Integration of tools and turf species to promote sustainability in residential lawns

Michael Brownbridge, Vineland Research & Innovation Center 2016

Project Summary:

Sustainable turf grass systems can bring many economic and environmental benefits to homeowners, while providing new opportunities for lawn care and landscape companies. In light of regional urban pesticide bans and increasing restrictions on resource use for turf grass maintenance, durable systems are required that integrate a variety of tools and practices to deliver the maximum benefits. An integrated strategy that includes several key components, including improved turf grass species and low-risk (biological) pest management practices, underpinned by the use of good cultural practices, appears to provide be the most cost-effective and sustainable option. Premium turf grasses such as those containing endophytes, while more expensive, are very complementary to the system and can deliver a range of benefits from improved pest resistance to enhanced performance under drought and nutrient stress. Coating of seeds with beneficial microbes also appears to enhance growth of the emergent seedlings, even under conditions where soil nutrients may be a limiting factor. Collectively, these components enhance the resilience of lawn turf in the most cost-effective manner. Findings enable homeowners and lawn care professionals to make more informed choices around selection of new grass species for seeding/turf installation and their use with soil inoculants and other biological and cultural inputs for improved establishment and long-term performance.

Project Research:

In light of regional pesticide bans, increasing restrictions on resource inputs, and our changing climate, new approaches are required to generate and maintain turfgrass in the urban landscape. In this project, we are investigating the integrated use of improved turfgrass species and low-risk pest management practices to provide solutions to these challenges. This will provide lawn care practitioners with the tools and techniques they need to sustain healthy turfgrass systems in residential environments. Specific activities include:

Objective 1. Evaluate the complementary activity of ‘insect-tolerant’ turf grasses and selected low-impact pesticides for European chafer and chinch bugs

Objective 2. i. Using improved turfgrass species, evaluate their growth performance in two soil types in the presence/absence of microbial inoculants applied as seed coatings;
ii. Establish the potential role of bioinoculants in providing protection against pests and diseases;
iii. Quantify microbial persistence on plant roots.

Objective 3. Perform a preliminary economic analysis to assess the cost-effectiveness of the approaches being tested to provide an estimation of potential costs to turf managers and homeowners.

Objective 1.
Trials were completed in July 2015 to detect chinch bug feeding preferences for seven grass types. Selections included a high endophyte ryegrass, two prototype mixes developed for insect-resistance, two ‘creeping’ ryegrass and tall fescue varieties, rhizomatous tall fescue and a standard ‘home lawn mix’ (control). Mini plots of the different turf-grasses were installed at

residential sites with a history of chinch bug infestation; four replicate trials were set up. Chinch bug levels were monitored in individual plots four days after installation to detect chinch bug preferences for the different grass types.

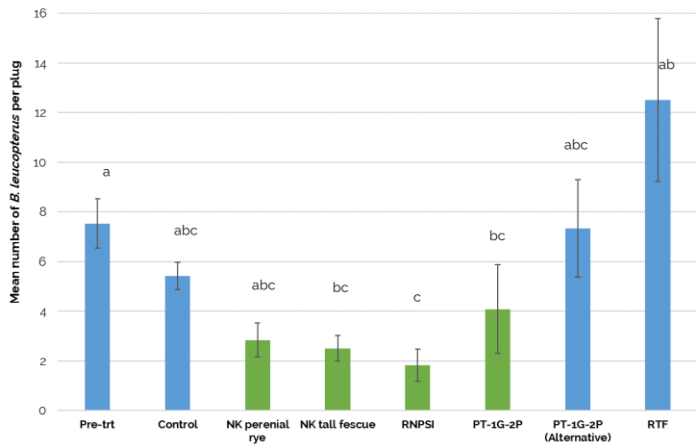

Figure 1. Relative susceptibility of seven grass types to chinch bugs.

Chinch bug numbers were lowest in the high endophyte rye (RNPSI), creeping ryegrass (NKPR), creeping tall fescue (NKTF), and an insect-resistant mix (PT-1G-2P) (Fig. 1). These grasses were consistently less preferred by chinch bugs across trial sites and experimental replications.

European chafer grub feeding preferences on the grasses were also evaluated in paired feeding choice tests. Although no statistically-significant differences in preference were observed, fewer grubs were found in the insect-resistant mixes (PT-1G-2P and PT-1G-2P ALT) compared to the other grass types.

No beneficial interactions were detected between grass type ('resistant') and nematodes. Grub mortality levels were statistically the same, irrespective of grass type, at the nematode concentrations used.

Results suggest that endophyte-containing grasses and mixes developed for insect resistance may play a valuable role in the suppression of both chinch bugs and grubs. Research plots have been set up at two locations to evaluate the performance and survival of these insect-resistant grasses in Ontario and (where appropriate) their associated endophytes. This information will be essential to their effective deployment.

Objective 2.

Greenhouse trials were completed to determine the growth performance of regenerative perennial ryegrass in ideal and sub-optimal soil in the presence/absence of a microbial seed coating (*Trichoderma harzianum*) applied using an electrostatic wax or talc. There was slight improvement in growth in the presence of *Trichoderma* in an 'ideal' soil, but differences compared to the non-coated seed were not significant. In the sub-optimal soil, though, some differences started to emerge after 12 weeks; grass development, as measured by shoot and root weight, was greater when ryegrass seed was coated with *Trichoderma*. While far from definitive, the results indicate that microbes might be used to support grass establishment in nutrient-limited soils.

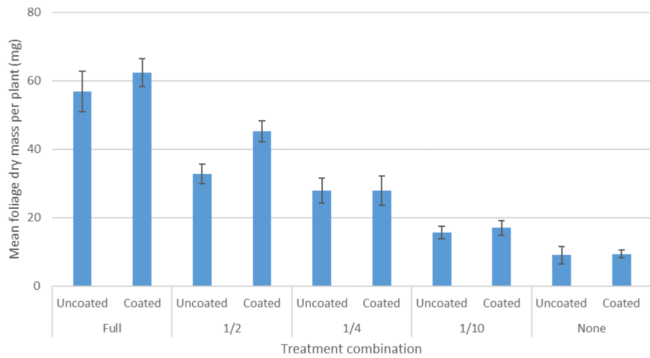

Figure 2. Mean dry mass of foliage per plant (mg) after 10 weeks under each seed coating/fertilizer treatment.

Given the highly variable nature of the sub-optimal soil, a different approach was then taken to eliminate the confounding variability brought by the soil media. Ryegrass seeds were coated with *Bacillus pumilus* using a PVA coating method and planted in a USGA 80:20 sand:peat mix. Five fertilizer rates (full, half, quarter, one-tenth, none) were used to simulate a range of soil fertility conditions from 'ideal' (full to half fertilizer rate) to 'suboptimal' (quarter rate) to 'poor' (one-tenth to zero). The substrate is essentially nutrient-free; growth responses will show whether the microbes can help the plant to access nutrients in an ideal vs nutrient-poor medium.

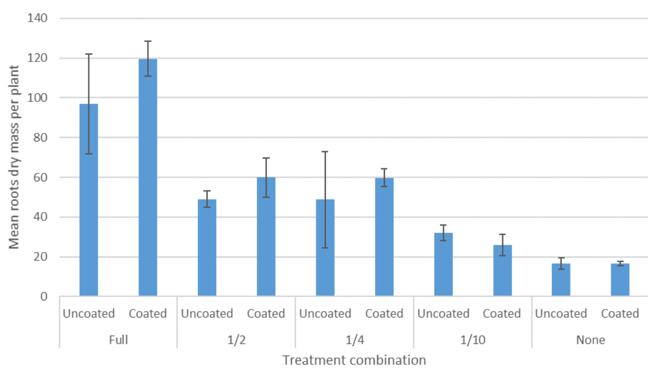

Figure 3. Mean root dry mass per plant (mg) after 10 weeks under each seed coating/fertilizer treatment.

As expected, the most significant differences in foliar and root biomass were due to differences in the fertilizer rates used. However, foliar and root biomass was greater in seeds treated with *B. pumilus* in the 'ideal' soils; slight differences were observed in the sub-optimal soil, but no differences were detected in the 'poor' soil. In this case, some benefits of seed coating with this microbe may be expected. Microbes can facilitate improved plant access to soil nutrients, resulting in improved root and shoot growth. This may be particularly important during the establishment phase of grasses, contributing to faster establishment and more robust growth. Additional microbes have subsequently been tested (*T. harzianum, Metarhizium robertsii*) with similar plant growth effects.

Ryegrass seeds were coated with the insect-pathogenic fungus *M. brunneum* and germinated in a soilless laboratory system. The developing roots were sampled over time and colonization by the fungus confirmed. A second series of trials was set up using similar protocols to determine whether the insect-active microbes established at sufficiently high levels on grass roots to (potentially) infect a root-feeding pest, using a surrogate test insect, *Tenebrio molitor.* Diseased insects were recovered, indicating the potential for infection to occur from colonized roots, but mortality in the control treatment was too high to determine whether effects were statistically significant.

Parallel trials were planned to assess whether antagonistic microbes (*Trichoderma, B. subtilis*) can protect developing grass seedlings from soil diseases. Unfortunately, we have not been able to complete this activity. It proved very difficult to acquire a virulent turfgrass pathogen and achieve consistent levels of infection. Four different fungi (3 x *Rhizoctonia solani, Fusarium* sp.), sourced from two labs, were tested using different soil inoculation methods and grass types (perennial rye, Kentucky bluegrass, tall fescue) but reproducible levels of infection not obtained.

Without a reliable bioassay procedure in place, we have not been able to complete this aspect of the project.

The Master's candidate (Mr. Paul Côté) is continuing his research project investigating turfgrass endophytes at the University of Guelph.

Objective 3.
Following the pesticide ban, alternative approaches to manage turf pasts have been tested. These include the use of pest-tolerant grasses, better lawn maintenance practices and applications of bio-pesticides. While the efficacy of biocontrol practices has been demonstrated, their economic feasibility has not been extensively evaluated. In addition, there is a need to assess the economic feasibility of an integrated management approach based on a combination of biocontrol and good cultural practices. This analysis was designed to fill this gap by examining the costs and efficacy of biological and cultural control practices for white grubs and chinch bugs. A simulation model was developed to estimate changes in the percentage of healthy turf coverage over five years under different pest infestation levels, environmental conditions and intervention scenarios. Cost effectiveness analyses were used to compare the relative costs and benefits of different strategies. The results suggest that certain intervention bundles (grass type, cultural practices and biological control) will maintain grass coverage at >95% over 5 years. Specifically:

- Well designed intervention combinations will enhance lawn health and result in higher levels of turfgrass survival, and lawn coverage.
- Selection of premium turfgrasses, e.g. NKPR and NKTF, can deliver savings when used for over seeding owing to their ability to tolerate/resist insect feeding and 'spread' via pseudo-stolons which allows a lower seeding rate to be used while providing a denser turf.
- Complete lawn renovation is approximately 60 percent more expensive than the most expensive intervention options when assessed over a 5-year period.

The estimated program costs highlight the long-term value of investing in preventative strategies, including use of higher-performing premium grass types. Outputs will enable informed choices around selection of new grass species for over-seeding/turf installation and their use with soil inoculants and other biological inputs for improved establishment and performance, and provides foundational data on the full value of this approach for homeowners and lawn care professionals.

Mini-plot trials were completed in July 2015 to detect chinch bug feeding preferences for seven grass types. Chinch bug numbers were lowest in the high endophyte rye, creeping ryegrass creeping tall fescue, and an insect-resistant mix. These grasses were consistently less preferred by chinch bugs. European chafer grub feeding preferences on the grasses were also evaluated in feeding choice tests. No statistically-significant differences in preference were observed but fewer grubs were found in the insect-resistant mixes (PT-1G-2P and PT-1G-2P ALT) compared to the other grass types. Turf plots of selected cultivars/mixes have been established at Vineland and the GTI to evaluate their relative performance (cover, weed ingress, overwinter survival) and confirm their resilience and suitability for use in Ontario. No beneficial interactions were detected between grass type ('resistant') and nematodes. Grub mortality levels were the same, irrespective of grass type, at the nematode concentrations used.
Greenhouse trials were completed to determine whether microbial seed coatings enhanced the growth performance of regenerative perennial ryegrass. There was slight improvement in growth in the presence of *Trichoderma harzianum* in an 'ideal' soil, but differences compared to the non-coated seed were not significant. In the sub-optimal soil, though, differences between coated and non-coated seeds were detected

after 12 weeks; grass development, as measured by shoot and root weight, was greater when ryegrass seed was coated with *Trichoderma*. The highly variable nature of the sub-optimal soil had a confounding effect on grass performance. To this effect, the trial design was changed; coated seeds were planted in a USGA 80:20 sand:peat mix. Five fertilizer rates were used to simulate a range of soil fertility conditions from 'ideal' (full to half fertilizer rate) to 'suboptimal' (quarter rate) to 'poor' (one-tenth to zero). Ryegrass seeds were coated with *Bacillus pumilus* using a PVA coating method and planted into tubes containing the sand:peat mix. Ten seeds were planted into soil tubes and allowed to germinate. Tubes were watered via overhead misters and 20.0 mL of each fertilizer rate was applied weekly using an electronic pipette. Shoot weight (dry), root weight (dry) and length (fresh) were assessed after 6 and 10 weeks. As expected, the most significant differences in foliar and root biomass were due to differences in the fertilizer rates used. However, foliar and root biomass was greater in seeds treated with *B. pumilus* in the 'ideal' soils; slight differences were observed in the sub-optimal soil, but no differences were detected in the 'poor' soil. Results showed that seed coatings can enhance the performance of grass seedlings. Microbes can facilitate improved plant access to soil nutrients, resulting in improved root and shoot growth. This may be particularly important during the germination and establishment phase of grasses, contributing to faster establishment and more robust growth. Additional microbes have subsequently been tested (*T. harzianum, Metarhizium robertsii*) with similar plant growth effects.
An economic analysis was carried out to examine the costs and relative efficacy (benefits) of biological and cultural control practices for white grubs and chinch bugs. A simulation model was developed to estimate changes in the percentage of healthy turf coverage over five years under different pest infestation levels, environmental conditions and intervention scenarios. Cost effectiveness analyses were used to compare the relative costs and benefits of the different strategies. The results suggest that certain intervention bundles (grass type, cultural practices and biological control) can significantly improve grass coverage over 5 years, and the costs of such preventative measures are considerably less than for a complete lawn renovation. Specifically: 1. Well designed lawn care strategies which include both cultural and biological inputs will enhance lawn health and result in higher levels of turfgrass survival, and lawn coverage. 2. Selection of premium turfgrasses, e.g. high endophyte and spreading grasses, in spite of their higher 'up-front' cost can deliver long-term savings when used for over seeding owing to their ability to 'spread' via pseudo-stolons which allows a lower seeding rate to be used while providing a denser turf, and their greater tolerance to insect feeding. 3. Complete lawn renovation is approximately 60 percent more expensive than the most expensive *intervention* options when assessed over a 5-year period.

The results show that there are differences in insect pest preferences for different grass types. Similarly, microbes, as endophytes or seed treatments, can deliver benefits to the grass in terms of increased insect resistance, and improved establishment and growth. In the face of biotic and abiotic challenges, lawn turf health and resilience appears to be promoted through the selection of a premium grass type combined with the use of good cultural practices and biological control. The cost effectiveness analysis indicates that while this approach may have higher up-front costs, it will deliver cost-savings over a 5-year period given that the alternative would be for total lawn renovation if no or limited maintenance was performed. Ideally, next steps would be to take these key findings and validate them in practice. This could provide a new template whereby lawn care practitioners could optimize lawn health, resulting is more sustainable and durable turfgrass systems which contribute to a healthier green environment.

In order to protect turf grasses against environmental, insect and disease pressures, an integrated management approach that promotes lawn health and resilience is required. Pesticides, while generally effective, were options that allowed pests to be quickly controlled. The pesticide ban removed these from the hands of lawn-care professionals and the current (biological) alternatives do not provide the same level or consistency of control. Therefore, it is essential that a variety of coordinated approaches are used to promote turf grass health and reduce the impact of pest incursions. Use of good cultural practices (mowing, fertilization, aeration, irrigation, overseeding) is essential, and will result in a healthier turfgrass system that is less prone to pests and diseases, and able to withstand insect feeding damage. Results from the current project show that additional benefits can be derived from the use of high-performing grass types, including those containing endophytes that are known to produce alkaloid compounds that can deter insect feeding. Such grasses had a significant deterrent effect on chinch bugs, for example. We were also able to show that coating of grass seeds with selected beneficial microbes could impart benefits in terms of improved growth even under less-than-ideal soil conditions, an effect that is likely to improve establishment. While we were not able to determine whether these coatings provided protection against soil diseases, did show that some microbes successfully colonized grass roots and that entomopathogenic organisms would infect root-feeding insects. Lastly, a cost-effectiveness analysis which incorporated data from current and previous trials, demonstrated the value of integrating the different approaches. The analysis, while rudimentary, showed that an integrated strategy would enhance lawn health and result in higher levels of turfgrass survival over time, and this preventative approach was the most cost effective way of maintaining lawn coverage and health in the face of biotic and abiotic challenges. Overall, the project allows us to present a framework for a sustainable turf management system that incorporates several elements.