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Influence of Application Timing on the Efficacy of Chlorantraniliprole and Imidacloprid against Japanese Beetle larvae in Turfgrass

Introduction

The Japanese beetles, (Popillia japonica Newman, (JB) is an invasive scarab, that feeds upon a diverse range of plant species (USDA, 2023). Causing more than $460 million in damage to agricultural and horticultural crops annually (USDA, 2015). The establishment of a management plan to effectively control these pests has significant economic and environmental importance. These beetles are often classified as a primary menace to turfgrasses, including areas such as home lawns, parks, and golf courses. The environmental significance of turfgrass is often overlooked as it provides several benefits, including soil enhancement, ecological restoration, air quality improvement, and temperature moderation. Additionally, it offers an affordable and secure recreational environment that enhances both mental and physical well-being (Potter, et al., 2002).

The larvae of this species inflict damage on turfgrasses by feeding on the grass roots, resulting in browning and eventually the demise of the turf (Hahn, 2022). Therefore, it is crucial for turfgrass professionals to effectively manage them. Fortunately, there exist a multitude of strategies to manage these troublesome pests. Most commonly, synthetic insecticides are routinely applied in the early months of April-June as a prevalent treatment method for managing the larvae. Chlorantraniliprole and imidacloprid are widely recognized as prevalent active ingredients utilized in the turfgrass industry for the purpose of effectively managing Japanese beetles (Cranshaw, 2018). These insecticides are administered onto grass and groundcover, followed by irrigation to facilitate infiltration into the soil. Both active ingredients exhibit root uptake and subsequent systemic transport inside the plant. The beetles are susceptible to exposure to these insecticides through soil contact and ingestion of plant tissues (OEHHA, 2021).

Japanese beetles undergo complete metamorphosis. Throughout several life stages, these organisms inhabit various areas within their habitat and consume different portions of plants, dependent upon their developmental phase. In the context of turfgrass, the larval stage is particularly problematic due to its natural tendency for consuming plant roots (USDA, 2015). One of the primary factors contributing to their preference for turfgrass is consistent soil moisture levels resulting from regular irrigation that is necessary to maintain healthy turf. A regular water source prevents the desiccation of eggs and promotes larval survival. The eggs need to absorb water before and during their embryonic development. Due to their preference for moist soil, they lack a mechanism to retain water (Ludwig, 1932).

During the winter season, JB larvae reside deep in the soil profile, moving higher in the profile during the spring to resume feeding on plant roots. Adults fly and deposit eggs into the soil during June and July, with neonate larvae eclosing from the eggs in July and August (Potter, et al., 2002). In accordance with JB ‘s life cycle, larval management strategies can be categorized into three different approaches, preventative, early curative, and late curative (Richmond, 2023). A preventive strategy is typically implemented from April through June, with long-residual insecticides being used as insurance against larval infestations occurring later in the summer. In contrast, the early curative strategy spans July to August with insecticides being employed in response to an existing infestation, but usually prior to the onset of visible damage. Finally, the late curative strategy extends from September to October with late instar larvae being targeted in response to turf damage.

Given the effectiveness of long-residual insecticides and logistical constraints of the lawn care industry (many properties to treat within a relatively short window of time), a preventive strategy has been widely adopted for management of JB larvae. However, information regarding the relative efficacy of early and late curative strategies is not widely available. Such information could be useful for turfgrass professionals working to optimize their operations. Considering temperature, biology, and the rate of material absorption into the feeding zone, it was expected that as the season progresses there would be a decrease in efficacy.

Materials and Methods

Experiments were located at the William H. Daniel Turfgrass Research and Diagnostic Center, or the Purdue University nursery, both in West Lafayette, IN, on stands of turfgrass consisting primarily of Kentucky Bluegrass maintained at 7.6 cm. Plots measuring 5 x 5 ft were arranged in a randomized complete-block design with 2 ft alleys between plots. Materials were applied on various application dates across the growing season, depending on the strategy being examined (preventive, early curative, or late curative). Liquid materials were applied using a hand-held CO2 boom sprayer configured with four 8010 nozzles operating at 30 psi and calibrated to deliver a spray volume of 2 gal/M. Application rates ranged from 32-560 g ai/ha for chlorantraniliprole and 229-1,111 g ai/ha for Imidacloprid.

Treatments were replicated 4-6 times in each individual trial with levels of post-application irrigation ranging from 0-0.15”. When post-application irrigation was included, it occurred within 8 h following applications. Field conditions were recorded on each application date and included soil temperature at 5 cm (°C), air temperature (°C), wind speed (mph), thatch depth (cm), and general atmospheric conditions (clear – overcast). Soil texture and % organic matter was also determined for each site (Table 1).

Japanese beetle larval infestations were created by driving either two or three, 20.3 cm diameter PVC cylinders (15.0 cm length into the centerline of each plot to a depth of approximately 3 cm, and caging two or three separate groups of 40 Japanese beetle adults (50:50 – 60:40 male:female sex ratio) within each cylinder during late June and July. Beetles were provided with an apple wedge as a source of food and moisture and were contained within each cylinder using nylon window screen held in place with a plastic snap-cap lid with the center cut out to allow sunlight, air, and precipitation to pass through.

Scarab larval populations in each plot were assessed in late September through mid-October using a sod cutter to remove a 0.25 m2 patch of sod lying directly beneath the caging area of each plot. The sod and underlying soil were intensively examined to a depth of 7.6 cm using a hand rake. All scarab larvae recovered from the plots were identified to genus level, counted, and recorded. At least one complete trial replicate was sampled in this way during the course of a day.

Variation in larval populations for each trial was examined using outputs of covariance and treatment means were compared using Fisher's LSD test ($\alpha=0.05$). Percent control was recorded for each treatment and used as a single data point for our combined analysis. The outcomes were evaluated by utilizing percent control as the dependent variable, management strategy as the independent variable, and application rate as a covariant.

Individual data points (% control) were grouped according to management strategy, which included preventative, early curative, and late curative approaches. For this purpose, the preventative strategy included application dates between April 15th - July 1st, the early curative strategy included application dates between July 2nd – August 15th, and the late curative strategy included application dates between August 16th – October 8th.

Results

The level of JB larval control was influenced by active ingredient and management strategy (Fig. 1, Table 2), with differences in application rate (g ai/ha) having only minor effects on efficacy. Mean percent control for preventive and early curative timing ranged from 91.4% to 94.4%, with imidacloprid providing only slightly lower levels of control compared to chlorantraniliprole in both cases. There was no relationship between efficacy and application date during either the preventive or early curative window (Table 3). While maintaining a relatively high level of overall control, the late curative management strategy for both the active ingredients provided decreased efficacy compared to preventive or curative strategies (Fig. 2). Mean levels of control provided by chlorantraniliprole (85.3%) and imidacloprid (74.2%) used in a late curative strategy decreased over time during this application window. After day of year 220, the average efficacy of imidacloprid decreased by 0.46% per day whereas the efficacy of chlorantraniliprole decreased more rapidly (0.75% per day).

Discussion

The preventive approach is found to be an effective method of control. This pertains to an operational aspect, specifically in the realm of lawn care. After the material is deposited into the soil and becomes washed in, it can disperse within the feeding layer. The substance adheres to the soil profile and remains in place for a duration of several months (Sutherland-Ashley, et al., 2020). By applying the material prior to the eggs being placed in the soil, it enables the material to disperse and be readily available when the grubs begin to feed.

Delaying the application of the material during the early curative timing does not affect efficacy. The window for optimal control remains open during the early curative stage. Avoiding a preventive approach is unnecessary from a lawncare care perspective. The timeframe for control can be extended until the beginning of August. Additionally, throughout the early curative strategy, the larvae are actively feeding on the turf roots and ingesting the material (Richmond, 2023). The larvae remain close to the soil surface during this time. By using a preventative strategy, the lawn care specialist applies insecticide before the eggs are laid in the ground. However, waiting until the early curative timing enables the consumer to assess the area for the presence of eggs and larvae, and decide if the application of the insecticide is necessary. This may aid in mitigating the presence of insecticides in the environment.

By the late curative timing, the grubs grow in size and temperatures decrease. The movement of material through the soil profile and its dispersion into the feeding layer is a process that requires a specific amount of time. As soil temperatures decrease, grubs gradually move deeper and reduce their feeding activity. There is no physical contact or ingestion of the material. During the fall season, when the soil temperature reaches approximately 60°F (15.5°C), the grubs initiate a burrowing process. Most of the grubs survive the winter at depths ranging from 2 to 6 inches, although a few may reach depths of 20 inches. Activity levels decline when the soil temperature reaches approximately 50°F (10°C) (Williamson, 2014).

In accordance with the statistics, it was found that material dispersion can be applied at a later time than what is typically recommended by lawn care providers. The timing of this could extend until mid to late August, but afterwards, the consumer may experience decreased effectiveness. Decreased effectiveness in the late curative strategy is likely attributed to temperature, biology, and the rate of material absorption into the feeding zone and as expected, the preventive and early curative strategies achieved greater efficacy outcomes for percent control compared to the late curative management strategy.

Table 1 Provides an analysis of the distribution of soil minerals and composition in the experimental area. In addition, two of the twelve soil texture classes identified by the USDA.

Location	Sand:Silt:Clay	% Organic Matter	USDA Texture Class
Purdue University Nursery	44:36:20	3.9%	Loam
W.H. Daniel Center	14:56:30	6.7%	Silty clay foam

Table 2 Univariate tests of significance for percent control over-parameterized model Type III decomposition; Std. Error of Estimate: 11.8549

Effect	Df	F	P
Intercept	1	974.1	<0.001
Application Rate (g ai/ha)	1	3.3	0.072
Management Strategy	2	14.4	<0.001
Active Ingredient	1	9.2	0.002
Management Strategy * Active Ingredient	2	1.3	0.282

Table 3 Parameter estimates and sigma-restricted parameterization across all management strategies and the two active ingredients. Test of SS Whole Model vs. SS Residual

Management Strategy	Active Ingredient	Parameter Estimates (±SE)	t	p	R^2
Preventive	Chlorantraniliprole	88.4±9.9	0.61	0.545	0.008
	Imidacloprid	78.3±12.6	1.14	0.266	0.049
Early Curative	Chlorantraniliprole	126.1±41.5	-0.77	0.446	0.020
	Imidacloprid	57.2±51.6	0.66	0.513	0.015
Late Curative	Chlorantraniliprole	270.9±70.5	-2.64	0.022	0.366
	Imidacloprid	196.7±55.5	-2.18	0.054	0.322

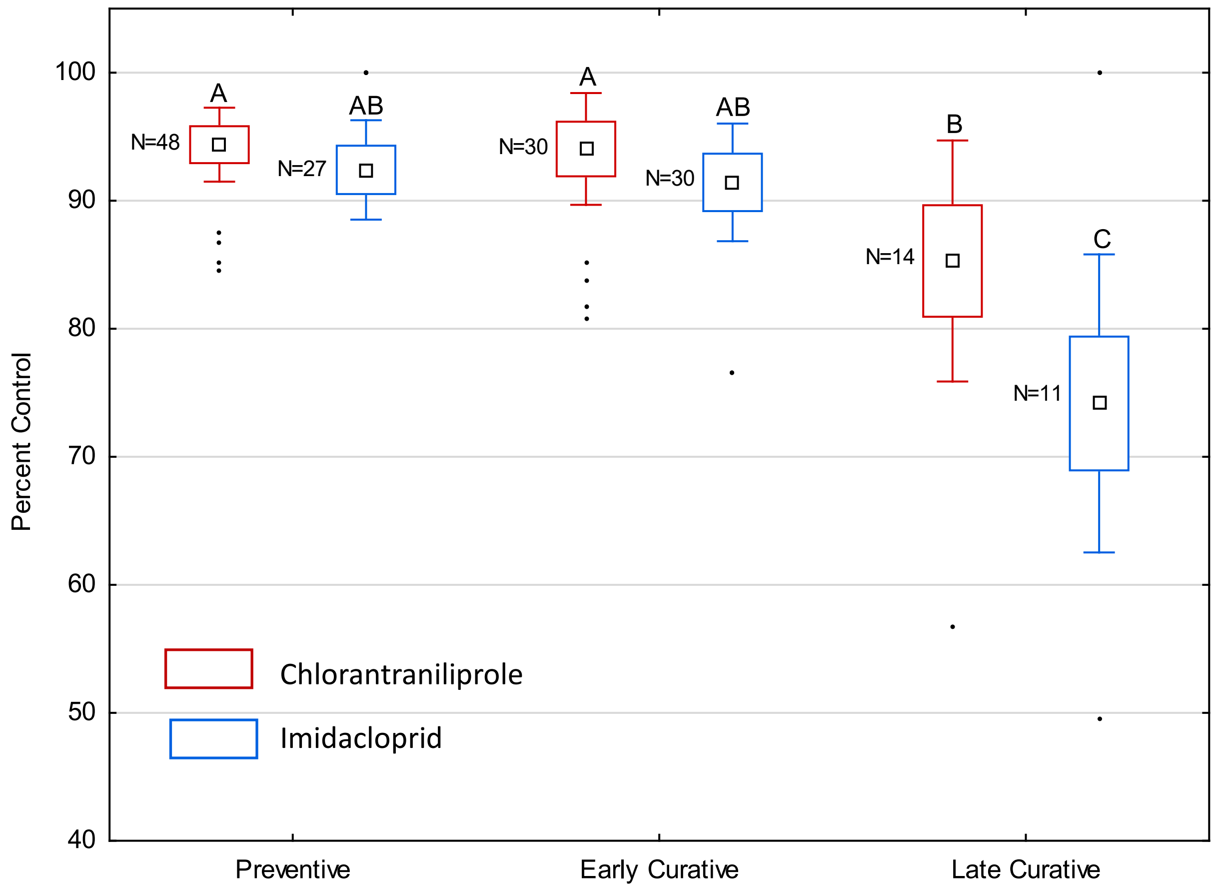

Figure 1 shows the percentage control over three management strategies. The whisker lines depict the 25%–95% interquartile range, the outside box represents the SE, and the central box is the mean. Rate was used as a covariant.

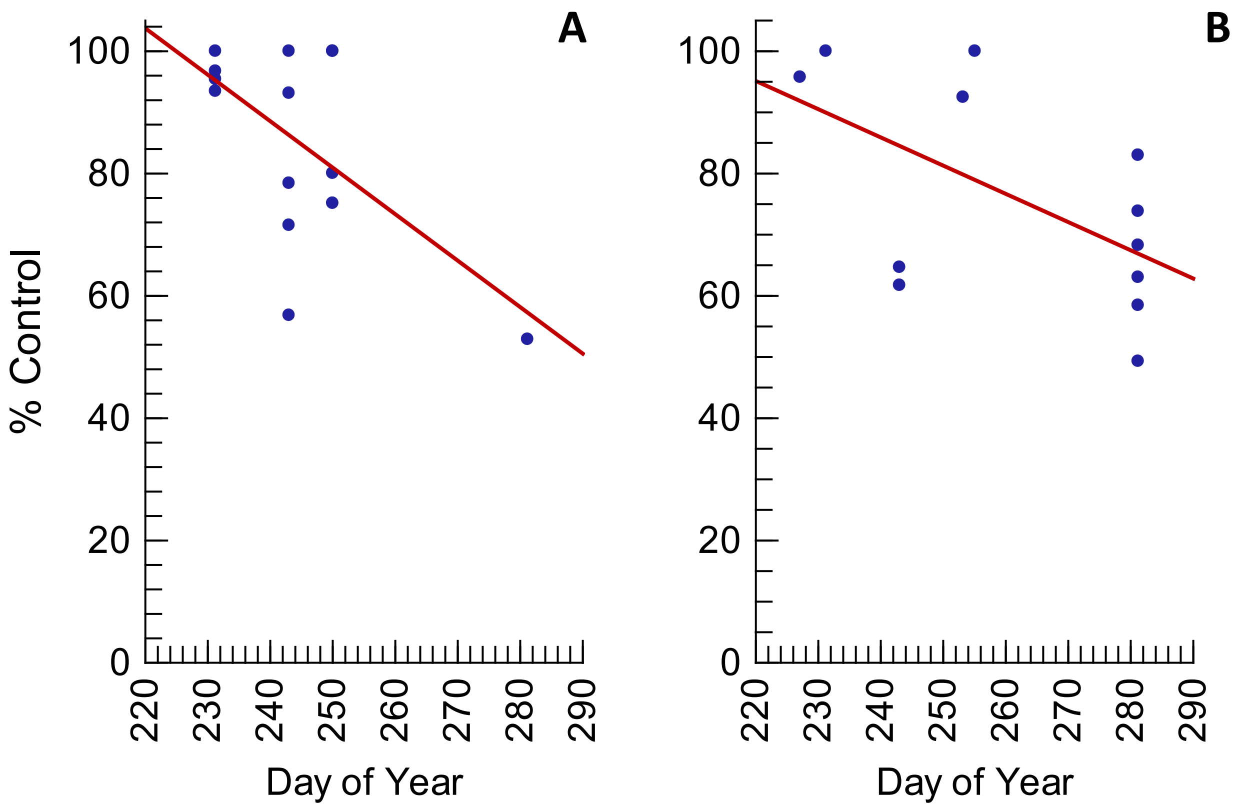

Figure 2 Parameter estimates for t, p and r^2 for regression analyses of % control on Day of Year for two different insecticide active ingredients, A (chlorantraniliprole) and B (imidacloprid), applied against white grubs during the late curative strategy.

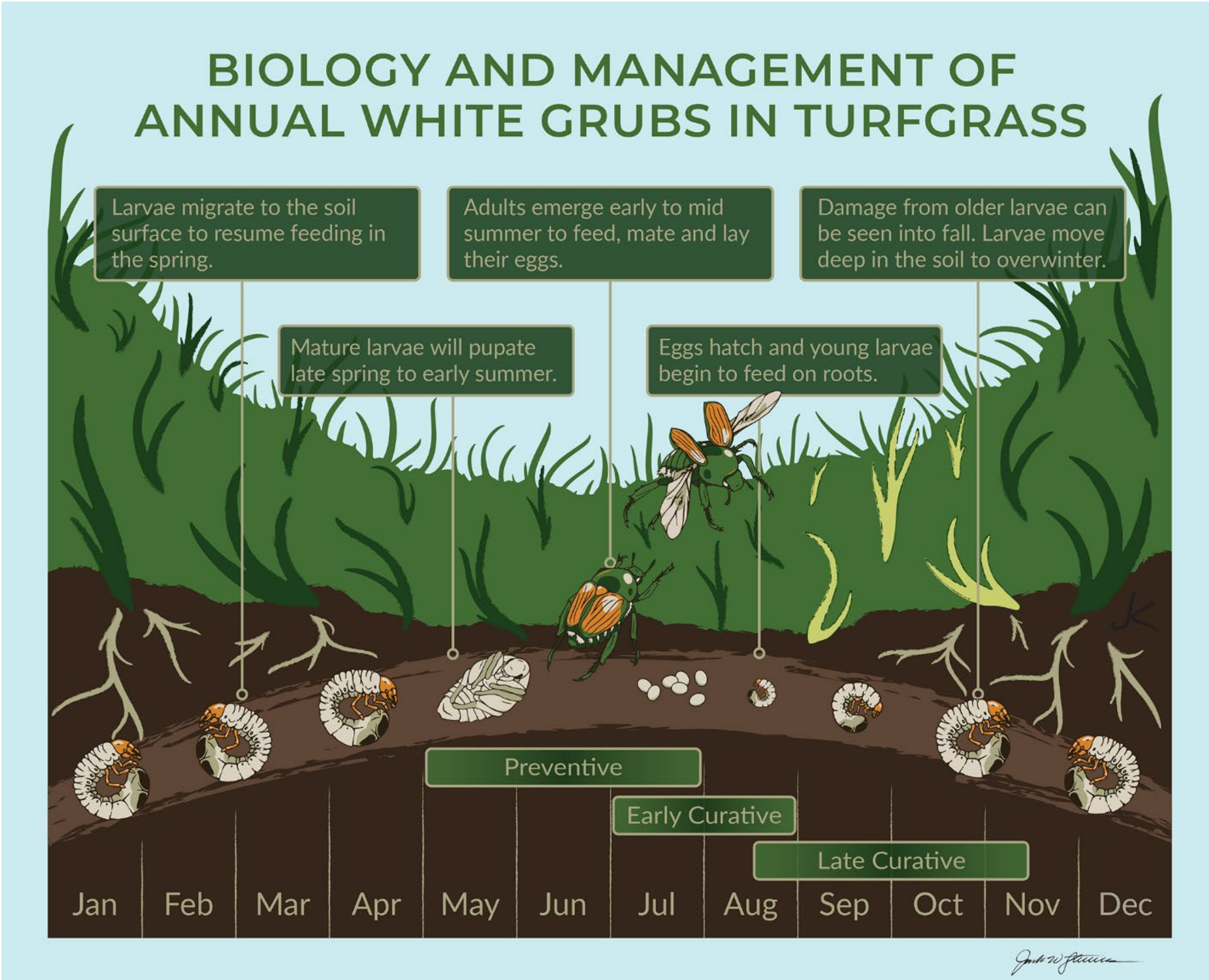

Image Created By: Jack Stevens

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