Title: Determining the efficacy of a single thinning application of carbaryl on two species of foliar feeding leafhoppers on apple to reduce late season pesticide intervention.

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Information update: acreage farmed, crop varieties and plantings remain the same as prior to receipt of grant.

Abstract Leafhoppers are a foliar insect pest of apple throughout the apple growing regions of the Hudson Valley of NY state, regions of Wayne Co. in western NY, and across the southern tier of New England. They have traditionally been controlled by apple producers through the use of seasonal pesticide applications aimed at the more susceptible nymphal stage of development. The mid to late season applications have become increasingly undesirable in light of present agricultural and environmental trends. The impact they may have on late season predator populations, the moderate to high toxicity levels and potential exposure risks to applicators, the need to reduce overall pesticide output and pesticide residual on fruit are some of the factors contributing to the need for alternatives to late season applications. Preliminary trials conducted in 1994 at the NYSAES in Highland, NY, and at Breezy Hill Orchard have shown substantial reductions of the egg laying adults of two primary leafhopper species and subsequent reduction of 2^{nd} and 3rd generation nymphs when carbaryl was used in a single thinning application shortly after petal fall on apple. The experimental results from this 1995 trial showed again the effectiveness of thinning applications of carbaryl by controlling early season populations of white apple and rose leafhopper nymphs and adults. The experiments conducted at the Hudson Valley Lab and at Breezy Hill Orchard using Rhone-Poulones new formulation of carbaryl, Sevin XLR, clearly demonstrated the effectiveness of a single application on the reduction of two of the three species comprising the Hudson Valley leafhopper complex. Data gathered on photosynthetic leaf measurements have shown a reduction of leaf photosynthesis as leafhopper feeding increased but only at the most severe leaf rating were the reductions substantial. This work and that of other university research entomologists will allow apple producers to maintain moderate levels of leafhopper feeding without concern to tree physiology and fruit quality.

Background and Justification: Leafhoppers are foliar feeding insects which pierce the underside of the leaf and remove the cellular contents from the palisade cells. The cells lose their color due to the destruction of the chloroplasts giving the leaf a whitish, stippled appearance. Recent photosynthesis readings using a CIRAS-1 gas-exchange analyzer have shown moderate to severe feeding damage reduces leaf photosynthesis (Table 1). The nymphal and adult stage of the leafhopper in later generations produce excrement which, in years of high populations, cause the fruit in pick your own operations to become unsightly. The excrement on fruit in commercial management is washed during post harvest storage procedures and so is not a serious problem in these operations. The adult leafhopper is also a nuisance to commercial fruit pickers and pick your own customers alike. It is believed that additional constituents such as drought and insect stress on the tree physiology (often caused by phytophagous mite & leaf miner) combined with season long leafhopper damage, contribute to overall reduction of fruit size, yield, return bloom, and growth. All of these factors have undoubtedly generated leafhopper control measures.

For the last forty years it has been presumed that the White Apple Leafhopper (WALH), *Typhlocyba pomaria* McAtee, an indigenous leafhopper species on apple, was the primary leafhopper infesting apple. A second species known as the Potato Leafhopper, *Empoasca fabae* (Harris), was also an occasional pest but because of the unpredictability of the migration numbers and infrequent habitation of northern orchards, it remains a secondary pest in mature orchard plantings. Recent findings however have pointed to the significance of a migrating species of leafhopper in the Hudson Valley known as the Rose Leafhopper (RLH), *Edwardsiana rosae* (Linnaeus) (Straub et al. 1994). This species, which closely resembles the WALH, has been found to inhabit 73% of the Hudson Valley orchards surveyed in late September of '91 (Table 2). The nymphs are almost identical in size and color and can only be distinguished in the later instars by the dark spots at the base of the thoracic setal hairs. The adults can be identified by removing the last abdominal segment and excising and keying the aedeagal structure in males and the ovipositor in the female. Recently a vacuum device has been employed at the Hudson Valley Laboratory (HVL) to capture adult leafhoppers throughout the growing season (Straub et al. 1994). Determination of occurrence and migration periods of the RLH has been made. This method has also proven to be a means by which to measure the efficacy of pesticides on adult populations of leafhopper.

1st generation WALH nymphs hatch in early May from over wintering eggs laid in the young wood of apple. They move to cluster leaves to feed, passing through five stages or instars, increasing in size and becoming more mobile and less susceptible to pesticides. The adults emerge in early June, mate and lay eggs in apple foliage giving rise to 2nd generation nymphs from late July through harvest (Graph 1). Migrating WALH adults from unsprayed and abandoned or low spray orchards have been found to re-infest orchards or blocks where the 1st generation nymphs had been previously controlled (Table 3).

The RLH has been found to over winter on a diversity of flora but resides, as an egg and first generation nymph, primarily on florabunda rose. 1st generation RLH nymphs hatch in late April, sooner than do the WALH. During the bloom of florabunda, the RLH adults emerge and begins its migration to alternate hosts including cultivated apple. This migration to apple has been found to begin early in June, just prior to the time WALH adults first emerge. The RLH adults then mate and shortly thereafter the female oviposits her eggs within the ventral mid-rib of the apple leaf. The second generation of the RLH will begin emergence in mid to late June, followed by the 2nd generation of WALH nymph in July. RLH adults begin emigration back to florabunda rose late in July continuing on into late Fall. The RLH has been found to have a partial to full third generation on apple arising in late July to early August. The nymphs continuing on apple until the first hard frost and the adults returning to florabunda rose to mate and lay over-wintering eggs. No over wintering eggs of RLH have been observed to be on apple. This interaction and overlapping of species has no doubt added to the confusing character and control of the LH complex in New York and New England.

The current IPM approach to leafhopper control on apple in NYS and New England is to initiate evaluating populations by scouting cluster leaves of apple shortly after bloom. Populations are monitored and if action threshold levels are exceeded, appropriate applications of efficacious insecticides are recommended at early instar stages while the insect is very vulnerable. Often multiple applications, for two generations, have been needed in years of high populations and prolonged hatch periods. Action thresholds vary from state to state and range from 0.15 to 1.0 nymphs / leaf in the first generation.

The present IPM control strategy of the LH complex will, in most years, call for multiple pesticide applications for each of these species. The adult leafhopper has not been considered a candidate in control strategies due to their perceived hardiness to pesticide treatments. The presence of adults in previously treated orchards generated the perception that the adult leafhoppers are difficult to control and so thresholds / applications have been made exclusively for the nymph stage of leafhopper. Our present understanding of the migratory RLH populations, combined with laboratory bioassays and recent field studies allows us to re-evaluate the nymphal control strategy and look for alternative application windows which may prove to be more effective.

In a recent laboratory bioassay conducted at the HVL, both the nymphal and adult stages were susceptible using a number of recommended LH insecticides (Table 6,7). These findings indicate carbaryl to have a moderate to high efficacy rating on RLH adults at levels well below the established field rate (low field rate of carbaryl 50W at 1 LB / 100 = 1200 ppm). Thus the premise that the nymph is the only susceptible stage for leafhopper control is inaccurate. There is little doubt that the earlier instar nymphs are in fact more easily controlled. Yet it appears from the data presented, that if a single application were to be timed properly, the net result would provide control of the late instar nymphs and early adults of 1st generation WALH as well as the adult of the migrating RLH prior to mating and oviposition, thus reducing the 2^{nd} & 3^{rd} generation of both species. On this basis was our '95 trial conducted at both Breezy Hill Orchard (BH) and at the HVL.

The rational for using carbaryl in these trials is based on three factors. First its ability to act as both a broad spectrum early season pest management tool and as a thinner. Secondly its persistence to maintain its viability as a LH adulticide during the migration of RLH and indigenous WALH adults. And third, it's cost. To add to its strengths, the XLR formulation has new properties, primarily a change in its particulate size, making it less adherent to foraging honey bees. Having a low bee hazard rating at a time when the application to apple will be made while weeds such as dandelion are in bloom makes it more desirable than the 50W formulation. In its broad spectrum efficacy it not only impacts the various stages of leafhopper, but also has been shown to control other fruit feeding early season insects such as Codling Moth, *Laspeyresia pomonella* (L), Oriental Fruit Moth, *Grapholita prunivora* (Walsh), and Plum Curculio , *Conotrachelus nenuphar* (Herbst) (PC). When applied within the conventional thinning window for most varieties, it would abate the need for a first cover insecticide spray usually applied 10D post petal fall. Problem blocks where PC pressure is high has typically required a second and at times a third application post bloom and in high pressure blocks a follow-up application most likely would be needed. This option would allow for PC control within the orchard and in high pressure blocks a boarder row spray for PC could be applied.

Years in which the season begins cool and wet, thinning application windows for plant growth regulators, such as NAA, have often been difficult to manage. Timing the spray at optimum fruit size (10 mm), optimum temperatures (above 70^{o}F), and dry ground permitting heavy spray equipment to make applications safely, is a difficult task. Carbaryl when applied as a thinner, allows for the thinning of fruit when temperatures are below that required for adequate thinning for NAA alone (>70^{o}F), thus buying precious time during a critical spray period. Typically growers in the Hudson Valley have erred on the side of caution and have not had the thinning response required to obtain optimum fruit sizes which command high prices. Understanding the proper use of Carbaryl as a thinner, may encourage growers to thin more aggressively, whereby achieving higher return for their crop.

Carbaryl is not without its weakness, especially in light of its use in an integrated pest management program. In terms of its impact on predators, the 1996 Pest Management Recommendations for Commercial Tree-Fruit Production published by Cornell Cooperative Extension has indicated it to be highly toxic to both cecidomyiid and syrphid fly larva which feed heavily on green aphid species on apple and also highly toxic to stethorus punctum, a predatory beetle which feeds on phytophagous mites. It is moderately toxic to Amblyseius fallacis, a mite predator in the Hudson Valley, and only slightly toxic to Typhlodromus pyri, a second mite predator found in the northeast apple regions.

Objectives: The primary objective of this study was to utilize the recent data on the biology of the leafhopper complex in New York and New England and reassess the present leafhopper control strategy in an attempt to minimize the pesticide usage to a single application made during the thinning period on apple. Within this parameter we theorized that by applying an application of carbaryl at the optimum timing for both thinning and RLH migration we could have an overall net effect on total seasonal LH population. We chose to use the new formulation of carbaryl, Sevin XLR, produced by Rhone-Poulonc. We believed it to be beneficial to determine optimum timing for both the thinning window and RLH migration by designing the experiment to include three timings and two rates. A second consideration we set out to determine was how this integrated approach of carbaryl as both insecticide / thinner would impact both phytophagous and predatory mite populations. Past recommendations using the higher rates of carbaryl as a thinner has been met with skepticism by the grower community. Many growers believe that in some varieties carbaryl may cause excessive thinning when rewetting occurs. So in addition to evaluating the effectiveness of carbaryl as a leafhopper nymph and adulticide, this study would also provide limited thinning data that regional growers may find useful.

This project was a one year study conducted at two sites in the Hudson Valley. Part of the trial was conducted at the Breezy Hill Orchard, located in Staatsburg, NY. They maintain a 20 acre, low input grower orchard block in Dutchess Co. The experiment at the BH site incorporated a randomized complete block design, replicated 3x, using >40 year old McIntosh trees on seedling rootstock, spaced 20' x 35' (62 trees / acre), averaging 22 ft. in height and 20 ft. in width. All treatments were applied dilute to runoff using a high-pressure handgun sprayer at 300 psi delivering 5.6 to 6.7 gal. spray/tree or 347 to 415 gal/acre.

The other location being the Hudson Valley Lab in Highland, NY. 'Red Delicious', 'McIntosh' and 'Cortland' varieties were used on EMII rootstock which were 32 years old, 10 ft high, and 12 ft wide, spaced 15 ft x 30 ft (96 trees / acre). Treatments were applied in a randomized complete block design replicated three times. The trees were not conventionally pruned but headed back both in height and width to maintain accessibility to technical data collection and spray equipment. All treatments were applied dilute to runoff using a high-pressure handgun sprayer at 300 psi delivering 1.7 gal. spray/tree or 163 gal/acre.

The sites differing in application rates, and timing as per APPENDIX II. In all cases, treatments received one application of carbaryl.

Maximum and Minimum Temperatures and Precipitation is found in APPENDIX I. Early spring temperature conditions were cool allowing for prolonged bloom throughout the Hudson Valley. Bloom occurred on 5/8, Petal Fall on 5/22, and king fruit at 10mm on 5/29 at the HVL. Bloom occurred on 5/14, Petal Fall on 5/28 at Breezy Hill Orchard. Note : At the Breezy Hill Orchard, king fruitlet dropped due to frost damage prior to 6/2 application and so that no true thinning data could be taken from that site. The total rainfall for the months of May and June was lower than normal. June rainfall was 1.64 inches and from May 31 to June 26 trees were exposed to only 0.48 inches of rainfall, allowing for greater persistence of material on foliage.

1st generation WALH nymphal populations were monitored by counting 100 random spur and or terminal leaves per tree. Representative florabunda rose plants in the orchard perimeter were monitored for RLH nymphal development, adult emergence and initiation of migration. RLH and WALH adult populations were monitored using a vacuum devise (described in reference) in 3 minute sweeps in all of the treatments, collected and dissected for species identification. 2nd and 3rd generation nymphal populations were monitored in all treatments by examining 100 terminal leaves. Phytophagous and predacious mite populations were evaluated by sampling 25 leaves from each 'McIntosh' at BH. Leaves were kept 'on ice' in coolers and brushed with a mite brushing machine, and the mites and eggs examined using a binocular scope. Representative leaves from 'McIntosh' were rated visually for degree of leafhopper nymph damage on a scale of 0-5. (0 = no LH feeding, 1 = <10%, 2 = 10% - 25%, 3 = 25% - 50%, 4 = 50% - 75%, 5 = >75% or almost white). The leaves in each of these categories were then measured to determine net leaf photosynthesis using a CIRAS -1 gas analyzer (PP Systems, MA). These data were taken from 5 spur and 5 terminal leaves for each rating per tree from trees which were treated with Omite 30W to eliminate mite influence on photosynthesis. The data are displayed as PNN (net photosynthetic activity of the measured leaf). Optical scans of representative leaves were made using a UMAX color scanner (UMAX Data System, Inc.) and leaf damage assessed using IPLab Spectrum software (Signal Analytics Corp.VA) with a Power Macintosh 7100/66 computer (Apple Computer, Inc. CA). Correlation's of PNN readings and visual ratings with percent chlorophyll loss as determined by % color loss were made. The thinning evaluations included limb diameter measurements, blossom cluster, and fruit harvest counts to determine crop density, mean fruit diameter, weight, and fruit / cm2 branch cross sectional area measurements. Data shown in graphs and charts were analyzed using analysis of variance (SuperANOVA, Abacus Concepts, Inc. CA) where indicated by letters following numeric data.

Evaluations:

Evaluations made on the effectiveness of the individual treatments as leafhopper management tools were assessed throughout the season on both nymph and adult populations of both LH species, as well as visual leaf ratings to assess season long LH feeding damage.

The BH Orchard was evaluated for nymphs post application twice during the growing season. Table 3 shows treatment #2, the higher rate of Sevin XLR at 32 oz./100 gal., having significant seasonal impact on populations of 1st and 2nd generation LH nymphs on both the 7/14 & 9/14 counts. Interestingly the populations of both counts of nymphs were primarily WALH in nature.

HVL evaluations (Table 8) showed the earlier spray of Sevin XLR at the 16 oz./100 rate at 5mm to be more effective at controlling 1st generation of WALH and reducing feeding more than the 10mm and 15mm timing. The later applications however had a greater impact on migrating LH populations and subsequently had a greater influence on (EOS) adults. The applications of Sevin XLR at the 32 oz./100 rate showed a rate response in all three treatments to show overall decrease in nymph populations, feeding damage, early and EOS adults. The evaluations made on early season adult populations were comprised of 93% RLH and 7% WALH whereas the late season evaluations contained 98% WALH and 2% RLH.

BH leaf feeding evaluations (Table 4) shows a greater numeric reduction in nymph feeding in the Sevin XLR at the 32 oz./100 rate when compared to both the Sevin XLR at the 16 oz./100 rate (11% PNN reduction) and the untreated (15.2% PNN reduction) resulting in a PNN reduction of 10.2%. The reinfestation of WALH adults into the treated plots demonstrates the need for whole farm LH control to reduce WALH migration from untreated blocks to treated blocks.

The HVL applications (Table 5) of Sevin XLR at the 16 oz./100 rate at 10mm in the HVL trials kept feeding damage to 8.5% reduction of PNN. Applications of Sevin XLR at the 32 oz./100 rate at 10mm reduced feeding damage further to a 5.0% reduction of PNN. The untreated trees desplayed a 21.1% PNN reduction.

The BH Orchard was evaluated for mite presence on 6/17 and 8/9 (Table 9). The early evaluation showed lower ERM mite and egg numbers in both the 16 and 32 oz. treatments of Sevin XLR than both the NAA and untreated treatments but they did not differ significantly. The late evaluations did show a numeric difference between treatments but only in the apple rust mite data did significant differences between treatments occur. The ARM populations were not high enough to cause foliar or fruit damage at these levels.

Due to extensive frost damage to the king blossom, thinning evaluations could not be made at the BH site. Thinning data from these trials taken at the HVL showed the insecticidal rates of Sevin XLR to have greater numeric reduction in fruit / blossoms in both McIntosh (Table 10) and Cortland (Table 11) varieties than the lower thinning rates but they did not differ significantly using Fishers protected LSD (P=0.05). In the McIntosh, both rates indicate the optimum timing to be 10mm for greatest fruit number reduction. In all cases in the McIntosh variety, the XLR treatments did not significantly differ in its reduction of fruit over NAA alone at 10ppm but did significantly differ from the carbaryl at the 1 lb./100 rate at the 10mm timing and the control.

This suggests that the XLR formulation at 16 oz./100 may in fact cause a greater thinning response than carbaryl 50W at the 1 lb./100 rate. Both of these rates having the same AI/100 gal. equivalent. It does not appear from this trial that the XLR over thinned either the McIntosh or Cortland varieties.

Because the trial was primarily designed as an insecticide trial, the trees on which the HVL trials were run were not chosen for their thinning suitability. It has been found that inconsistencies in pruning from treatment to treatment and tree to tree to be a considerable factor in the trees thinning response. The trees used in this study, because of the nature of their use in entomological field studies and need for technical and equipment maneuverability, were pruned for access and ease of data collection and so lack the uniformity needed for thinning experiments. The thinning data presented here is primarily an attempt to show that high recommended insecticide rates can be used at thinning without considerable over thinning. Before recommendations for thinning can be issued, further thinning experiments will need to be conducted on trees which are more aptly suited for thinning trials to determine the extent at which carbaryl at the high insecticide rates cause over thinning, especially on sensitive varieties.

Economic findings: The primary economic results observed here were derived from the photosynthetic data measurements taken using the Ciras-1 gas analyzer. The measurements show the reduction of photosynthesis to be relatively small even in leaf ratings considered to represent high LH feeding levels. This study has surmised that trees with high leaf to fruit ratios without compounding environmental, pathological or additional foliar impact may be able to tolerate moderate to high levels of LH feeding damage. A single timely application aimed at the adults, reducing overall feeding damage, tolerating moderate populations of LH can be accomplished. This understanding provides a strategy to have greatest impact on the LH complex, thus reducing late season sprays and overall pesticide usage.

In evaluating this approach we also find economic benefits in the use of Sevin XLR as both a thinner and insecticide when compared to other insecticide strategies. If applications of NAA were used alone to thin a variety such as McIntosh, the cost of NAA at the 10ppm rate would be $25.80 / acre (300GPA trees). When using Sevin at the 16 oz./100 or higher insecticide rate (32 oz./100gal dilute) the cost of NAA to thin McIntosh is reduced to $12.90 / acre due to the reduction of NAA required when used in combination with carbaryl. The cost of Sevin XLR at the 32 oz./100 rate is $21.40 / acre. When evaluating the cost of both thinning and leafhopper control in this program timed at the 10mm king bloom fruitlet size we would be spending $34.30 / acre.

If we compare this to a single spray IPM approach using a common leafhopper material such as Thiodan 50W we find the thinning costs to be $25.80 / acre. Thiodan 50W would cost us $22.00 / acre. The total cost for this program would be $47.80 / acre. The net savings in this single comparison would be $13.50 / acre. The lack of persistence that Thiodan 50W delivers may not give us the control the Sevin XLR program has shown and so multiple applications may be needed to achieve the same degree of management which of course would increase the overall costs. It would also be more advantagous to use this material (due to its short residual) shortly after the arrival of the adult RLH to obtain greatest control of the adult population and so a separate application to time Thiodan 50W more accurately would be required. This would result in greater cost for two separate applications rather than a tank mix in a single application.

A second option in which Provado 1.6F at the 2.0 oz./100 rate at PF can be used in an IPM LH strategy.

leafminer at this timing. It has a low toxicity toward natural enemies and fits very well into an IPM / low spray program. Again the thinning costs would be $25.80 / acre. Provado 1.6F at the 2.0 oz./100 rate would cost us $24.00 / acre. The total cost for this program would be $49.80 / acre. The net savings in this single comparison would be $15.50 / acre. The additional costs of separate thinning and insecticide applications are not included.

Further research: Many questions have risen from the summary of this data. With the possible acceptance of greater foliar feeding by leafhopper, a number of growers in the Hudson Valley have asked some difficult questions which must be addressed prior to the adoption of new strategies of LH management. Some of the research which needs to be addressed is as follows:

1. The production of ethylene late in the season by the destruction of foliage caused by leafhoppers may contribute to the drop in McIntosh. Determination of ethylene production by LH feeding and its part in causing the abscission of fruit needs to be evaluated.
2. Early season damage to cluster and spur leaves by very high LH populations has been shown to have little or no effect on trees on M-111 and M-7 in Washington and Virginia studies. These trees are moderate to large trees and do not have the leaf to fruit ratio that smaller dwarfing root-stock trees have. Research on dwarfing root stock using common cultivars such as McIntosh which are susceptible to premature drop is required to determine if moderate to high levels of LH feeding induce stress to reduce fruit quality or induce drop.
3. Season long feeding of LH nymphs to non-bearing, newly planted trees by all three species has prompted LH control measures to reduce foliar damage. Research needs to be conducted to determine the effects of LH feeding on non-bearing trees to determine if in fact this feeding effects tree physiology and early fruit production.
4. Imidacloprid or Provado 1.6F at the high 2.0 oz./100 rate at PF has shown excellent seasonal control in the field and a high degree of efficacy at extremely low rates in bioassay on LH nymphs. To evaluate the potential of reducing pesticide volume and costs, a study to evaluate the control of LH adults when Provado 1.6F is applied at the 0.5, 1.0 & 1.5 oz./100 rate at thinning should be conducted.

Summary

Recent research from Virginia (Welker et al. 1995) and Washington State (Beers et al. 1995) has found that fruit size, fruit quality, fruit firmness, return bloom and return crop of apple was relatively unaffected by 1st and 2nd generation WALH with populations of > 3 nymphs and 6.5 LH nymphs / leaf respectively. Both papers suggest increasing present thresholds. In light of these findings and the data presented here it appears that moderate LH feeding damage has little impact to fruit and tree physiology with regards to photosynthetic reductions from nymph feeding. With this understanding, a significant reduction of pesticide use can be achieved, especially late in the season when residue reduction and predator preservation is critical. This approach results in saving the grower time and expense in pesticide application costs. A strategy of early season intervention focusing on the unique LH complex and its migration patterns can be taken. A seasonal reduction in LH presence and acceptable levels of foliar feeding can obtained using this approach in management.

Presentation of findings: The results of the experiments were presented by Peter Jentsch to researchers at the 1995 New England, NY & Canadian Fruit Management Workshop in Vermont. Some of the data has also been presented at the annual fruit school in Kingston, NY sponsored by Cornell Cooperative Extension of Ulster and Dutchess Co. Excerpts will be submitted for publication to growers in written form in the Hudson Valley Fruit Newsletter and Scaffolds newsletter.

References Cited

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Graph 1

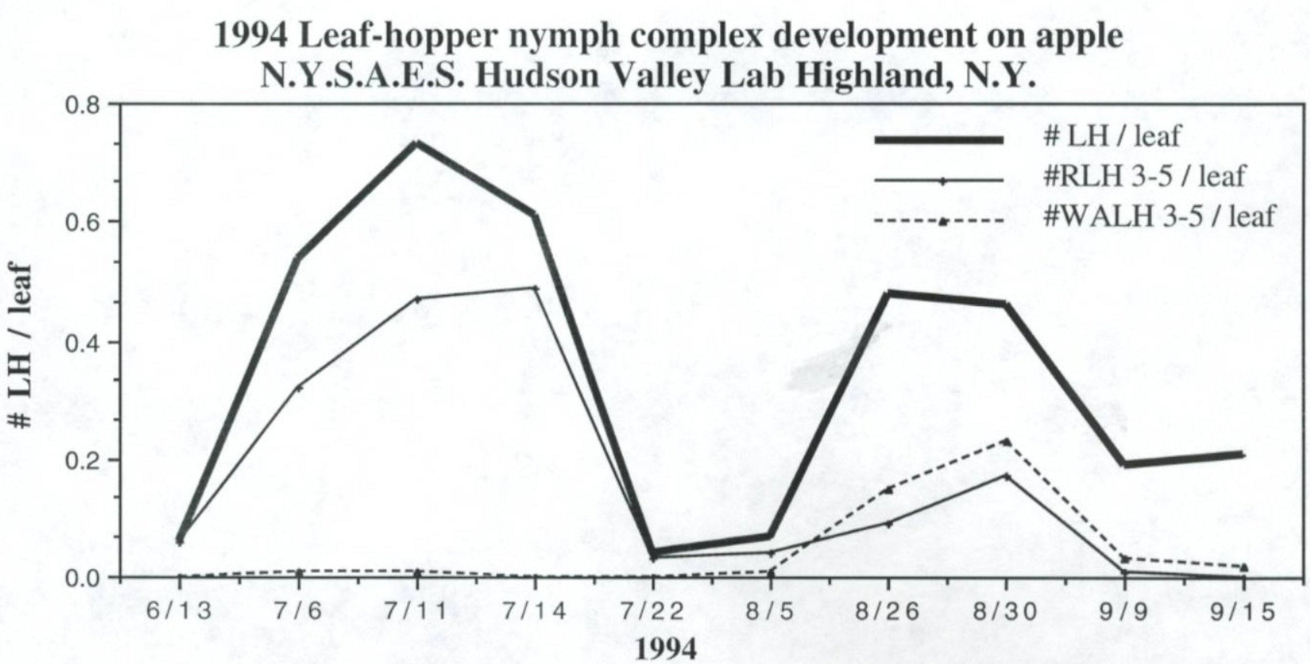

Table 1.

CIRAS photosynthetic measurement of leafhopper feeding on apple[1,2], N.Y.S.A.E.S., Hudson Valley Lab., Highland, N.Y. -1 995

Visual Leaf Rating[3] 0-5	PNN Spur lvs	PNN Terminal lvs	PNN S&T lvs	% PNN Reduction
0	-	18.7 e	15.7 c	-
1	14.5 b	17.1 de	15.8 c	-
2	13.6 b	15.5 cd	14.5 bc	7.7%
3	12.4 b	14.0 bc	13.2 b	16.0%
4	13.0 b	12.9 b	12.9 b	17.6%
5	6.5a	8.2a	7.4a	52.8%

1 Data taken from 'McIntosh' on EMII rootstock, 32 year old trees, over three replicates in a complete block design. Omite 30W applications (PF-2C) provided season long mite control so as to limit foliar feeding to leafhopper species.

2 Mean separation by Fishers Protected LSD (P=<0.05). Log_{10} (X + 1) used prior to transformation for statistical analysis of data. Treatment means followed by the same letter are not significantly different.

3 Visual leaf rating 0 = no observable damage; 1 = < 10% damage; 2 = 10-25% damage; 3 = 25-50% damage; 4 = 50-75% damage; 5 = 75-100% damage

Table 2

Occurrence of LH nymphs on apple, 1991

Site	Relative % (late Sept.) WALH	RLH	n
New Paltz	12.5	87.5	40
New Paltz	6.0	94.0	133
New Paltz	4.4	95.6	45
Milton	1.4	98.6	71
Milton	0.0	100.0	88
Walden	1.7	98.3	180
Modena	0.5	99.5	181
Highland	8.5	91.5	197
Ardonia	39.6	60.4	91
Clintondale	99.4	0.6	166
Highland	90.0	10.0	100

Table 4

Ciras evaluations of leaf damage by season long leafhopper populations on apple[1,2,3], Breezy Hill Farm., Staatsburg, N.Y.-1995

Treatment[4]	Formulation amt./100 gal.	Visual Leaf Rating 6/9 **Spur**	Visual Leaf Rating 9/14 **Spur**	Visual Leaf Rating 9/14 **Terminal**	Mean Leaf Rating	% Reduction PNN
1. Sevin XLR + NAA	16.0 oz. 5.0 ppm	0.2a	2.0a	2.7ab	2.4	11.0%
2. Sevin XLR + NAA	32.0 oz 5.0 ppm	0.1a	2.3ab	2.2a	2.3	10.2%
4. NAA	5.0 ppm	2.4 b	2.5 b	2.6ab	2.6	12.7%
11. Untreated	-	2.2 b	2.6 b	3.1 b	2.9	15.2%

1 Data from ' McIntosh'

2 Mean separation by Fishers Protected LSD (P=<0.05). Log_{10} (X + 1) used prior to transformation for statistical analysis of data. Treatment means followed by the same letter are not significantly different.

3 LH populations = rose leafhopper, white apple leafhopper, potato leafhopper

4 Application Date 6/2

5 Visual leaf rating 0 = no observable damage; 1 = < 10% damage; 2 = 10-25% damage; 3 = 25-50% damage; 4 = 50-75% damage; 5 = 75-100% damage

Table 5

Ciras evaluations of leaf damage by season long leafhopper populations on apple N.Y.S.A.E.S., Hudson Valley Lab., Highland, N.Y. -1 995

Treatment	Leaf Rating / 25 term. lvs 10/ 26	Leaf Rating / 25 spur. lvs 10/ 26	% Reduction PNN
Provado 1.6F 2 .0 oz / 100 (5/23, 6/11)	0 .3 a	0 .4 a	< 1.0
Sevin XLR 5mm 16 .0 oz / 100 (5/25)	2 .9 c	3 .6 c	16.4
Sevin XLR 10mm 16 .0 oz / 100 (5/31)	**1 .5 b**	**2 .7 b**	**8.5**
Sevin XLR 15mm 16 .0 oz / 100 (6/6)	1 .7 b	2 .6 b	9.0
Sevin XLR 5mm 32.0 oz / 100 (5/25)	1.9 c	2.7 c	10.2
Sevin XLR 10mm 32 .0 oz / 100 (5/31)	**1.3 b**	**2.0 b**	**5.0**
Sevin XLR 15mm 32 .0 oz / 100 (6/6)	1.0 b	2.0 b	3.9
Untreated	3 .8 d	4 .4 d	21.1

Table 6 **Summary of RLH Nymph Bioassay**

Treatment	Conc.	% Mortality 24 Hrs.	Feeding Severity	% Mortality 48 Hrs.	Feeding Severity
Carbaryl 50W	37.5 ppm	6.7 g	1.5 f	16.7 ef	2.3 h
Carbaryl 50W	75.0 ppm	26.7 f	1.0 e	50.0 c	1.5 g
Carbaryl 50W	150.0 ppm	80.0 bcd	0.4 c	86.7 ab	0.6 cd
Endosulfan 50WP	37.5 ppm	63.0 de	0.7 d	88.9 ab	0.9 de
Endosulfan 50WP	75.0 ppm	60.7 e	0.9 de	85.7 ab	1.1 ef
Endosulfan 50WP	150.0 ppm	96.7 ab	<0.1 a	100.0 a	<0.1 ab
Lannate 90WP	37.5 ppm	92.0 abc	0.0 a	100.0 a	0.0 a
Lannate 90WP	18.8 ppm	26.0 cde	0.4 bc	100.0 a	0.4 bc
Lannate 90WP	9.4 ppm	79.2 bcd	0.7 d	85.2 ab	0.8 de
Lannate 90WP	4.7 ppm	60.0 e	0.8 d	84.0 b	1.0 ef
NTN 240SF (Imidicloprid)	37.5 ppm	100.0 a	0.0 a	100.0 a	0.0 a
NTN 240SF	18.4 ppm	100.0 a	<0.1 a	100.0 a	<0.1 ab
NTN 240SF	9.2 ppm	100.0 a	<0.1 a	100.0 a	<0.1 ab
NTN 240SF	4.7 ppm	100.0 a	0.1 ab	100.0 a	0.1 ab
NTN 240SF	2.3 ppm	100.0 a	0.0 a	100.0 a	0.0 a
NTN 240SF	1.2 ppm	100.0 a	0.1 ab	100.0 a	0.1 ab
Untreated	-	0.0 g	1.5 f	0.0 g	2.4 h

Table 7 **Summary of RLH Adult Bioassay**

Treatment	Conc.	% Mortality 18 Hrs.	Feeding Severity
1. Carbaryl 50W	150.0 ppm	73.0	-
2. Carbaryl 50W	300.0 ppm	100.0	-
3. Untreated	-	7.0	0.0

* Florabunda leaves containing 7-9 leaflets were dipped in treatment solution and hug to air dry for 30 minutes. Adult RLH were placed in modified microcentrifuge tubes[1] and allowed to feed on leaves for 18 hours. All treatments including the untreated leaves recieved AG-98 spreader at 3 ml. / 150 ml of solution at dip time.Tubed opened at 18 hours for feeding and mortality examination.

[1] Fisherbrand Flat Top Microcentrifuge Tube; 1.5 mL polypropylene. Cat.# 05-407-10 Natural. Tube base was removed and screening hot glued to new opening to create a 1.5 cm. cage. Cotton dental wick cut to 5 mm watered and placed in cap. Dorsal leaf surface placed on cotton, leafhopper placed in tube and cap closed.

Table 8

Evaluation of early season insecticides on foliar feeding insects on apple[1,2], N.Y.S.A.E.S., Hudson Valley Lab., Highland, N.Y.-1995

Treatment	Formulation amt./100 gal.	# WALH nym. /100 lvs 6/9	Leaf Rating[3] /25 spur lvs 6/19	# 2nd Gen. adult [2] / 3 min. Vac. Sweep 6/9	# 3rd Gen. adult [2] / 3 min. Vac. Sweep 9/11
Provado 1.6F PF (5/23)	2.0 oz.	0.0a	0.03a	0.0a	0.8a
Sevin XLR 5 mm (5/25)	16.0 oz	2.1a	0.13ab	1.0a-c	-
Sevin XLR 10 mm (5/31)	16.0 oz	10.2a	0.30 c	0.6a-c	13.4 cde
Sevin XLR 15 mm (6/6)	16.0 oz	5.9a	0.69 d	0.3ab	8.2 bcd
Sevin XLR 5 mm (5/25)	32.0 oz.	1.4a	0.21 bc	0.4a-c	5.0 bc
Sevin XLR 10 mm (5/31)	32.0 oz.	0.7a	0.23 bc	0.3ab	5.4 bcd
Sevin XLR 15 mm (6/6)	32.0 oz.	1.6a	0.19 bc	0.0a	4.0 b
NAA 10 mm (5/31)	10ppm	60.7 b	0.61 d	1.9 c	15.0 de
Carbaryl 50W 10 mm (5/31)	16.0 oz	0.0a	0.16abc	1.6 c	3.6 b
Untreated		174.8 c	1.41 e	10.2d	25.7 e

1 Data from ' Red Delicious'.

2 Mean separation by Fishers Protected LSD (P=<0.05). Log_{10} (X + 1) used prior to transformation for statistical analysis of data. Treatment means followed by the same letter are not significantly different. Untransformed data are presented. WALH = white apple leafhopper, LH adult = leafhopper complex consisting of white apple leafhopper, rose leafhopper, and potatoe leafhopper. Of 64 adults collected on 6/9 adult vacuum sweep 92.2% were RLH sp. Of 292 adults collected on 9/11 adult vacuum sweep 1.7% were RLH, 98.2% were WALH

3 25 spur leaves / tree representing 1st gen WALH damaged leaves. 0 = no stipling, 1 = slight stipling (<10% of leaf), 2 = low stipling (>10-25%), 3 = moderate 25-50%, 4 = heavy stipling (50-75%), 5 = extreme (2-3rd generation) >75%.

Table 3

Evaluation of early season insecticides on foliar feeding insects on apple[1,2],
Breezy Hill Farm., Staatsburg, N.Y.-1995

Treatment	Formulation amt./100 gal.	# LH nym. /100 lvs 7/14	# 2nd Gen. WALH nym. /100 lvs 9/14
1. Sevin XLR + NAA	16.0 oz. 5.0 ppm	8.4 b	71.4 b
2. Sevin XLR + NAA	32.0 oz 5.0 ppm	1.2a	54.9a
3. NAA	5.0 ppm	15.1 c	123.4 c
4. Untreated		11.4 b	76.2 b

1 Data from ' McIntosh'.
2 Mean separation by Fishers Protected LSD (P=<0.05). Log_{10} (X + 1) used prior to transformation for statistical analysis of data. Treatment means followed by the same letter are not significantly different.
LH nymph = rose and white apple leafhopper; WALH = white apple leafhopper only

Table 9

Evaluation of Sevin XLR for managing mite populations on apple[1,2],
Breezy Hill Farm., Staatsburg, N.Y.-1995

		6/17 Mean # of mites or eggs / leaf**					8/9 Mean # of mites or eggs / leaf**				
Treatment[3]	Formulation amt./100 gal.	ERM	ERME	TSM	AMB	ARM	ERM	ERME	TSM	AMB	ARM
1. Sevin XLR + NAA	16.0 oz. 5.0 ppm	8.1a	6.2a	0.1a	<0.1a	0.0a	3.1a	3.4a	0.0a	0.9a	9.4 b
2. Sevin XLR + NAA	32.0 oz 5.0 ppm	10.2a	5.6a	0.1a	0.0a	0.0a	2.1a	1.7a	0.0a	1.0a	2.3a
4. NAA	5.0 ppm	12.4a	6.4a	0.3a	<0.1a	0.0a	1.0a	0.8a	0.0a	0.7a	1.3a
11. Untreated	-	25.8a	13.9a	0.9a	0.1a	0.0a	1.7a	0.8a	0.0a	0.3a	2.6a

1 Data from ' McIntosh'
2 Mean separation by Fishers Protected LSD (P=<0.05). Log_{10} (X + 1) used prior to transformation for statistical analysis of data. Treatment means followed by the same letter are not significantly different.
* *ERM = European Red Mite, ERME = ERM Egg, TSM = Two Spotted Mite, AMB = Amblyseius fallacis,
ARM = Apple Rust Mite.
3 Application Date 6/2

Table 10

Evaluation of early season insecticides on fruit thinning on apple[1,2],
N.Y.S.A.E.S., Hudson Valley Lab., Highland, N.Y.-1995

Treatment	Formulation amt./100 gal.	Mean Fruit Diameter (mm)	Mean Fruit Weight (gr.)	fruit / blossoms	Fruit / cm^2 BCA
Sevin XLR 5 mm (5/25)	16.0 oz	66.3 a-d	108.6 a-d	0.43abc	3.68 bcd
Sevin XLR 10 mm (5/31)	**16.0 oz**	**66.0 a-d**	**109.7 a-d**	**0.34a**	**1.98ab**
Sevin XLR 15 mm (6/6)	16.0 oz	68.8 b-d	113.2 b-d	0.36ab	1.61a
Sevin XLR 5 mm (5/25)	32.0 oz.	69.8 cd	126.4 cd	0.45abc	2.46abc
Sevin XLR 10 mm (5/31)	**32.0 oz.**	**70.6 d**	**133.9 d**	**0.30a**	**1.74a**
Sevin XLR 15 mm (6/6)	32.0 oz.	64.8 a-c	103.5 a-c	0.44abc	3.5 bcd
NAA 10 mm (5/31)	10ppm	64.7 ab	97.9 ab	0.45abc	3.21a-d
Carbaryl 50W 10 mm (5/31)	16.0 oz	65.4 a-d	107.6 a-d	0.63 c	5.31 d
Untreated		62.1 a	89.2 a	0.60 c	3.75 cd

1 Data from ' McIntosh'.

2 Mean separation by Fishers Protected LSD (P=<0.05). Treatment means followed by the same letter are not significantly different.

Table 11

Evaluation of early season insecticides on fruit thinning on apple[1,2], N.Y.S.A.E.S., Hudson Valley Lab., Highland, N.Y.-1995

Treatment	Formulation amt./100 gal.	Mean Fruit Diameter (mm)	Mean Fruit Weight (gr.)	fruit / blossoms	Fruit / cm^2 BCA
Sevin XLR 5 mm (5/25)	16.0 oz	-	-	-	-
Sevin XLR 10 mm (5/31)	16.0 oz	76.8 c	158 bc	0.42ab	4.30 bc
Sevin XLR 15 mm (6/6)	**16.0 oz**	**78.6 c**	**168.3 c**	**0.32ab**	**1.34 a**
Sevin XLR 5 mm (5/25)	32.0 oz.	72.9abc	136.1ab	0.31ab	1.70a
Sevin XLR 10 mm (5/31)	**32.0 oz.**	**74.9 c**	**148.8 bc**	**0.28a**	**1.20a**
Sevin XLR 15 mm (6/6)	32.0 oz.	69.0ab	121.1a	0.29ab	1.62a
NAA 10 mm (5/31)	10ppm	77.3 c	163.4 c	0.43 b	1.90a
Carbaryl 50W 10 mm (5/31)	16.0 oz	73.6 bc	137.6abc	0.34ab	4.42 c
Untreated		67.8a	116.2a	0.43 b	3.10 b

1 Data from ' Cortland'.

2 Mean separation by Fishers Protected LSD (P=<0.05). Treatment means followed by the same letter are not significantly different.

Appendix I

1995 MAXIMUM AND MINIMUM TEMPERATURES AND PRECIPITATION,

Hudson Valley Laboratory, Highland NY

All readings were taken at 0800 EST on the dates indicated for preceeding 24 hours.

	May				June			
Date	Max	Min	Precip		Max	Min	Precip	
1	53	43	0.30		85	52	-	
2	61	40	-		86	61	-	
3	56	36	-		79	65	0.01	
4	70	38	-		85	64	-	
5	72	51	-		78	50	-	First RLH adult on apple
6	60	38	0.01		83	55	-	**Appl. Mc king at 15mm**
7	64	33	-		83	65	-	
8	64	38	-		84	64	-	
9	64	37	-		75	52	0.05	RLH Migration complete
10	72	50	-		77	58	-	
11	52	49	0.16		73	60	-	
12	55	51	0.07		77	61	0.22	
13	64	48	-		64	54	0.20	
14	69	42	-		73	51	-	
15	70	52	-		74	47	-	
16	72	40	0.05		77	48	-	
17	79	49	-		81	55	-	
18	65	56	0.10		89	59	-	
19	62	51	0.07		91	65	-	
20	59	42	0.07		95	70	-	
21	73	44	0.09		93	62	-	
22	80	45	-		80	63	-	
23	73	40	-		81	54	-	
24	78	56	-		81	60	-	
25	86	58	0.95	**Appl. Mc K/B 5mm**	84	67	0.01	
26	70	57	0.10	First RLH adult FBR	86	69	-	
27	64	50	-		86	66	1.15	2nd gen. RLH hatch
28	72	46	0.06		78	46	-	
29	67	54	0.07		78	51	-	
30	78	58	0.47		84	56	-	
31	71	50	-	**Appl. Mc K/B 10mm**				
Ave/Tot	67.6	46.5	2.66		81.3	58.3	1.64	

APPENDIX II

Hudson Valley Lab Carbaryl Schedule

	Treatment	Formulation Rate / 100 gal.	Timing
1	Sevin XLR	16.0 oz	5 mm (5/25)
2	Sevin XLR	16.0 oz	10 mm (5/31)
3	Sevin XLR	16.0 oz	15 mm (6/6)
4	Sevin XLR	32.0 oz.	5 mm (5/25)
5	Sevin XLR	32.0 oz.	10 mm (5/31)
6	Sevin XLR	32.0 oz.	15 mm (6/6)
7	NAA	10ppm	10 mm (5/31)
8	Carbaryl 50W	16.0 oz.	10 mm (5/31)
9	Untreated	-	-

Breezy Hill Orchard Carbaryl Schedule

	Treatment	Formulation Rate / 100 gal.	Timing
1	Sevin XLR +NAA	16.0 oz 5.0 ppm	10 mm (6/2)
2	Sevin XLR +NAA	32.0 oz. 5.0 ppm	10 mm (6/2)
3	NAA	10ppm	10 mm (6/2)
4	Untreated	-	-