Alternative Weed Controls for the 21st Century

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Label restrictions for turf and ornamental pesticides are increasing due to the Food Quality Protection Act of 1996. In the near future (in some cases now!) certain products will no longer be available for use on turf and ornamentals. The good news is FQPA has streamlined the registration process for new compounds based on natural products or organisms. The big questions are who will develop these new compounds, will they be developed in time to replace conventional chemicals, and how effective will the new compounds be? A good herbicide should have the following characteristics: 1) Be effective, 2) Specific for the target pest(s), 3) Degradation to innocuous products following a finite lifetime, and 4) Be safe for humans and the environment.

The potential for biological weed controls is seemingly endless. Numerous viruses are known to infect specific plant species. Bacteria, which can multiply nearly as quickly as viruses, can be devastating to certain plants, including woody species. Fungi are a group of plant pathogens well known to superintendents who battle turf diseases caused by a relative few fungal species. Worldwide, including the U.S., insects and animals have been released for biological control of weeds in environments ranging from dry, semi-desert rangeland to aquatic habitats. Plant products offer another line of potential weed control agents.

Unfortunately the realistic potential of many biological pesticides is at best challenging. Turf, unlike crops, rangeland, or forests, requires at or near 100% weed control since we grow it for quality and not quantity. Weed-eating insects are unlikely to be effective. Insects are difficult to rear, to ship, and tend to wander off when they are released. Animals such as geese are used in certain crops to eat offending weeds, but a golf course fairway or green is hardly the place for a vertebrate animal (humans excepted). In some cases the animal may find it prefers turf: I once watched a muskrat eat turf on our plots; going down the line, he chewed a bit from each of the low N turf, then the low N turf with Primo, and then the high N turf. He apparently liked the high N and Primo plots the best, because by the time I got there to catch him he had eaten most of the turf on the plot!

Fungi typically require free water and moderately warm temperatures for infection. If superintendents provide these conditions for mycoherbicides (fungi are the active ingredient), they risk more turf diseases as these environmental conditions are also favored by turf-pathogenic fungi. Furthermore, most of the weed-controlling fungi would also be susceptible to the same fungicides used to control turf diseases. Viruses are an unlikely source for weed control in turf because they typically require a vector, i.e., an insect, to transmit them into susceptible weed hosts. Bacteria require openings in the plant, such as wounds, for infection. In turf, frequent mowing provides the opportunity for bacterial infections. The bacteria are fastidious little creatures, though, and require high concentrations to cause lethal infections. They also have to be able to compete with and supplant microbes already on or in the plants. Moreover, only certain species of bacteria are capable of forming spores. Bacteria experience rapidly rising and falling populations, making it difficult to keep non-spore-forming bacteria alive in sufficient concentrations to be effective. Bacteria can also be degraded by UV light (sunlight), suggesting a nighttime application would be more effective than during the day.

Even with all the pitfalls, microorganisms may yet play an important role in weed control. In non-turf systems, several fungi have been developed for weed control. One example is *Colletotrichum gloeosporoides* f. sp. *aeshynomene*. It is sold as Collego for control of northern jointvetch in rice. A *Phytophthora* spp. (distantly related to *Pythium* spp.) is sold as DeVine for control of strangler vine in Florida citrus crops. A third one which could eventually be used on turf is BioMal, another *Colletotrichum* subspecies which controls round-leaved, or dwarf, mallow (*Malva rotundifolia*).

During the 1990's a bacterium (*Xanthomonas* *campestris* pv. *poaannua*) was assessed for its potential to control annual bluegrass in turf. This bacterium causes a wilt disease by clogging the vascular system of infected plants. Weekly inoculations controlled 92% of *P. annua* var. *annua* and 82% *P. annua* var. *reptans* in growth chamber conditions (Zhou and Neal, 1995). Unfortunately, control was less than 15% in field tests. *P. annua* control in the field was increased to 40% when the bacterium was applied three times weekly, but the *P. annua* population recovered within two to five weeks after applications were stopped. It is unlikely very many superintendents in Wisconsin will care that *X. campestris* pv. *poannua* isn't likely to be registered as a *P. annua* control agent. Due to the predominance of *P. annua* on golf courses, its utility as a putting surface, and good management practices, *P. annua* is now often considered a desirable turfgrass in Wisconsin.

Natural plant products may be the best option for turf weeds. Several cool-season turfgrass species may produce allelotoxins (plant-produced toxins) which inhibit germination or establishment of other plants (Hagin, 1991; Hisle and Powell, 1993; King et al., 1994; Lickfeldt and Voigt, 1999). To date, none have been marketed for weed control.

Corn gluten meal is the first plant product to have any real utility for weed control in turf. Hailed as a cure-all by some environmentalists, corn gluten meal does have some efficacy as a pre-emergent herbicide. In addition to its herbicidal properties, corn gluten contains approximately 10% slowly available nitrogen which is useful for turf growth. The properties of corn gluten meal were discovered and developed at Iowa State University. Unlike many alternative pesticides corn gluten meal is supported by research data.

Research shows nearly 60% weed control can be achieved in the first year when applied at 20 lb per 1000 ft^2. Weed control may improve with continued use over several years. Corn gluten is sold as a dry product under various trade names, including Dynaweed, Safe 'N Simple, Earth Friendly, W.O.W.!, Corn Gluten Meal Herbicide, and Propac. Until recently it was only offered in powder form. A granular form is now available which can be more easily be applied with Vicon, rotary and drop spreaders. Suggested application rates vary from 12 to 20 lbs per 1000 ft^2 depending on the intended use. For crabgrass control in turf, two applications are recommended at 12 lb/1000 ft^2, once in early to mid-spring and another in early to mid-August. Since the corn gluten meal is about 10% nitrogen, this strategy catches two flushes of crabgrass and spreads out the nitrogen effect. Two applications at 12 lb/1000 ft^2 will provide nearly 2.5 lb N/1000 ft^2 per year. The nitrogen is in a slow release form so there is little to no potential for foliar burn.

Pre-packaged corn gluten is relatively expensive. It can be purchased in bulk from feed mills where it is sold as animal feed. Some users have reported odor problems and it may attract rodents during storage. Some users report dissatisfaction with weed control at the recommended rates, and indeed the data indicate weed control is significantly enhanced at rates of 40-60 lb/1000 ft^2 (Table 1). These rates become cost-prohibitive and provide what is now viewed as excessive nitrogen (4 to 6 lb N per application).

What is good could be made better. The herbicidal activity of corn gluten meal is due to at least two peptides (protein fragments). These peptides inhibit cell division of roots, which can stop a germinating weed seedling dead in its tracks. Many conventional pre-emergent herbicides also stop cell division in roots of germinating weed seedlings. Research shows the peptides can be extracted from the raw product (corn gluten hydrolysate) and are considerably more efficacious (Table 2). The hydrolysate form could be packaged, sold, and used in a manner similar to conventional pesticides, facilitating its entry into the professional market. Raw corn gluten does not require an EPA registration to be used as an herbicide. However, since the hydrolysate is a derived-product, it requires an EPA registration to be labeled as an herbicide. Therein lies the kicker: until a company steps forth to develop the hydrolysate form, we are unlikely to see a more usable product. To be fair a company would be risking much; the development costs are unknown but likely to be high, and recovery of marketing costs is not guaranteed.

That which supports us can also strangle us. While government restrictions begin to remove conventional chemistries from turf and ornamentals, the lack of funding for alternative products in turf and ornamentals does not provide industry or university researchers with support to develop new products. Government regulations, at times seemingly excessive, stifle industry's initiative to develop new products. Much of the governmental and private funding

Table 1. Crabgrass reduction using corn gluten meal in field trials on Kentucky bluegrass turf.†

1998 (4 weeks pre-emerge)			1991 (1 week pre-emerge)	
Rate (lb/M)	% control		Rate (lb/M)	% control
0	0		0	0
40	50		20	58
81	65		40	86
122	80		61	97
162	95		122	87
203	92		201	79

† Adapted from Christians, N.E. 1993. The use of corn gluten meal as a natural preemergent weed control in turf. p. 284-290. Proc. 7th International Turfgrass Society Research Conference, Palm Beach, FL, USA, 18-24 July, 1993. International Turfgrass Society, No. 7. Intertec Publishing Corp., Overland Park, KS.

Table 2. Comparison of raw corn gluten meal to corn gluten hydrolysate as an herbicide for germinating grass seedlings.†

	Application rate		
Treatment	0.6 lb/1000 ft^2	1.2 lb/1000 ft^2	4.5 lb/1000 ft^2
Corn gluten meal	100	100	50
Corn gluten hydrolysate	12	0	0
LSD (0.05)	12		

† Adapted from Liu, D.L., N.E. Christians, and J.T. Garbutt. 1994. Herbicidal activities of hydrolyzed corn gluten meal on three grass species under controlled environments. J. Plant Growth Regul. 13:221-226.

these days is devoted to biotechnology, with dwindling support for applied research and researchers.

As conventional herbicides are "lost" during the next few years some companies will undoubtedly develop alternative control measures. New alternative chemicals are likely to cost more and be less efficacious, though safer, than conventional compounds. In all likelihood we are headed toward a system of reduced reliance on pesticides, whether natural or synthetic. In some cropping systems, the research is steering away from chemical control and back towards manipulation of cultural practices for weed control. On the farm we used a field cultivator to rip out weeds between the corn rows. As turf managers, we will have to develop something a bit more creative.

Christians, N.E. 1993. The use of corn gluten meal as a natural preemergent weed control in turf. p. 284-290. Proc. 7th International Turfgrass Society Research Conference, Palm Beach, FL, USA, 18-24 July, 1993. International Turfgrass Society, No. 7. Intertec Publishing Corp., Overland Park, KS.

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