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CONTROLLING TURF WEEDS WITH A NATURAL PRODUCT

When modern lawn care began in the late 1960's, there was little concern about the use of pesticides. Homeowners were interested in achieving a high quality turf area and they left the details to the lawn care company. Pesticides were even seen in a positive light by many consumers and company names and advertisements often reflected and emphasized pesticide use. Things have changed considerably since that time.

These changes became very apparent in the last decade. There has been widespread concern expressed by the public over a variety of environmental issues. Lawn care has caught the brunt of much of this concern because of its visibility. While pesticide use in rural farming operations may be a concern to the consumer, its not a part of their everyday experience. Lawn care, however, is taking place in their front yard or at least along their street. Proximity to the consumer has also been a big problem for the lawn care industry. Children and pets are often in contact with the treated areas shortly after application. While posting of treated lawns has helped reduce this contact, it has also heightened awareness of the problem. There have been many attempts in the last few years to pass strict regulations concerning the use pesticides. Some environmental groups have attempted outright bans on pesticides in urban areas. With this change in public perception and subsequent pressure for reduced use, has come a demand for natural substitutes for synthetic pesticides. Progress has been slow in developing these substitutes, but headway is being made and

many things are showing potential for use in landscape and gardening.

Research activity has been greatest in the field of entomology and a number of products such as insecticidal soaps, grass varieties that contain endophytes, selective bacterial pathogens, nematodes that attack insect pests, predatory insects, and natural plant-derived chemicals with insecticidal properties are available. Progress on the control of diseases with natural substitutes has been slower, but there is some promising work involving the use of environmentally safe bacteria to inhibit the activity of fungal pathogens.

The development of natural substitutes that can be used for weed control has made particularly slow progress. There are soap-like materials that can be used for nonselective vegetation control and there has been some research on selective pathogens, but up to recently there has been little available for those who would choose natural substitutes in place of synthetic herbicides for weed control.

A NATURAL PRODUCT FOR WEED CONTROL

About 10 years ago, a research project at Iowa State University led to development of a natural product for weed control that just recently reached the market. The original project had nothing to do with weed control or natural products. Its objective was to study the effect of a fungal pathogen on grasses. The work involved the growth of the fungal organism on corn meal in the laboratory followed by the incorporation of the fungal-corn meal combination into the soil of a new golf course green at the field research area. At the same time, adjacent field areas were treated with the same amount of corn meal that had not been cultured with the fungal pathogen. The study area was then seeded with creeping bentgrass.

It was anticipated that the fungal organism would affect the grass and a reduced stand would be observed in the treated plots. That did not happen and the original study was unsuccessful. However, something unusual was observed. In the control plots that had received the raw corn meal that had not been inoculated with the fungal organism, the grass stand was very thin. Whereas in the plots that were treated with the corn meal on which the organism had been cultured, the establishment of the grass was normal. The amount of corn meal on the two areas was exactly the same and it had come from the same lot of material. The only difference was that the fungal organism had been cultured on the corn meal on the plot with the healthy grass.

This response was hard to explain. One possibility was that there was some type of organic compound or compounds in the corn meal that had the ability to reduce the stand of grass. Possibly this active component was destroyed by the activity of the fungal organism during the culturing process in the laboratory. To test the hypothesis that there was some activity in the corn, several components of corn were obtained for further testing. These included starch, germ, fiber, and gluten meal (the protein

fraction). These components were tested along with corn meal in the greenhouse to determine if they had some type of inhibitory effect on grass germination. These studies showed that there clearly was some type of inhibitory effect on the establishment of the grass at germination and that the inhibitory material was concentrated in the corn gluten meal, the protein fraction. Close observation showed that the effect was on the root system of the germinating seed. There was something in the gluten meal that stopped root formation at the time of germination while shoot tissue formed normally. With drying of the soil surface, plants that did not develop a root system simply died while plants with a well developed root survived.

The corn gluten meal (CGM) is a 60% protein material that is approximately 10% nitrogen (N) by weight. It is a byproduct of the wet-milling process and is sold as a feed material for cattle, poultry, and several other species of livestock. It has been used in fish food for commercial fish production and it is also a primary constituent of some dog food products. Corn gluten meal is produced as a fine, yellow powder, but can be pelletized for easier application to the soil.

The high N content of CGM made it a potential N source for mature plants. Testing in the field and greenhouse showed that it was an excellent source of slow-release N for mature turf. Once this was understood, the idea developed that CGM had potential as a natural 'Weed and Feed' product. It could be used as a fertilizer on mature grass and, if timed properly, could be used to

inhibit the establishment of annual weeds, such as crabgrass, that germinate into the turf. Field tests showed that the material was effective for that purpose and US Patent #5,030,268 was issued on the use of corn gluten meal as a natural preemergence herbicide for use on turf in July of 1991. For a more complete description of the early development of this work, see GOLF COURSE MANAGEMENT October 1993 pages 74 to 76.

Since the publication of the original article, many new developments have occurred with this project. Further work with CGM in other crops such as strawberry showed that the idea had potential in several management systems where the use of a natural substitute for synthetic pesticides is desirable. Following submission of new data to the patent office, the original patent was reissued in April 1994 as US patent Re 34, 594. The reissue expanded the original claims to include the use of CGM as a preemergence material in field crops, gardens and other agricultural areas.

The invention was licensed to Gardens Alive, Inc., 5100 Schenley Place, Lawrenceburg, Indiana 47025, in 1993. The company registered corn gluten meal as preemergence herbicide with the US Environmental Protection Agency (EPA) in August of 1994 under EPA Registration #56872-1 and EPA Est. #56872-IN-1 with the trade mark A-MAIZING LAWN. The product went on sale by mail order in the fall of 1994. The product is recommended to be applied at 20 pounds product/1000 ft2 (2 lbs N/1000 ft2) to turf before germination of annual weeds in the spring and 20 lbs product/1000 ft2 in late

summer. This provides a total of 4 lbs N/1000 ft2/year. Research has shown that the material has excellent slow release characteristics and provides a uniform turf response throughout the season. Work is also underway to determine in rates as low as 10 lbs CGM/1000 ft^2 can be used to achieve satisfactory weed control. Some work has indicated that this may be possible.

FIELD RESEARCH

Research with corn gluten meal has been conducted at Iowa State University for a number of years. The longest running study has continued for four consecutive years, from 1991 to 1994, on the same plot area. Treatments on the area were applied for the fifth year in April of 1995.

The objective of the study is to observe the effects of corn gluten meal on weed control and turf quality of Parade Kentucky bluegrass under field conditions. Corn gluten meal was applied to the same 5 ft x 5 ft plots at the research station during 1991, 1992, 1993 and 1994 at levels of 0, 2, 4, 6, 8, 10, and 12 lb N/1000 ft^2 (0, 20, 40, 60, 80, 100, 120 lbs corn gluten meal/1000 ft^2). Application dates were April 22 in 1991, April 28 in 1992, April 26 in 1993, and April 27 in 1994. The very high rates were included to determine if the product has any detrimental effects of the turf over extended times of application.

Table 1 includes data on crabgrass control over the 4 year period from 1991 to 1994 and data on clover and dandelion control for 1994. In the first year of the study, the 2 lb N (20 lb

CGM)/1000 ft^2 rate reduced crabgrass by 58% and the 4 lb rate reduced infestation by 86%. The crabgrass control improved to 85% at the 2 lb rate in 1992 and to 91% in the 1993 season. Crabgrass was nearly eliminated in plots treated with CGM rates above 2 lb N/1000 ft^2 in 1992 and 1993. The 1993 season was one of the wettest seasons in history. The grass on the plots often became very long on the plots between mowing, resulting in some thinning of the stand. Crabgrass control dropped to 70% at the 2 lb rate in the spring of 1994, although it remained good at higher rates of application. No detrimental effects on the Kentucky bluegrass have been observed at even the highest rate over the 4 year period.

There is no postemergence effect of CGM on weeds. The effect is entirely preemergence. Little effect on the infestation of perennial broadleaf weeds was anticipated in the study. By the end of 1994, however, there was a considerable difference in clover and dandelion infestation between nontreated and treated plots. Over the 4 year period, clover and dandelion infestation in the area surrounding the plots and in the control plots began to increase, whereas treated plots maintained very low infestation levels (Table 1). The clover infestation was very uneven, with most of the clover in the control of the first replication, resulting in no statistical significant differences among plots. Numerically, plots treated with 2 lb N/1000 ft^2 had 81% less clover than control plots. Areas receiving higher levels of CGM had even less clover. Dandelion infestation was reduced by 71% in plots treated for 4 years with the 2 lb N rate of CGM. Plots treated with higher

levels were almost completely clean of dandelions. The control plots showed an average infestation of 16% cover of clover and had 14 dandelion plants in the 25 ft^2 plots. The reduction in broadleaf weeds is likely due to a combination of the CGM inhibiting germination of these species and the competition of the grass in the treated plots with the weeds. Broadleaf infestation will be monitored in future years of the study.

Timing is important for proper weed control. If the material is applied after the weed has rooted, no control can be expected. The germinated weeds also will thrive on the N in the CGM. This, off course, is also true of synthetic preemergence herbicide fertilizer products if they are applied after the weed has germinated. If the material is applied too early, weed control is less effective. This is likely due to microbial degradation of the active component of the CGM. In our original study, corn meal that had been inoculated with the fungal organism and cultured in the laboratory for several weeks was not effective in reducing establishment of the creeping bentgrass. The length of time before weed germination that the material must be applied will depend on weather and soil conditions. Experience has shown that the material should be applied in the 3 to 5 weeks before weed germination. Under extremely wet conditions, weeds that are initially prevented from forming a root can grow out of the problem and control is reduced. It was also observed in early studies that if the material in allowed to sit on the surface for several weeks during dry conditions, effectiveness is limited

The ideal way to achieve control is to apply the material a few weeks before germination. Water it in if there is no rain. When the weeds have germinated, allow a short drying period for plants without a root to dye before irrigation is continued.

Like other natural substitutes for synthetic pesticides this material will require a greater level of knowledge by the consumer. They will have to know the life cycle of the weed species that is to be controlled and have a good level of understanding concerning the management of turf. Control at lower rates of CGM also requires persistence. Weeds are phased out over several seasons of application.

WEED SPECTRUM

A question that is often asked about CGM, relates to the spectrum of weeds that are affected by the material. To help answer this question, 22 plant species were screened for susceptibility to CGM. The ten dicotyledonous species used were: black medic *(Medicago lupulina L.),* black nightshade *(Solanum nigrum L.),* buckhorn plantain *(Plantago lanceolata L.),* catchweed bedstraw *(Galium aparine* L.), common lambsquarters *(Chenopodium album L.),* curly dock *(Rumex crispus* L.), dandelion *(Taraxacum officinale* Weber), purslane *(Portulaca oleracea* L.), redroot pigweed *(Amaranthus retroflexus* L.), and velvetleaf *(Abutilon theophrasti* Medic.). Twelve monocotyledonous species were screened: annual bluegrass *(Poe annua L.),* barnyardgrass *[Echinochloa crus-galli (L.)* Beauv.], creeping bentgrass *(Agrostis palustris* Huds.), giant

foxtail *(Setaria faberi* Herrm.), green foxtail *[Setaria viridis* (L.) Beauv.], large crabgrass *[Digitaria sanguinalis (L.*) Scop.], orchardgrass *(Dactylis glomerta* L.), quackgrass *[Agropyron repens* (L.) Beauv.], shattercane *(Sorghum bicolor L),* smooth crabgrass *[Digitaria ischaemum*

(Schreb.) Schreb. ex Muhl], woolly cupgrass *[Eriochloa villosa* (Thunb.) Kunth], and yellow foxtail *[Setaria lutescens* (Weigel) Hubb.].

Corn gluten meal reduced plant survival, shoot length, and root development of all tested species. Black nightshade, common lambsquarters, creeping bentgrass, curly dock, purslane, and redroot pigweed, were the most susceptible species. Plant survival and root development for these weeds were reduced by 75% and shoot length was decreased by > 50%. Catchweed bedstraw, dandelion, giant foxtail, and smooth crabgrass, exhibited survival and shoot length reductions > 50% and rooting reductions 80%. Barnyard grass, quackgrass, and velvetleaf were the least susceptible species showing survival reductions 30%.

SEARCHING FOR THE ACTIVE COMPONENT

Once the observation had been made that corn gluten meal could reduce weed infestation, the next logical question was why. What is the active component in the material that is responsible for the activity? The isolation and identification of an unknown chemical substance is a difficult process that requires a thorough knowledge of chemistry. It also takes a great deal of tenacity and patience. The graduate student chosen to take on the work was Dianna Liu. Dianna had completed a master of science degree in food science at Iowa State and had a good knowledge of food chemistry. She also had experience in Horticulture and had a good working knowledge of the plant sciences.

Dianna began her work in 1989. To isolate the unknown active ingredient, Dianna needed to use a machine called a high pressure liquid chromatograph (HPLC) that can separate chemicals by distinquishing among different chemical properties. The problem was that this requires a soluble material that can be injected into the machine. Corn gluten meal is very insoluble. (One of the reasons that it makes a good fish food is that it can be pelletized and placed in the water where it sinks to the bottom and species like caffish can feed on it.) The first step was to find a soluble form of corn gluten meal that she could inject into the HPLC Dianna tested the efficacy of 53 different extracts and components of the CGM, most of which were supplied by an Iowa grain company, to find one that showed a high degree of the root inhibiting activity observed with the CGM and a high solubility. After 12 months of work, a material called corn gluten hydrolysate was identified as the best candidate for future study. This material was found to have a much higher degree of activity on a weight basis than CGM and to be soluble enough for injection into the HPLC.

The next phase of the work was very time consuming As the HPLC separates out the components of the mixture that is injected into it, a peak is registered by a detector. Each chemical, or mixture of chemicals, associated with each peak had to be tested on germinating grasses to determine if they contained the root inhibiting activity. As the work continued, smaller and smaller amounts of material were available for testing and new techniques had to be developed to observe the activity on plant roots.

Finally, after 2 additional years of work, 5 distinct peaks were identified as individual compounds with a high degree of activity. But their structure was still unknown.

The five compounds were identified by the Iowa State University protein laboratory as five individual dipeptides (combinations of two amino adds). They included glutarninyl-glutamine, glycinyl-alanine, alaninyl-glutamine, alaninyl-asparagine, and alaninyl-alanine. The process wasn't finished, however. The final step was to obtain synthetically produced samples of these compounds and test them to determine if they had the same root inhibiting activity as that observed with the naturally occurring dipetides. This work was completed in 1993 and it was shown that the activity was the same. The idea of using these naturally occurring dipeptides as substitutes for synthetic preemergence herbicides was submitted to the US Patent office in 1993 and the patent was issued on March 1,1994 as Patent # 5,290,757 titled Preemergence Weed Control Using Dipeptides From Corn Gluten Hydrolysate.

The idea also developed of using the CGM hydrolysate as a natural herbicide. This material has the advantage of being sprayable, whereas CGM must be applied in

the granular form. In laboratory tests, it appears to have a higher degree of activity on a weight basis than CGhI and it is 14% N by weight. (Corn gluten hydrolysate is presently being developed as a protein source for human consumption by another Iowa company, indicating its potential as an environmentally safe material.) Work on other hydrolyzed grain materials was also performed. In 1993, a patent application titled Preemergence Weed Control Using Plant Protein Hydrolysate that included a description of corn, soybean, and wheat gluten hydrolysates was submitted to the patent office. The patent was also issued on March 1, 1994 under the patent # 5,290,749. Foreign patent filings were also made in 1995 on the hydrolysate and dipeptide patents to cover the use of the materials in Canada, Europe, and parts of Asia.

Field work to assess the feasibility of using the hydrolysates and dipeptides as preemergence herbicides is just beginning in 1995 and there are still a lot of unanswered questions. It is unlikely that products based on this technology will reach the market for a few years.

The type of research described in this paper is a newly developing area of technology. There are likely many other naturally-occurring, plant-derived chemicals that have the potential for use as substitutes for synthetic pesticides. What has increased interest in this type of work in recent years has been the concern of the public over synthetic pesticides. Improvements in the methodology by which natural materials are isolated and identified have also made this work possible. The impact that these new technologies will have on pest management is yet to be determined, but the future looks very promising.