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Chapter 35 The Use of Corn Gluten Meal As A Natural Preemergence Weed Control in Turf

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ABSTRACT

In a study involving the use of food-grade corn meal as a growth media for microorganisms, it was observed that stand establishment of creeping bentgrass seedlings was reduced by the incorporation of corn meal into the soil. Studies on the effect of adding corn starch, corn gluten meal, corn germ, corn seed fiber, or corn meal to the soil surface before seeding creeping bentgrass (*Agrostis palustris* Huds.) demonstrated that the greatest concentration of the inhibitory substance responsible for stand reduction was in the corn gluten meal. Further studies have shown that corn gluten meal contains a substance that inhibits root formation in several species, including crabgrass (*Digitaria spp*.). Gluten meal is the protein fraction of the corn extracted in the wet-milling process and is used as an animal feed. It contains approximately 10% nitrogen (N) by weight and makes a good natural fertilizer for turf. In field studies on the effect of corn gluten meal on crabgrass control, larger amounts were required when the material was applied 4 weeks before crabgrass germination than when it was applied 1 week before germination. Corn gluten meal applied at 99, 198, 297, 396, 495, and 594 g m^{-2} reduced crabgrass infestation by 50, 65, 80, 95, and 93%, respectively when applied 1 week before application.

INTRODUCTION

The last few years have brought increased public interest in environmental issues concerning the use of pesticides. This has been particularly true in the turf industry in which the general public may be involved in the applications of pesticides to their own lawns or may see the application of these materials on golf courses or by lawn care companies. With this concern has come an increased interest in natural products that are perceived by the public as being safer than traditional synthetic pesticides.

In 1986, a research project involving food-grade corn meal as a growth medium for a microorganism produced some observations that led to the patenting of a natural organic product for the preemergence control of annual weeds. The objective of this work was to establish a *Pythium* fungi in the soil of a new golf course green that had been constructed at the Iowa State University turfgrass research area. The effects of this pathogen were then to be observed on creeping bentgrass (*Agrostis palustris* Huds.)

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that was to be seeded on the infested soil.

Pythium was cultured in the laboratory for several weeks on corn meal and then taken to the field area where it was placed on the surface and tilled into a 7.5 to 10 cm depth of the soil. In addition to the inoculated corn meal plots, plots of the same size were treated with fresh corn meal that had not been treated with *Pythium.* The same total amount of corn meal was used in each treatment. A third 'control' plot to which no corn meal was applied also was included. Three cultivars of creeping bentgrass were then seeded in strips over the top of the plots.

The attempt to establish *Pythium* in the treated plots was a failure and normal germination of creeping bentgrass occurred in those areas. Normal germination also was observed in the control plots. But establishment was greatly reduced in the plots that had received the fresh corn meal. The reason for the inhibition was uncertain. One possible explanation was that there was some type of organic compound contained in the fresh corn meal that was destroyed by the activity of the fungal organism. To test this, a series of studies were conducted, the objectives of which were to determine if some component of corn meal was capable of reducing seeding establishment of plant species.

MATERIALS AND METHODS

STUDY I. A greenhouse trial was conducted to compare the effects of corn meal, corn starch, corn gluten meal, corn germ, and corn seed fiber on the germination of creeping bentgrass. The soil used in the study was a Nicollet (fine-loamy mixed mesic Aquic Hapludoll) that contained 23 g kg^{-1} organic matter, 26 kg P ha^{-1}, and 105 kg K ha^{-1} and had a Ph of 7.1. Based on Iowa State University soil test interpretation, this is sufficient P and moderate to low K. The soil was placed in 785-cm^3 pots, with a 103-cm^2 surface area. Each pot was seeded with 0.1 g of creeping bentgrass seed. The five corn fractions were applied at 0, 680, 1,360, and 2,720 g m^{-2} to the soil surface. The study was conducted as a randomized complete block with a factorial arrangement of corn fractions and levels of application. Each treatment was replicated four times. The pots were placed on a mist bench and maintained in a moist condition for 14 days until germination was complete. The pots were then moved to a greenhouse bench and maintained for 28 days. During the 28-day period, the surface of the pots was allowed to dry and all pots were then irrigated uniformly with 100 ml distilled water per pot. Data were collected on the number of live plants following recovery from the single application of water. An analysis of variance was performed on the data.

STUDY II. The second greenhouse study was designed to evaluate a larger number of treatment levels and to compare the effect of corn gluten meal with the effect of a commercially available, natural-organic turf fertilizer, Milorganite®, a 6-2-0 material produced by the Milwaukee Metropolitan Sewerage Dist., Milwaukee, WI. The target species in study II was large crabgrass *(Digitaria sanguinalis* L. Scop.), which was seeded on the surface of the pots at 0.3 g per pot. The corn gluten meal or Milorganite® was applied to the surface of the pots at levels 0, 194, 388, 582, 776, 970, and 1,164 g m^{-2}, in three replications. The soil, pots, statistical design, and protocol used in study I were used in the second study. Data were collected on the number of live plants at termination of the investigation and analysis of variance was performed on the data.

STUDY III. Study III was a field study to compare corn gluten meal as a nitrogen (N) source for turf with urea and two commercially available, natural organic fertilizer materials from Ringer Corporation of Minneapolis, MN: Turf Restore® and Greens Restore®. Corn gluten meal contains 10% N and negligible amounts of phosphorus and potassium. Turf Restore® has a 10-2-6 analysis and the Greens Restore® has a 6-1-3 analysis. The materials were applied to 4.7-m^{-2} plots of Glade Kentucky bluegrass *(Poa pratensis* L.) in 1988 at N application levels ranging from 24.5 to 98 kg ha^{-1} (Table 3). The study was conducted as a randomized complete block with 3 replications. Quality ratings, evaluating color, density, and uniformity were made weekly on a scale of 9 to 1; 9 = best quality, 6 = acceptable, and 1 = poorest quality. Data from the second year of the study are presented (Table 3).

STUDY IV. In study IV, corn gluten meal was taken to the field to test its efficacy on crabgrass establishment in Kentucky bluegrass turf. Field studies were conducted at the Iowa State University Horticulture research station in 1988 and 1991. The study area has a Nicollet soil of the same type used in the greenhouse studies. In 1988, corn gluten meal was surface applied to 2.3 m^{-2} plots at 0, 198, 396, 594, 792, or 990 g m^{-2} approximately 4 wk before crabgrass germination in the spring. In 1991, corn gluten meal was surface applied to 2.3 m^{-2} at 0, 99, 198, 297, 396, 495, or 594 g m^{-2}, approximately 1 wk before crabgrass germination. Both studies were conducted as randomized complete blocks with three replications. Data were collected on the reduction of crabgrass infestation in both studies and analyses of variance were performed on the data.

RESULTS AND DISCUSSION

STUDY I. The corn starch, corn germ, corn seed fiber, and the corn meal slightly

Table 1. Effects of five corn components on the establishment of creeping bentgrass seedlings

	Component				
Level	Corn starch	Corn gluten meal	Corn germ	Corn seed fiber	Corn meal
-g m^{-2}-	---------------------	plant number dm^{-2}	-------------------		
0	195	211	176	150	181
680	142	30	145	148	178
1,360	110	0	140	161	148
2,720	131	0	123	167	115

ANOVA

Source	d.f.	M.S.	Pr > F
Rep	3	2,633	0.0794
Component	4	28,078	0.0001
Level	3	25,480	0.0001
Component * Level	12	7,557	0.0001
Error	57	1,108	

LSD 0.05 for the comparison of all means = 47

reduced the establishment of the creeping bentgrass at the greatest levels of application (Table 1), likely due to a mulching effect. But, the inhibitory effect observed in the original field study was clearly present in the pots treated with corn gluten meal in which creeping bentgrass establishment was reduced 86% at the 680 g m^{-2} level and completely stopped establishment at the higher levels. Observations during the study revealed that the corn gluten meal had a growth-regulating effect on the root system of bentgrass. As the level of application increased, root inhibition increased. Shoot development was observed to be normal at all levels of corn gluten meal application. At lethal doses, no root system developed and plants died when drying of the soil occurred.

STUDY II. In study II, corn gluten meal reduced crabgrass establishment by 63, 77, and 95% at the 194, 388, and 582 g m^{-2} levels, respectively (Table 2). It completely stopped crabgrass establishment at greater concentrations. The same growth regulating effect observed on the creeping bentgrass also was observed on the crabgrass. Milorganite® also reduced crabgrass establishment, but no inhibitory effect was observed on rooting with this material and the reduction was likely due to a mulching effect.

Table 2. Comparison of the effects of treated sewage sludge (Milorganite®) and corn gluten meal on the establishment of crabgrass seedlings.

Level	Material	
	Corn gluten meal	Milorganite.
--g m^{-2}--	-------plant number dm^{-2}---	
0	94	101
194	35	93
388	22	77
582	5	55
776	0	41
970	0	21
1,164	0	13

ANOVA

Source	d.£	M.S.	Pr > F
Rep	2	13	0.7999
Material	1	13,752	0.0001
Level	6	6,882	0.0001
Material * Level	6	728	0.0001
Error	24	59	0.0001

LSD 0.05 for the comparison of all means = 13

STUDY III. Quality-ratings made on 'Glade' Kentucky bluegrass plots treated with corn gluten meal, urea, Turf Restore®, or Greens Restore® during a 13-wk period demonstrated that corn gluten meal can serve as a reliable source of N for turf (Table 3). It was slower to release N than urea at equivalent application levels, but maintained a better quality rating in the 11th and 12th wk of the study. Its N release was very similar to the other two natural organic materials. Several other trials comparing corn gluten meal with other fertilizer materials under the coded name 'ISU Exp.' can be found in the Iowa Turfgrass Research Report (Agnew and Kassmeyer, 1991 a and b).

Table 3 Visual quality' r atings comp aring corn gluten meal to urea and 2 natural organic fertilizers

Treatment	R ate	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	Mean
	-kg N ha^{-1}-	---------------------Quality rating———————													
Urea	245	7	6	6	6	6	7	7	7	7	6	8	8	8	7
Urea	49 0	8	8	7	6	7	8	8	8	8	8	8	8	9	8
Turf Rest	72.0	7	6	7	7	8	9	8	8	9	9	8	9	9	8
Turf Rest	980	8	6	7	8	9	9	9	9	9	9	9	9	9	8
Greens Restore	40 0	7	6	6	7	7	8	7	8	7	7	8	9	9	8
Corn Glut. Meal	49 0	7	6	6	7	8	8	8	8	7	8	9	9	9	8
Corn Glut. Meal	98 0	7	8	8	8	9	9	9	9	9	9	8	9	9	9
LSD 005		7	6	7	6	7	5	7	10	9	8	8	7	4	2

' Quality based on a scale from 1 to 9; 9 • best quality, 6 + acceptable quality, 1 = dead turf

STUDY IV. Crabgrass establishment was reduced by 50, 65, 80, 95, and 92% at the 198, 396, 594, 792, and 990 g m^{-2}, respectively in the 1988 field trial. The crabgrass reduction in 1991 was 58, 86, 97, 88, 79, and 97% at the 99, 198, 297, 396, 495, and 594 g m^{-2} levels, respectively (Table 4). The improvement in control in 1991 was likely due to timing of application. The 1988 treatments were applied 4 wk before crabgrass germination, whereas the 1991 treatments were applied approximately 1 wk before germination. In the original study, corn meal was observed to lose its inhibitory effect on germination when it was used as a medium for microbial growth. Microbial activity reducing the effectiveness of the inhibitory substance is the likely reason for the somewhat more limited crabgrass reduction in 1988.

Excessively wet conditions in the 1990 season, during which plots were under water for 2 wk after application, resulted in a lack of crabgrass control in that year (data not shown). It also was observed in 1989 that corn gluten meal applied too late is ineffective in controlling crabgrass, as is the case with synthetic preemergence herbicides.

The inhibitory effects of corn stover on both shoot and root elongation of germinating plants have been recognized for several years (Bonner, 1950; Nielsen et al., 1960), but inhibitory effects have not been previously reported from the grain. These inhibitory residues from the stover can be very persistent, with soil persistence of up to 22 wk reported (Guenzi et al., 1967).

Laboratory and field studies with corn gluten meal indicate that this material has the potential of being used as a natural 'weed and feed' product to inhibit the establishment of germinating weeds in mature turf stands. There is an inhibitory substance in this corn byproduct that acts as a growth regulator to prevent root formation of germinating plants. When drying occurs, the plant dies. A drying period is required for weed control. If the treated area remains excessively wet

Table 4 Crabgrass reduction in Kentucky bluegrass turf treated with corn gluten meal in field trials.

1988		1991	
Level -g m^{-2}-	Control -%-	Level -g m^{-2}-	Control -%-
0	0	0	0
198	50	99	58
396	65	198	86
594	80	297	97
792	95	396	87
990	92	495	79
		594	97
LSD 0.05	22	LSD 0.05	26

during the germination period, control is reduced. For plants with fully developed root systems, the material acts as a natural, organic N source with N release characteristics similar to other commercially available organic N sources. For the material to be used as a weed control, timing will be important. If the material is applied too early or too late, weed control is reduced. Further work is presently under way to determine the best time of application.

Although nearly complete control of crabgrass in Kentucky bluegrass turf is possible with corn gluten meal, the application levels required are excessive. A level of 99 g m^{-2} (2 Ibs. N 1000 ft^{-2}), which can provide 58% reduction in crabgrass establishment, would be practical in the spring application and is the suggested application level for crabgrass control with this material. In July 1991, U.S. patent #5,030,268 was issued on the use of corn gluten meal as a preemergence herbicide when the material is applied to the soil surface (Christians, 1991). Marketing agreements are under negotiation in the spring of 1993.

Other studies not included in this paper have shown that corn gluten meal is an effective inhibitor of a wide variety of monocotyledonous and dicotyledonous plants. Further tests are being conducted to determine the weed spectrum and to investigate the use of this material in other cropping systems.

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