INTEGRATED PEST MANAGEMENT RESEARCH AND IMPLEMENTATION IN MASSACHUSETTS

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The Nursery IPM Program in Massachusetts has just completed its second season. During this time the goals of the program have been to: determine the key pests of Massachusetts nurseries; find the best methods for monitoring these pests; and find ways to better manage pests through the implementation of IPM techniques. The program includes scouting major crops at seven cooperating nurseries located throughout the Commonwealth.

As part of the IPM project, we also conduct experiments to provide additional information about the management of key pests.

ROOT WEEVIL RESEARCH

Black vine weevil (*Otiorhynchus sulcatus*) is a major pest in Massachusetts nurseries. Recently, strawberry root weevil (*Otiorhynchus ovatus*) larvae have also been found to cause significant damage. The significance of these pests lead to several investigations to improve the management of root weevil pests.

Monitoring Black Vine Weevil Adults. Growers commonly time their spray schedules for black vine weevil based on calendar date estimations of adult emergence or when signs of adult feeding (leaf notching) are first detected. Although pit-fall traps have been recommended for monitoring adult black vine weevils (7), Massachusetts growers rarely used traps for monitoring weevil populations, and found that looking for signs of adult feeding was easier than maintaining the traps.

We investigated the use of burlap traps, trap-boards, and visual inspection to determine the most accurate means of early detection of adult black vine weevil activity in nursery crops. Burlap traps and trap-boards were selected because they are simple to construct and are maintenance free (4, 6), which might make them more attractive to growers than pit-fall traps. The traps were placed under *Taxus* plants in a commercial nursery and were inspected twice each week for adult weevils. Plant foliage was also inspected for signs of recent feeding.

Burlap traps were the most effective method for detecting adult black vine weevil activity (Table 1). Signs of adult weevil presence in a block were first detected through the use of burlap traps 81% of the time. Burlap traps were also more attractive as resting places for weevils (Table 2), with an average of 6 weevils caught per burlap trap, compared to 1 weevil per trap-board. Further investigations are planned to determine whether burlap traps can be used to estimate weevil populations in nursery fields.

Table 1. Efficacy of monitoring methods for detection of adult black vine weevil

Monitoring method	Percent first detection of adult black vine weevil activity
Foliar inspection	14.9 ± 10.1
Trap-boards	4.2 ± 4.2
Burlap traps	81.0 ± 11.2

Table 2. Efficacy of burlap traps and trap-boards for monitoring adult black vine weevil

Trap	Ave. number of adult black vine weevils collected per trap
Burlap trap	6.5 ± 3.0
Trap-board	1.2 ± 0.2

Burlap traps are now used in the Massachusetts IPM program to monitor black vine weevil and strawberry root weevil adults. In addition, a fact sheet containing information on the use of burlap traps was sent to Massachusetts nurserymen (6).

Controlling Black Vine Weevil Larvae Using Nematodes. Infested *Euonymus fortunei* radicans, growing outdoors in 2-gal containers in a Massachusetts commercial nursery were treated with three nematode strains: two strains of *Heterorhabditis* sp. (HL 81 and HP 88) are one strain of *Steinernema carpocapsae* (NC All). The applications were made on three dates in May and June (Table 3) and the nematodes were applied at a rate of 1 million nematodes/m^2 of container medium surface. Efficacy of the treatments was determined by the number of black vine weevils that successfully completed metamorphosis and emerged as adults from the container medium (the plants were covered with cheesecloth netting to keep emerging adult weevils in the containers and to exclude migrating weevils).

All nematode preparations were successful in reducing the black vine weevil population, and the nematode strains were equally effective in controlling the weevils (Table 3). Additional experiments will be conducted to determine the effect of container medium temperature of nematode efficacy

Table 3. Effect of nematodes on the incidence of adult black vine weevil emergence from container-grown *Euonymus fortunei* radicans

Nematode strain	No. weevils/container[a]
Untreated check	0.4 a
Heterorhabditis sp	
HL 81	0.2 b
HP 88	0.1 b
Steinernema carpocapsae	
NC All	0.1 b

[a] Means followed by the same letter are not significantly different as determined by Duncan's Multiple range test, P = 0.05

Insecticide Efficacy for Controlling Strawberry Root Weevil Adults. Strawberry root weevil larvae have been found in large numbers infesting hemlock and arborvitae and larval feeding has been associated with the death of hemlock plants in Massachusetts nurseries. The adults have been found infesting hemlock, yew, rhododendron, and arborvitae. Significant damage from the adults has not been noted in Massachusetts, although adults can damage arborvitae by girdling the stems (3). Since there is relatively little published information on strawberry root weevil, a laboratory experiment was conducted to determine the efficacy of several pyrethroid insecticides and Orthene for controlling strawberry root weevil adults in hemlock (*Tsuga canadensis*) fields. To ensure complete foliar coverage, hemlock twigs were submersed in insecticide solutions. The cut ends of the twigs were then placed in small vials filled with tap water to inhibit desiccation of the plant tissue. Twigs were placed in cages containing five adult strawberry root weevils. In addition to the hemlock, each cage also contained a cotton ball that was kept moist with tap water to supply adequate water to the weevils. The effect of the insecticides were evaluated from 2 through 20 days after treatment (DAT). Weevils were considered injured if they behaved atypically as compared to untreated weevils; i.e., if they had diminished coordination when walking or were moribund. The percent dead insects and percent total injury (injured + dead insects) were used to evaluate insecticide efficacy.

Within 2 DAT all the insecticides except Asana and Mavrik significantly injured strawberry root weevil (Table 4). However, some of the weevils that were initially injured by the insecticides recovered, so that by 20 DAT only Tempo 2, Orthene, and Orthene + Danitol caused significant injury. Also, weevils that recovered did not resume feeding on treated foliage and mortality may have been higher if the weevils did not have access to moisture from the cotton balls. Weevils exposed to untreated twigs fed on the foliage throughout the duration of the experiment. (Under field conditions, where environmental conditions are harsher than the lab., mortality may also be higher.) Only Orthene and Orthene + Danitol caused significant mortality. Since Orthene and Orthene + Danitol were equally effective in controlling strawberry root weevil while Danitol alone was ineffective, mortality resulting from Orthene + Danitol may be caused by Orthene.

Table 4 Efficacy of insecticides for controlling adult strawberry root weevil (laboratory study)

Treatment	Rate lb AI/100 gal	2 DAT % mortality	2 DAT % total injury	10 DAT % mortality	10 DAT % total injury	20 DAT % mortality	20 DAT % total injury
Untreated	—	0 (NS)	0 e	7 c	13 c	27 bc	27 cd
Asana 1.9 EC	0.05	0	10 de	3 c	3 c	17 c	17 d
Ambush 2 EC	0.2	0	27 bcd	3 c	27 c	20 c	47 bc
Tempo 2	0.03	0	83 a	17 bc	60 b	47 b	57 b
Mavrik Aquaflow	0.16	0	7 de	3 c	17 c	17 c	20 d
Danitol 2.4 EC	0.4	0	30 bcd	13 c	17 c	17 c	33 cd
Orthene 75 S	0.75	0	43 b	60 a	93 a	100 a	100 a
Orthene 75 S + Danitol 2.4 EC	0.5 + 0.2	0	33 bc	33 b	83 ab	100 a	100 a

Data transformed to arcsine $\sqrt{x}$ before ANOVA. Means within columns followed by the same letter are not significantly different (Waller-Duncan K-ratio t-test, K = 100). (NS) = not significant.

Of the insecticides used in this experiment, only Orthene and Mavrik list strawberry root weevil as a target pest. Based on the results of this experiment, Univ. Massachusetts Cooperative Extension is recommending Orthene for control of strawberry root weevil adults infesting hemlock.

WEED MANAGEMENT

There is limited data on the competitive ability of weed species in nursery crops. However, as more information is generated on the tolerance of specific nursery crops to various levels of weed infestation, nursery managers can use the information to determine whether additional herbicide applications are needed or to determine the frequency of hand or mechanical weeding that will be needed to prevent weeds from reducing crop growth.

Common Groundsel Interference in Nursery Crops. Common groundsel (*Senecio vulgaris*) is considered particularly troublesome in container-grown nursery crops because it begins growing in containers stored in overwintering houses prior to spring applications of preemergence herbicides. Common groundsel seed also germinates in late summer and early autumn in both containers and field-grown crops, when many spring-applied preemergence herbicides are no longer active. Although common groundsel is frequently found in northern nurseries, its effect on the growth of nursery crops has not been established.

Common groundsel interference was determined in container-grown boxwood (*Buxus microphylla* var. *koreana* 'Wintergreen'), euonymus (a variegated sport of *Euonymus fortunei* var. *radicans*), and Sargent juniper (*Juniperus chinensis* var. *sargentii*). Bare-root liners of each species were planted in 1-gal and 2-gal containers. One month later, three-week-old groundsel seedlings were transplanted into the containers at rates of 0, 1, 2, 3, and 4 weeds/container. Any additional weeds that germinated in the containers during the experiment were removed by hand. Nursery crop growth index (Tables 5 and 6) was used to determine the effect of groundsel interference on the growth of the nursery crops. Growth indices were measured 0, 2, 4, and 6 weeks after transplanting (WAT) the groundsel seedlings. The experiment was terminated after the 6 WAT measurement since the groundsel plants had set seed and some had begun to senesce by 6 WAT. The experiment was conducted in a polyhouse where the temperatures were maintained between 75° F (day) and 65° F (night).

Common groundsel did not interfere with the growth of euonymus, but reduced the growth of boxwood 2 through 6 WAT. The decrease in boxwood growth was linear at 4 and 6 WAT (Table 5). There was also a linear decrease in juniper growth at 4 and 6 WAT (Table 6).

Table 5. Effect of common groundsel and container size on the growth index of 'Wintergreen' boxwood

	Mean growth index (cm)[a]			
Treatment significance	0 WAT[b]	2 WAT	4 WAT	6 WAT
Weeds	NS[c]	**	**	**
Linear	—	NS	*	*
Quadratic	—	NS	NS	NS
Container size	NS	*[d]	*[d]	NS

[a] Growth index is determined by (height + width 1 + width 2)/3 Width 1 and width 2 are measurements taken in north-south and east-west directions

[b] WAT = weeks after transplanting common groundsel seedlings into containers

[c] NS, *, ** = Nonsignificant or significant at P = 0 05 or 0 01, respectively

[d] The interaction of weeds and container size was not significant at P = 0 05

Table 6. Table 6. Effect of common groundsel and container size on the growth index of Sargent juniper

Treatment significance	Mean growth index (cm)[a]			
	0 WAT[b]	2 WAT	4 WAT	6 WAT
Weeds	NS[c]	NS	**	**
Linear	—	—	**	**
Quadratic	—	—	NS	NS
Container size	NS	NS	NS	NS

[a]Growth index is determined by (height + width 1 + width 2)/3 Width 1 and width.2 are measurements taken in north-south and east-west directions

[b] WAT = weeks after transplanting common groundsel seedlings into containers

[c] NS,*,** = Nonsignificant or significant at P = 0.05 or 0 01, respectively

Groundsel did not interfere with the growth of euonymus and was moderately competitive in boxwood and Sargent juniper. From this study and similar studies on the effects of weed species on nursery crop growth, a rating system can be devised to determine which weeds species are likely to compete with nursery crops. Growers can use this information to determine whether to tolerate the presence of certain weed species or whether action must be taken to prevent a significant loss of growth of the crop. From the available literature on weed competition in nursery crops, the following rating system was devised (Table 7):

Table 7. Competitive ability of weeds in nursery crops

Highly competitive[a]
Redroot pigweed (2)
Large crabgrass (2, 8, 9, 10)
Giant foxtail (8, 9, 10)
Baryardgrass (8, 9, 10)
Moderately competitive[b]
Common groundsel (6)
Prostrate spurge (1)
Slightly or not competitive[c]
Bittercress (11)
Common yellow woodsorrel (1)

[a] One or two weeds reduces crop growth as much as many weeds, or the relationship between crop growth reduction and weed numbers is quadratic.

[b] Crop growth continues to decrease as weed numbers increase

[c] Little or no reduction of crop growth occurs

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