Effects of Kaolin Particle Film on the Viburnum Leaf Beetle During Container Production of *Viburnum dentatum* under Different Levels of Nitrogen Fertilization[1]

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Abstract

We investigated two pest management strategies for *Pyrrhalta viburni* (Paykull), a non-native leaf beetle that has invaded New England and is defoliating susceptible wild and cultivated species of *Viburnum*. SurroundWP (kaolin wettable powder) was tested as a barrier spray during container production of *V. dentatum*, to determine if it would affect *P. viburni* leaf damage, oviposition and plant growth. The effect of added N (nitrogen) was also tested. SurroundWP significantly lowered leaf damage and numbers of egg masses in amended plants, without a negative effect on plant growth. Nitrogen use significantly increased leaf damage by adults, numbers of egg masses, and plant growth. These results suggest that commercial growers of susceptible *Viburnum* species in areas where *P. viburni* is found could benefit from the use of SurroundWP, and that N amendment should be kept to a minimum.

Index words: *Pyrrhalta viburni*, pest control, SurroundWP.

Significance to the Nursery Industry

Because V*iburnum* species are widely grown commercially for use in managed landscapes including yards, gardens, restoration projects and highway plantings, significant economic impacts could result if large numbers of the shrubs succumb to the viburnum leaf beetle. A responsible, sustainable alternative to controlling the pests solely with potentially toxic chemical pesticides would be beneficial to the industry. If a combination of cultural and non-toxic controls can be developed to facilitate plant health and resistance without harming naturally occurring predators of the beetles, humans or other species, a reduction in deleterious economic and ecological effects could result. To date no other studies have been conducted with SurroundWP on woody ornamental plants. Our findings indicate that a kaolin particle film is a viable control for reducing leaf damage and oviposition by the viburnum leaf beetle in nursery stock of *V. dentatum* without negatively affecting growth.

Introduction

The viburnum leaf beetle (*Pyrrhalta viburni*), a relative of the elm leaf beetle (*Pyrrhalta luteola*), is specific to members of the genus *Viburnum*, although its preference varies among the species, hybrids, and cultivars (21). The beetles skeletonize leaves, and can completely defoliate a plant in one season. Two to three seasons of complete defoliation usually kill a plant. *Pyrrhalta viburni* over winters in the egg stage. As many as 500 eggs per female (3) are laid in the fall in excavations along the underside of terminal twigs and hatch in mid May. The larvae begin eating leaves immediately, keeping to the undersides and folds of opening leaves. After progressing through three instars in a period of three to four weeks (3), they crawl (Paul Weston, Cornell University, personal communication) to the ground to pupate several centimeters under the soil surface. In mid July the adults emerge to eat, mate, and lay eggs.

P. viburni was first discovered in North America in 1956 in Ontario, Canada, and in 1994 it was found in the United States in a southern Maine nursery (2). Populations are now established in Maine, New York, Vermont, Pennsylvania, and Ohio (20), and sightings have been reported in Connecticut, Massachusetts, Michigan and Washington State (Paul Weston, Cornell University, personal communication). The beetle appears to be spreading steadily south and west at 15 to 20 miles per year (13), following stands of the native *V. dentatum* var. *lucidum* (formerly *recognitum*) that grow as understory vegetation in wet, low-lying areas (20). In Maine the beetle has followed the state highway plantings of *V. opulus* var. *americana* in addition to the naturally occurring native stands (19).

The genus *Viburnum* contains approximately 150 known species of woody shrubs plus their hybrids and cultivars that exist in North America, Europe, and Asia. The United States has approximately 15 native species, only one of which is known to be resistant to the beetle. Viburnums provide berries, browse, pollen and nectar to an assortment of birds, mammals and insects (14, 15, 8, 9). Their loss could disrupt community food webs resulting in the weakening or loss of species that depend upon them. Such an upset of the community structure, with a possible lowering of species diversity, could result in poor resilience to future disruption and susceptibility to invasive species. Native and non-native *Viburnum* species and their cultivars comprise a substantial share of nursery stock. The rapidly expanding, highly mobile trade in nursery stock can easily spread the beetle to new natural areas, and natural stands act as highways for the insects. There could be major negative impacts, both ecological and economic, if native stands, established plantings and nursery material are lost to the invading beetle.

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SurroundWP, containing kaolin, a fine-grained, chemically inert, aluminosilicate ($Al_4Si_4O_{10}[OH]_8$) is primarily used at this time by organic growers of apples, pears and grapes for controlling insect pests and insect vectored diseases (5), decreasing heat stress (4) and increasing fruit yield (16). Studies with blueberries (18), mangoes (7), peaches (10), persimmons and nectarines (12), eggplant (11), and cotton (17) have shown encouraging results in pest control when tested with SurroundWP. Kaolin particle film technology has not yet been applied to the production of ornamental landscape plants, but its inhibitory activity toward insects warrants investigation.

There is ample evidence to show that insect performance may be enhanced by host plant fertilization (6). In his recent review of literature on effects of fertilization on insect resistance in woody ornamental plants Herms (6) did not find any conclusive evidence showing that fertilization enhances resistance to insects, and recommended implementation of fertilization programs for woody ornamentals proceed with caution.

Current literature reports several chemical insecticides that are effective against the larval stage, but none have been tested against the adults. It was our objective to combine particle film technology with manipulation of nitrogen amendment to see if a sustainable method of control for both the larval and adult stages could be found for commercial growers.

Materials and Methods

All experiments took place in the research area adjacent to the Lyle Littlefield Ornamental Garden on the campus of the University of Maine, Orono, ME.

Experiment #1 — 2003. This experiment tested the effects of SurroundWP and N on adult *P. viburni* leaf damage and oviposition, and plant growth. *Viburnum dentatum* 'Morton' liners (rooted cuttings) were purchased from Western Maine Nurseries, Fryeburg, ME. The 216 plants were potted in #2 plastic, nursery pots. Scotts coir-based Metro Mix 560 was amended with Scotts Osmocote Plus (15–9–12) 5–6 month formulation for three treatment levels: N1 = 0; N2 = 1.5 g/liter (1.5 oz/ft^3); N3 = 3 g/liter (3 oz/ft^3). All rates are given in weight of Osmocote, not N. N2 and N3 approximate rates used by commercial nurseries in Maine. In addition to the 72 pots for each N level, 27 unamended 'inoculator' pots were prepared, each containing two plants. Terminal twigs containing *Pyrrhalta viburni* egg masses were collected from wild and campus *Viburnum* plants and wired to the plants in the 'inoculator' pots. The test pots were randomly chosen for placement into a prearranged design of eight pots in a square with an 'inoculator' pot in the center. The squares were arranged into two rows per block with three blocks. All plants were irrigated for one hour per day throughout the growing season with spray stakes, one per pot, from Roberts Irrigation Products, Inc., San Marcos, CA. This insured water run-out from the pot bottoms.

The larvae that hatched on the 'inoculator' plants were allowed to feed on those plants. Additional plants were inserted into 'inoculator' pots when the larvae overwhelmed their host plants. When the larvae entered the soil to pupate in mid-June, the 'inoculator' plants were cut off at soil level and discarded. Before the adult beetles emerged in mid-July, half the test plants in each N level in each block were randomly chosen for SurroundWP treatment and sprayed three times to establish a base coat, then as needed during the season to cover new growth or after each significant rain. SurroundWP, was mixed 227 g (8 oz or 3 cups) per 3.8 liters (1 gal) of water, and applied with a backpack sprayer. A tar-paper cone was used to isolate the plants for spraying. Emerging beetles were allowed to feed at will. In order to insure enough beetle damage to measure and enough egg masses to insure larvae for next year, an additional 54 beetles, 27 male and 27 female, were collected from campus plants and placed on the test plants on August 11. On November 10 the plants were moved to the Fedco cold storage warehouse in Clinton, ME, and over wintered at above freezing temperatures.

Height and two widths (in perpendicular planes) of each plant were measured on May 28 and 30 and again November 7, and a growth index was calculated for each plant by multiplying the dimensions together and subtracting the spring value from the fall value. Leaf damage as a % of total leaf area was estimated for each plant on September 29th to the nearest 10% range. The ranges were: 0%; 1–10%; 11–20%; 21–30%; 31–40%; 41–50%; 51–60%; 61–70%; 71–80%; 81–90%; and 91–100%. Leaf samples were taken July 9 before the beetles emerged and on September 2. One leaf of the first fully opened pair of leaves below a growing tip was picked from each plant. Similar sized leaves were chosen. The leaves were combined by N treatment within blocks for a total of 9 samples. The total leaf N was analyzed by combustion at the Maine Agricultural and Forestry Experimental Station Analytical Laboratory at Orono, ME, using a Leco CN-2000 (Leco Corp., St. Joseph, MI.). Insect egg masses were counted at the end of the winter storage period on May 17, 2004.

Experiment #2 — 2004. This experiment was similar to the 2003 beetle study with fewer plants and only two levels of N. Ninety-six egg mass-free plants were chosen from those over wintered during 2003–2004. On July 12 'inoculator' pots containing pupating larvae were taken from the unsprayed group of the completed Experiment #3 (see below). The plants in the 'inoculator' pots were cut off. Half the plants were randomly chosen to receive a top-dressing of Osmocote Plus (15–9–12) equivalent to 0.75 g/liter (0.75 oz/ft^3) if incorporated. The remainder received a top-dressing equivalent to of 3 g/liter (3 oz/ft^3) if incorporated.

Before the adult beetles emerged in mid-July, half the test plants in each N level in each block were randomly chosen for SurroundWP treatment and sprayed three times to establish a base coat, then as needed during the season to cover new growth or after each significant rain. All pots were irrigated as previously described.

Height and two widths (in perpendicular planes) of plants were measured on May 24 and November 24, and a growth index was calculated for each plant as previously described. Leaf damage was estimated for each plant on October 14 as previously described. Leaf samples were taken on July 21 and analyzed for N as previously described. Insect egg masses were counted on November 9.

Experiment #3 — 2004. This experiment tested larval *P. viburni* leaf damage and plant growth in a matched pair design in one block. One factor, SurroundWP, was tested at two levels: with spray and without. Plants with egg masses from the 2003 study that had been over wintered during 2003–2004 were chosen so that there were 47 pairs of plants with approximately the same number of egg masses (1 to 74 per plant) on each member of a pair. The pairs were then split up, each member of a pair being placed into one of two groups.

One of the groups was randomly designated to receive the SurroundWP spray. Plants designated for spray were randomly chosen to be placed alternately among randomly placed non-sprayed plants. All plants received a top-dressing of Osmocote Plus (15–9–12) equivalent to 1.5 g/liter (1.5 oz/ ft^3) on May 21. Each pot was then topped up with ~ 448 g (16 oz) Scott's Metro Mix 560. The plants were hand-watered every three days to maintain even moisture.

Before the larvae hatched in mid-May the designated plants were sprayed three times with SurroundWP as previously described, once on May 17 and twice on May 21 to establish a base coat. Subsequently they were sprayed as needed after each significant rain until pupation (mid-June). Hatched larvae were allowed to feed at will.

Height and two widths (in perpendicular planes) of each plant were measured on May 24 and July 2, and a growth index was calculated for each plant as previously described. Leaf damage was estimated as previously described on June 29 during pupation.

All analyses were performed with Systat 11.0 software. Two-way analyses of variance (ANOVA) were performed using the general linear model (GLM) procedure, and all means comparisons were performed using Tukey HSD multiple comparison. Normality of model error terms was evaluated with either the correlation test or Lilliefors test. Constancy of variances was tested using Levene's test. If one or both assumptions were not met, a series of transformations (e.g. $Y^{1/2}$, $Y^{1/3}$, log (Y), were applied to bring the error terms into compliance. If no transformation was successful, the data were analyzed using a randomization test. The 2004 egg mass data required a $Y^{1/2}$ transformation, the 2003 plant growth data required a log (Y) transformation, and randomization tests were performed on the 2003 egg mass and 2004 leaf damage data. All significant differences are at $\alpha \leq 0.05$ level.

Results and Discussion

In 2003 there was no SurroundWP/N interaction with respect to leaf damage. There was a significant ($p < 0.05$) 35% reduction in beetle leaf damage due to SurroundWP spraying when averaged across N levels (Fig. 1). The individual reductions were 29% for N1, 40% for N2, and 33% for N3. There was an increase in beetle damage due to increasing N

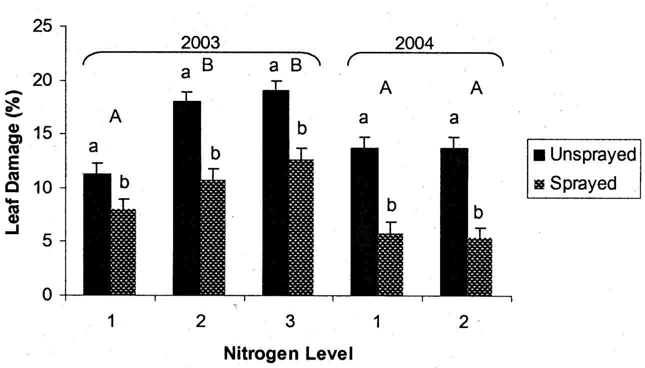

Fig. 1. 2003, 2004 leaf damage due to beetle feeding at three N levels, unsprayed and sprayed with SurroundWP. Lower-case letters show significant* differences between SurroundWP treatments at each N level. Upper-case letters show significant* differences between N treatments, unsprayed and sprayed averaged. Means labeled with the same letter are not significantly different. *p ≤ 0.05

Table 1. Effect of Three N Levels on Percent Leaf N Content Assayed on Three Dates.

		Percent Leaf N		
		N Level		
	Replication	N1 (0)	N2 (1.5 g/L)	N3 (3 g/L)
	1	1.50	2.03	2.07
7/9/2003	2	1.52	1.86	2.23
	3	1.78	1.67	2.12
Average		1.60a	1.85ab	2.14b
SE		.08	.08	.08
		N1 (0)	N2 (1.5 g/L)	N3 (3 g/L)
	1	1.36	1.85	1.95
9/20/2003	2	1.54	1.81	1.85
	3	1.43	1.91	1.85
Average		1.44a	1.85b	1.89b
SE		.04	.04	.04
		N1 (.75 g/L)	N2 (3 g/L)	
	1	1.60	2.30	
7/21/3004	2	1.73	2.54	
	3	1.68	2.24	
Average		1.67a	2.36b	
SE		.07	.07	

Lower case letters show significant* differences between N levels for each sampling date. Means followed by the same letter are not significantly different. *p ≤ 0.05

amendment when averaged across sprayed and unsprayed plants. This increase was significant ($p < 0.05$) from N1 to N2 (49%) and N1 to N3 (64%) (Fig. 1) and may be a reflection of the N content of these plants which also showed significant differences ($p < 0.05$) from N1 to N3 in both July and September (Table 1). The similarity between the leaf N results and the leaf damage may be related to N effects on beetle plant preferences. It has been shown that addition of N above an adequate level does not significantly increase insect performance (1). Leaf N at N2 may have been adequate because damage was not increased from N2 to N3. Because N1 plants received no amendment, they may have been the least efficient N source for the beetles thus the least preferred by them.

There was a SurroundWP/N interaction (F = 5.776, p-value 0.004) with respect to egg masses. There was a significant ($p < 0.05$) reduction of 78% in the number of egg masses due to spraying with SurroundWP when averaged across N levels (94% for N1, 86% for N2, and 69% for N3) (Fig. 2). The reduction in the N1 plants was not significant ($p = 0.933$), and there were few egg masses on any of the plants. There was an increase in the number of egg masses with the increase in N level. The increases in egg mass numbers were significant ($p < 0.05$) only between N1 & N2 (529%) and N1 & N3 (557%), and only in unsprayed plants (Fig. 2). These results paralleled the % leaf N results as did the previously discussed leaf damage results. The egg-laying females may have chosen the unsprayed N2 and N3 plants, because the higher N amendment resulted in softer, less woody twigs that were easier to excavate for oviposition. Most egg masses are laid in the softer terminal twigs of the current season's growth, rarely in older wood. Alternatively or in addition, they simply laid the eggs on the plants on which they were feeding.

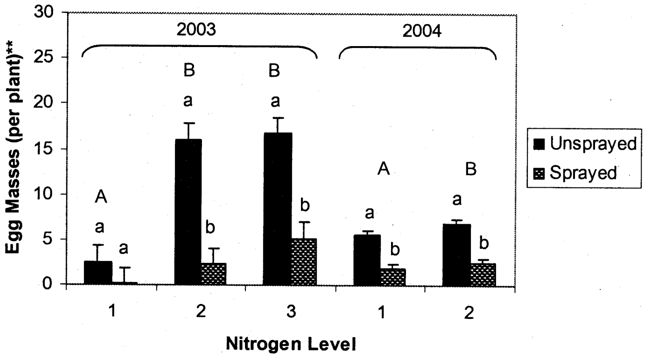

Fig. 2. 2003, 2004 egg masses at three N levels, unsprayed and sprayed with SurroundWP. Lower case letters show significant* differences between SurroundWP treatments at each N level. Upper-case letters show significant* differences between N treatments for unsprayed plants in 2003 and between sprayed and unsprayed plants averaged in 2004. There were no significant differences between N treatments for sprayed plants in 2003. Means labeled with the same letter are not significantly different. *p ≤ 0.05. ** Scale represents v(Y) transformation data for 2004

The similarity in egg mass numbers between sprayed and unsprayed N1 plants was in contrast to the leaf damage results which showed that the beetles chose the unsprayed N1 plants over the sprayed N1 plants for food. This difference in the utilization of the N1 plants for food and oviposition is probably due to the different tissues involved. Even though the N content was low in all the N1 plants, the unsprayed ones apparently were palatable enough for feeding since their leaves incurred more damage than the sprayed ones, but were not palatable enough for excavation of oviposition sites since they did not contain more egg masses than the sprayed ones.

There was no SurroundWP/N interaction with respect to plant growth. There was no significant effect of SurroundWP on plant growth at any N level (Fig. 3). There was a significant ($p < 0.05$) effect of N on plant growth with an increase in plant size associated with an increase in N level when averaged across sprayed and unsprayed plants. The size increase was significant ($p < 0.05$) between N1 and N2: 14%, N1 and N3: 24%, N2 and N3: 9% (Fig. 3).

In 2004 there was no SurroundWP/N interaction with respect to leaf damage. There was a significant ($p < 0.05$) 59% reduction in leaf damage by beetles due to spraying SurroundWP when averaged across N levels (Fig. 1). The reductions were 58% for N1 and 61% for N2. There was no effect of N on leaf damage by beetles (Fig. 1). The total leaf N analyses showed similar results for each level for all three blocks and clear cut differences between the two N levels (Table 1). The 2004 N1 level corresponds to half the 2003 N2 level, and the 2004 N2 level corresponds to the 2003 N3 level. According to the 2004 leaf N analyses, an increase in N level resulted in an increase in leaf N as expected, but there was no resulting increase in leaf damage. Unexpectedly, the leaf N % for the 0.75 g/liter level in July, 2004 (1.67) was very close to the leaf N % for the 0 level in July, 2003 (1.6).

In 2004 there was no SurroundWP/N interaction with respect to egg mass numbers. There was a significant ($p < 0.05$) reduction of 64% in the number of egg masses due to spraying SurroundWP when averaged across N levels (Fig. 2), and there was a significant ($p < 0.05$) increase of 28% in egg masses due to the rise in N level when averaged across SurroundWP treatments (Fig. 2). It appears that the efficacy of SurroundWP in decreasing egg masses is good, but that N amendment may facilitate oviposition on unsprayed plants. An increase in N level resulted both in an increase in leaf N (Table 1) and an increase in the number of egg masses. However, beetle feeding did not increase with an increase in N amendment (Fig. 2).

In 2004 there was no SurroundWP/N interaction with respect to plant growth. There was no significant effect of SurroundWP on the growth of the plants (Fig. 4). There was a significant ($p < 0.05$) effect of N on plant growth with an increase of 216% in plant size associated with the increase in N level when averaged across SurroundWP treatments (Fig. 4).

In the 2004 larval experiment there was a significant ($p < 0.05$) reduction of 76% in larval leaf damage resulting from SurroundWP spray (Fig. 5). Even though the amount of larval damage in unsprayed plants was double that for beetle damage, SurroundWP was as efficacious in reducing leaf damage from larvae as it was for beetles.

The plant growth data for the larval experiment was problematic because of one very large plant in the unsprayed

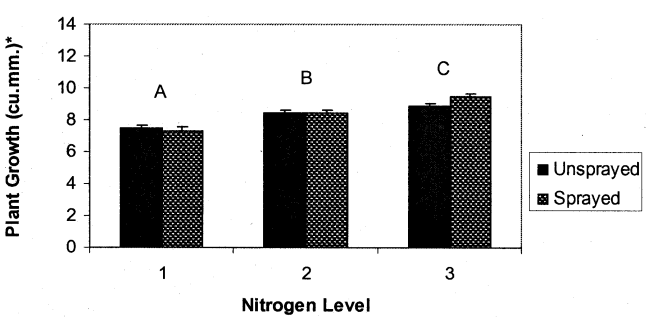

Fig. 3. 2003 plant growth at three N levels, unsprayed and sprayed with SurroundWP. There were no significant differences in plant growth between SurroundWP treatments at any N level. Upper-case letters show significant differences in plant growth between N levels, sprayed and and unsprayed averaged. Means labeled with the same letter are not significantly different. *Scale represents log (Y) transformation. **p ≤ 0.05**

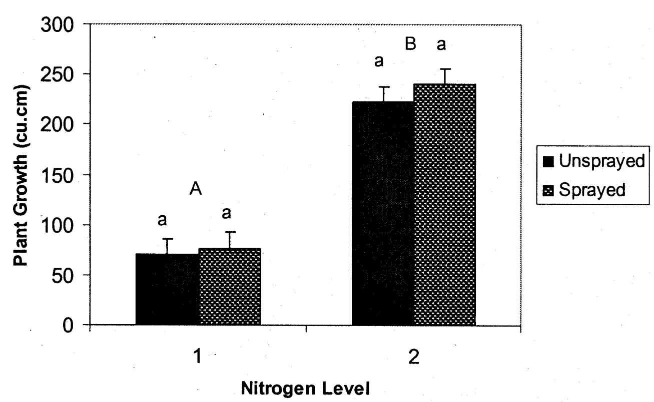

Fig. 4. 2004 plant growth at two N levels, unsprayed and sprayed with SurroundWP. Lower-case letters show there are no significant differences in plant growth between SurroundWP treatments at each N level. Upper-case letters show significant* differences in plant growth between N treatments, unsprayed and sprayed averaged. Means labeled with the same letters are not significantly different. *p ≤ 0.05

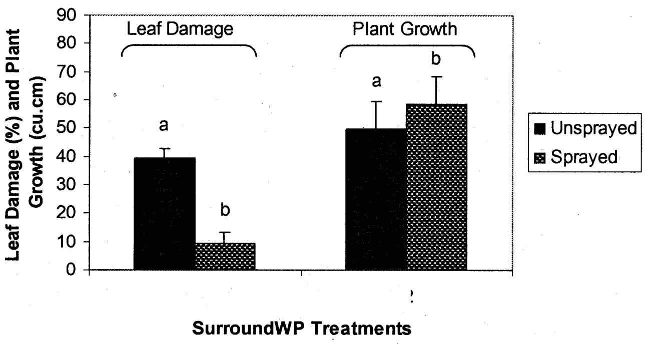

Fig. 5. 2004 larval experiment. Leaf damage and plant growth, unsprayed and sprayed with SurroundWP. Lower-case letters show significant* differences between SurroundWP treatments. *p ≤ 0.05

group. The mean growth indexes of the unsprayed and sprayed plants were 50 cm^3 and 59 cm^3 respectively, while the index for the one very large plant was 372 cm^3. There was no significant ($p > 0.05$) increase in plant growth when the outlier was included in the analysis, but when the outlier was removed, plant growth significantly increased ($p < 0.05$) by 38% due to spraying (Fig. 5). A Wilcoxon signed rank test, which is more immune to outliers, was run with the outlier included in the data, and also gave a $p < 0.05$. This significant increase in size with spraying, which was not seen in the beetle experiments, could have resulted from less loss of N (needed for growth) due to the large (76%) decrease in larval feeding seen on the sprayed plants, and less loss of leaf area utilizable for photosynthesis. In unsprayed plants, the large amount of larval damage early in the season may have had a greater impact on the growth of the plants than later season beetle damage. These results suggest that a large amount of leaf damage on unsprayed plants may be associated with small plant size. In these situations, SurroundWP may both prevent leaf damage and promote plant growth.

In conclusion, SurroundWP has potential as a sound alternative to conventional pesticides that are used for ornamental plants in the nursery industry. Its ability to reduce leaf damage and oviposition by *P. viburni* in these experiments, without negatively affecting desired growth, suggests that its use can substantially reduce the economic effects of leaf damage and shrub decline accompanying the infestation of the beetle. However, since its beneficial effects are impacted by the N amendments routinely used by the industry to increase growth desirable from the marketing standpoint, the recommendation that amendments be kept to a minimum in order that the maximum benefit would result from spraying SurroundWP, must be made. Amendment levels kept below 0.75 g Osmocote/liter (0.75 oz/ft^3) would be the most effective, but consideration should be given to the desired level of plant growth and the level of leaf damage that would be acceptable to the grower.

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