PROJECT TYPE: Research and Development Grant

TITLE: Assessment of Non-Chemical White Grub Control in Turf through Mechanical and Injection Cultivation Methods

PROJECT LEADER: Dr. Benjamin A. McGraw - State University of New York – Delhi
156 Farnsworth Hall, Delhi, NY 13753
(607-746-4433); mcgrawba@delhi.edu

COOPERATOR(S): Kevin Trotta – Environmental Turf Craft
102 Russell Street, Cornwall, NY 12518,
(845-534-4064); turfipmguy@aol.com

Dr. Jennifer Grant – NYS IPM Program at Cornell University
630 West North St., Geneva, NY 14456
(315-787-2209); jag7@cornell.edu

ABSTRACT:

We sought to determine if various turfgrass cultivation machinery was capable of reliably reducing populations of below-ground feeding white grubs in two different turfgrass systems (golf course and athletic field turf). In the first experiment, grub mortality was observed with all equipment types (hollow-tine, solid, vibratory-tine, air and solid injection equipment). However, given the low densities (~ 5 larvae per ft.^{2}) and patchiness of the natural grub populations, only single- and double-passes of hollow-tine equipment were able to reduce populations when compared to untreated controls. In the second study, hollow- and solid, vibratory-tine treatments were capable of reducing grub populations below commonly accepted damage thresholds (< 10 larvae per sq. ft.), though hollow-tine treatments provided the only statistically significant reductions. In both study locations, traditional hollow-tine cultivation provided superior control to solid, vibratory-tine cultivation in both grub mortality and surface disruption. These studies indicate that performing routine cultivation can provide secondary benefits in reducing grub populations, and when performed intensively, may serve as a stand-alone pest management tactic for turfgrass systems where chemical insecticides are not an option.

BACKGROUND AND JUSTIFICATION:

Beetles in the family Scarabaeidae, commonly referred to as “white grubs” are widespread, destructive pests of many cropping systems worldwide, including turfgrass. Damage to turf is often two-fold in nature: direct, from larvae feeding on the roots of the plant, and indirect, from vertebrate predators digging in search of larvae. Management of white grubs in turfgrass is mainly through the use of broad-spectrum preventive chemical insecticides, with imidacloprid being the most popular choice in New York State. However, in 2010 the New York State legislature passed into law the “Child Safe Playing Fields Act”, effectively limiting, if not eliminating the use of chemical insecticides to day cares, school grounds, playgrounds, and athletic fields. The Act greatly reduces the amount of tools available for turfgrass managers to maintain turf in an Integrated Pest Management (IPM) framework, and limits the ability to respond to infestations in a rapid manner. Though several biological control products are commercially available as an alternative to chemical insecticides, their use is not widely adopted due to higher costs and greater inconsistency of control compared to chemical insecticides. Given the increasing public demand for less-toxic alternatives to chemical insecticides and the tighter governmental scrutiny placed on the use of chemical pesticides in turf, there is a dire need to develop technologies or best management strategies that are capable of delivering consistent, high levels of control of white grubs.

Previous research (McGraw, in preparation) has demonstrated that moderate to substantial reductions in white grub densities (upwards of 90%) can be achieved when performing routine cultivation (e.g. hollow- and solid-tine aerification). The discovery and implementation of best management practices for injection and mechanical controls to reduce white grub populations has many benefits including 1) no fear of environmental contamination 2) inability of the insects to develop resistance and 3) increased turf health through decreased compaction, increased soil porosity, and increased rooting. Mechanical controls do not have any of the inherent issues that chemical and biological controls have, including sensitivity to timing, species specific susceptibility, and inconsistency with weather and site conditions.

In this study, we sought to compare grub control with traditional equipment and with newer cultivation equipment technologies (vibratory tine, air and solid injection). In previous studies, the percent reduction in populations has been inconsistent between trials, varying greatly with the densities of grubs in natural infestations. Replicating the experiment across different turfgrass systems and locations across the state allowed us to test the reliability of these methodologies in naturally variable densities and spatial patterns as well as determine if the practice of performing cultivation with these technologies would interfere with the aesthetic demands of the different playing surfaces.

OBJECTIVES:

Objective 1: Demonstrate the ability of traditional aerification timings and machinery (e.g. hollow-tine aerification) and newer cultivation technologies (vibratory cultivators, injection systems) to reduce natural white grub populations in turf
Objective 2: Determine the effect of population density on the observed level of control
Objective 3: Project Evaluation

PROCEDURES:
Objective 1:

Small plot field trials were conducted in golf course roughs at the College Golf Course at Delhi (Delhi, NY) and an athletic field at North Rockland High School (Thiells, NY). Each research field was composed of established, rough mown (> 1.5 inches) Kentucky bluegrass/Perennial ryegrass/Fine fescue mixes. Aerfication treatments were applied in small plots (6 ft x 6 ft) which were replicated eight times. Plots were arranged in a random complete block design to counteract the effects of the inherent patchiness of natural grub populations. Untreated controls were randomized amongst the aerified plots to determine the effects that various aerification treatments had on reducing grub densities.

The first experiment (Delhi Trials) examined the effects that multiple cultivation techniques had on reducing white grub densities. Treatments consisted of plots cultivated with traditional hollow tine aerification (Toro ProCore ® 648) (Figure 1), cultivation machinery combining vertical and horizontal action (First Products UA-60 Aera-vator ®) (Figure 2), and air/solid injection treatments (Cambridge ® Liquid/Air Injection System) (Figure 3). Two variables or treatments were assessed on each cultivation technique. Hollow-tine and solid, vibratory-tine treatments were applied as either one or two passes over the replicate plot. In treatments with two passes, the second pass was conducted perpendicular to the first pass, immediately following the initial application. Cambridge injection treatments consisted of injection of either pressurized air or injection of air plus a solid material (Turface ®). To standardize injection treatments, injection pressure was maintained between 100 and 150 pounds per square inch. A total of six injections were made to each injection treatment replicate.

Figure 1 Hollow-tine cultivator (Toro ProCore) at the Delhi Trial

Figure 2 Tractor mounted solid, vibratory-tine cultivator (First Product UA-60)

Figure 3 Cambridge Air Injection equipment

Objective 2:

In the second experiment (North Rockland Trials), we sought to determine repeatability of hollow-tine (Toro ProCore ® 648) and solid, vibratory-tine cultivation machinery (First Product's UA-60 Aerovator ®). In previous studies (McGraw, in preparation), the variability in grub densities has appeared to affect the level of control observed and the inability to statistically differentiate control methods. Given that natural populations of white grubs are unlikely to be the same between two sites, this trial allowed for further investigation into the effects of population density on control.

Objective 3:

Project evaluation consisted of assessing the effect of the different technologies to provide high levels of control of natural white grub populations and the consistency of results between sites. Assessment of level of control was determined by destructively sampling the interior portion of each treatment replicate or plot using golf course cup cutter (4.25" diam.). Percent control was determined by the number of live larvae found in 10 cup cutter samples per plot (averaged across all replicates) and compared to the untreated control plots. Both experiments were evaluated within two weeks of cultivation (Figure 4).

Figure 4 Data collection and plot layout from North Rockland trial

Data were analyzed using Statistix 9.0 Analytical Program (2008). Larval counts were square root transformed (sqrt x + 0.5) prior to analysis. Shapiro-Wilks tests were used to determine if the grub count data conformed to a normal distribution. Transformed data were subjected to one- and two-way Analysis of Variance (ANOVA) to separate differences in treatment means. When significant differences were detected, Tukey's all-pairwise comparisons were made, with means separation at $p < 0.05$.

Future project evaluation (as included in the Objectives of the Research Proposal) will include communicating the findings to turfgrass manager groups through newsletters, regional and national presentations. Currently scheduled presentations to disseminate these findings include two talks at a regional seminar (New England Regional Turf Foundation Show, Providence RI, March 6th and 7th) and a national conference (Golf Course Superintendents Association of America Annual Education Conference, San Diego, CA; February 4th). A peer-reviewed journal manuscript summarizing the data presented here, as well as previous trials is currently in preparation.

RESULTS:

DELHI TRIAL

All treatments were capable of causing grub mortality (as determined by visual examination following application of treatments). Reductions in beetle populations (> 95% Japanese beetle, mostly 2nd and 3rd instar larvae) in cultivated plots ranged between 0 to 30%, with the greatest reductions observed in plots with the most surface area disruption (two passes with hollow-tine aerator (Figure 5). Single and double passes with the hollow-tine aerator resulted in 26% and 30% reductions in grub densities, respectively, when compared to the untreated checks. However, given the low grub densities in the trial, no statistical differences were observed. Multiple passes with both hollow- and solid, vibratory-tine aerators resulted in slight, non-significant reductions compared to one pass. Densities in hollow-tine and solid, vibratory-tine treatments, as well as the air injection treatment were lower than commonly accepted white grub damage thresholds (10 larvae per ft^2). Though both Aera-vator and injection treatments were incapable of numerically reducing white grub densities, only the solid-injection treatment was statistically higher than the untreated controls ($df = 6$; $F = 4.21$; $P = 0.002$).

NORTH ROCKLAND TRIAL

Grub densities in the North Rockland Trials were approximately two-fold higher than that of the Delhi Trial. Given that the populations consisted of mixed infestations of third-instar Japanese and Oriental beetle larvae, populations were at commonly accepted damage thresholds for these, and most annual white grub species (10 larvae per ft^2). Moderate (41-49%) to high (66-74%) percent reductions in grub densities were observed with solid, vibratory- and hollow-tine treatments, respectively (Figure 5). Even though substantial numerical reductions were observed with individual tine treatments, variability in untreated control plots made detecting significant statistical differences impossible ($df = 4$; $F = 2.02$; $P = 0.11$). Multiple passes did not result in improved reductions with either tine treatment. Therefore, data were combined by tine treatment and re-analyzed. Hollow-tine treatments provided statistically significant reductions when compared to that of the untreated controls ($df = 2$; $F = 4.17$; $P = 0.02$). However, solid-vibratory tine treatments, though not statistically different from hollow-tine treatments, did not provide significant decreases compared to untreated plots.

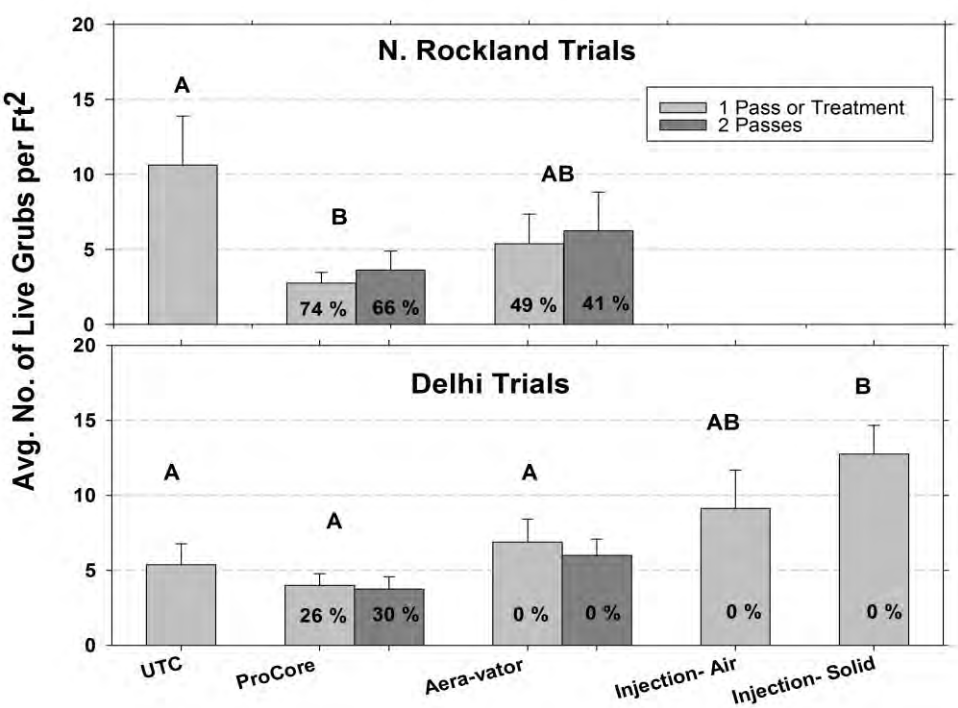

Figure 5 Effect of cultivation equipment type and frequency on white grub densities in athletic fields. (N. Rockland Trial; N. Rockland High School, Thiells, NY) and golf course roughs (Delhi Trial; College Golf Course at Delhi, Delhi, NY). Numbers within columns indicate percent reduction relative to the density in the untreated control. Bars above columns indicate standard error of the mean. Letters above columns indicate significant differences (Tukey's pairwise comparison test, $P < 0.05$) between cultivation equipment when all frequencies/intensities were combined.

DISCUSSION:

Multiple small plot field trials over a four-year period have demonstrated that common turfgrass cultivation equipment can reduce white grub populations. In this study, we sought to compare different equipment options that would be available to turfgrass managers in New York State and determine if the percent reductions or the reliability in control in earlier studies with traditional cultivation equipment could be improved upon. The newer cultivation technologies used in this study (solid, vibratory tine and injection treatments) were examined in hopes of being able to alternate between cultivation equipment types to maximize the impact on grub populations while minimizing stress on the turf. However, though all equipment types were capable of causing grub mortality, the newer technologies failed to improve on either the consistency or level of grub suppression.

The percent reduction in grub populations was quite variable between the two trials, and is likely to be affected by the differences in densities between the two populations. Hollow-tine cultivators delivered the highest levels of suppression at both sites, though these effects were only significant in one trial. Hollow-tine treatments were not only capable of significantly reducing grub densities in the North Rockland Trial, but also capable of reducing grub densities below damaging thresholds in one-time applications. Multiple passes with either the hollow- or solid, vibratory-tine cultivators did not have a consistent effect in reducing grubs when compared to one pass with the same equipment. However, common sense would suggest that aerification treatments that impact a greater amount of surface area should provide greater levels of control. ProCore treatments (1.5” spacing, ½” tine) created 48 holes per square foot and disrupted 8.54% of the total surface area, whereas the Aera-vator (9/16” tine) only creates 9 holes per square foot while disrupting 1.55% of the total surface area. Each injection treatment is capable of impacting the soil around a three foot radius from the point of application, though the comparison to vertical and vertical-vibratory tines is not as straight forward.

The degree of disruption to playing surfaces from an aesthetic standpoint is of equal concern to turfgrass managers as the level of grub control. Though not directly quantified, injections resulted in the least amount of aesthetic damage to the surface of the turf (Figure 6), followed by one pass and two passes of the ProCore (Figure 7), and lastly the use of the Aera-vator (Figure 8). Despite creating fewer holes per square foot than the ProCore, the Aera-vator was extremely rough on the turf, especially when operated slowly. The benefit of the tractor mounted Aera-vator is likely to be realized only on large areas of low maintenance turf. However, based on these findings, the Aera-vator is likely to have only a minimal effect on white grub populations. Similarly, the air- and air + solid (Turface ®) injections are likely to have even less of an impact, and would be far too labor intensive to be practically performed on large areas.

Figure 6 Surface disruption to golf course rough following Air injection treatment

Figure 7 Surface disruption to golf course rough following 2 passes with ProCore (1/2" diameter hollow tines, 1.5" forward spacing)

Figure 8 Surface disruption to golf course rough following solid, vibratory tine cultivation

Cultivation, when practiced appropriately, has many direct benefits to developing and maintaining a strong, healthy turf stand. However, certain equipment may actually be more of a detriment than a benefit when performed aggressively or during periods of stress on the turf (e.g. summer, early winter). These trials were conducted during a periods when cool-season turfgrasses are nearing optimal environmental conditions for shoot and root growth, allowing the greatest probability of recovery from the stress of cultivation. Similarly, white grub populations are developing rapidly during this period, growing in size as they advance from second- to third-instar larvae. Previous studies have only examined the effect that mechanical controls have in either late Spring or early Fall, since this is a time period that most practitioners would traditionally cultivate the turf, the turf is capable of withstanding the stress, and when grubs are at their largest size. No differences have been observed with these two timings, though it is possible that, if performed too early (e.g. when the majority of the grub population is between 1st and 2nd instars), that the effects of mechanical controls would be lessened given the probability of a tine hitting a smaller sized insect. However, since white grubs are present at shallow depths in the soil for many months in Spring and in Fall, the opportunities to impact a greater percentage of the population than observed in one-time aerification seems feasible. Aerifying concentrated turf areas may not be feasible for all operations and all areas (e.g. golf course tees and greens), especially in short periods of time. However, applying treatments over an extended period is likely to have the same effects on reducing densities, while minimizing turf stress. Additionally, no differences were detected in the ability of different types of tines in previous studies (e.g. ProCore outfitted with either a ½" hollow or ½" solid tine). Solid tining may be performed during periods when the turf is under greater stress, or times when hollow tining will likely be too traumatic to the turf. Switching between tine types may be a way to limit turf stress, while improving turf health, and reducing white grub densities.

The discovery and implementation of best management practices for mechanical controls to reduce white grub populations has many benefits including eliminating the potential for environmental contamination, while improving overall turf health by reducing compaction, increasing soil porosity, and improving gas exchange. Mechanical controls do not have any of the inherent issues that chemical and biological controls have, including sensitivity to timing, and inconsistency with weather and site conditions. Additionally, the cost for turf managers to implement this research may be minimal if the facility currently has cultivation equipment and the labor to perform intensive aerification. The research also has implications for pest management outside of the turfgrass industry. Although the data will be most useful for all types of turf operations (e.g. athletic fields, sod farms, home lawns, and golf courses), numerous other cropping systems are plagued by white grubs. Additionally, these methodologies could also be used to reduce subterranean resting stages of other insect pests in other systems. More work is needed to address the variable levels of reductions in white grub populations. However, with the increased public demand for non-toxic pest management solutions and greater governmental scrutiny on the use of chemical pesticides in turf, the research findings represent a proactive measure towards developing novel, environmentally friendly pest management strategies.

PROJECT LOCATIONS:

The findings from this research are likely to be a great value to turfgrass managers and pest management practitioners in all turfgrass systems in New York State and beyond. White grubs are problematic in turfgrass systems in all areas of the country as well as in many locations across the world. However, the findings may be of greatest value to turfgrass managers in areas where chemical insecticides are restricted.

ACKNOWLEDGEMENTS:

We would like to thank Toro - Grasslands Equipment and Irrigation (Roger Lind and Bruce Haworth), Tri-Turf Incorporated (Jerry and Ryan Hutchinson) for their time and equipment support on this project. Many thanks go to the New York State Turfgrass Association for providing past funding to get this project off the ground, and to the New York State Community IPM program for selecting this project for current funding. Finally, we would like to thank various SUNY-Delhi students, either enrolled in Horticultural Entomology or the members of the Turf Club, for assisting in data collection.

SAMPLES OF RESOURCES DEVELOPED:

See figures and digital photographs.