Evaluation and Utilization of Allelopathic *Festuca rubra* Turfgrass Cultivars and Selected Groundcovers for Alternative Weed Management Strategies in the Landscape

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Abstract: The development of alternative weed management strategies in landscape and turf settings involves the use and implementation of novel bio-control practices which can provide efficaceous control over the course of the growing season. Use of pathogenic organisms to control weeds has not proven particularly effective, due to problems in obtaining consistent control and difficulty in formulation of biocontrol organisms. Organically derived products, such as corn gluten or cramby meal, have also not provided consistent or inexpensive control, especially in commercial settings such as golf courses, parks and athletic fields where complete control is often desirable. One novel approach which shows strong potential is the selection, development and use of allelopathic or weed suppressive turfgrasses or groundcovers to naturally control annual weeds in the landscape, without the use of herbicides. Fescues, especially Festuca rubra spp., produce secondary products known as allelochemicals with potent ability to suppress weed seed germination and growth. A collection of fescues was established as part of the NTEP trials at Cornell's turf farm in 1998. Quality and weed suppressive ability were evaluated by C. Bertin in both 1999 and 2000. Of the 80 cultivars evaluated, nine cultivars were identified that provided greater than 90% weed suppression as compared to other cultivars in 1999. Iin 2000, seven of these same cultivars were also extremely weed suppressive, showing that despite variability in season weather patterns, the weed suppressive trait remains active in selected cultivars. Laboratory and field research was conducted to determine which fescue cultivars are consistently most weed suppressive in field and laboratory settings and the mechanisms of suppression. Results from the laboratory and field trials, along with new plots recently established in Ithaca and Riverhead NY will determine which fescue cultivars can be successfully established and maintained with fewest invasive weeds in Central NY and Long Island NY growing conditions. A weed suppressive index will be determined for the materials under evaluation, based on growth measurements obtained. Long term studies are now underway to evaluate the allelochemicals, secondary metabolic pathways and genes involved in this suppressive trait in selected fescue cultivars. Recommendations will be developed for cultivar and species selection, seeding or planting rate and mowing height.

Materials and Methods:
Field plots were established in 1999 according to NTEP trial specifications. Eighty fine fescue accessions were evaluated at standard densities for turf quality in response to mowing height and traffic evaluations. Plots were approximately $1m^2$ each and were replicated 3 times for each cultivar. Ratings were taken on each of 240 plots and data was compiled and analyzed. In addition, they were evaluated at 4 week intervals during the 2000 growing season for weed suppressivity using visual ratings of total weed infestation (based on a 0-100% infestation scale) and separate weed species infestations, including large crabgrass, white clover, creeping bentgrass and dandelion.

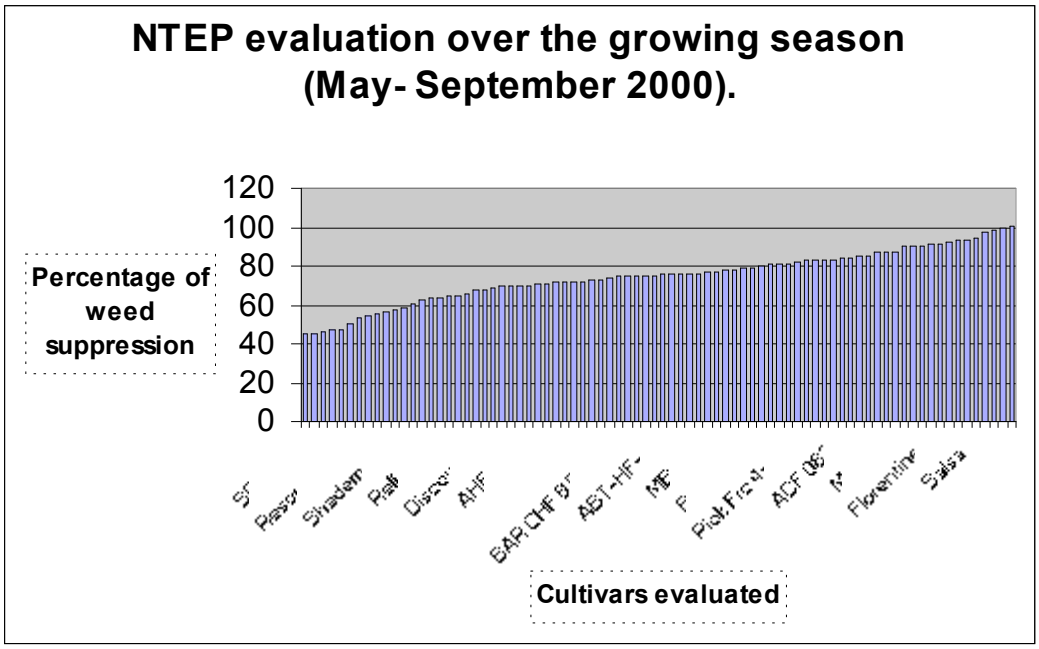
Laboratory evaluations of most and least suppressive festuca accessions were also conducted in 1999 and 2000. Two bioassays were designed to assess the impact of fescue seedlings of various accessions and their root exudates upon large crabgrass and curly cress seedlings. Fescue accessions were separately established in sterilized sand placed in sterile well plates and then moistened with 350 micro-liters of autoclaved water. Water was added every 2 days to maintain moisture. Large cress and crabgrass seed was then introduced after 1 week, when fescue seedlings were newly established. After 10 days of growth, seedling biomass of seed indicators was measured. Roots and shoot weights were collected separately. In a separate bioassay, magenta boxes were filled with 50 mls of sterile 0.2 % water agar. Twenty fescue seedlings of each accession were established in each box and allowed to grow for 14 days in a growth chamber under 12 hours of light and 12 hours darkness photoperiod at 25 degrees C. After 14 days, an equal number of large crabgrass seeds were placed in each box and

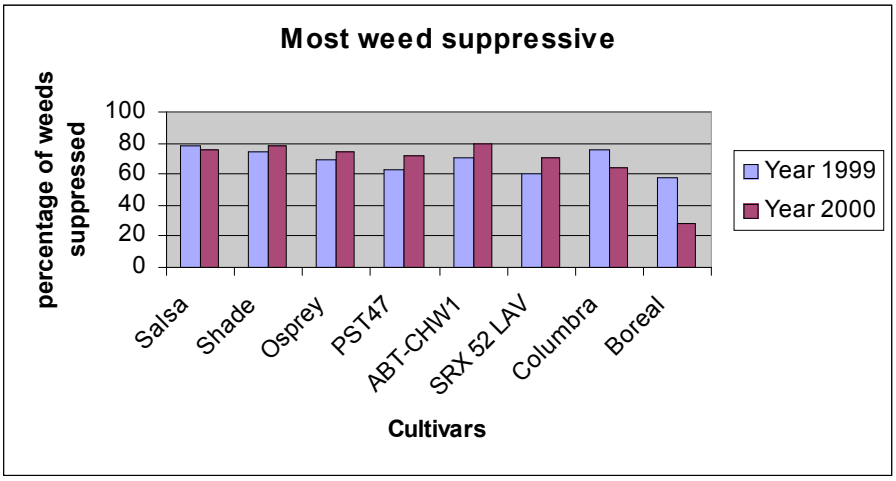
returned to the growth chambers. After 10 days, crabgrass germination and seedling biomass was measured. All treatments were replicated at least 5 times and experiments were repeated in time. Data presented is an average of several experimental runs.

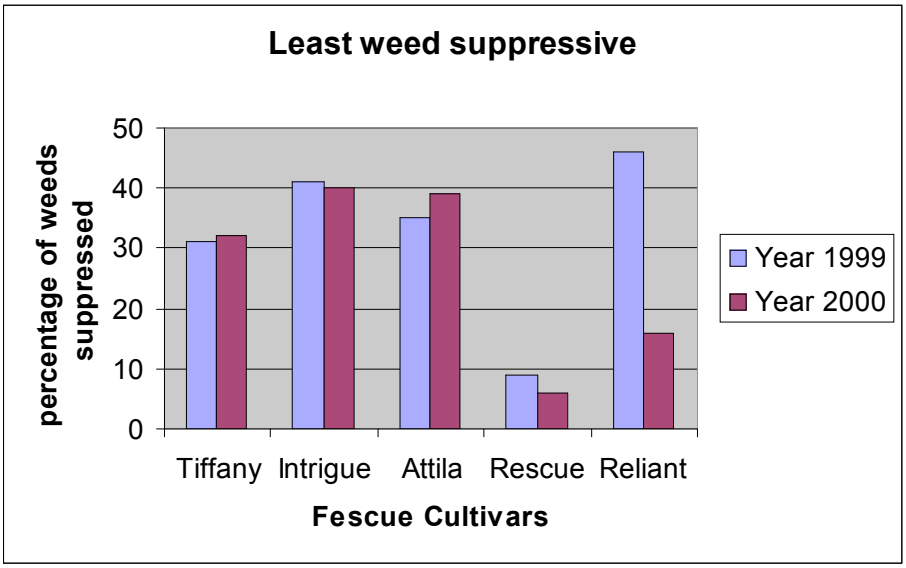
A capillary mat system (Czarnota et al, 2001) was designed to collect large quantities of fescue root exudates. Fescue seed was placed on the sterile mat system and allowed to germinate for a period of 2 weeks. During this time, fescue seedlings developed an extensive root system which was supported between layers of cheesecloth and absorbent fabric. After 14 days, the roots were harvested by removal with a razor blade. Roots were extracted for bioactive root exudates in methylene chloride. Each accession was also produced separately on this capillary mat system. Exudates were dried using rotoevaporation, followed by exposure to a stream of purified nitrogen gas. The exudates were subjected to bioassay to test for inhibitory activity. Extracts were tested at concentrations of 0.125 to 2.0 mg/ml using a standard petri dish assay to assess seed germination and seedling growth over a 72 hour period. Extracts were also evaluated for their chemical constituents by thin layer chromatography with various silica plates and by HPLC (Waters Reliance system, reverse phase, C18 Nova pak column, Waters Inc.) using an acetonitrile: water mobile phase at 2 mls/minute. Detection was at UV 254 nm using a photodiode array detector.

Results:

There were significant visual differences among cultivars in terms of appearance, density of establishment and weed infestation. Many cultivars were completely infested with large crabgrass, clover and annual bluegrass. Others exhibited only moderate infestation. Several cultivars (7) proved to be highly weed suppressive across all replicates in both 1999 and 2000. They produced a uniform turf appearance and had few, if any, weeds established within the plot. In contrast, there were approximately 10 cultivars that had greater than 80% levels of weed infestation. This indicated a great variance in suppressive tendencies within this collection of fescue germplasm (also see NYSIPM final report, 1999, Weston et al).



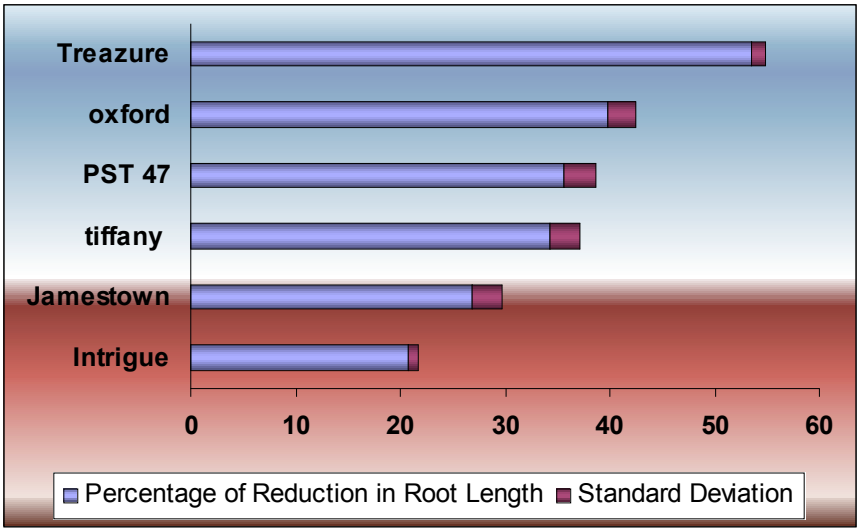


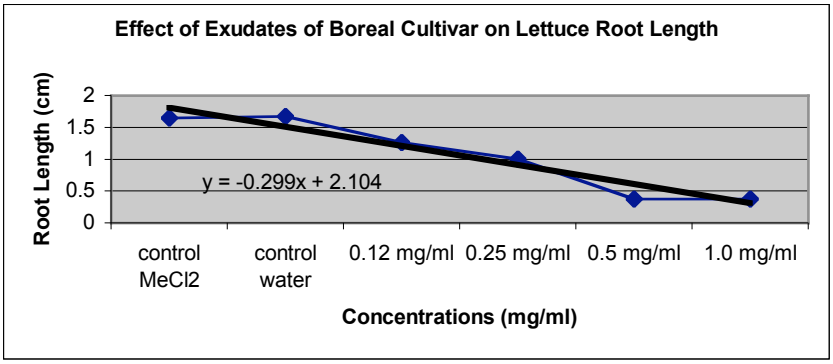


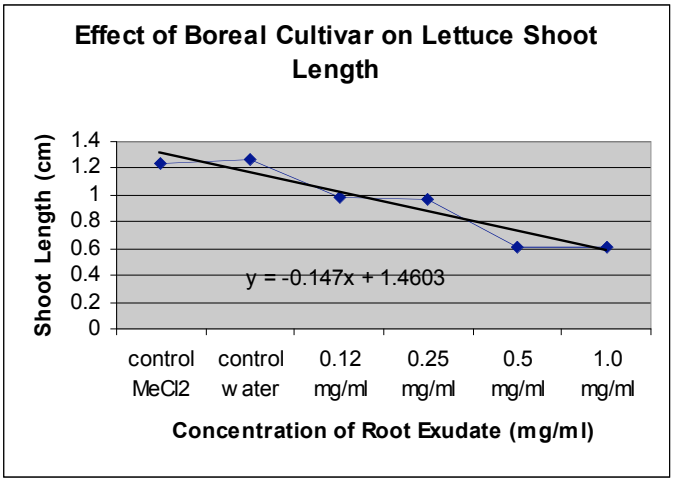
The finding that at least 7 creeping red fescue cultivars are highly suppressive to annual weeds in field settings over the course of an Ithaca growing season over a 2 year period indicates that these cultivars could potentially be used alone or in mixtures to establish a high quality, fine turf surface, with few, if any, weeds established under a no herbicide spray regime. Herbicide use for treatment of annual weeds could potentially be very significantly reduced for the homeowner or the commercial groundsman. The incorporation of this weed suppressive trait in other turfgrass species could prove tremendously useful in reduction of pesticide usage over the course of the production season, given that weeds are usually by far the major pest in turfgrass management regimes.

When crabgrass was co-cultivated in the presence of different accessions or cultivars of fescue, differential responses in growth inhibition were also observed in the laboratory. Treasure and Oxford were quite suppressive in this assay, causing up to 60 % greater reductions in seedling crabgrass root growth than when crabgrass was produced by itself. In contrast, Intrigue and Jamestown cultivars were much less suppressive to crabgrass growth.

Percent reduction in crabgrass root and shoot length when grown in sand culture in the presence of various fescue accessions







Root exudates of various accessions of fescue were also collected after production upon a capillary mat type of biomass production system. The system worked very effectively to generate quantities of healthy fescue roots within a 14 day growth period. After collection, significant quantities of root exudates were observed. These quantities differed with the accessions evaluated. When Boreal exudates were collected, they were evaluated along with exudates of other accessions, in bioassays assessing effects upon lettuce seed germination and seedling growth. In the above figures, it is evident that with increasing concentration of Boreal exudates, increased inhibition in growth of lettuce roots and shoots was observed. Effects were most pronounced on crabgrass root inhibition.

Fescue root exudates are clearly exuded by living root hairs of seedling fescue. All exudates contains a number of chemical constituents, one or more which exhibit potent activity in reducing crabgrass and other seedling's growth. Studies are currently underway in our laboratory to separate and characterize these chemical constituents and observe how they may differ among accessions. Thin layer chromatography and high pressure liquid chromatography are utilized for effective separations of these components. Separation has resulted in enhanced purity of the active component(s) within the root exudates, leading to increased potency of the purified fraction in inhibiting seed germination and growth. Identification of these components may lead to novel herbicidal structures which can act as templates for synthetic and natural products for the agrichemical industry. In addition, an enhanced understanding of the biosynthetic pathways regulating production of these root exudates may allow the discovery of genes which regulate production of these compounds and allow us to select for fescue and other turfgrass accessions with enhanced weed suppressive activity.

Literature Cited:

1. Czarnota, M. A., J. A. Buxton and L. A. Weston. 2001. Weed Technology (Submitted 2/01).