Novaluron, a novel insect growth regulator, as an effective control for Black cutworm *Agrotis ipsilon* Hufnagel in managed turfgrass

Ryan Beard

Abstract

Novaluron is a synthetic insect growth regulator that shows promise for controlling one of the problematic turfgrass insect pest in North America, the annual bluegrass weevil. It works by interfering with chitin synthesis and is effective against the adults, eggs and larvae of this insect. However, its spectrum of activity has not been thoroughly explored, making it difficult to understand its full potential within the context of holistic insect management program. This study examined the efficacy and residual activity of novaluron against another important turfgrass insect, the black cutworm, compared to a current industry standard, chlorantraniliprole. Novaluron provided statistically similar levels of black cutworm control compared to chlorantraniliprole up to 35 days after treatment (DAT). Although chlorantraniliprole provided longer residual activity against black cutworm, results indicate that Novaluron may serve as a viable alternative to chlorantraniliprole with the additional benefit of providing excellent protection against the annual bluegrass weevil inside a multiple targeting scheme.

Introduction

The development of integrated pest management (IPM) tactics and programs has long been a major focus of applied entomologists. IPM focuses on the idea that insecticide use should be limited to situations when it is absolutely necessary to keep pest populations below levels where economic or aesthetic injury is likely (Shankar, 2012). In this way, IPM also aims to manage focal pests, while avoiding detrimental impacts on beneficial insects that may provide important ecosystem services. In some cases, IPM has allowed us to substantially reduce insecticide use or decrease the negative impacts of insecticide applications by replacing broad spectrum materials with more targeted, environmentally benign, biological and biorational materials. In turfgrass systems, such materials may consist of viruses, bacteria, microbial byproducts, nematodes or insect hormone mimics with a reduced ecological footprint (Rodriguez, 2010). At the same time, practitioners need materials that allow them to target multiple pests to reduce costs and the amount of insecticide applied each year.

The spectrum of activity of a given insecticide product is important for golf course superintendents when they must deal with a wide variety of insect pests that destroy the quality of their turf. The annual bluegrass weevil causes major damage in areas around the country. They are typically found in the northeast and have become a growing problem in the Midwest (McGraw, 2022). The annual bluegrass weevil causes massive damage to turf through excessive feeding in the larval stage. The adults will attack the grass plant by chewing notches into grass blades, but do not cause much damage at that stage. The larval stage causes the most damage by feeding inside in plant stems and on plant crowns. The larger larvae in the soil will begin to feed extensively on the crowns and roots of plants causing significant damage (Billeisen, 2017). The damage appears as yellow patches of dead grass which can be caused by many different factors including other insects. There are multiple sampling methods suggested to discern the correct cause of the damage. In areas of high annual bluegrass weevil infestation, turf areas can be flushed with a soapy water solution to sample for adults. For the larvae, soil cores are cut from the turf and physically broken apart. Signs of infestation may include frass, dead roots, or the larvae themselves (Billeisen, 2017).

The black cutworm is another important pest to manage in the Midwest. It is the immature stage of an insect that infests high value turfgrass across North America. The adult moths migrate annually to the Midwest in late February through June to oviposit in early spring vegetation (Richmond, 2016). This early spring vegetation could be agricultural products, or in some cases, well managed turf. The moths typically prefer dense vegetation and will oviposit on the tips of the grass blades when available. In two to four weeks the immature black cutworms will emerge and begin to feed, typically at night. The feeding behavior is what causes the damage to a lot of vegetation. Black cutworms will feed on leafier vegetation and then drag it into the soil during daylight to continue feeding. This is the primary concern for golf course superintendents who's turf must meet a high aesthetic standard. The feeding behavior of black cutworm larvae causes depressions in the turf that could be damaging to the aesthetic and cause alterations to play on golf courses. The current approach to manage this pest is primarily the use of the chemical insecticide chlorntraniliprole. Unfortunately, chlorantraniliprole has not been as effective for controlling the annual bluegrass weevil, so there is a growing interest in a new approach for turf pest management in areas where both of these insects may damage turf (Brocklesby, 2009).

Novaluron is a insect growth regulator that affects the production of chitin in insects. It has shown promise in controlling annual bluegrass weevils and some lepidopteran insects (Kim, 2011). It also displays reduced impacts on pollinators, increasing the benefits to golf course superintendents that may want to introduce natural areas to their course (Scott-Dupree, 2009). Novaluron has not yet been examined for the range of its activity and it would benefit from multiple studies examining different key insects. If found to have a reasonably broad spectrum of activity, it may serve as a useful, multiple targeting alternative in areas where annual bluegrass weevil is perennial pest, but other common pests are also an important concern.

In this study the efficacy of Novaluron against black cutworm was compared to an untreated control and an industry standard. The industry standard was the chemical insecticide chlorantraniliprole (Acelepryn). Acelepryn is a very effective black cutworm insecticide, providing up to 100% up to 56 days after application to turf (Rebek, 2012). I hypothesized that Novaluron would provide levels of black cutworm control similar to Acelepryn, but that its residual activity may be reduced in comparison.

Methods

To evaluate the effectiveness of Novaluron against black cutworm larvae, we tested it on creeping bentgrass. This is a common type of grass used in highly managed turf at a height of 1/10 inch, similar to most golf course putting surfaces. The creeping bentgrass used in this study was located at the W.H. Daniel Center for Turfgras Research and Diagnostics, on the campus of Purdue University in West Lafayette, IN. Sixteen, 2x6 ft plots were established with 1 ft alleys in-between each plot. Each plot was randomly assigned to receive one of four different treatments (Table 1) and each treatment was replicated 4 times. The insecticide treatments were applied with a CO_2 powered back-pack sprayer operating to deliver 2 gallons of spray solution per 1000 ft^2.

After application of the insecticides, one PVC cylinder (8" diameter x 6 " high), was driven into the sod within each 2x6 ft plot to a depth of about 1" to act as a cage for subsequent black cutworm larval infestation. Black cutworm larvae were purchased from a commercial supplier, (Benzon Research, Carlisle, PA) and twenty 2nd and 3rd instar larvae were then placed in each cylinder at 1, 14, 28 and 42 days after treatment (DAT), with the cylinders being moved to a fresh, undisturbed area of each plot each time a new infestation was created. The cylinders were then covered with mesh lids. The number of surviving larvae (n/20) was recorded at 7, 21, 35, and 49 DAT, respectively, by pouring a soapy water solution of ½ ounce of liquid dish soap per 3 gallons of water on the specified area within each plot (Smitley, 2015). The soapy water caused black cutworm larvae to rise to the top of the soil where they were collected using soft forceps. The soft forceps were used to transfer each surviving black cutworm larva to a labeled vial of 70% ethanol. The vials containing the larvae where then were taken back to the lab where the larvae were counted and weighed. For the statistical analysis a repeated measures analysis was used to examine variation in the efficacy of the treatments over time.

Results

The repeated measures showed that there was indeed a statistically significant interaction between the time of the treatment and the efficacy of that treatment (Table 2). This interaction between time and treatment was statistically significant with a p-value of 0.000720. This means that the time does have an influence on the efficacy of the treatment. Overall, I collected 269 black cutworm larvae that weighed over 7.96 g in total. The different treatments all showed a similar trend, that they were able to cause above 80% mortality up until 35 DAT (Figure 1). At 49 DAT there was a decrease in the effectiveness of Novaluron. Acelepryn remained effective at 95% control, while Novaluron dropped to 38% at the higher rate and 5% control at the lower rate (Table 2). A statistically significant difference between all treatments and the untreated control was detected until 35 DAT (p=0.002). However, there was no significant difference between either of the two rates of Novaluron and Acelepryn up to 35 DAT (P=0.07). At 49 DAT there is little residual activity provided by either of the Novaluron treatments although Acelepryn still provided levels of control that were significantly different from all other treatments.

Discussion

Pesticides are often labeled in many different ways to market their effectiveness. They can be used in organic agricultural fields, gardens, or golf courses. Their effectiveness can often be categorized by the efficacy, residual activity, and spectrum of activity for each insecticide. The efficacy is one of the most important aspects to many consumers. These consumers typically want to control as much of the pest population as possible to eradicate their issues. Most insecticides allow the consumer to do that, but there are other factors that can make the application process more complicated. These complications can come in the form of labor costs or the need to purchase different insecticides to control different pests. That is why residual activity and spectrum of activity are important properties of an insecticide. Each of these properties was examined in this study to determine if Novaluron was an effective insecticide in the golf setting.

The efficacy is one of the most important aspects for insecticides because it is important to have confidence in the product. The product needs to primarily control pest species for it to be an effective pesticide. The greater the control, the easier it is for the consumer. I analyzed the efficacy of Novaluron by examining survival of these larvae and compared it across different treatments. In this study Novaluron was compared to Acelepryn to understand the quality of control. I was able to accept the first part of my hypothesis that up until 35 DAT, both rates of Novaluron were effective at controlling the black cutworm population. However, the sampling date of 21 DAT created some complications for this study due to extremely high mortality rates. There was almost no surviving population in many of the plots, including some of the controls. Multiple replicates had to be thrown out during this date but replicates with a population in the controls were kept in the study. Ants were thought to be a possible explanation of this vacancy in data due to their predatory behavior.

Residual activity is also an important factor. For corporate farmers or golf course super-intendants, managing a large area can be difficult. The amount of time that an insecticide remains effective allows them to focus on other responsibilities. This saves them time, money, and labor. I examined the residual activity of Novaluron by examining levels of control provided from 7 DAT to 49 DAT. I was unable to accept my ambitious hypothesis about the residual activity of Novaluron at 49 DAT. It was no longer effective at this date and was therefore not similar to the industry standard. However, that is much longer than the residual activity of a typical biorational. Similar work was seen by Dr. Magalhaes, where he conducted a study to look at the residual activity of multiple insecticides. This study was only carried out until 28 DAT for the Tortricidae family, but he found that Novaluron had one of the highest lengths of residual activity out of a collection of 5 other biorationals (Magalhaes, 2011).

Spectrum of activity can be another factor that reduces the cost of insecticide and increases the overall effectiveness of it. In any agricultural or turf setting there can be a multitude of pests causing damage to the product. Multiple applications are typically used, but overuse may damage beneficial species. To ease the application process for many consumers, it is beneficial for these insecticides to have a wider spectrum of activity. Less inputs are typically better for the environment and in an area like highly managed turf pests there are many different pests that need to be controlled. Permanent turf provides a suitable habitat for many different insect species, including white grubs, mole crickets, weevils, and various moth larvae in the family Noctuidae (Klein, 2007). This creates the need for an insecticide that can tackle an emerging pest in Indiana, like the annual bluegrass weevil, and a common pest like black cutworm.

Novaluron has primarily been used as an effective control method for annual bluegrass weevils across the industry of turfgrass management. The findings in this study allow that insecticide to become even more applicable to different consumers and allow it to be used on multiple pests. Novaluron was able to effectively reduce black cutworm populations and the residual activity was impressive. This insecticide could be used primarily to focus on annual bluegrass weevil and then used to control black cutworm as a secondary pest. The next step of this research would be to examine efficacy against additional pest species to further evaluate the spectrum of activity.

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Table 1: This shows the percent of the black cutworm population that was controlled by each treatment compared to the days after treatment was first applied. Novaluron was applied at two different rates per 1000 ft^2. Acelepryn was applied at a standard rate of 0.9 floz/1000 ft^2.

		BCW/ 64π in^2 (% Mortality)			
Treatment	**Rate**	**7 DAT**	**21 DAT**	**35 DAT**	**49 DAT**
Untreated	---				
Nova 10 SC	0.7 floz/1000ft^2	97.2%	100%	92.9%	4.8%
Nova 10 SC	1.5 floz/1000ft^2	83.3%	100%	96.4%	38.7%
Acelepryn	0.09 floz/1000ft^2	99.5%	100%	100%	95.2%

Table 2: This is the output table for the Repeated Measures analysis used to examine the interaction between treatment and time.

Effect	Repeated Measures Analysis of Variance (Sheet1 in CUTWORM DATA for paper) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 4.1546				
	SS	Degr. of Freedom	MS	F	P
Intercept	1207.563	1	1207.563	69.96138	0.000002
Treatment	429.313	3	143.104	8.29089	0.002958
Error	207.125	12	17.260		
TIME	734.313	3	244.771	16.58292	0.000001
Time*Treatment	574.313	9	63.813	4.32322	0.000720
Error	531.375	36	14.760		

Figure 1: The mean number of black cutworm larvae found in the 8-inch diameter area of a PVC cylinder days after treatment (DAT). The treatments were an untreated control (blue), Novaluron at a rate of 0.7 floz/1000 ft^2 (red), Novaluron at a rate of 1.5 floz/1000 ft^2 (orange), and the industry standard Acelepryn (purple). The standard error bars were constructed with 1 standard error from the mean.