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Integrated Control of Apple Mites

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Amblyseius fallacis **about to feed on a twospotted spider mite (note color).**

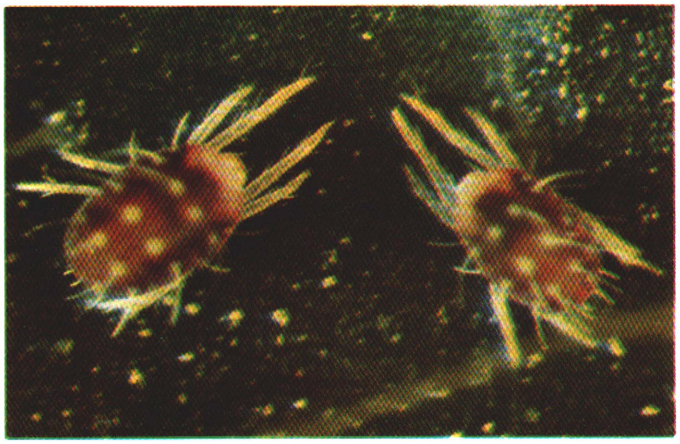

Fig. 1. The European red mite is a common and destructive pest mite. Adult females are shown here.

Fig. 2. Male European red mite.

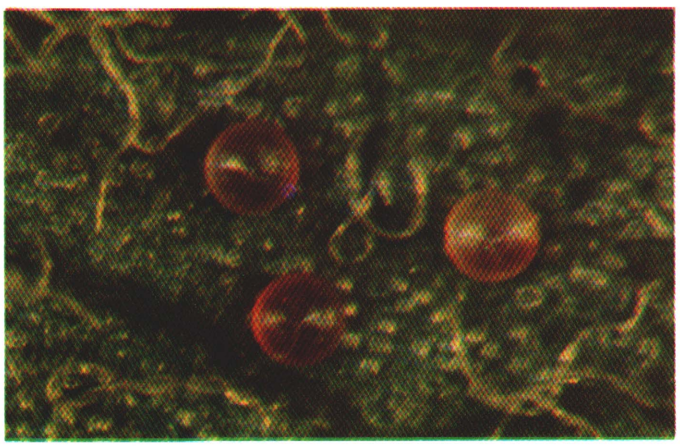

Fig. 3. Summer eggs of European red mite attached to apple leaves.

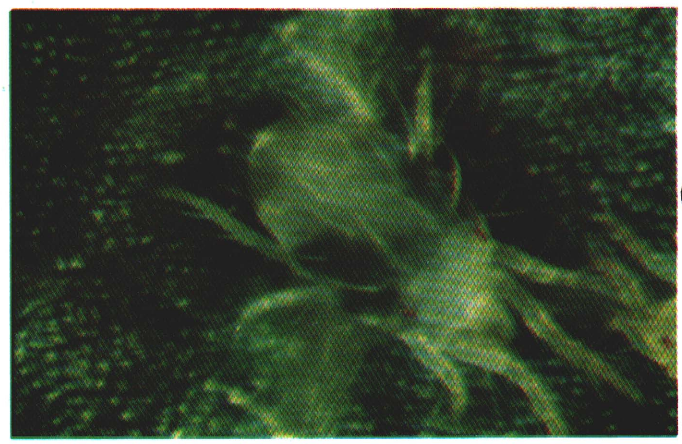

Fig. 4. Female adult twospotted spider mite.

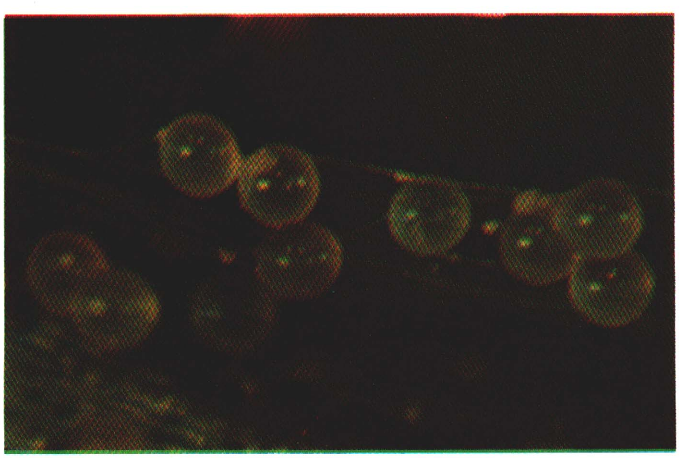

Fig. 5. Eggs of the twospotted spider mite in mite webbing.

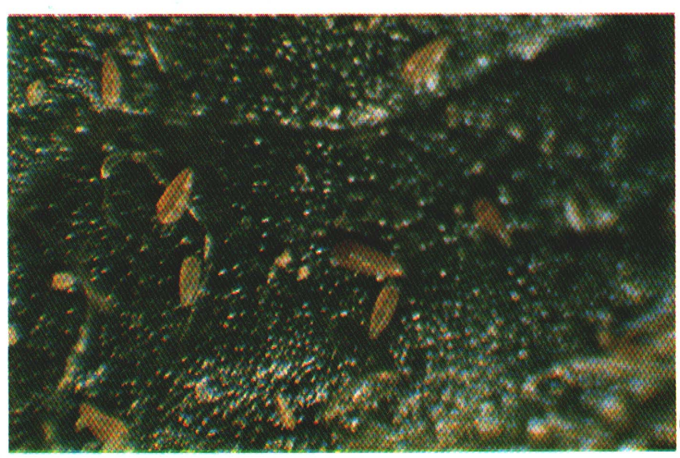

Fig. 6. Various life stages of the apple rust mite.

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INTRODUCTION

Plant-feeding mites are major pests of tree-fruits in Michigan. On red delicious apples, for example, an average of $20-30 per acre is often spent for mite supression by chemical pesticides and this amount is 20-30% of the annual cost for insect and disease control. Chemical mite control is expensive because mites quickly develop resistances to pesticides and miticides often are not effective on other fruit pests.

In Michigan apple orchards plant-feeding mites have large complexes of natural enemies. These beneficial organisms can provide for complete biological control of mites if they are left undisturbed by pesticides used for control of insects such as the codling moth, plum curculio, apple maggot, redbanded leafroller, and diseases such as apple scab and powdery mildew.

In the past, mite control programs in Michigan apple orchards have been based almost solely on chemicals, and the occurrence and benefits of natural enemies of plant-feeding mites were largely not realized.

In 1970, research was initiated to study possibilities of controlling plant-feeding mites by biological methods. This bulletin summarizes the results of this work and presents an alternate program of integrated chemical and biological control of plant-feeding mites. It is based on simultaneous use of selective pesticides to control most orchard pests while conserving certain key predators of mite pests. The benefits of this program are savings due to decreased miticide use and control of mite pests which often are resistant to chemical control measures.

There are five steps to initiating and maintaining an integrated spider mite control program:

(1) Know the effect of orchard pesticides on the disease, insect, and mite pests of apples, and the predators of plant-feeding mites; know how to use these materials to provide good chemical pest control and best conserve predators of spider mites.

(2) Recognize the major plant-feeding mites; know their seasonal habits, be able to determine their relative abundance and recognize when they are approaching intolerable damage levels in an orchard.

(3) As spider mites begin to increase in an orchard, be able to recognize the principal predators of plant-feeding mites, know their habits and be able to determine their absence, presence, or better yet, their relative abundance.

(4) Be able to decide from the abundance of plant-feeding mites and predators whether to rely on (a) complete chemical control of mites, (b) selective chemical control of mites plus biological control by predators, or (c) complete biological control of plant-feeding mites by predators.

(5) If decision (a) is made, know which chemicals and rates not only give effective control of plant-feeding mites, but also are least poisonous to predators; if decision (b) is made, know which miticides are not poisonous to predators and what rates will give substantial, but not complete, control of plant-feeding mites. If decision (c) is made, recheck the orchard periodically to confirm that biological control is effective.

Later in this bulletin, these five procedures will be briefly discussed. Because an overall understanding of the biologies and habits of predators and pest mites and the general philosophy of integrated control is necessary to make the proper choice of pesticides (step 1), a discussion of these topics will be given first.

PLANT-FEEDING MITES

There are three principal mite pests which occur in Michigan's commercial apple orchards. They are the European red mite *Panonychus ulmi* (Koch), the twospotted spider mite *Tetranychus urticae* Koch and the apple rust mite *Aculus schlechtendali* (Nalepa). The European red mite is the most common and most destructive mite pest of the three. The adult female (Fig. 1) of this species is dark velvet red, oval shaped, and about the size of a pin head, with conspicuous white spots at the base of dark bristles on its back. Winter eggs are bright red and are laid on the underside of twigs and small branches. Immature mites which hatch at bloom and males (Fig. 2) are variably red, greenish or even blackish in appearance. These stages occur on apple leaves as do summer eggs (Fig. 3) which are also red; there are six to eight generations per season and populations may exceed 100 mites per leaf in June to August. Twospotted spider mites (Fig. 4) are yellowish-green, and feeding stages have dark pigmented spots on either side of their oval bodies. The eggs (Fig. 5) and immature stages of this pest are yellowish-green. In spring, twospotted spider mites are found on the ground cover beneath apple trees after spending the winter period as orange female adults in debris or under bark near the tree base. From mid- to late summer these pests may migrate into fruit trees and cause damage, but in the fall they return to the tree base or litter to overwinter. Apple rust mites (Fig. 6) are very small, wedge-shaped, pinkish white with two pair of legs at the head and a tapered posterior. They occur in virtually all commercial apple orchards in Michigan. Rust mites overwinter as adults under apple bud scales. In spring, they migrate onto the foliage before bloom. Several generations are reproduced per season and these mites can attain levels of more than 1000 per leaf during June or July.

TOLERANCE LEVELS

In most commercial apple orchards, one or more of the mite pests previously described will infest apple trees annually and each has the potential to increase to high densities. If populations are not controlled, they will cause a withdrawal of the contents from leaf cells to the extent that leaves turn brown or become bronzed. Severe damage to foliage may ultimately cause poor sizing and color quality of fruit, excessive fruit drop, reduced blossom and fruit set in subsequent years and a general decline in tree vigor. Generally, European red or twospotted spider mites can be tolerated at levels from 15 to 20 per leaf (or 200 rust mites per leaf) feeding for a maximum of 10-14 days before fruit production or tree vigor are adversely affected.

PREDATORS OF PLANT-FEEDING MITES

There are four predators of plant-feeding mites which can be important in establishing an integrated control program for plant-feeding mites.

• ***Amblyseius fallacis*—a pear-shaped predaceous mite** (Fig. 7). The shape of this mite is distinctly different from any plant-feeding mite. Whereas the European red mite and twospotted spider mite are elliptical and the apple rust mite is wedge shaped and extremely small, *A. fallacis* is about the same size as the two spider mite pests, but is longer with a broad abdomen. Depending on how recently predators have eaten, their color will vary from white to pinkish or darker red (see cover and Figs. 7 and 8). The best way to identify this predator without a microscope or hand lens is by exposing it to direct sunlight. Predators will be on the underside of apple leaves and when the leaf is inverted in the light, the adult mite, especially the female, will move much more rapidly over the leaf surface than any of the three pests or other predatory mite species. Eggs (Fig. 9) of *A. fallacis* are larger than spider mite eggs, oval shaped, and almost transparent. They are usually laid along the leaf midrib or near leaf hairs at a rate of 1-5 per day. Immature stages are transparent or colored like the adults. Development from egg to adult takes about 7-9 days at 70° F and *A. fallacis* populations can develop from less than 10 per 100 leaves to 200-500 per 100 leaves in 2-3 weeks.

Adult female *A. fallacis* overwinter mostly at the base of apple trees or in the ground cover litter. In spring, they feed on twospotted or other plant-feeding mites on the ground cover until mid-June to July before migrating into the apple tree. During June and July the best location to find this predator is on the underside of leaves taken from spurs in the lower and innermost portions of the tree. As *A. fallacis* populations begin feeding on pest mites and increase in numbers they will disperse throughout the tree. If a sufficient ratio of *A. fallacis* to pest mites is present, predators will destroy the pest mites and virtually eliminate them from the apple tree. As predators run out of food they will leave the apple tree and return to the ground cover to feed on other mites or to overwinter.

• ***Agistemus fleschneri* and *Zetzellia mali*—two yellow predaceous mites (Figs. 10 and 11).** These two mites are so similar they can be described together. The egg of either species is round, smaller than a spider mite egg, and bright yellow. The active immature stages of either predator are lemon yellow, but later stages become reddish yellow after feeding on pest mites. Adults are almost oval but have a more pointed posterior than spider mites and they are slightly smaller than either adult spider mite or *A. fallacis*. Both predators feed on all stages of spider mites and rust mites, but prefer feeding on rust mites and the egg or immature stages of spider mites.

• ***Stethorus punctum*—a predaceous black ladybird beetle:** This small beetle (Fig. 12) is relatively large compared to any of the plant-feeding or predatory mites discussed previously. Both the larval and adult stages feed on spider mites in apple trees. The larva is somewhat elongate, light black to brown, and is about 3/16 in. long when fully grown. *Stethorus* pupae are black, flattened and are usually fastened to the upper sides of apple leaves. The adult is jet black, has wings, and is very round and somewhat shiny. During the winter, adult *Stethorus* hibernate in debris at the base of apple trees and in fields and woodlands adjacent to the orchard. In the summer, adults fly to the apple leaves where high densities of spider mites are present and lay their whitish elongated eggs which hatch into hungry larvae. *Stethorus* larvae will consume 100-400 spider mites a day. Development of this insect predator is relatively slow compared to the mite predators and takes 25-35 days at 70° F. When development is completed the newly emerged adults may produce a second generation if pest mites remain in the tree; if not they will fly off in search of new spider mite infestations.

Each predator listed above has features which allow it to live in commercial fruit orchards where chemical pesticides are intensively sprayed. *Amblyseius fallacis,* the pear shaped predator mite, is highly resistant to normal field rates of several organophosphorus chemicals in most orchards throughout Michigan. Both yellow mite predators, *A. fleschneri* and *Z. mali,* are inherently tolerant to a wide spectrum of organophosphorus chemicals. Insecticide resistance has not been reported for the predatory black ladybird beetle *S. punctum,* but its ability to fly allows it to migrate into fruit orchards after spray residues have dissipated, and this beetle seems to tolerate reduced rates of many insecticidal compounds.

PEST MITE/PREDATOR RATIOS

It is possible to practice integrated mite control without being able to recognize predaceous mites and insects, but the greatest success is achieved where their presence, absence, or better yet, their relative numbers are determined. To do this one must be able to estimate the number of these beneficial organisms or have a trained person make detailed evaluations at the appropriate time when pest mites are beginning to increase. In either case, the grower or a trained technician (mite counting service personnel) should collect 100 leaf samples, 10 each taken sequentially from the inside to the outside of 10 individual trees in no larger than a 10-acre block. In blocks with a mixture of varieties, samples should be taken from varieties which are most likely to develop high mite populations (red delicious, northern spy, golden delicious, winesap). With experience it is possible to estimate predator populations in the orchard without making such detailed determinations.

As spider mites increase to 1-5 per leaf in an orchard, their control by predators, the ultimate level they attain, and how much damage they do all depend on how favorable a ratio of pest to predators is present in the orchard. From research experiments, a simple index for making mite control decisions has been developed for counts of spider mites and the most effective predator, *A. fallacis.* Although this index was designed to use mite samples processed by a mite brushing machine and counted with a microscope (method used by mite counting service), it also is useful for estimating predator pest conditions by less accurate methods (eye or hand lens approximations). When spider mites per leaf are plotted on one axis and *A. fallacis* per leaf on the other, the likelihood of biological control occurring can be forecast (Fig. A and Table 1). For example,

Table 1. Spray recommendations for pest/predator ratio regions in Figure A

Region	Suggested Recommendation	Probability for Biological Control
1	As bronzing appears, spray Plictran miticide 50 WP at full rate (4-6 oz/100 gal or 16-20 oz/A)	Very low
2	If bronzing appears, spray Plictran 50 WP @ 2 oz/100 gal or 8 oz/A.	Equal to or less than 10%
3	If bronzing appears, spray Omite 30 WP @ 1¼ lb/100 gal or 5 lb/A or Plictran 50 WP @ 1½ oz/100 gal or 6 oz/A. (See Table 4 for use limitations.)	Greater than 10% but less than 50%
4	Wait one week, biological control should occur soon; if not, spray Omite @ 1¼ lb or Plictran 1½ oz/100 gal. (See Table 4 for use limitations.)	Approximately 50%
5	Same as 4	Greater than 50% but less than 90%
6	Wait one week—biological control is almost certain	Greater than 90%

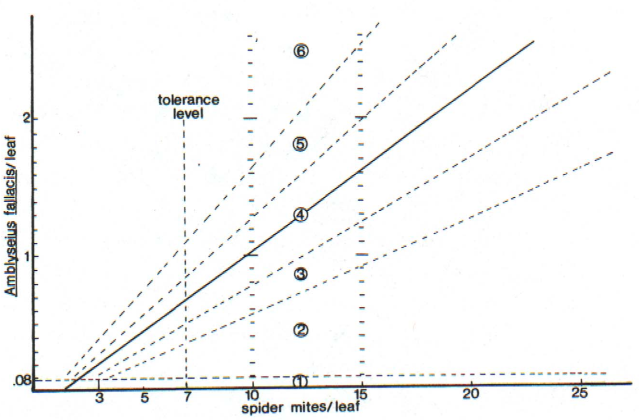

Fig. A. A decision-making index for estimating biological control of spider mites by *Amblyseius fallacis.*

according to this graph (Fig. A) it is not necessary to make a mite control decision until spider mites (European red mites or twospotted spider mites) exceed 7 per leaf. If spider mites number more than 7 per leaf and only a few *A. fallacis* (less than .08 per leaf) are present, a full strength, selective miticide spray is recommended (see region 1 in Fig. A and Table 1).

If the spider mite to *A. fallacis* ratio falls in regions 2 or 3, an application of a selective miticide spray is necessary to establish a more favorable pest/predator relationship (Fig. A and Table 1). The chemicals at the rates specified in Table 2 will reduce, but not eliminate spider mites (complete elimination of spider mites would cause predators to starve to death or leave the apple tree) and are non- or slightly toxic to *A. fallacis*. If a plot falls in region 2, a selective miticide application is recommended for substantial, but not complete spider mite control; in region 3 either a lower rate of miticide or another compound can be used (Table 1). After either of these applications is applied, predators should increase and keep spider mites at low densities for the remainder of the season. Also, to reduce the likelihood of resistance developing rapidly among spider mites, we suggest that growers alternate miticides whenever possible.

If a prey to predator ratio falls in region 4, the possibility for complete biological control of spider mites is 50% (Fig. A and Table 1). Growers should examine their orchards at frequent intervals and determine if control has occurred or is occurring. If spider mite levels do not begin to decline within a week, a selective miticide spray should be applied (Table 1). Plots falling in regions 5 or 6 indicate a high likelihood for complete biological control (Fig. A and Table 1). However, even under these conditions, periodic checks or samples are recommended to insure that predators are reducing spider mites.

Successful biological control of spider mites by *S. punctum* or *A. fleschneri* and *Z. mali* is not as easy to predict as when *A. fallacis* is present in an orchard. In general, an average population of 15-30 *Stethorus* per 3-minute count (taken while walking around 10 apple trees) is able to maintain populations of spider mites below tolerable levels if they are present early enough and are distributed throughout an orchard. No reliable ratios of *A. fleschneri* and *Z. mali* can be given to estimate complete biological control. These predators are somewhat effective in early season when *A. fallacis* is not yet in trees. Also, they can effectively control spider mites in Jonathan apple trees or other varieties which develop limited spider mite populations. When two or more natural enemies are preying on spider mites and an intolerable pest population is present, it is even more difficult to predict control. Under these conditions, one should watch closely for a decline in pest levels or be safe and spray a selective miticide (Table 2).

Table 2. Selective miticide sprays and rates for substantial, but not complete chemical control of spider mites

Chemical	Formulation	Rate/ 100 gal	Rate/ Acre	Use limitations
Omite	30W	1¼ lb	5 lb	Prey/predator ratio in region 3. Less effective in cool weather, careful measurement of rate not as critical.
Plictran	50W	2 oz or 1½ oz	½ lb or ⅜ lb	Prey/predator ratio in region 2 or 3. Effective in cool or warm weather, careful measurement of rate critical.

PREDATOR-SPIDER MITE INTERACTIONS

Apple rust mites can sometimes become a pest in apple orchards, but more often they are a contributing factor to successful biological control of spider mites. Moderate populations (10-100 per leaf) in an apple orchard during the spring provide an alternate prey for *A. fallacis*. Predators feed and develop on rust mites in early season and become well distributed throughout the apple tree before the time spider mites normally begin to increase. Later, when spider mites appear, and if rust mite populations are low, the predator population will switch food sources and destroy spider mites before they become abundant in the tree. If high densities of rust mites and predators are present when spider mites begin to increase, a reduced rate of Thiodan (50W @ ½ lb/100 gal *or* 2 lb/A) will eliminate the rust mites and not affect predators. Selective suppression of rust mites will force predators to shift their feeding to spider mites and provide good control for the remainder of the season.

INTEGRATED MITE CONTROL

Ways to use pesticides to accomplish integrated mite control are explained later in this bulletin. With this information, one should be prepared to initiate and maintain an integrated mite control program. We suggest trials be carried out on small pilot plots, before the program is used in large acreages. Also, we recommend using a mite counting service to provide accurate estimates of spider mite and predator populations until you are confident you can accurately assess these values.[1]

One might assume that once an integrated control program is established, predators would become more abundant in the orchard and control programs would also improve in successive years. Although this is often so, research has shown this is not always the case. The abundance of predators depends mostly on the abundance of spider mites. Depending on the peculiarities of the season, predators can be fewer during the second year of integrated control than they were during the first year. Remember that each year is a different spider mite/predator situation and the pest manager must treat it as such. Careful observations of pest mite and predator development are necessary each season to evaluate the possibilities for biological control.

Production of quality apples requires management of many factors. Although mite control costs are a major expenditure in apple pest control, there are many other decisions related to apple production which at times have a higher priority. For example, the program described in this bulletin assumes that the pesticide schedules one chooses usually will be adequate to provide complete chemical control of virtually all insect, disease and weed pests. If a certain pest which directly attacks the apple or renders the fruit unmarketable becomes unmanageable with a selective spray program, one would always sacrifice an integrated mite control program to save the crop. These conditions, however, are rare. During most seasons the program presented here will provide good control of all pests, and the additional benefits of integrated mite control can be realized.

Various levels of integrated control can be carried out and the relative degree of benefits realized will depend on the effort expended. For example, if a grower will simply attempt to use pesticides in the patterns presented here without determining if predators are present, he still will realize fewer mite control problems and will reduce the times he sprays for spider mite control. If others determine if predators are present or absent when it is time to spray for spider mites and make the appropriate decisions, they will further reduce their miticide costs. Finally, by using a mite counting service and accurately determining pest to predator ratios one can cut down most on control measures.

Implementation of an integrated mite control program in Michigan apple orchards and the entire concept of pest management stresses *management;* that is, applying control measures in response to monitored pest problems in the orchard. This does not mean that chemical control measures are abandoned, but they are carefully used to manage specific pest problems and yet conserve natural enemies in the orchard.

Unfortunately, pest managers often over-react and expect biological control to eliminate spider mite problems. We extend caution to this attitude and stress that a better approach is to allow natural enemies to provide as much natural control as possible. When and where predators are unable to accomplish control, we recommend the use of chemicals to insure that plant-feeding mites do not cause excessive damage and a marketable apple crop is produced.

ORCHARD PESTICIDE PROGRAMS

The first step to an integrated mite control program is selecting a spray program to provide good chemical control of other orchard fruit insect pests and to conserve predators of plant feeding mites. If this is not done, predators will never appear in the orchard, making biological control of spider mites impossible.

In Michigan apple orchards, the heaviest period of pesticide application occurs before the second cover spray. If chemicals are effectively used earlier in the season most disease and insect problems should be under control. Occasionally, maintenance programs may be necessary later in the season for apple scab, powdery mildew, codling moth, apple maggot, redbanded leafroller, aphid and white apple leafhopper control. Fortunately, the biology and behavior of *A. fallacis* are well synchronized with this pattern of pesticide use. Prior to the first or second cover spray period, this predatory mite is found mostly in the protected ground cover habitats beneath apple trees. Research has shown that even though sprays moderately toxic to *A. fallacis* are applied to fruit trees during this period, they have no appreciable effect on predator populations. If the chemical residue is gone before predators migrate into the trees, large numbers of predators and good biological control interactions will develop later in the growing season. Some materials (Sevin, Zolone) are so toxic, however, that even the small amount falling on the ground cover in early season can eliminate *A. fallacis* for more than a month.

Since few *A. fallacis* predators are present in apple trees until June and July, the following features should be included in a chemical schedule for an integrated control program.

(1) Chemically control as many pests as possible before predators are present in the fruit trees

[1]Contact your district horticultural agent or appropriate extension service personnel for information on cost and where to obtain mite counting services in your area.

and then minimize use of pesticides for the remainder of the season.

(2) Use a spray application technique (2-10 X) which reduces the amount of run-off to the ground in early season and avoid highly toxic treatments. This will increase the likelihood that large populations of predators will survive on the orchard floor.

(3) Because predators are not in the tree in early season, provide chemical control of the European red mite prior to June or July by using an early season oil or miticidal spray (see recommendations in Michigan Fruit Spraying Calendar, Bulletin 154).

(4) Research shows good integrated programs are possible where intensive herbicide treatment or clean cultivation is practiced, provided there are a few annual weeds present near the tree base or a small reservoir of plants is left around the tree trunk. Total elimination of ground cover vegetation by clean cultivation or herbicide treatment should be avoided.

The toxicity of orchard pesticides to the European red mite, the twospotted spider mite, the apple rust mite, and their principal predators, *Amblyseius fallacis*, *Agistemus fleschneri* and *Zetzellia mali* and *Stethorus punctum* is presented in Table 3. Specific use and rate recommendations for each compound are listed in the Michigan Fruit Spraying Calendar. In all instances, each chemical toxicity rating is based on the highest recommended rate presented in the spray calendar.

Knowing the effect of the compounds listed in Table 3, the biology and habits of the various natural enemy species, especially *A. fallacis*, and having tested these materials in extensive field integrated control programs, we have developed some use guidelines for most of the chemicals used in commercial fruit production (Table 4). These data provide a variety of chemical alternatives for control of the specific apple pest problems a grower might encounter.

Table 3—Toxicity of orchard pesticides to plant-feeding mites and their principal predators occurring in Michigan apple orchards

Chemical	Rate/ 100 gals(a)	Rate/ Acre	European red or 2-spotted spider mite	Apple rust mite	*Amblyseius fallacis*	*Agistemus fleschneri* or *Zetzellia mali*	*Stethorus punctum*
Benlate 50WP	4-6 oz	1-1½ lb	M	M(d)	H(e)	H	----(b)
Captan 50WP	2 lb	8 lb	O(c)	O	O	O	O
Cyprex 65WP	⅜-½ lb	1½-2 lb	O	O	O	O	O
Dikar 80WP	2 lb	8 lb	H	HR(f)	M	HR	O
Karathane 25WP	½ lb	2 lb	H	HR	M	HR	O
Lime Sulfur	2 gal	8 gal	O	HR	H	HR	H
Polyram 80WP	2 lb	8 lb	O	----	O	O	O
Wettable Sulfur	6 lb	24 lb	O	HR	H	HR	H
Dimethoate 50 WP	2 lb	8 lb	M	M	M	O	M
Diazinon 50WP	1 lb	4 lb	M	H	M	O	----
Guthion 50WP	½ lb	2 lb	O	M	O	O	M
Imidan 50WP	1 lb	4 lb	O	M	O	O	H
Parathion 15WP	2 lb	8 lb	O	----	M	O	H
Phosphamidon 8EC	¼ pt	1 pt	O	M	H	M	H
Sevin 50WP	2 lb	8 lb	O	HR	HR	HR	HR
Systox 6EC	⅓ pt	1⅓ pt	H	M	H	O	H
Thiodan 50WP	1 lb	4 lb	O	HR	M	HR	M
Zolone 3EC	1 pt	4 pt	M	H	HR	H	H
Acaralate 2EC	1 qt	4 qt	H	----	HR	----	M
Carzol SP	¼-½ lb	1-2 lb	HR	----	H	----	M
Galecron or Fundal SP	½ lb	2 lb	HR(g)	HR	HR	H	H
Galecron or Fundal 4EC	1 pt	4 pt	HR(g)	HR	HR	H	H
Kelthane 3WP	1¼ lb	5 lb	H	HR	HR	----	----
Morestan 25WP	½ lb	2 lb	HR	HR	H	HR	O
Omite 30WP	1¼ lb	5 lb	H	HR	O	HR	O
Plictran 50WP	4-6 oz	1-1½	HR	HR	M	HR	M
TEPP 40%EC	⅓ pt	1⅓ pt	H	----	H	----	----

(a) Represent highest rates recommended in the 1975 Michigan Fruit Spraying Calendar, Bulletin 154.
(b) .... = no information available
(c) O = non-slightly toxic
(d) M = moderately toxic
(e) H = highly toxic
(f) HR = highly toxic, long residual action
(g) May not be extremely toxic to European red mites in orchards where resistance has developed.

Table 4—Pesticide usage and timing for integrated mite control

Chemical	Formulation	Rate/100 gal	Rate/Acre	Usable to June 1 or 1st cover	Usable to June 10 or 2nd cover	Usable June 10 or to harvest	Usable after predator-prey interaction
Fungicides							
Lime sulfur	----------	2 gal	8 gal	X			
Cyprex	65 WP	½ lb	2 lb	X	X	X	X
Phygon	50 WP	¼ lb	1 lb	X			
Captan	50 WP	2 lb	8 lb	X	X	X	X
Dikar	80 WP	2 lb	8 lb	X	X		X
Dikar	80 WP	1 lb	4 lb	X	X	X	X
Wettable sulfur	----------	6 lb	24 lb	X(a)			
Wettable sulfur	----------	2 lb	8 lb	X	X		
Polyram	80 WP	2 lb	8 lb	X	X	X	X
Difolitan	4 EC	5 qt	5 gal	X			
Karathane	25 WP	½ lb	2 lb	X	X		X
Karathane	25 WP	¼ lb	1 lb	X	X	X	X
Benlate	50 WP	6 oz	1½ lb	X			X
Insecticides							
Parathion	15 WP	2 lb	8 lb	X	X		X
Phosphamidon	8 EC	½ pt	2 pt	X			X
Phosphamidon	8 EC	¼ pt	1 pt	X	X		X
Phosphamidon	8 EC	⅛ pt	½ pt	X	X	X	X
Systox	6 EC	⅓ pt	1⅓ pt	X	X		X
Systox	6 EC	¼ pt	1 pt	X	X		X
Dimethoate	2.7 EC	1½ pt	6 pt	X	X		X
Dimethoate	2.7 EC	1 pt	4 pt	X	X	X	X
Dimethoate	25 WP	2 lb	8 lb	X	X		X
Dimethoate	25 WP	1 lb	4 lb	X	X	X	X
Guthion	50 WP	½ lb	2 lb	X	X	X	X
Imidan	50 WP	1 lb	4 lb	X	X	X	X
Gardona	75 WP	⅔ lb	2⅔ lb	X(a)			
Thiodan	50 WP	1 lb	4 lb	X	X		X
Thiodan	50 WP	¾ lb	3 lb	X	X	X	X
Sevin	50 WP	2 lb	8 lb	X(a)			
Diazinon	50 WP	1 lb	4 lb	X	X		X
Zolone	3 EC	1 pt	4 pt	X(a)			
Miticides							
Superior Oil + phosphate	----------	2 gal	8 gal	X			
Acaralate	2 EC	1 qt	4 qt	X(a)			
Carzol	SP	½ lb	2 lb	X(a)			
Fundal	SP	½ lb	2 lb	X(a)			
Galecron	SP	½ lb	2 lb	X(a)			
Kelthane	35 WP	1¼ lb	5 lb	X(a)			
Morestan	25 WP	½ lb	2 lb	X			
Morestan	25 WP	¼ lb	1 lb	X	X		
Omite	30 WP	1¼ lb	5 lb		X	X	
Plictran	50 WP	6 oz	1½ lb	X	X		
Plictran	50 WP	2 oz	½ lb		X	X	
TEPP	40% EC	⅓ pt	1⅓ pt	X	X		

(a) Use as early in the season as possible.

AN INTEGRATED SPRAY SCHEDULE

Table 4 shows that a large variety of suitable integrated control spray schedules can be developed and all will allow some degree of biological control success. Research has shown, however, that certain programs are more successful than others and we present a highly effective program here. At each plant development stage a choice of materials is given. It is expected that growers will use only the materials listed for each stage as pest problems in their orchards justify treatment. These recommendations are not designed for use as a calendar schedule or to be rigidly followed at each development stage.

Stage	Pest	Material	100 gal Rate/	Acre Rate/
Silver tip to pre-pink	Apple Scab	Dodine (65 WP) (a) (Cyprex)	⅜-½ lb	1½-2 lb
	European Red Mite, San Jose Scale, Aphids	Superior Oil 70 sec vis + phosphate(b)	2 gal	8 gal
	Aphids	Phosphamidon 8 EC	¼ pt	1 pt
		or		
		Demeton (Systox) 6 EC	¼ pt	1 pt
		or		
		Dimethoate (Cygon) 2.67 EC	¾ pt	3 pt
		25 WP	1 lb	4 lb
		or		
		Thiodan 50 WP(c)	1 lb	4 lb
		2 EC	1 qt	4 qt
	Tarnished Plant Bug, Green Fruitworm, Leafrollers, Climbing Cutworms	Parathion 15 WP	1 lb	4 lb
		or		
		Guthion 50 WP	½ lb	2 lb
		or		
		Imidan 50 WP(d)	1 lb	4 lb
		Diazinon 50 WP(d)	1 lb	4 lb

(a) See notes on mixing fungicides with oil treatment, Bulletin 154.

(b) If scale is a problem add Ethion 1 lb actual or Flowable Parathion .6 lb actual or Diazinon 2 lb actual or Trithion 1 lb actual to the recommended per acre rate of oil.

(c) Thiodan also controls Tarnished Plant Bug and Green Fruitworm.

(d) Imidan and Diazinon also provide aphid control.

Stage	Pest	Material	100 gal Rate/	Acre Rate/
Pink	Apple Scab	Captan 50 WP	2 lb	8 lb
		or		
		Dodine 65 WP (Cyprex)	⅜-½ lb	1½-2 lb
	Powdery Mildew, Mite Suppression	Dinocap 25 WP (Karathane)	½ lb	2 lb

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
Pink	Aphids, White Apple Leafhopper	Thiodan 50 WP	1 lb	4 lb
		2 EC	1 qt	4 qt
		or		
		Demeton 6 EC (Systox)	⅓ pt	1⅓ pt
		or		
		Dimethoate 2.67 EC	1½ pt	6 pt
		(Cygon) 25 WP	2 lb	8 lb
	Tarnished Plant Bug, Green Fruitworm, Fruit Tree Leafroller	Parathion 15 WP	1 lb	4 lb
		or		
		Guthion 50 WP	½ lb	2 lb
		or		
		Imidan 50 WP	1 lb	4 lb
		or		
		Diazinon 50(e)WP	1 lb	4 lb

(e) Diazinon will also control white apple leafhopper.

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
Petal Fall	Disease recommendations same as pink stage.			
	Aphid, leafhopper recommendations same as pink stage.			
	Redbanded Leafroller, Plum Curculio (f)	Guthion 50 WP	½ lb	2 lb
		or		
		Imidan 50 WP	1 lb	4 lb

(f) If Plum Curculio is a serious problem increase Guthion rate by 25% and Imidan at 1½ lb in petal fall and first cover sprays.

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
First Cover	Apple Scab	Captan 50 WP	1½-2 lb	6-8 lb
		or		
		Dodine (Cyprex) (65 WP)	¼ lb	1 lb
	Apple Scab, Mite Suppression or Powdery Mildew	Dikar (80 WP)(g)	1½ lb	6 lb

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
First Cover	Powdery Mildew, Mite Suppression	Karathane(g) (25 WP)	½ lb	2 lb
	Redbanded Leafroller, Plum Curculio	Guthion (50 WP) or Imidan (50 WP)	½ lb 1 lb	2 lb 4 lb

(g) Normally a good oil application will provide mite control until the second to fourth cover period or until predatory mites have migrated into the fruit tree. If mites appear before predators are present Dikar and Karathane will provide adequate mite suppression until predators arrive in the tree.

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
Second Cover	Apple Scab	Same as first cover		
	Apple Scab, Mite Suppression or Powdery Mildew	Same as first cover		
	Powdery Mildew, Mite Suppression	Same as first cover		
	Codling Moth	Guthion (50 WP) or Imidan (50 WP)	½ lb 1 lb	2 lb 4 lb
Third Cover	Scab	Captan (50 WP) or Dodine (Cyprex) 65 WP	1 lb ¼ lb	4 lb 1 lb
	Scab, Mite Suppression, Mildew	Dikar (80 WP)(h)	1 lb	4 lb
Third Cover	Mite Suppression, Mildew	Dinocap (25 WP) (h) (Karathane)	¼ lb	1 lb
	Aphids	Thiodan 50 WP or Phosphamidan (8 EC)	¾ lb 2 fl oz	3 lb 8 fl oz
	Codling Moth	Guthion 50 WP or Imidan 50 WP	½ lb 1 lb	2 lb 4 lb

(h) Reduced rates of Dikar and Karathane should allow spider mites to increase slowly and allow for the buildup of *Amblyseius fallacis*.

Stage	Pest	Material	Rate/ 100 gal	Rate/ Acre
Fourth Cover	Apple Scab	Captan 50 W Dodine (Cyprex) (65 WP)	1 lb ¼ lb	4 lb 1 lb
	Codling Moth, Apple Maggot	Guthion 50 WP or Imidan 50 WP	½ lb 1 lb	2 lb 4 lb
Fifth-Eighth Cover	Disease recommendations same as fourth cover.(i)			
	Codling Moth, Apple Maggot, Redbanded Leafroller	Guthion 50 WP or Imidan 50 WP	½ lb 1 lb	2 lb 4 lb
	White Apple Leafhoppers, Aphids	Thiodan 50 WP Phosphamidon 8 EC	¾ lb 2 oz	3 lb 8 oz

(i) Summer spider mite control—see discussion on pages 5-6 or Fig. A and Table 1.

Fig. 7. ***Amblyseius fallacis*** feeding on a twospotted spider mite (note color).

Fig. 8. ***Amblyseius fallacis*** feeding on European red mite (note color).

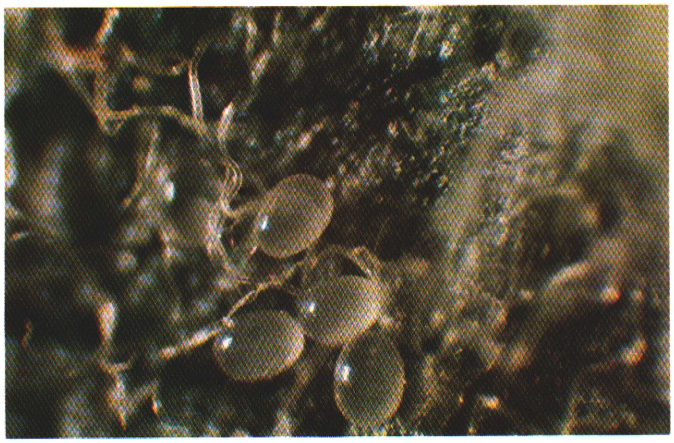

Fig. 9. Eggs of ***Amblyseius fallacis.***

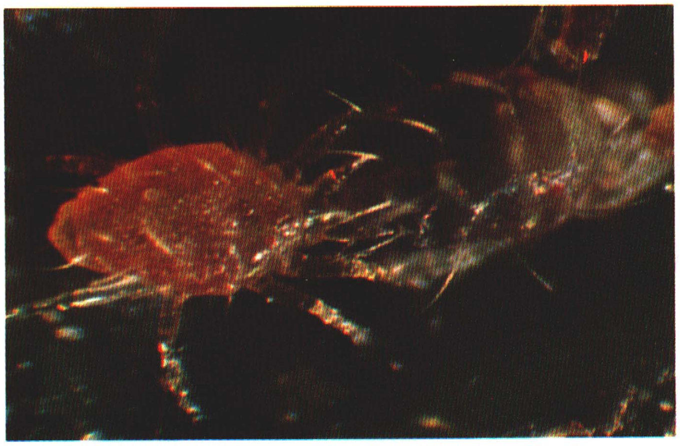

Fig. 10. ***Agistemus fleschneri***, female adult feeding on quiescent stage of European red mite.

Fig. 11. ***Zetzellia mali***, female adult.

Fig. 12. ***Stethorus punctum*** feeding on European red mite.

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