Urban Forestry & Urban Greening 11 (2012) 426–431

Contents lists available at SciVerse ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.de/ufug

Evaluation of organic, synthetic and physical insecticides for the control of horse chestnut leaf miner (*Cameraria ohridella*)

Glynn C. Percival[a,*], Jon Banks[a], Ian Keary[b]

[a] R.A. Bartlett Tree Research Laboratory, John Harborne Building, School of Biological Sciences, The University of Reading, Reading, RG6 6AS, UK
[b] Department of Entomology, John Harborne Building, School of Biological Sciences, The University of Reading, Reading, RG6 6AS, UK

ARTICLE INFO

Article history:
Received 17 January 2012
Received in revised form 17 April 2012
Accepted 23 July 2012

Keywords:
Insecticides
Insect growth regulators
Integrated pest management
Plant health care

ABSTRACT

Two separate trials during 2007 and 2008 were conducted using containerized white flowering horse chestnut trees (*Aesculus hippocastanum* L.) to assess the efficacy of a range of insecticides applied at three different times during a growing season against the insect pest, horse chestnut leaf miner (*Cameraria ohridella* Deschka and Dimic; HCLM). Insecticides were timed to coincide with the emergence of the adult moth, the target organism. A conventional synthetic insecticide (deltamethrin) used within the UK for HCLM control was included for comparison. A marked impact of insecticide type and frequency of application on HCLM severity was recorded. The effectiveness of each insecticide on mean number of HCLM mines per leaf and percent HCLM larvae/pupae mortality increased when applied at increasing frequencies, i.e. three sprays provided a higher degree of control than two sprays while two sprays provided a higher degree of control than one spray. Limited efficacy as HCLM protectant compounds was demonstrated when the insecticides pyrethrum and soap were applied, irrespective of number of applications. The synthetic insecticide deltamethrin and insect growth regulator diflubenzuron provided the greatest degree of HCLM control. In some instances two foliar sprays provided 100% HCLM control. Efficacy of remaining insecticides based on reduction of HCLM mines per leaf after three sprays averaged across both the 2007 and 2008 trials was in the order silicon dioxide > alginate/polysaccharide combination > organic plant extract > spray oil. Results show commercially registered insecticides exist that provide growing season control of HCLM provided two sprays are applied.

Introduction

Within Europe, *Cameraria ohridella* Deschka and Dimic, the horse chestnut leaf miner (HCLM) has become a devastating pest of the white flowering horse chestnut tree (*Aesculus hippocastanum* L). Damage occurs when larva tunnel into the leaves of the tree, causing physical destruction of leaf tissue (Straw and Bellet-Travers, 2004; Percival et al., 2011). Infected leaves are covered in small brown patches which spread rapidly across the entire canopy, giving the tree an autumnal appearance (Nardini et al., 2004). Eventually infested leaves die and fall prematurely. If new leaves are formed they can be re-infected (Kehrli and Bacher, 2003; Raimondo et al., 2003; Salleo et al., 2003; Thalmann et al., 2003). Aesthetic characteristics such as flowers, bark, berry and leaf colour are an important considerations for trees planted within town and city streets, public recreation areas, parks etc. (Ware, 1994; Percival and Hitchmough, 1995). With severe HCLM induced defoliation of horse chestnut trees observed by mid-July the aesthetic damage alone to HCLM infested trees is now highly questionable. For these reasons development of HCLM control strategies may be warranted.

Due to stringent government regulations regarding the registration and use of insecticides within amenity environments few products exist for HCLM control. Of that available, imidacloprid is a systemic neonicotinoid insecticide that is applied via soil injection. A single soil application has been shown to provide greater than 80% reductions in HCLM severity over a growing season (Ferracini and Alma, 2008). However, soil drenches are not recommended for HCLM control due to the potential of groundwater contamination, expense and inapplicability in areas where trees are containerised or in asphalt (Mešić et al., 2008) Diflubenzuron is an insect growth regulator (Anon., 2009). Reported uses of diflubenzuron against HCLM have been favourable providing 80–100% control (Tomiczek and Krehan, 1998). However, total foliar spray coverage has to be achieved as diflubenzuron is non-systemic and does not penetrate plant tissues and so consequently has to be targeted against the adult moth (Blümel and Hausdorf, 1997). Deltamethrin is a synthetic pyrethroid insecticide registered for use within amenity landscapes to control a range of insect pests such as aphids, whitefly, thrips and oak processionary moth. While deltamethrin possesses broad spectrum insect activity and persistence of 6–8

* Corresponding author.
E-mail address: gpercival@bartlettuk.com (G.C. Percival).

1618-8667/$ – see front matter © 2012 Elsevier GmbH. All rights reserved.
http://dx.doi.org/10.1016/j.ufug.2012.07.001

weeks on foliar tissue after application, such long term persistence and broad spectrum activity can result in significant collateral damage to beneficial insecticides (Ray and Fry, 2006). For this reason the organic pyrethroid pyrethrum may offer an environmentally acceptable alternative. Pyrethrum provides a rapid knock down of existing adult insect populations to include greenfly, whitefly, aphids, flea beetle and caterpillars. Due to its rapid degradation in ultra violet light the persistence of pyrethrum is generally less than 24 h (Liu et al., 2007). Consequently as insect populations tend to consist of differing stages of the life cycle; eggs, larvae, nymphs prior to developing into adults repeat applications of pyrethrum are generally required (Liu et al., 2007). The potential of deltamethrin and pyrethrum to control HCLM has not been investigated. Insecticidal soaps have been used for many years to control soft bodied insects such as aphids, whitefly and caterpillars (Copping and Duke, 2007). The primary mode of action by which insects are killed is via soap penetration through fatty acids present in the insects' cuticle in turn dissolving and/or disrupting cell membrane integrity (Copping and Duke, 2007). The use of an insecticidal soap specifically for HCLM control has not been investigated. Over the past few years developments in plant protection technology have led to the formulation and commercialization of a range of physical insecticides. Physical insecticides mode of action is via non chemical means such as suffocation or abrasion of the insect cuticle (Najar-Rodríguez et al., 2007; Žanić et al., 2008; Stadler and Buteler, 2009). Importantly because of their non-chemical mode of action, physical insecticides are not subject to government legislative restrictions that relate to conventional pesticides used for insect control. Likewise the use of physical insecticide sprays against HCLM, has not been investigated.

Aims of this study were to (i) evaluate the impact of foliar sprays of a range of organic, synthetic and physical insecticides as well as an insect growth regulator for use in a HCLM management strategy programme and (ii) the number of sprays required for maximal control.

Materials and methods

Field site and experimental trees

Two year old, bare rooted stock of horse chestnut (*A. hippocastanum* L.) was obtained from a commercial supplier and planted into 20 litre pots containing a general tree compost (loamy texture, with 23% clay, 46% silt, 31% sand, 3.1% organic carbon, pH 6.6) supplemented with the controlled release nitrogen-based N:P:K (29:7:9) fertiliser Bartlett BOOST (The Doggett Corporation, Lebanon, New Jersey, USA) at a rate of 5.0 g/kg soil. Following potting, trees remained outdoors on a free-draining mypex covered surface at the University of Reading Shinfield Experimental Site, Reading, Berkshire (51°43′ N, 1°08′ W) subject to natural environmental conditions and watered as required. From 2005 to 2007 trees were trained to produce a central-leader system to an average height of 1.0 ± 0.15 m with mean trunk diameters of 8.0 ± 1.5 cm at 60 cm above ground level. Weeds were controlled by hand prior to and during the study. Historically the horse chestnut trees suffered from HCLM infestation on an annual basis. Prior to the trial commencing in 2007 trees were inspected in September 2006 and only trees with >70% of leaves affected with HCLM infestation with concomitant severe defoliation were included in the trial.

Spray treatments and timing

Due to the non-systemic nature of the insecticides used, all treatments (Table 1) were applied to coincide with the appearance of the adult moth at each generation namely: April 18, June 4 and August 12, 2007 and April 28, June 12, August 16, 2008. The adult moth was the primary target of the insecticides applied as this was considered the most susceptible stage of the leaf miner life cycle. Detection of the adult moth was achieved by placing HA515-Agralan mini yellow sticky traps at 2.5 m^2 spacings throughout the trial site and inspecting daily. Sprays commenced once a threshold of 30 adult moths per trap had been caught (Ledieu and Helyer, 1985; Sukhija et al., 1986). All insecticides were applied at manufacturers recommended rate (Table 1) and between the hours of 10.00 am and 12.00 noon on each spray date. To determine the influence of one vs two vs three sprays, in the case of the 2008 trial for example all 15 trees were sprayed on April 28, two thirds (10) of the trees were sprayed on June 12 and one third (5) of all trees sprayed on August 16. Foliar sprays of all insecticides were applied until run-off using a 5 litre Cooper Peglar hand-held sprayer and during spray treatments polythene screens 1.5 m high were erected around each tree to prevent dispersal of sprays and possible cross contact of other trees. Spraying with water served as the control and the experimental design used was a Completely Randomized Block Design (CRBD) in which pots were re-randomized on a weekly basis. Five trees per insecticide treatment were used at 1.0 m spacings to prevent competition for light

HCLM severity

Evaluation of HCLM severity was conducted at week five after each spray treatment by collecting fifteen fully expanded leaves at random according to the height of the tree (5 leaves in the lower canopy, 5 in the middle canopy, 5 in the upper canopy). Excised leaves were placed in a darkened cool box and returned to the laboratory within 2 h of collection.

Samples collected in the field were observed under a microscope and the number of mines recorded on each leaf. Afterwards each mine was opened and observed to detect the presence of living or dead larvae and pupae (September examination only). The effect of each treatment was tested by comparing population levels in insecticide treated vs. non-treated controls. The binary data obtained (0 for dead larvae/pupae and 1 for living larvae pupae) was subjected to survival analysis statistics using the Wilcoxon–Gehan method. Data on the number of mines were analysed by two and one-way analysis of the variance with mean separation by Student–Newman–Keuls using the Genstat for Windows 11th Edition program.

Results

The influence of insecticide treatment, number of sprays and interactions between these two factors is shown in Tables 2 and 3 with respect to the mean number of HCLM mines and percent mortality of HCLM larvae/pupae. In all instances a significant effect and interaction was recorded. Damaging outbreaks of HCLM were recorded on control trees in both the 2007 and 2008 trials as indicated by mean number of HCLM mines per leaf of 48.9 and 43.5 at the cessation of the 2007 and 2008 growing season respectively (Tables 2 and 3). There was little difference in the degree of HCLM severity between the 2007 and 2008 growing season (Tables 2 and 3). None of the treated or control trees died as a result of HCLM attack during the course of the two year study. Likewise none of the insecticides evaluated was phytotoxic to the test trees (data not shown). A marked impact of insecticide type and frequency of application was recorded. The effectiveness of each insecticide on mean number of HCLM mines per leaf and in most cases percent mortality of HCLM larvae/pupae increased when applied at increasing frequencies, i.e. three sprays provided greater control than two sprays while two sprays provided greater