Incidence and Severity of Buprestid Infestation in Field-Grown *Acer platanoides* Related to Cardinal Orientation of Understock Bud Union[1]

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Abstract

Flatheaded appletree borers (FAB) (*Chrysobothris femorata* Olivier) pose a significant risk to field production of shade and flowering trees because attack by one larva can render a tree unsalable. This insect attacks wounded and stressed trees, susceptible cultivars, or newly transplanted trees that might be stressed by desiccation, high temperature or both. The insect is managed by a combination of monitoring and scouting using purple panel traps, growing degree days and plant phenology, and use of chemical insecticides. An observational study of field-planted liners of 'Royal Red' Norway maple (*Acer platanoides* L.) determined that FAB only attacked the area directly around the stubbed portion of the rootstock at the union where the cultivar was budded. Trees with the stubbed area facing north or northeast were 46 to 61% less likely to be attacked by FAB than if the stubbed area was facing southwest.

Index words: beetle, cultural practices, integrated pest management, ornamental plants

Species used in this study: 'Royal Red' Norway maple (*Acer platanoides* L.); flatheaded appletree borer (Coleoptera: Buprestidae, *Chrysobothris femorata* Olivier).

Significance to the Horticulture Industry

Field-grown trees of 'Royal Red' Norway maple were attacked by flatheaded Buprestid borers only at the stubbed portion of the bud union where the understock and cultivar were joined. Trees with this stubbed area of the understock facing a northerly direction were approximately 40% less likely to be attacked by borers than trees with this area facing a southerly direction. The simple cultural practice of orienting the bud union facing north could reduce flatheaded appletree borer infestation in other field planted liners of shade and flowering trees.

Introduction

Borers were ranked by growers in the southeastern United States as one of the most damaging and difficult pests to control (Fulcher et al. 2012). Borers are most damaging because one larvae of flatheaded appletree borer (FAB) can render a tree unmarketable (Adkins et al. 2010). Moreover, FAB is difficult to control because the adult life stage is the one monitored to determine treatment application schedules but the larvae stage, not the adults, is the stage that causes damage. FAB adults emerge in late spring or early summer, mate, and then lay eggs on target hosts. Larvae hatch, feed all summer under the bark, pupate sometime in winter, and emerge as adults in spring just as the cracked bark and cambial tissue damage becomes evident from feeding the previous summer (Adkins et al. 2010). Simply waiting for the damage to be evident before intervention is taken is too late to prevent economic or aesthetic loss.

Management recommendations for FAB require monitoring adult emergence in spring using purple panel traps coated with a sticky substance (Oliver et al. 2004.), some experience identifying the *Chrysobothris femorata* complex (Hansen et al. 2009), and experience discriminating against other buprestids since traps are not specific to FAB (personal observation by the authors). Very few woody ornamental growers in the southeast U.S. use pheromone lures, ethanol traps, or purple panel traps to monitor for key borers like clearwing moths (Lepidoptera: Sesiidae), granulate ambrosia beetle (*Xylosandrus crassiusculus* Motschulsky) (Coleoptera: Curculionidae), or FAB, respectively (LeBude et al. 2012). More growers use growing degree days or plant phenology as a reference for pest emergence (LeBude et al. 2012), but it was not clear which pests were being monitored using these methods.

After adult emergence is detected, chemical sprays are applied to trunks to prevent eggs from being laid or to kill larvae after eggs hatch. Additionally, chemical soil drenches kill larvae inside the trees. Potter et al. (1988) found that one spray of either chlorpyrifos or lindane two weeks after emergence controlled FAB all season. These long residual chemicals are no longer recommended and have been replaced by shorter residual pyrethroid insecticides, e.g., permethrin and bifenthrin, thus requiring more frequent trunk applications. Therefore, monitoring beetle emergence is even more critical to determine spray timing. Less than 40% of nursery growers in the southeast deliberately scout for insects or use a standardized sampling scheme when searching for pests (LeBude et al. 2012). Instead, pests are scouted while performing other tasks or by visually scanning wide areas of the nursery for either a pest or the damage it causes.

Adult FAB emerges after the first flush of growth occurs (April in the upper piedmont of North Carolina, USDA hardiness zone 7b), which is just after the control period begins for maple shoot borer (*Proteoteras aesculana* Riley) (Lepidoptera: Tortricidae), and during control periods for potato leafhoppers (*Empoasca fabae* Harris) (Hemiptera: Cicadellidae) and some scales (Hemiptera: Coccidae, Diaspididae) (Oliver et al. 2002, Frank et al. 2013). The early focus on trunk sprays to control granulate ambrosia beetle followed

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by an influx of foliage-feeding pests in the tree canopy may cause growers to shift scouting and management activities from the trunk to the canopy. Seagraves et al. (2012) found that approximately 64% of FAB infestations in selected cultivars of red maple (*Acer rubrum* L.) occurred on the southeast and southwest side of the trunk and above the soil line within the first 40 cm (15 in) of trunk. The preference of FAB for the first 40 cm of trunk may make it difficult to control when simultaneous sprays for insect pests on the terminal leaders in the canopy are co-occurring, especially if weed or cover crop growth obscures the root flare and lower trunk. Collectively, the low use of deliberate scouting methods or monitoring devices, shorter residual chemical controls, earlier treatment interventions for wood boring insects and a later focus toward canopy complexes might explain the increased borer damage reported in nursery systems and the concomitant difficulty to control them.

Most shade and flowering trees are propagated vegetatively by budding to increase growth and decrease production time at liner producers. One- to three-year-old understock is field planted in spring or early summer in nurseries to obtain an established root system. In late summer, buds of desired cultivars are affixed just under the bark of the understock using various budding techniques (Garner 2003). The following winter, just as the new bud is beginning growth, the understock is pruned off and its resources are channeled through the single cultivar bud, thus producing tremendous growth of the desired cultivar in one year. When plants reach the desired height for liner production, they are dug dormant and field planted elsewhere. During the budding process, stubbing-off the understock leaves a scar at the plant base that is essentially a wound until it calluses completely in two to three years prior to final sale. The practice of budding is not detrimental to plant growth, and has been used successfully with many cultivars and hundreds of thousands of plants transplanted into the landscape. The objective of this observational study was to determine if the cardinal direction of the stubbed portion of the bud union affected infestation of FAB after liners were field planted into a nursery.

Materials and Methods

In February 2009, 200 32-mm (1.25 in) caliper 'Royal Red' Norway maples were planted as branched liners in a field along the Johns River in Caldwell County, NC. Trees were planted without attention to orientation of stubbed cuts associated with bud unions, thus cardinal orientation was randomized by the transplant crew without regard to future observation. Soil type was a Chewacla loam with an average pH of 6.0 and 0.5% organic matter. Trees received 14 g (0.5 oz) of nitrogen (N) at planting and were provided supplemental irrigation by hose reel and irrigation cannon as needed for establishment in the first year. Plants received standard nutrient additions according to soil tests using North Carolina State University recommendations (Bilderback et al. 2013). The field was planted as part of a commercial production operation and the observational experiment was applied *ex post facto.*

Following grower notification of a severe pest infestation in summer 2012, the production field was scouted August 2012, during which time the authors made observations on natural levels of pest infestation. Flatheaded appletree borer attacks on infested trees were restricted to the stubbed portion of the bud union only and not any other portion of the trunk (Fig. 1). For example, if the stubbed portion was oriented north and the tree was attacked, the damage would be constrained to the cut-stub area that was oriented north and not on the southwest side of the trunk as expected based on previous observations in the literature (Oliver et al. 2002). Thus, the treatment variable, cardinal direction of cut stub, was established *ex post facto* by categorizing cut stub orientation of each tree into either north, northeast, east, southeast, south, southwest, west, or northwest direction using a compass from a mobile phone application (Catch, Inc., San Francisco, CA). After designating cardinal direction of the cut-stub area, it was next noted whether the tree was currently or had been infested previously by FAB at those stubbed areas. Larvae of the borer were excised from a few of the active host wound sites (Fig. 1). Although larvae were not reared to adulthood to identify species, they were determined to be buprestid beetles and were subsequently attributed to the *Chrysobothris femorata* complex (Hansen et al. 2009).

The experimental design was considered completely randomized since the planting crew planted trees without regard for future experimentation. However, the row (1 to 5) and

Fig. 1. Stubbed portion of understock at bud union of 'Royal Red' Norway maple (*Acer platanoides* L.). Damage surrounding the stubbed area is attributed to flatheaded appletree borer (*Chrysobothris* sp.) larva (inset) found in the wound of one of the infested trees.

Table 1. Association of eight different cardinal directions of bud union, cut-stub orientation to percent damage attributed to flatheaded appletree borer (*Chrysobothris femorata* Olivier) larvae among field-planted liners of 'Royal Red' Norway maple (*Acer platanoides* L.).

Cardinal orientation[z]	Number of trees facing this direction	Estimated probability of larval damage[y] (%)	SEM[x]
Northeast	12	7.1a	7.1
North	28	22.2a	8.6
East	31	28.6ab	8.9
Northwest	11	34.2ab	15.1
West	21	49.8ab	12.0
Southeast	21	60.0ab	12.8
South	25	64.7ab	10.5
Southwest	34	68.3b	8.8

[z]Refers to the direction the stubbed portion of the bud union at the base of the plant faces at planting.

[y]Feeding damage attributed to flatheaded appletree borer larvae was only observed at the cut-stub portion of the bud union. Injury was defined as the appearance of bark cracking, missing tissue, and general malformation of growth (Fig. 1). The percentage is defined as the number of trees attacked divided by the number of trees facing that cardinal direction multiplied by 100; therefore, the column will not add to 100%. Least squares means were separated using Tukey's (HSD) to adjust for unbalanced data; therefore, means followed by a different letter within a column are significantly different using the adjusted P value ($P < 0.05$).

[x]SEM, Standard error of the mean.

tree position within row (1 to 40) was noted when collecting data and each designation was included in the class statement of the model to test as a potential source of error. The eight stub orientation categories were replicated unevenly by single tree plots (see Table 1 for number of trees in each treatment). Data were unbalanced and binomial in nature (either infested or not); therefore, PROC GLIMMIX (SAS v. 9.4) (SAS Institute, Inc., Cary, NC) was used for analysis of variance using a binomial distribution and the default logit link. To adjust for unbalanced data when comparing means, least squares means (LSMEANS) were separated using Tukey's HSD using adjusted P values with a probability of finding a greater F value set at 0.05. A separate contrast statement using pooled variances was used to compare the combined probability of being attacked in categories 'Southeast-South-Southwest' to 'Northwest-North-Northeast.' The adjusted mean probability of being attacked and its standard error is presented in the table and text for each cardinal direction.

Results and Discussion

By August 2012, about 3 years after transplanting, approximately 183 trees were alive (92%), yet, of those, 44.8% had been or were infested by FAB. Among trees with cut stubs facing either south (n = 25) or southwest (n = 34), 65 to 68% were infested by FAB (Table 1). By contrast, when the stubbed area was facing either north (n = 28) or northeast (n = 12), about 22 and 7% of trees were infested by FAB, respectively. Troxclair (2005) noted the same propensity for FAB to infest the same stubbed area on field-transplanted apple trees that were grafted previously. According to Seagraves et al. (2012), FAB attacks are more common on the lower southwest side of tree trunks, and the observations from the present study support greater frequency of attacks if the southwestern side contains a wounded area such as a cut-stub from the understock.

The presence of a cut-stub region on this cultivar might attract more females to oviposit in this area. The south side of tree trunks generally have higher temperatures than the northern side. This temperature gradient might stimulate oviposition by FAB, or increase either egg or larvae survival and development compared to the same number of oviposit chances on the northern side of a tree.

The combined overall probability for larval damage of the Southeast, South, and Southwest directions was approximately 64%. Trees facing Northwest, North or Northeast had a 21% probability of attack. Operationally, field crews planting tree liners may not be precise in their efforts to orient trees facing due north or northeast. Therefore, a contrast statement was created to compare planting trees facing a northerly direction (Northwest-North-Northeast) to trees facing a more southerly direction (Southeast-South-Southwest). The significant outcome ($P < 0.01$) (data not presented) of the contrast allows for error in placement when planting trees with the stubbed bud union facing a northerly direction.

Complete control of FAB (100% of trees not infested) was recorded over four years in three cultivars of red maple when newly field-planted liners were drenched with cyfluthrin plus imidacloprid (Oliver et al. 2010). The trunk-applied contact insecticides chlorpyrifos and bifenthrin, however, were less effective in preventing damage to the same maple cultivars (Oliver et al. 2010). Permethrin, another trunk-applied contact insecticide, has also been recommended for use on maples (*Acer* spp.) (Frank et al. 2013). Drenches, however, have higher initial costs than trunk-applied contact insecticides, which may encourage growers instead to monitor beetle emergence in May or June and to better time lower costing trunk-applied sprays during that time. This requires use of purple panel traps (Oliver et al. 2004.) and some experience identifying the *Chrysobothris femorata* complex (Hansen et al. 2009). Since these trunk applied sprays are required yearly and multiple times per year, missed or poorly timed applications increase the likelihood of attack during the 24 to 60 month production cycle of shade trees. Placement of stubbed bud unions facing north at planting might increase effectiveness of trunk-applied sprays, however, this needs to be tested independently in field research.

Other cultural practices include shading the lower southwest side of the trunk of field planted apple trees with boards inserted into the ground or applying white interior latex paint to the same region to ostensibly lower the bark temperature and deter FAB oviposition (Troxclair 2005). Kaolin clay, an inert aluminosilicate that uses the same principle as latex paint to reduce temperature or provide an inopportune surface for oviposition (Glenn 2012), has been reported to reduce infestation of viburnum leaf beetle (*Pyrrhalta viburni* Paykull) during container production (Schultz et al. 2007). Kaolin clay, however, was not effective in reducing squash vine borer (*Melittia cucurbitae* Harris) (Lepidotera: Sesiidae) on winter squash (Adam 2006). The effectiveness of these cultural and alternative spray treatments would need further testing before recommendation, especially with the superior efficacy of drench applications.

Based on the observations of this study, planting trees with the stubbed portion of the bud union facing a northerly direction is a simple cultural practice that can be employed by nurseries This cultural practice might decrease the probability of FAB infestation by as much as 40%. Additionally, summer field scouting protocols should now include inspection of the stubbed area of cultivars that were budded or grafted to determine if FAB is present. Focusing solely on this area, especially when it is facing a southerly direction, might increase the chances of detecting the presence of FAB while decreasing the actual time spent scouting for the pest.

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