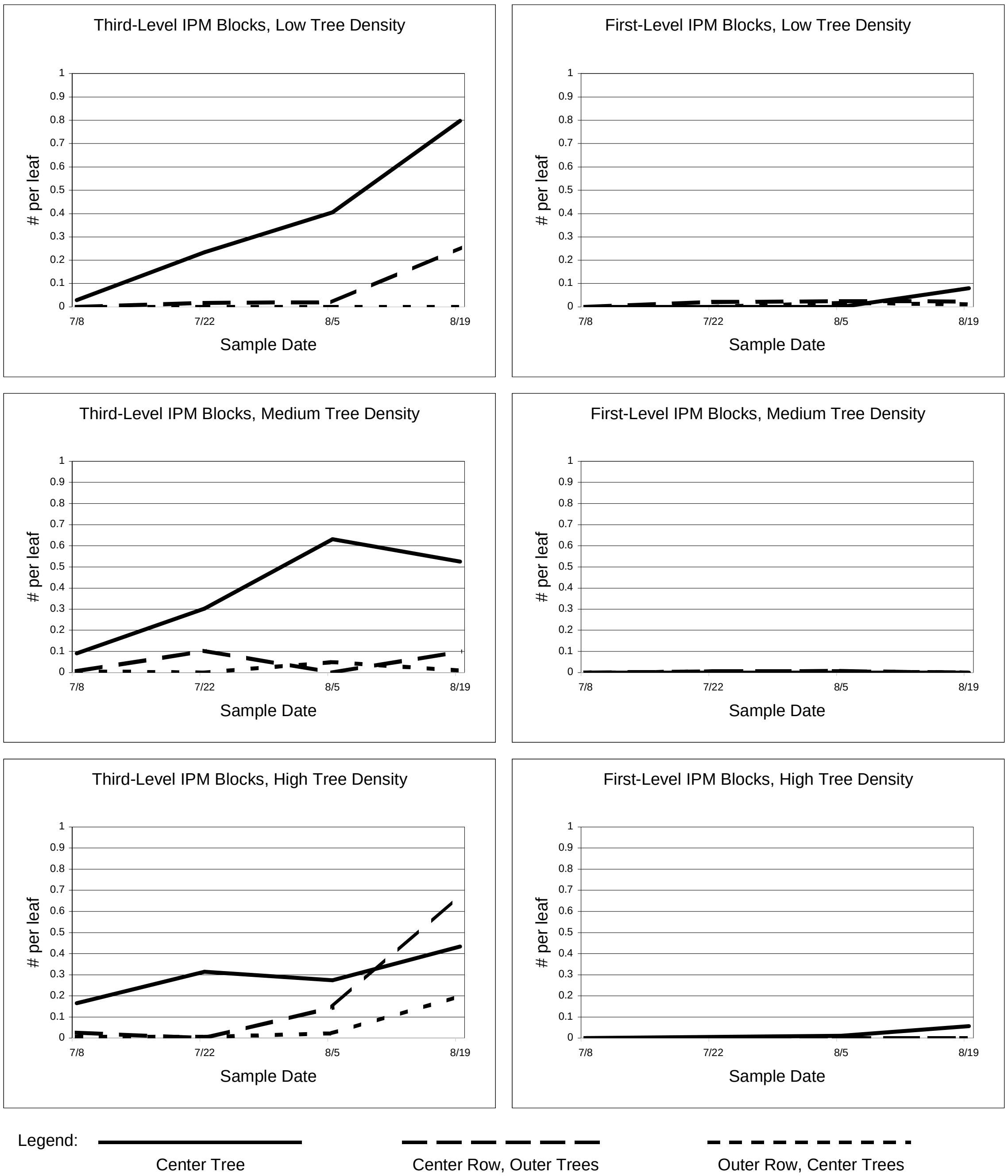
Studies in New York, other states, and other countries have shown that the predatory mite *Typhlodromus pyri*, where established, can be highly effective in providing season-long suppression of pest European red mites in commercial apple orchards. Three of the reasons why *T. pyri* is more reliable than the mite predator *Amblyseius fallacis* in maintaining pest mites below injurious levels year after year are its better ability to endure cold winter temperatures, its better ability to withstand low relative humidity, and its better ability to survive periods of short supply of pest mites as food (as may occur in springtime). In Massachusetts, *A. fallacis* has been found present in about 90% of commercial apple orchards sampled since 1978. In contrast, *T. pyri* has been found present in numbers large enough to be detected in fewer than 10% of Massachusetts commercial apple orchards sampled since 1978.

In 1997, we initiated a program of introducing *T. pyri* into eight commercial apple orchards in Massachusetts in which it was not previously detected. Three of our aims were to (1) chart the degree of establishment of *T. pyri* in each orchard as affected by types of pesticide used; (2) chart the rate at which *T. pyri* spread from trees on which they were released to other trees in the same orchard blocks, as affected by tree size and planting density; and (3) determine the impact of *T. pyri* on pest mite populations. Our study was intended to extend over a period of at least 3 years. In the Fall 1997 issue of *Fruit Notes*, we reported on our findings from 1997, the first year. Here, we report on our findings from 1998, the second year.

Materials & Methods

As indicated in the Fall 1997 issue of *Fruit Notes*, our experiment was conducted in six blocks of apple trees in each of eight commercial orchards. Of the six blocks per orchard, two each contained trees on M.9, M.26, or M.7 rootstock, designated as small, medium-size, or large trees. One block of each pair received first-level IPM practices, wherein growers applied insecticides and fungicides of their own choosing and timing of application, which extended from April through August. The other block of each pair received third-level IPM practices, wherein the initial intent was that no pesticides known to cause a moderate or high level of harm to *T. pyri* were to be used. These included synthetic pyrethroid insecticides (at any time) and EBDC fungicides (after mid-June). In addition, after mid-June, no insecticides of any type was to be used, and captan or benomyl were the only fungicides to be used. There was no restriction on type of miticide allowable for use in third-level blocks, except for Carzol, which was not used. Each block was comprised of 49 trees (7 rows of 7 trees per row) and of the cultivars McIntosh, Empire and Cortland. Third-level IPM is similar to second-level IPM in focus on using biologically-

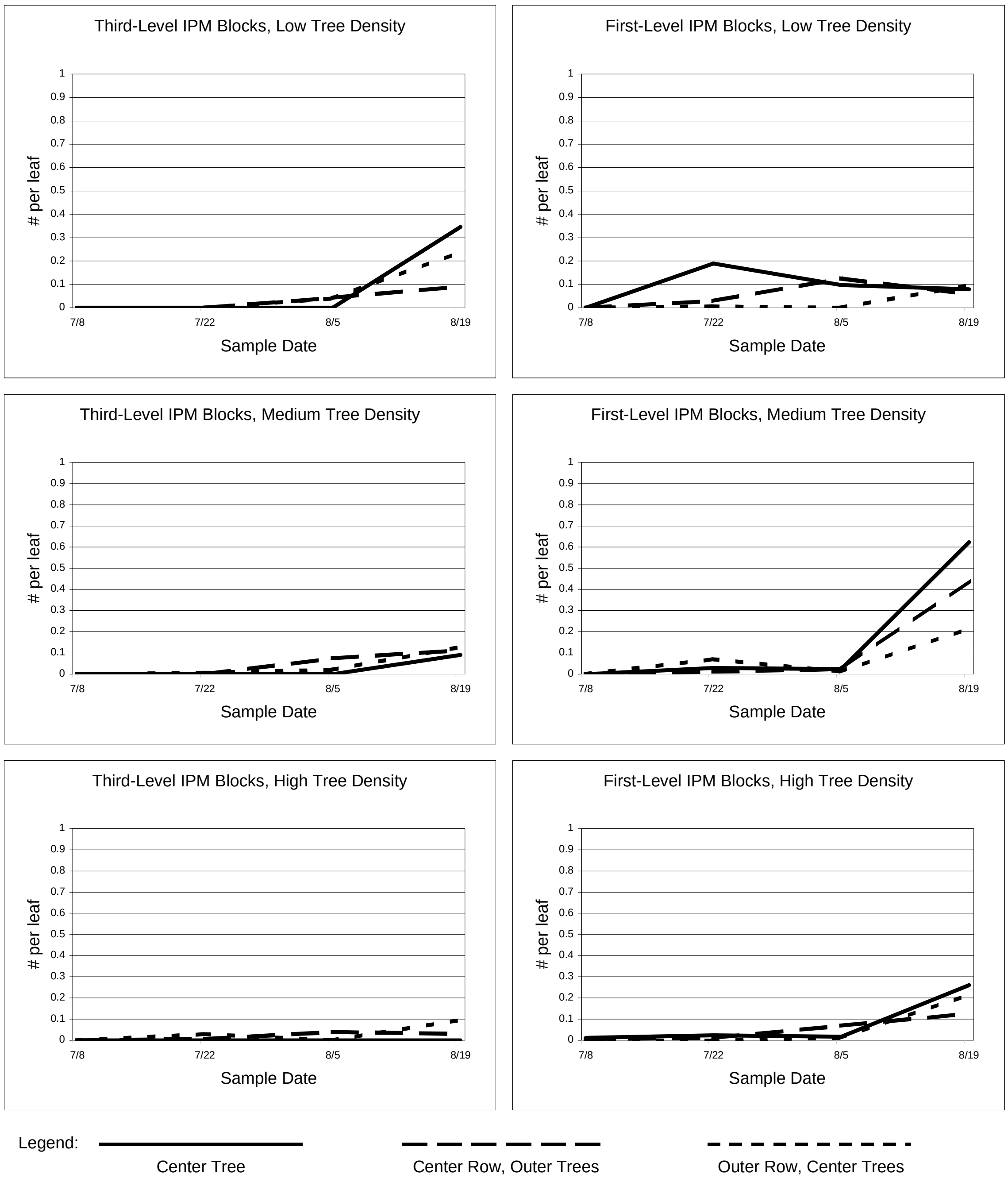
Figure 1. In July and August of 1998, abundance of ***T. pyri*** mite predators on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



based pest management practices, but it embraces integration with horticultural concerns (such as tree size) as an added component.

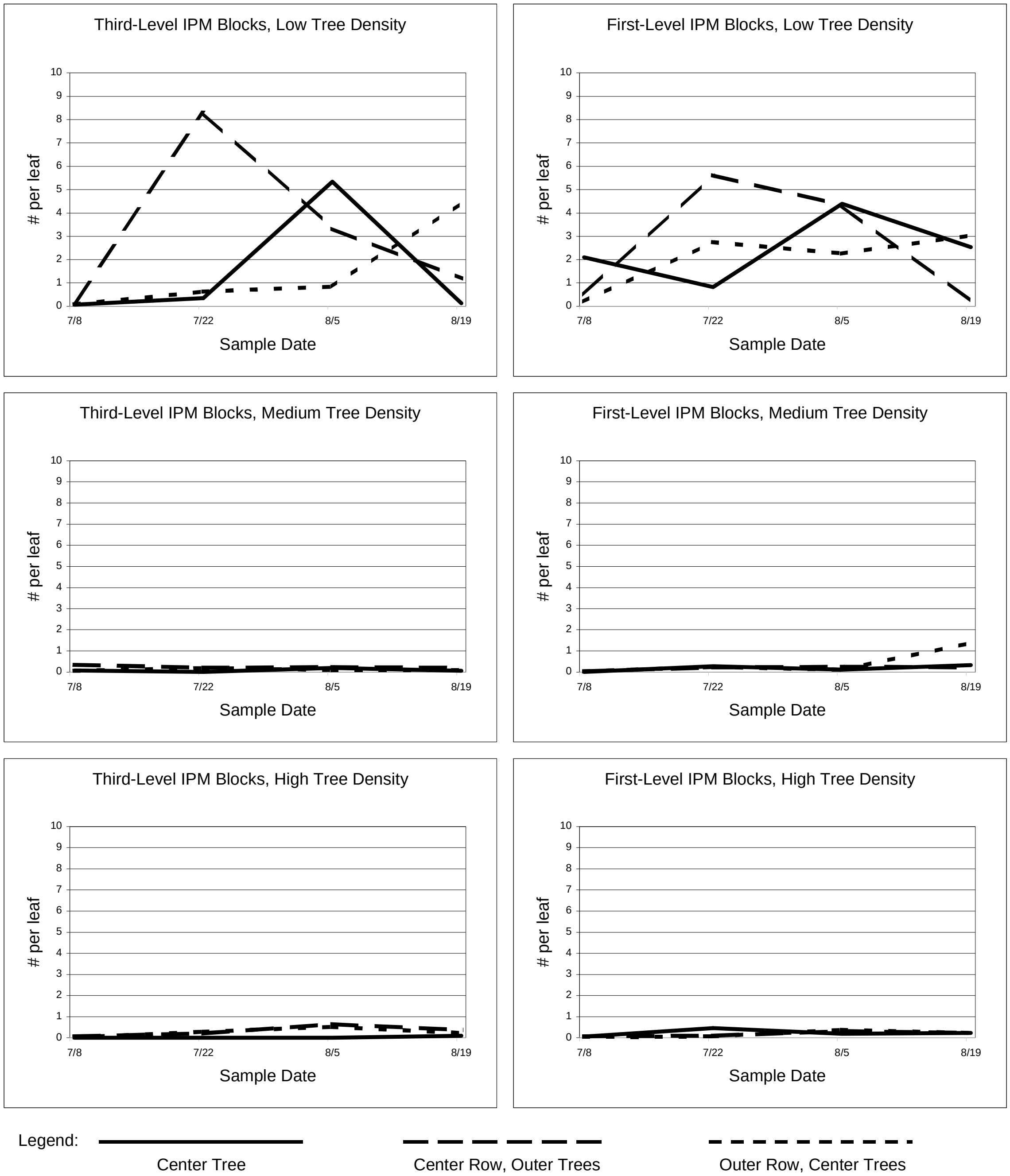
T. pyri were released onto the center tree of each third-level IPM block in May of 1997, in the manner described in the Fall 1997 issue of *Fruit Notes*. No *T. pyri* were released in first-level IPM blocks. Three times during the summer of 1997 and four times during the summer of 1998 in each of the 48 blocks, we sampled 25 leaves from the

Figure 2. In July and August of 1998, abundance of ***A. fallacis*** mite predators on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



center tree, 15 leaves from each of the two outermost trees in the center row, and 15 leaves each from the center tree in each of the two outermost rows. The leaves were sent by overnight mail to Geneva, New York for the identification and counting of pest and predatory mites. In all, more than 12,000 leaves were sampled in 1997 and more than 16,000 in 1998.

Figure 3. In July and August of 1998, abundance of **European red mites** on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



Results

As shown in Figure 1, *T. pyri* were found in low but detectable average numbers in early July of 1998 on center trees in which they were released in third-level IPM blocks in 1997. Populations on center trees in early July averaged greatest on small (high density) trees, middle range on middle-size (middle density) trees, and least on large (low density) trees. By the latter part of August, *T. pyri* on center trees reached 0.4, 0.5, and 0.8 per leaf on small, middle-size, and large trees, respectively. At this time, *T. pyri* on the two outermost trees of the center row averaged 0.8, 0.1, and 0.3 per leaf on small, middle-size, and large trees, respectively, indicating spread of *T. pyri* up and down the same row in which they were released, particularly in blocks of small trees. There was little or no detectable spread of *T. pyri* onto center trees of the outermost rows of blocks of medium-size and large trees but detectable spread onto such trees in blocks of small trees. In 1998, *T. pyri* were largely absent or at most present in extremely low numbers in first-level IPM blocks in which they were not released in 1997 (Figure 1).

As shown in Figure 2, by the latter part of August of 1998, *A. fallacis* had built to larger populations in first-level than in third-level IPM blocks of both small and medium-size trees, although the reverse was true in blocks of large trees. In contrast to *T. pyri*, which was detectable in third-level blocks of all tree sizes in early July, *A. fallacis* was not detectable in any blocks (either third- or first-level IPM) until the latter part of July.

As shown in Figure 3, populations of European red mites in 1998 were barely detectable during July and August in either third- or first-level IPM blocks of small or medium-size trees. They did, however, reach substantial (though not damaging) average numbers in both third- and first-level blocks of large trees.

Table 1 provides information on the possible influence of both type of pesticide used and abundance of European red mites as prey on population levels of *T. pyri* in third-level IPM blocks. It appears that abundance of European red mites had less of an influence on buildup of *T. pyri* than did type of pesticide used. For example, in Orchard A, latter-August populations of *T. pyri* in 1998 averaged nearly double those of 1997, whereas in Orchard H, latter-August populations in 1998 averaged less than one-fourth those of 1997. Latter-August populations of European red mites in 1998 averaged the same in both of these orchards. No insecticide harmful to *T. pyri* was applied in third-level IPM blocks in either Orchard A or Orchard H in 1997 or 1998. In 1997, neither orchard received any EBDC fungicide or Agri-Mek as a miticide. In 1998, Orchard H received three applications of EBDC fungicide and one application of Agri-Mek, as opposed to use of only one application of EBDC fungicide and no Agri-Mek in Orchard A. These combined data suggest that either the greater number of EBDC applications or the use of Agri-Mek was responsible for the rather sharp decline of *T. pyri* in 1998 in Orchard H.

Data from other orchards (Table 1) support the lack of strong influence of abundance of European red mites on extent of *T. pyri* buildup or decline from 1997 to 1998 (compare Orchard D with Orchard A) and the lack of strong influence of number of applications of EBDC fungicides (compare Orchard H with Orchard B, and Orchard E with Orchard A). Instead, it appears that use of Agri-Mek in third-level IPM blocks was the principal factor responsible for the decline in abundance of *T. pyri* from 1997 to 1998 in third-level blocks in some orchards (compare Orchards D, E, G, and H, all of which experienced a decline by an average amount of about 75% in *T. pyri* from 1997 to 1998 and all of which received Agri-Mek in 1998, with Orchards A, B, C, and F, all of which experienced an increase in *T. pyri* by an average amount of about 240% from 1997 to 1998 and none of which received Agri-Mek in 1998).

Conclusions

Combined data from 1997 (reported in the Fall 1997 issue of *Fruit Notes*) and 1998 (reported here) indicate that *T. pyri* mite predators released in 1997 became firmly established and proliferated in 1998 in those third-level IPM blocks that in 1998 did not receive Agri-Mek as a miticide. Our evidence suggests that abundance of European red mites as prey of *T. pyri* was a less important factor affecting population increases or decreases of *T. pyri* than was the effect of Agri-Mek per se on *T. pyri*. Our findings also indicate that by the end of 1998, *T. pyri* had spread at least as far as three trees up- and down-row from the tree in which it was released in 1997, particularly so in blocks of small (high density) trees where intra-row tree foliage was rather contiguous. Spread to third rows on either side of the row in which *T. pyri* were released in 1997 was only slight in blocks of small trees and essentially nil in blocks of medium-size and large trees in 1998.

Table 1. Mean numbers of *T. pyri* and European red mites (ERM) per leaf in late August and pesticides used in third-level IPM blocks in eight commercial apple orchards in Massachusetts in 1998 where *T. pyri* were released in May of 1997.

	Mean no. per leaf*			Miticide used		No. EBDC** fungicide applications		No. insecticide*** applications	
	T. pyri		ERM						
Orchard	1997	1998	1998	1997	1998	1997	1998	1997	1998
A	1.02	1.93	0.03	Oil	Oil	0	1	0	0
B	0.92	1.74	3.92	Oil	Savey	3	3	0	1
C	0.08	1.03	0.09	Oil	Oil	0	0	0	0
D	0.67	0.41	0.05	Savey	Agri-Mek	0	2	0	0
E	1.09	0.33	0.00	Savey	Agri-Mek	0	1	0	0
F	0.03	0.16	0.31	Agri-Mek	Pyramite	0	1	0	0
G	1.41	0.13	0.01	Savey	Agri-Mek	0	2	0	0
H	0.38	0.09	0.03	Pyramite	Agri-Mek	0	3	0	0

* Averaged across all three sizes of trees sampled.
** Application through mid-June, none thereafter.
*** Includes only insecticides known to be moderately or very harmful to *T. pyri*: synthetic pyrethroids, oxamyl, methomyl and chlorpyrifos.

We are encouraged by these findings and plan to continue our study of the extent of establishment and spread of *T. pyri* in these same third-level IPM blocks in 1999. At the same time, we find it sobering that the rate of spread of *T. pyri* into non-release trees is apparently quite modest and that certain pesticides that were believed to be no more than moderately harmful to *T. pyri* (e.g. Agri-Mek) may in fact be very harmful.

Acknowledgments

We are grateful to the eight growers participating in this experiment and who made special effort to apply pesticide selectively to third-level IPM blocks: Bill Broderick, Dave Chandler, Dana Clark, Dave Shearer, Joe Sincuk, Tim Smith, and Mo Tougas. This work was supported by State/ Federal IPM funds.

Budagovsky 9: A Summary of Fifteen Years of Trial

Wesley R. Autio
Department of Plant & Soil Sciences, University of Massachusetts

New rootstocks are becoming available every year, some from breeding programs in the United States and others from a wide range of different countries. Before commercial plantings of these rootstocks begin, it is necessary to conduct trials to understand all of the potential values of and problems with these rootstocks. Mark is an example of a rootstock that was planted widely before adequate testing had occurred. It was first planted in a large-scale test only six years before widespread commercial planting began. Problems with Mark started to appear in research trials just a few years later, after many trees were already in the ground. Hindsight suggests that waiting a few more years would have been prudent, but the release and promotion of new rootstocks before we truly understand them likely will continue to occur.

Significant quantities of data have been collected on rootstocks that were released or brought into the U.S. in the 1970's and 1980's. This collection of rootstocks, not those that are just being released, should form the list of alternatives to the well known Malling and Malling-Merton series. A few of these rootstocks will be discussed in upcoming issues of *Fruit Notes*. In this issue, Budagovsky 9 is the focus.

In 1974, Jim Cummins and Dick Norton described Budagovsky 9 (B.9) as "the most promising candidate to replace M.9." B.9 was released from the Michurin College of Horticulture in central Russia, having been selected from a cross of M.8 and 'Red Standard.' In many respects, it was considered very similar to M.9; however, it was more cold hardy and more resistant to collar rot (Ferree, D.C. and R.F. Carlson. 1987. Apple rootstocks. In: Rootstocks for Fruit Crops. John Wiley & Son, New York).

In Massachusetts, the first planting including B.9 was part of an NC-140-coordinated trial established in 1984. This trial included 15 rootstocks with Starkspur Supreme Delicious as the scion cultivar. Since then, additional trials including B.9 were established in 1990, 1994, 1995, and 1997 with Marshall McIntosh, Golden Delicious, Jonagold, Empire, Rome, Gala, Cortland, Rogers McIntosh, Pioneer Mac, Ginger Gold, Fortune, and Honeycrisp as scion cultivars. This article will provide data from all but the most recent plantings, extracting data from each experiment to compare B.9 with M.9 and/or M.26. These data are given in Table 1.

In general B.9 produced a tree similar in size to M.9, possibly slightly smaller than those on M.9 EMLA and slightly larger than those on M.9 (dirty 9). The trunk cross-sectional area of trees on B.9 was on average 50% (40 and 75% range) of that of trees on M.26.

Rootstock did not affect yield per tree significantly. Efficiency, however, was dramatically affected by rootstock. M.9 and B.9 resulted in similar efficiency, but they were about 50% more efficient than trees on M.26. The practical result of this difference in efficiency is that trees on M.9 or B.9 will yield more per acre than those on M.26.

B.9, M.9, and M.26 all resulted in good fruit size, and there were no consistent differences among the three rootstocks. Overall, average fruit size in these studies averaged about 200 g (96 count), attesting to the fact that these dwarfing rootstocks regularly result in large fruit, even with a lack of irrigation, as was the case in all of the trials.

Other data not shown here suggested that B.9 results in a similar timing of fruit ripening and similar fruit quality to those from trees on M.9.

In conclusion, 15 years of study show B.9 to be a good apple rootstock. Performance in Massachusetts, however, does not suggest that B.9

Table 1. Characteristics of trees of various cultivars on B.9 in comparison to M.9 and M.26. These data were extracted from several replicated trials, and in most cases, represent conditions through the end of the 1998 growing season (Delicious data, however, were collected through the end of the 1993 season). Fruit size is the average over all fruiting years for each trial.

Tree age (years)	Cultivar	Rootstock	Trunk cross-sectional area (in^2)	Cumulative yield per tree (bu)	Cumulative yield efficiency (lbs/in^2 TCA)	Fruit size (no./42-lb box)
10	Delicious	B.9	3.9	7.3	78	84
		M.26 EMLA	6.4	9.1	63	83
9	Marshall McIntosh	M.9 EMLA	5.6	6.1	13	112
		B.9	4.0	5.4	17	111
		M.26 EMLA	10.9	6.3	7	127
	Golden Delicious	M.9 EMLA	5.7	5.1	37	101
		B.9	5.7	5.4	40	99
		M.26 EMLA	7.4	5.8	34	96
	Jonagold	M.9 EMLA	5.6	6.3	47	71
		B.9	6.4	6.4	41	75
		M.26 EMLA	11.8	7.8	29	73
	Empire	M.9 EMLA	5.1	7.1	57	101
		B.9	4.5	5.6	56	103
		M.26 EMLA	9.5	5.2	24	106
	Rome	M.9 EMLA	8.5	9.8	48	75
		B.9	5.4	7.4	58	79
		M.26 EMLA	8.8	8.6	41	71
5	Gala	M.9 EMLA	3.9	1.8	20	110
		B.9	2.9	1.7	26	120
		M.26 EMLA	5.9	1.9	16	120
4	Cortland	M.9	1.2	0.2	7	88
		B.9	1.4	0.4	10	90
	Rogers McIntosh	M.9	1.6	0.3	10	101
		B.9	1.7	0.2	4	121
	Pioneer Mac	M.9	1.1	0.3	9	108
		B.9	1.7	0.2	4	127
	Ginger Gold	M.9 T337	1.1	0.3	13	80
		B.9	1.1	0.3	13	80

is a better rootstock than M.9. However, northern apple-growing regions where winter damage may be a problem and in blocks where collar rot may be a problem, growers may see better performance from B.9 than M.9.