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Evaluating the Influence of Liquid Organic Polymer on Soil Aggregation and Growth of Perennial Ryegrass

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ABSTRACT. Soil aggregate is a vigorous procedure including soil physical, chemical, and biological processes. Pore space created by binding these particles together improves retention and exchange of air and water. Various researches have reported that the benefits of organic polymers that may increase aggregate stability. The purpose of the study was to determine if a liquid organic polymer mixture has any influence on perennial ryegrass quality or soil aggregation. Turf2Max® was applied to two soils as a source of liquid organic polymer. Fine-loamy soil from local Iowa topsoil with 4.0% organic matter was screened and dried. Commercial baseball infield clay, QuickDry®, was used as the second soil. There were three rates of liquid organic polymer (0, 2, and 4%). there was no visual improvement in turfgrass color, quality, or growth by using organic polymer. It is possible that aggregate stability increases with use of organic polymer. The aggregate stability study needs to be repeated in the greenhouse and then substantiated under field conditions for these preliminary observations.

Key words: Organic polymer, Perennial ryegrass, Soil aggregates

Introduction

A soil aggregate is defined as many soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism (Brady and Weil, 2002). Soil aggregate is a vigorous procedure including soil physical, chemical, and biological processes (Juma, 1993; Monreal et al., 1995). Pore space created by binding these particles together improves retention and exchange of air and water. Stability of soil aggregate refers to the ability of soil aggregates to resist disruption when outside forces are applied. A number of researches have reported the research results of soil aggregates including microbial activities, macroaggregates, and soil erodibility. Six et al. (2000) observed that soil aggregate protect the mineralization of organic carbon (C) and total nitrogen (N) in soil by reducing microbial activities to the substrates that bind them. Soil aggregate has been categorized into two groups by particle sizes. Macroaggregates (>0.25 mm) is produced around particles of undecomposed soil organic matter and microaggregates (<0.25 mm) due to the effects of binding agents, such as polysaccharides and fungal hyphae (Tisdall and Oades, 1982; Beare et al., 1994). Macroaggregates had higher C and N concentrations than microaggregates because macroaggregates are composed of microaggregates and organic binding agents (Elliott, 1986). Macroaggregates would be used as a predictor of potential C responses to tillage because of their importance for protecting recently deposited light fraction of organic matter (Jastrow et al., 1996). Soil loss caused by erosion result in major agricultural and environmental problems like loss of fertility and increased sedimentation (Cruse et al., 2000). Annual soil loss resulted from erosion in the United States has estimated at $6 billion (Clerk et al., 1985). Aggregate stability is generally considered to be the most significant soil physical property that influences soil erodibility. Barthès and Roose (2002) reported that topsoil aggregate stability is negatively related to soil vulnerability to runoff and soil loss. Drury et al. (1991) reported that soil erosion can be controlled by increased soil organic matter and aggregates in the southeastern USA.

Products that increase soil aggregation would benefit turfgrass growth on compacted soils with poor soil aeration. Organic polymer products are often produced from petroleum. Cruse et al. (2000) tried soybean protein as a source of organic polymer to evaluate water drop impact angle on soil detachment. Various researches have reported that the benefits of organic polymers. Lentz and Sojka (1994) concluded that soil organic matter stabilizes soil against erosion. Cruse and Larson (1977) reported that long chain organic polymers increase soil shear strength and reduce soil detachment. However, relatively little is known about the effect of soil properties for turfgrass growth. The purpose of the study was to determine if a liquid organic polymer mixture has any influence on perennial ryegrass quality or soil aggregation.

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Materials and Methods

The study was conducted from December 22, 2003 to March 16, 2004 (76 day growing period) in the research greenhouse at the Iowa State University Horticulture Department, Ames, IA. Turf2Max® was applied to two soils as a source of liquid organic polymer. Fine-loamy soil from local Iowa topsoil with 4.0 % organic matter was screened and dried. Commercial baseball infield clay, QuickDry®, was used as the second soil. Material for both soils was processed through a hammer mill and soil that passed a 149 micron sieve was used in the green house study. Soil was placed in 7 by 7 cm plastic pots and treated with organic polymer solution. The Iowa-Soil required 100 g of soil treated with 89 ml of organic polymer solution and clay soil required 70 g of porous clay material treated with 76.5 ml of organic polymer solution to fill each pot. Pots were seeded with 'Catalina' Perennial ryegrass (*Lolium perenne* L.) at 34 g m^{-2} on December 22, 2003. Fertilizer was applied 30 days after planting to supply 5 g m^{-2} of N, P, and K. Three cm of water per week was applied to promote growth during the study.

Turfgrass color, quality, and density were visually estimated according to National Turfgrass Evaluation Program guidelines. Turfgrass color was evaluated on a visual scale of 1-9 where, 1= completely straw brown, 6 = lowest acceptable color, and 9 = dark green. Turfgrass quality was rated on a scale of 1-9 where, 1 = poorest, 6 = lowest acceptable quality, and 9 = best. Plant height was measured 46 days after treatment (DAT). Beginning 46 DAT, turfgrass was mowed weekly at 5 cm and clippings were collected. On 16 Mar 2004, at the end of the study period, turfgrass was clipped at the soil level and combined with the weekly mowing samples to produce a total clipping dry weight for the 76 day growing period. The collected clippings were oven-dried at 67°C for 24 h and weighed. At the end of the study, root dry weight was determined by washing and oven-drying samples at 67°C for 24 h. Because it was impossible to completely separate the roots from the soil, oven dried roots were ashed at 490°C for 8 h in a muffle furnace and then weighed to determine total organic matter. Aggregate stability was measure according to a modified method by Cambardella and Elliott (1993).

The experimental design was a randomized complete block with three replications and 6 treatments (Table 1). There were three rates of liquid organic polymer (0, 2, and 4%), two soil sources (fine-loamy and clay soil) for a total of 6 treatments. The data were analyzed using PROC ANOVA of the SAS software, Version 8 of the SAS System for Windows (SAS Institute, 1999). Means were separated (α = 0.05) by Fischer's protected LSD.

Table 1. Treatments showing three rates of organic polymer and two soil types.

Treatment number	Treatment list
1	Soil A[z] and 0% organic polymer
2	Soil A and 2% organic polymer
3	Soil A and 4% organic polymer
4	Soil B[y] and 0% organic polymer
5	Soil B and 2% organic polymer
6	Soil B and 4% organic polymer

[z] Soil A: fine loamy soil
[y] Soil B: silica clay soil

Results and Discussion

The aggregate particle size distribution and the aggregate mean weight diameter (MWD) are presented in Table 2. Mean weight diameter of soil aggregates is an indication of the stable fraction of the aggregates in the soil system. A higher mean weight diameter value indicates more stable aggregates. Treatment effects were significant for mean weight diameter. The soil A had more stable aggregates than

Table 2. Mean aggregate size distribution and mean weight diameter treated by organic polymer.

Treatment	Particle size distribution of aggregate						
	2 mm	250 μm	90 μm	53 μm	< 53 μm	Macro aggregate	MWD[z]
Soil A[y] and 0% OP[x]	24.2 b[w]	5.9	42.4	10.0 b	14.9 cd	30.1 b	0.62 b
Soil A and 2% OP	48.0 a	8.7	27.0	5.6 b	8.5 d	56.8 a	1.09 a
Soil A and 4% OP	38.1 b	12.0	29.9	7.3 b	10.9 d	45.3 ab	0.95 a
Soil B[v] and 0% OP	2.4 c	9.1	39.3	19.5 a	27.2 ab	11.6 c	0.17 c
Soil B and 2% OP	1.6 c	6.7	39.7	17.8 a	31.5 a	8.4 c	0.14 c
Soil B and 4% OP	1.3 c	9.7	42.5	24.4 a	21.3 bc	11.1 c	0.16 c

[z] MWD indicates mean weight diameter.
[y] Soil A: fine loamy soil
[x] OP indicates organic polymer.
[w] Means in a column followed by the same letter are not significantly different according to Fisher's LSD (P=0.05).
[v] Soil B: silica clay soil

Table 3. Mean turfgrass color, quality, height, clipping dry weight, and root dry weight.

Treatment	Turfgrass color		Turfgrass quality		Turfgrass height (mm)	Clipping dry weight (mg)	Root dry weight (mg)
	46 DAT[z]	76 DAT	46 DAT	76 DAT	46 DAT	76 DAT	76 DAT
Soil A[y] and 0% OP[x]	7	8	7	8	90 a[w]	722 b	485 b
Soil A and 2% OP	7	8	7	8	77 a	718 b	486 b
Soil A and 4% OP	7	8	7	8	90 a	817 ab	593 b
Soil B[v] and 0% OP	6	8	6	8	57 b	853 a	1006 a
Soil B and 2% OP	6	8	6	8	57 b	808 ab	910 a
Soil B and 4% OP	6	8	6	8	57 b	831 a	1163 a

[z] DAT indicates day after treatment.
[y] Soil A: fine loamy soil
[x] OP indicates organic polymer.
[w] Means in a column followed by the same letter are not significantly different according to Fisher's LSD (P=0.05).
[v] Soil B: silica clay soil

soil B. The effect of organic polymer for soil aggregates was found among treatments on soil A. However, no significant effect was found between two rates of organic polymer. Among the rates of organic polymer in soil B, increasing organic polymer rate from 0 % to 4 % did not influence aggregate MWD. Soil A had produced more macroaggregates and bigger particle size than soil B. There were no visible differences in turfgrass establishment or growth during the 76 day study period. Turfgrass color and quality was not significantly different from the organic polymer treated on turfgrass during the 76 day study (Table 3). Although no significant differences for clipping dry weight were found among three rates of organic polymer on soil A and soil B respectively, soil A had greater turfgrass height than soil B. Soil B had more clipping dry weight than soil A except soil A with 4 % organic polymer and soil B with 2 % organic polymer. There were no significant differences for root dry weight among the rates of organic polymer in soil A and soil B, respectively. Soil B had more clipping dry weight than soil A.

Aggregate stability provides various benefits to soil physical properties which may influence plant growth. Soil A, a loamy soil, produced more soil aggregates by organic polymer than soil B which is clay soil based on the results of the study. However, soil A which had greater NWD had less clipping dry weight and root dry weight than soil B. Our preliminary observations indicated that under the conditions of a 76 day greenhouse study, there was no visual improvement in turfgrass color, quality, or growth by using organic polymer. It is possible that aggregate stability increases with use of organic polymer. The aggregate stability study needs to be repeated in the greenhouse and then substantiated under field conditions for these preliminary observations.

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유기중합물이 토양의 입단화와 페레니얼 라이그래스의 성장에 미치는 영향

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요 약: 토양입단화는 토양의 물리적, 화학적, 그리고 생물학적인 변화를 일으키는 활발한 과정이다. 토양입단화를 통해서 생성된 토양공극은 토양에서 공기와 물의 순환을 증가시키는 역할을 하게 된다. 유기중합물이 토양입단 안정화에 대한 긍적적인 역할은 많은 연구결과에서 보고가 된 바 있다. 본 실험의 목적은 유기중합물이 토양입단화와 페레니얼 라이그래스의 성장에 미치는 영향에 대해서 알아보기 위해서 수행 되었다. 유기중합물의 세가지 농도가 적용이 되었으며 실험을 위해 두가지 토양이 사용이 되었다. 첫번째 토양으로 4.0 % 의 유기물이 함유된 양토가 건조된 후 사용이 되었으며 두번째 토양으로 점토가 사용이 되었다. 유기중합물 처리에 따른 페레니얼 라이그래스의 색, 품질, 성장에 미치는 영향은 나타나지 않았다. 그러나 유기중합물이 토양입단화에는 토양의 종류에 따라 영향이 있는 것으로 나타났다. 본 실험의 결과의 구체적인 실증을 위해서 필드 실험이 필요한 것으로 판단이 된다.

주요어: 유기중합물, 페레니얼 라이그래스, 토양입단화