Physical Barriers to Prevent Dogwood Borer (Lepidoptera: Sesiidae) Infestation of Apple Burrknots[1]

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Abstract Dogwood borer, *Synanthedon scitula* (Harris), infestation of burrknot tissue on apple dwarfing rootstocks is an increasing problem throughout the northeastern United States. One insecticide, chlorpyrifos, is currently the only efficient chemical control available for dogwood borer. Because of scrutiny of chlorpyrifos under the US EPA's Food Quality Protection Act policy and the desire to increase options available to growers, we investigated other dogwood borer control options. Barriers to dogwood borer oviposition may offer an effective, efficient physical control. We tested 4 types of barriers including white latex paint, trunk wraps of spunbonded polyethylene fabric Tyvek® HomeWrap® (E. I. du Pont de Nemours and Company, Wilmington, DE) and self-adhesive veterinary gauze, and a sprayable, nonwoven ethylene vinyl acetate (EVA). These were compared with chlorpyrifos and an untreated check starting in late spring of 2006. All barriers were effective in preventing dogwood borer infestation and remained intact throughout the first growing season. The paint and EVA treatments persisted longer than other treatments. However, by March 2007, the paint treatment was beginning to fade and flake off. By May 2007 the EVA treatment was ≈ 95% (± 9.4%) intact, and trees were significantly less infested than trees in the paint treatment or an untreated check in September 2007. Whereas barriers were significantly less intact in the Tyvek and gauze treatments than in the EVA treatment in 2007, borer infestations were equivalent among treatments. EVA was the least costly of the barriers and its cost may be competitive with conventional chemical control.

Key Words dogwood borer, apple, oviposition barriers, ethylene vinyl acetate

Apple growers are increasingly concerned with the impacts of borers on dwarf apple trees. Apple trees grown on size-controlling (dwarfing) rootstocks have a tendency to develop burrknots, aerial aggregations of root initials, on the rootstock portion of the trunk. Borers, such as dogwood borer, *Synanthedon scitula* (Harris), and American plum borer, *Euzophera semifuneralis* (Walker) (Lepidoptera: Pyralidae), infest apple tree trunks by ovipositing on these burrknots (Rom and Brown 1979). In a statewide survey of dwarf apple orchards in NY, approximately 60% of dwarf apple trees were damaged by borers and approximately 32% of trees were actively infested (Kain et al. 2004). We have not yet determined the overall effect of borer feeding on dwarf apple trees, but borer infestation may result in decreased vigor and even death in affected trees (Riedl et al. 1985). The lifespan of tart cherry trees was estimated to be reduced by one third by American plum borer infestation (Biddinger 1989). Borer

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feeding may also increase tree susceptibility to diseases, such as rootstock fireblight (Rom and Brown 1979). Most insecticides tested provide control of only the summer brood and require multiple applications, and only chlorpyrifos will provide season-long control with one application (Kain et al. 2004). However, chlorpyrifos is under increasing scrutiny by regulatory authorities, prompting an ongoing search for alternatives. In addition, growers are reluctant to apply insecticides to control borers because, to be effective, sprays must be applied with a handgun applicator, which entails considerable labor and potential for worker exposure. Barriers to borer infestation of burrknots may offer effective, long-lasting alternatives to insecticides. In addition, these barriers may possibly be helpful in reducing winter and rodent injury.

Materials and Methods

This study was conducted in a high-density, dwarf apple planting in Huron, NY. This orchard has had a high proportion of trees expressing burrknots and has been historically heavily infested by dogwood borers, averaging 23 - 77% infested trees in untreated check plots over the previous 4 yrs (DPK, unpubl. data). The experimental design was a randomized complete block with each treatment replicated 3 times. Each replicate included 40 trees (2 rows × 20 trees per row).

Evaluating barrier materials for efficacy against dogwood borer infestation. Barriers were applied to the rootstock portion of apple trees between 25 May and 6 June 2006 prior to the beginning of the dogwood borer flight (12 June). A non-woven ethylene vinyl acetate (EVA) treatment was applied using a hot-melt adhesive supply unit fitted with a hand-held spray head (ITW Dynatec, Henderson, TN). The unit was powered in the field by a generator and a compressor so that fluid EVA was extruded as filaments that were then carried to the target by a jet of air (Hoffmann et al. 2001). Undiluted white latex paint (Exterior Flat White 8 - 2000, Yenkin-Majestic Paint Corp., Columbus, OH) was applied with a paintbrush. Strips of spunbonded polyethylene fabric (Tyvek® HomeWrap® E. I. du Pont de Nemours and Company, Wilmington, DE) measuring 7.6 cm wide × 91.4 cm long were precut in the laboratory, then wrapped in a spiral around the lower (rootstock) portion of each trunk and affixed to the trunks with duct tape. A cohesive flexible gauze bandage (SyrVet, Waukee, IA), which comes in 10.2 cm wide × 4.65 m rolls, also was wrapped around the rootstock portion of trunks. There also was an untreated check and a chlorpyrifos standard. Chlorpyrifos (Lorsban 4E, E. I. du Pont de Nemours and Company, Wilmington, DE) was applied at a rate of 1.4 L per 379 L of finished spray solution using a Nifty-Pul-Tank sprayer (Rears Manufacturing Co., Eugene, OR) operating at 10.5 kg/cm^2.

Barriers were removed from half (20) of the trees in each replicate on 16 October 2006. On 18 September 2007 barriers were removed from the remaining trees in each replicate on which some barrier persisted (up to 20; some trees had no barrier remaining and some trees had been rogued by the grower during the winter of 2006 - 7). At each sample date, burrknots were counted and examined for freshly produced frass (an indication of borer infestation) and the proportion of burrknots infested per replicate was determined.

The data violated assumptions for analysis of variance, and transformations were ineffective for stabilizing variance and normality, so the nonparametric Kruskal-Wallace test was used (PROC NPAR1WAY, SAS Institute 1988). The SAS macro, %dunn.sas (available online: www.bfro.uni-lj.si/MR/ggorjan/software/SAS; 12/09/2008), was used to perform Dunn's method rank separations (Dunn 1964).

Determining the longevity of barrier materials. Barriers on 20 trees in each plot were left undisturbed and were examined monthly, beginning 1 month after application (July 2006), through Sep 2007, to determine whether they would last a sufficient amount of time to be of value in prevention of winter injury and rodent injury, though these were not evaluated in these trials, and the length of time that they are likely to provide a barrier to dogwood borer oviposition. The percentage of each material remaining was estimated visually at each monthly inspection. Percent cover remaining was regressed against sample date with the constraint that y-intercept = 100%. Differences among slopes were determined for unconstrained regressions using an ANCOVA model for raw data rewritten as a weighted ANOVA model (SAS Institute 2002).

Economic evaluation. Barrier costs (materials and cost of application) were compared with those of a standard treatment of one trunk application of chlorpyrifos using a handgun applicator. EVA was applied to 10 additional trees, and barriers were subsequently removed and weighed. The total amount of paint used was recorded. Each tree in the Tyvek® treatment was wrapped with an equal-sized strip. The total number of rolls of gauze used, the total amount of finished spray required in the chlorpyrifos treatment, and the time required to apply each treatment were recorded. The average amount and cost per tree for each material was thus calculated.

Results

Efficacy. In October 2006, approximately 20 wks after barriers were applied, infestation by dogwood borer was significantly lower in the EVA and Tyvek® barrier treatments than in the untreated check. Differences between the paint and gauze treatments and the check, and the other barrier treatments, were not significant. All barrier treatments were statistically equivalent to the chlorpyrifos treatment. In 2007, approximately 67 wks after treatment, infestation in only one treatment (gauze) was significantly different from the untreated check. Infestations were significantly lower in the Tyvek and gauze, but not in the EVA, treatments than in the paint treatment. (Table 1).

Longevity. Linear regressions of percent cover against sample date were significant for all treatments, and multiple comparisons of slopes indicated that there were differences among slopes (Fig. 1, Table 3). Of the barriers tested, EVA demonstrated the greatest longevity and gauze the least. Percent coverage remaining in the paint treatment was difficult to quantify because of the nature of the loss of coverage; some of the paint was lost when bark flaked off. More often, ratings were based on paint fading, which was difficult to quantify by visual inspection.

Economic evaluation. An average of 12.4 g (range = 10.3 - 14.8 g) of EVA was applied to each tree. The average amount of paint applied was 95 ml per tree. Each tree in the Tyvek® treatment was wrapped with a 695 cm^2 strip. A total of 23 rolls of gauze was applied to 120 trees; the average amount was 0.89 m/tree. An average of 1.2 ml of chlorpyrifos product (Lorsban 4E) was applied to each tree. Table 2 includes the time required to apply each treatment and contrasts the costs of treatments on a per-tree basis. To provide a more easily relatable illustration, cost of each treatment per hectare is included, using 2964 trees per hectare, and US $8.00/h for labor, as a basis for calculation. The EVA barrier was the most economical at US $345 per hectare, followed by Tyvek at US $846, and gauze at US $1084. Paint was the most expensive treatment at US $1245. In contrast, the cost of the standard insecticide treatment, chlorpyrifos, was US $93.

Table 1. Efficacy of barriers applied to dwarf apple trunks to control dogwood borer in a New York orchard.

Treatment	n	Proportion of burrknots infested*	SE	95% CI
		2006**		
Check	143	0.193 a	0.035	0.044 — 0.342
Paint	134	0.050 ab	0.050	−0.074 — 0.175
Gauze	156	0.039 ab	0.012	−0.012 — 0.089
Tyvek	158	0.013 b	0.013	−0.044 — 0.071
Chlorpyrifos	152	0.009 b	0.009	−0.029 — 0.048
EVA	126	0.000 b	0.000	—
		2007†		
Check	85	0.155 ab	0.017	0.080 — 0.231
Paint	127	0.182 a	0.018	0.106 — 0.259
Gauze	128	0.010 c	0.010	−0.033 — 0.053
Tyvek	138	0.059 bc	0.016	−0.011 — 0.128
EVA	112	0.073 abc	0.035	−0.079 — 0.225

* Means followed by the same letter are not significantly different ($P < 0.05$).

** Approx. 20 wks after application.

† Approx. 67 wks after application.

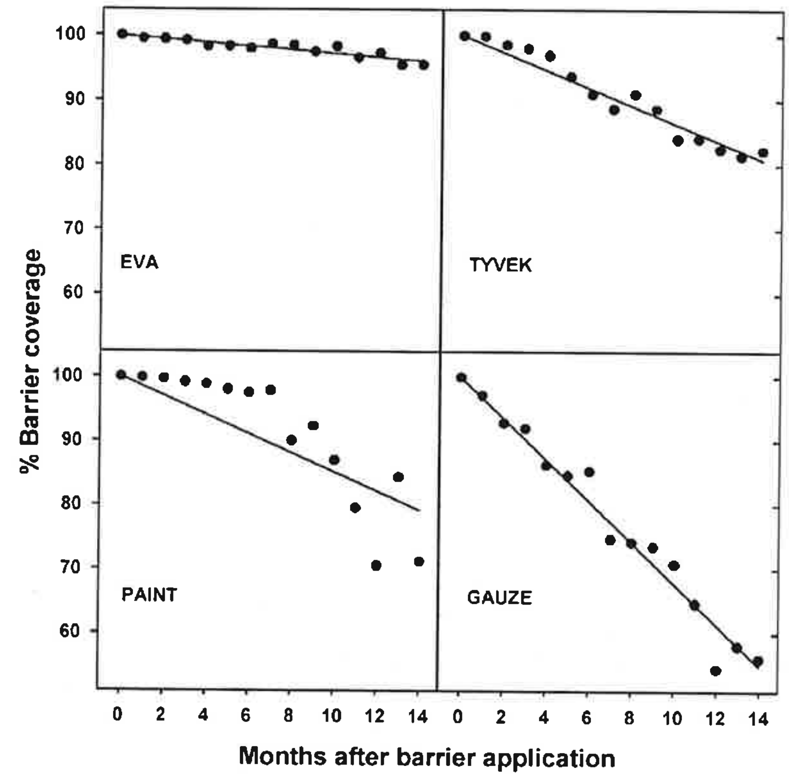

Fig. 1. Percent barrier coverage remaining over time, of barriers applied to dwarf apple trunks to control dogwood borer in a New York orchard.

Discussion

In addition to seasonal control of dogwood borer, it is desirable that barriers remain intact long enough and in good enough condition to provide some measure of rodent deterrence during the winter, as well as multiseason control of dogwood borer. Also desirable is a barrier that is "breathable" and that transmits light so is, presumably, unlikely to cause conditions that lead to the elongation of the root initials that make up burrknots. Barriers must also be economical to apply.

The gauze treatment was chosen because it has an open weave and is, therefore, breathable and because it is impregnated with an adhesive that allows it to adhere to itself when wrapped around the trunk. This seemed to be a practical consideration for its eventual adoption because it is quick and easy to apply. However, within 1 - 2 months the adhesive began to deteriorate and the gauze began to fall away from the trunk. In some cases the gauze itself deteriorated. It degraded more than the other treatments over the winter months and by summer 2007, remaining coverage of trunks was less than 60%, on average (Fig. 1). Although coverage remaining was low in the gauze treatment by the time of the 2007 efficacy evaluation, the part that remained

Table 2. Cost of barriers applied to dwarf apple trunks to control dogwood borer in a New York orchard.

	Cost per tree		Total cost per ha
	Labor	Material	
Treatment	(mins)	(US $)	(US $)
Gauze	0.89	0.247	1084
Tyvek	1.33	0.108	846
Paint	0.96	0.292	1245
EVA*	0.61	0.035	345
Chlorpyrifos**	0.167	0.009	93

* EVA material cost is based on a price of US $2.81/kg.
** Material cost based on a price of US $7.80/liter for Lorsban 4E.

covered the lower 8 cm of the rootstock, where most of the burrknots were found. As a result, efficacy against dogwood borer was equal to that in the Tyvek and EVA treatments. Burrknots found lower on the rootstock were older than those found higher up. Older burrknots tend to be more highly damaged and more highly infested than younger burrknots. However, because it deteriorated significantly prior to the onset of winter, it is apparent that the gauze treatment would offer little protection against rodents.

Riedl et al. (1985) found that spraying paint on apple tree trunks at a 50:50 (paint:water) rate, and brushing the paint on undiluted, both were somewhat effective against new infestation by dogwood borer. However, they evaluated efficacy only in the season of application. Kain et al. (2004) applied a 50:50 mixture of water and white latex paint using a pesticide sprayer. Whereas spraying the paint on was efficient, it was not effective in preventing dogwood borer infestation at the 50:50 (paint:water) rate, even in the season of application. In the study reported herein, we applied paint at full strength with a paintbrush. This took considerably more labor than spraying, but it was more effective during the season of application. However, burrknot tissue soon became unprotected either because it grew through the paint layer, or paint did not adhere well to that tissue, even while it remained on the bark. Paint began to deteriorate rapidly once winter weather began, and so would not likely serve as an effective rodent-feeding deterrent. It degraded further over the winter months and, by September 2007, it was no longer effective against dogwood borer (Table 1). Paint was the most expensive treatment. If paint is applied with a sprayer, it may be more economical in terms of labor to apply it, but material cost was the highest of the materials tested (Table 2).

Tyvek was chosen as a treatment because it was assumed to be impenetrable to the ovipositing moth. It also was chosen, in part, because it is "breathable", or vapor permeable, allowing the passage of moisture vapor. However, presumably due either to higher humidity or lack of sunlight under the barrier, the root initials that form burrknots elongated under this barrier, whereas this did not occur with any of the others. Leskey and Bergh (2005) noted this growth of rooting tissue on trees on which the lower portion of the trunk had been mounded with soil. They stated that >50% of trees

Table 3. Parameter estimates for percentage coverage regressed against sample date for barriers applied to dwarf apple tree trunks to control dogwood borer in a New York orchard.

Treatment	Intercept*	Slope**	r^2	P
EVA	100	−0.28 a	0.82	<0.0001
Tyvek	100	−1.37 b	0.95	<0.0001
Paint	100	−1.49 b	0.68	<0.0001
Gauze	100	−3.22 c	0.97	<0.0001

*Intercept constrained to 100% coverage at time = 0.

**Slope values followed by same letter are not significantly different ($P < 0.05$).

that had been mounded later became infested by dogwood borer and that "rooting tissue seemed to provide an ideal habitat for developing larvae." As applied, it often detached from the trunk and unraveled, but if a more effective method of affixing it to the trunk were devised, it should last indefinitely.

EVA was chosen because it is breathable, easy and efficient to apply, and because it had previously been shown to be an effective barrier to insect pests in other crops (Hoffmann et al. 2001). This barrier was equal in efficacy to the other treatments, including chlorpyrifos, in 2006 and remained in better condition over the course of the experiment than the other barriers. No elongated root tissue was found beneath this barrier. In 2007, the proportion of burrknots infested in the EVA treatment was not significantly different from the untreated check or the least effective treatment (paint). This may be explained by variability in the data due to one tree in the EVA treatment on which 4 of 6, or 67%, of the burrknots were infested. Coverage was poor, and burrknots protruded through the barrier on that tree. The biggest impediment to its adoption is that it must be applied with specialized equipment that is expensive (≈ US $8000–$9000) and not readily available in a configuration suitable to field use. However, the current configuration is a prototype and, if such a unit were produced commercially, its cost would likely decrease. Application cost (labor and material) for EVA was the lowest of the barriers tested (Table 2).

To further evaluate the cost of these treatments, we assumed that if they lasted throughout the winter, they would be effective as rodent barriers and their cost should be compared with the cost of applying another type of mouseguard or rodent bait. At a cost of US $0.50 each, and assuming a labor cost equal to that of applying the gauze treatment, the cost of applying plastic spiral mouseguards, a type commonly used in New York, would be US $1834/ha. In addition, this type of mouseguard does not prevent, and may actually exacerbate, dogwood borer infestation, so that chlorpyrifos would need to be applied as well, increasing the cost to US $1926/ha. In the absence of a rodent barrier, rodenticides should be applied every fall (Agnello et al. 2006) at an approximate cost of US $32/ha for labor and materials (2007 cost using zinc phosphide bait pellets). Therefore, the total cost to control both dogwood borer and rodents chemically (using chlorpyrifos and zinc phosphide bait pellets, respectively) equals US $124/ha each season. If the EVA barrier will provide multiseason (2 - 3 yrs) control of both dogwood borer and rodents, its cost (US $345/ha) will be competitive with conventional control of these two pests.

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