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"Merging pheromones and other semiochemicals with integrated fruit production: current approaches and applications from research to field implementation in a changing environment"

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Potential new invasive pest species in United States – spotted lanternfly, *Lycorma delicatula*

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Abstract: A new invasive insect species, spotted lanternfly (SLF), *Lycorma delicatula* (White), (Hemiptera: Fulgoridae) was first found in Pennsylvania, USA in September 2014. During the summer 2018 multiple research projects were initiated to understand the available management and monitoring options for this insect. Residual and direct contact insecticide bioassays revealed good efficacy of compounds from various IRAC groups such as neonicotinoids, pyrethroids, carbamates and organophosphates. Nymphs were also affected by products approved for organic production such as natural pyrethrum and mineral oils. Complete mortality of eggs was observed after treatment of overwintering egg masses with chlorpyrifos while partial mortality was observed after treatments with dormant oils, flupyradifurone and dinotefuran. To better understand the movement and behavior of SLF adults and nymphs two available SLF monitoring lures were also tested in field setting inside vineyards, orchards and in woods. Unfortunately, when lures were combined with sticky clear traps or placed with insecticide treated nets none of the tested lure x trap combinations was attractive to nymphs or adults SLF. Additional studies are planned to better understand the potential impact of this new invasive insect species on fruit orchards and vineyards.

Key words: *Lycorma delicatula*, spotted lanternfly, invasive pest, grape pest, monitoring

Introduction

A new invasive insect species, spotted lanternfly (SLF), *Lycorma delicatula* (White), (Hemiptera: Fulgoridae) a potentially economically important insect pest native to China, India, Vietnam and Cambodia was first found in Pennsylvania, USA in September 2014. Within three years since the original detection in very localized area of few towships located in the eastern Berks County, PA, the SLF quarantine zone was expanded in 2017 to over 17 thousands square kilometers, encompasing 13 southeast counties in Pennsylvania and additionally increased during the winter of 2019. The current SLF quarantine area is the home to over 25 percent of Penssylvania orchard and vineyard farms (720 out of 2,686 farms, USDA, NASS, 2013). SLF adults were also recently detected in states of Delaware, New York and New Jersey while eggs and adults were found in Virginia automatically making it a regional and potentially a national pest (Barringer et al., 2015; Parra et al., 2018). This phloem-feeding treehopper insect has a wide range of host plants, with feeding being reported on over 65 species of plants and as such, is projected to become a serious pest of timber, ornamental trees, pome fruit orchards, grapes, stone fruit, and other small fruits such as blueberries. SLF adults were also reported to feed on hops and were observed on several types of vegetables. SLF honeydew (sugary excrement) and sooty mold (fungi growing on

honeydew) (Kim et al., 2011) was found to cause economical plant injuries in vineyards in less than two years after the initial detection. SLF spread to more vineyards in 2017, with documented yield reduction in one, and potential, although still undefined long-term effects on health of grapevines. In late August 2017, for the first time, large numbers of SLF were also observed flying into and feeding on the wood and branches of apple trees as well as nectarines and peaches. Direct damage to tree fruit was not observed, but SLF egg masses found on the trees put the trees at risk for heavier and more sustained feeding by SLF nymphs and adults in the spring and summer during the following season.

Material and methods

The initial experiments related to SLF were conducted in the field laboratories, often utilizing grower orchards and buildings located within the SLF quarantine area in south-eastern Pennsylvania, USA. The SLF egg masses, nymphs and adults used in the insecticide trials were collected directly from the infested trees. All SLF monitoring trials were also conducted in and around commercial plantations located within the SLF quarantine area in PA.

Direct ovicidal bioassays

The efficacy of various insecticides against SLF eggs was evaluated either during direct insecticide applications on egg masses collected directly from wild settings during January and February 2018 or by spraying directly SLF egg masses deposited on hosts such as cultivated grapevines (*Vitis* sp.), maple trees (*Acer* sp.) or combination of various wild host trees for a total of 6 separate bioassays. The egg mortalities were assessed in late May - early June after the complete natural hatch of eggs in the control treatment. For the list of tested products please see caption within the Figure 1.

Residual nymphal and adulticidal bioassays

The residual efficacy of various insecticide products available for purchase from retail stores for home owners was evaluated utilizing 3rd and 4th instar SLF nymphs and adults collected directly from wild hosts. The specimens were collected 24-48 hours prior to the bioassays and kept in mesh cages with sunflower, pepper and bean plants serving as the food. Individual sunflower plants were treated with solution of tested insecticides and after air drying at least 20-30 SLF individuals were placed on individual treated plants and enclosed with mesh sleeve. Mortalities were evaluated at 24, 48 and 168 h after the placements of SLF on treated plants. The assortment of tested insecticide active ingredients is listed in Table 1.

SLF monitoring trials

Two commercial lures expected to monitor SLF: PredaLure MS90 (AgBio, Inc, Westminster, CO, USA) and LYCDEL (AlphaScent, Inc. West Linn, OR, USA) were placed at various locations including vineyards, apple and peach orchards and woods next to orchards. The monitoring lures were deployed either on sticky clear traps (Pherocon® StinkBug STKY™ Dual Panel, Trece, Adair, OK, USA) or placed with insecticide treated nets (D-Terrence® net, Vestergaard S.A., Lausanne, Switzerland). The sticky cards were placed at wooden poles at 0.9 m or 1.5 m high. The numbers of collected SLF nymphs or adults were checked weekly and accompanied with a 3 minute visual count of SLF on wild vegetation surrounding each trap.

Table 1. Mortality of SLF nymphs and adults at 24 hours after the exposure to fresh residue of insecticide products available for pest control for homeowners. Means followed by the same letter(s) within each column are not different (ANOVA, LSD *sqrt x* transformation, $p \leq 0.05$).

Active ingredient	Percent mortality at 24 hours after the exposure to dry residue	
	Nymphs	Adults
zeta-cypermethrin	80.0 ab	55.6 cdef
imidacloprid/beta cyfluthrin	100 a	93.3 a
deltamethrin	100 a	88.9 ab
bifenthrin/zeta-cypermethrin	100 a	100 a
carbaryl	98.0 ab	52.2 cdef
taufluvalinate/tebuconazole	95.0 ab	86.7 abc
malathion	100 a	100 a
spinosad	28.0 c	33.4 def
potassium salts of fatty acids	8.0 c	30.0 ef
neem oil (extract)	73.0 b	26.7 f
natural pyrethrum/piperonyl butoxide	88.0 ab	100 a
water (control)	3.0 c	39.0 def

Results and discussion

During the SLF ovicidal bioassays a complete mortality of eggs was observed only after direct treatment of overwintering egg masses with chlorpyrifos (organophosphate) while partial mortality was observed after treatments with dormant oils and dinotefuran (Figure 1). No differences were observed between mortalities exhibited by eggs treated directly on wild hosts or directly on pieces of wood collected from the field and treated in the field laboratory.

Residual and direct contact insecticide bioassays revealed good efficacy of compounds from various IRAC groups such as neonicotinoids (e. g., dinotefuran, imidacloprid), pyrethroids (i. e., bifenthrin, deltamethrin, zeta-cypermenthrin), carbamates (e. g., carbaryl) and organophosphates (e. g., malathion). Nymphs were also affected by products approved for organic production such as natural pyrethrum and mineral oils.

During the SLF lure and trap evaluations none of the lures were attractive to either SLF nymphs or adults. Higher numbers of SLF were observed during the visual observations on surrounding trees than captured by evaluated traps (Figure 2). Also, the placement of traps and the trap height did not influence the numbers of captured of SLF nymphs and adults. Some feeding preferences were observed based on the tress species, although data was highly variable, and no the same patterns were observed at every location.

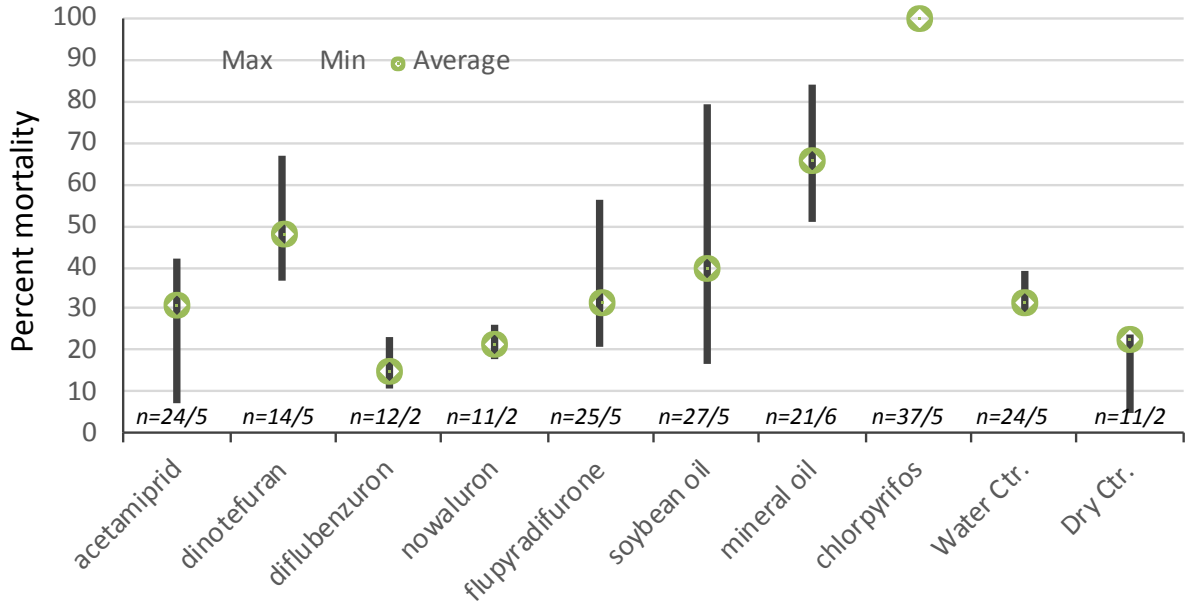

Figure 1. Mortality of SLF egg after direct treatment with various insecticides. Data represents the minimum, maximum and average mortality during multiple bioassays. The number of treated egg masses and number of bioassays with individual compound is presented as "n".

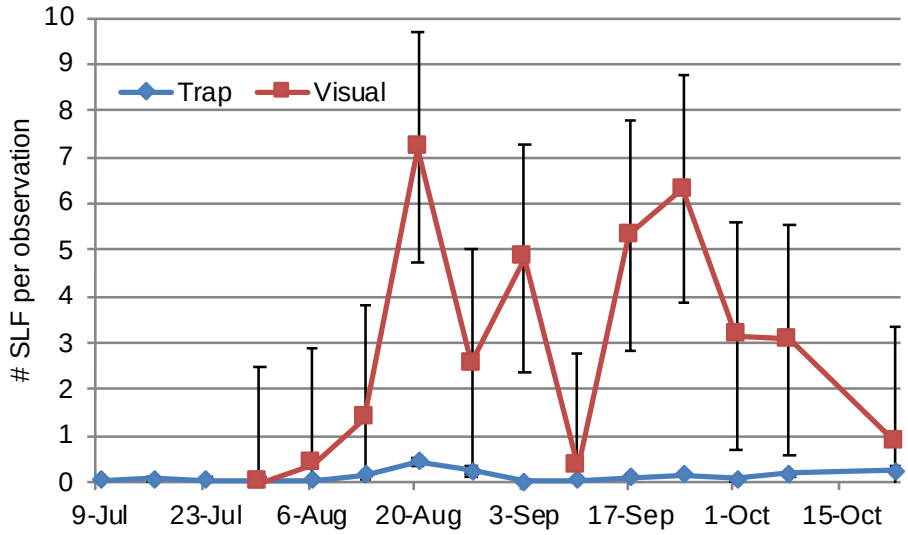

Figure 2. Numbers of SLF nymphs and adults observed utilizing monitoring traps and during weekly visual observations on wild trees surrounding vineyard or orchards. Average data collected from three separate sampling locations with at least 8 traps per location.

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