PROGRESS REPORT ON CULTIVATION AND GYPSUM STUDIES

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The problem of compaction is basic to any turf area subjected to traffic from people, animals and maintenance equipment. Numerous solutions for the compaction problem have been proposed. Perhaps the most widely followed practice has been some type of cultivation (i.e. coring, spiking, slicing, etc.). Physical and chemical amendments have been used to ameliorate compaction. In addition, traffic control and the use of flotation tires have reduced compaction to some degree. The research reported here involves two bentgrass cultivation studies and an evaluation of gypsum ($CaSO_4$) as a chemical soil conditioner on fine textured soils.

Bentgrass Cultivation Studies

Two experiments were initiated during the summer of 1977. The first study was designed to examine the influence of soil moisture content, artificial compaction, frequency of application and size of tines of a Ryan aerifier on the soil macro and micro structure and the overall turf quality of Penncross creeping bentgrass at the Soils Farm, Michigan State University. Treatments were initiated in early July and only preliminary data was collected and will not be presented at this time.

The second study compared the Ryan, Dedoes and Hahn aerifiers with and without topdressing and the Maple Lane and Power Spiker under artificially compacted conditions. An outline of the experiment is found in Table 1. The experimental site was a 14 year old Toronto bentgrass green with a considerable thatch-mat layer. The coring treatments were applied July 20 and repeated during the October 4 thru 18 period and were topdressed shortly after each treatment. The topdressing material was composed of a mix of sand-soil-peat and was applied at the rate of 1/4" or 0.77 cu.yd./1000 sq. ft. Spiking was initiated on July 20 and continued at weekly intervals to October 31. Compaction started on July 28 and was applied 2 to 3 times a week depending on weather conditions. The plots were 5' by 6' in size.

Visual quality ratings, taken in August, October and November are shown in Table 2. Several general trends are apparent. First, that topdressing of the cored and untreated plots resulted in an overall better quality turf. This positive effect of topdressing may be due in part to a nitrogen response from the topdressing material. Second, the turf quality in October and November was slightly better on the compacted half of each plot. On all cultivated plots, slight to severe damage occurred on the uncompacted sections compared to the compacted side. The damage was in the form of scalping of the turf as a result of an uneven cutting surface left after cultivation. The Dedoes, Hahn and the Ryan 1/4", 3/8" and 1/2" treatments gave similar results under compacted conditions. The Maple Lane Spiker gave a slightly superior turf than the Power Spiker; however, both caused turf damage to some degree.

One root sample per plot was taken in late September, washed free of all soil and debris and oven dried at 55°C (Table 3). Generally, compaction as expected slightly reduced root growth. In almost all cases, plots cored and topdressed had less roots than plots that were cored only. This probably occurred since the coring holes were filled with the topdressing material decreasing the space for rooting which negated the beneficial aeration effects of coring. However, the

plot with topdressing had greater root growth than the untreated check. Under compacted conditions, the Maple Lane Spiker and the Ryan 5/8" untopdressed treatments limited root growth to a degree. Since statistical analyses of the data has not been performed at this time further comments will not be made.

Research will be conducted within the next year at the two field sites, which will give us further insight into this area.

Evaluation of Gypsum for use as a Soil Conditioner on Fine-Textured Michigan Soils

Gypsum has been used to a limited extent on turfgrass as a source of both calcium and sulfur where pH alteration is not required. The primary use of gypsum in agriculture is for the reclamation of high sodium soils. It has also been proposed that gypsum can be used to improve the structure of fine-textured soils, especially those soils containing a low level of calcium.

The purpose of this research report was to examine:

(1) the effects of gypsum applied to the surface or incorporated into a poorly structured fine textured soil (typical of many fine-textured Michigan soils) on initial sod root growth and top growth of Merion Kentucky bluegrass; and

(2) the effects of gypsum on overall turfgrass quality and soil physical properties of field test plots.

Gypsum-Wetting Agent Greenhouse Study - Winter 1977

The experiment was arranged in a randomized complete block design containing 4 replicates of the following 16 treatments: gypsum applied at the rate of 1, 4, 8 and 16 ton/A to the surface or incorporated into the soil; two wetting agents, Hydro-Wet and Aqua-Gro applied at the rates of 16 and 32 oz/1000 sq ft and dry Aqua-Gro on a vermiculite base at the rate of 640 oz/1000 sq ft mixed into the soil; and 3 check treatments which include a check for the mixing operation, 640 oz/1000 sq ft of vermiculite mixed into the soil and a untouched check.

Treatments involving soil incorporation consisted of applying the material to the dry soil and mixing in a small soil mixer. Plastic columns, 4" I.D. by 9" long were packed with 2100 grams of treated and untreated soil to a height of 8.25 inches resulting in a bulk density of 1.25g/cc. Surface gypsum treatment and liquid wetting agents were applied to the soil surface of the pack columns then sodded with Merion Kentucky bluegrass grown on organic soil. Four weeks following sodding the liquid wetting agent treatments were reapplied.

Clipping yields obtained throughout the study are shown in Tables 4 and 5. Neither gypsum nor the wetting agents had any appreciable effect on top growth for the first 16 days of the study. However, after 23 days of the experiment several isolated treatments were significantly different but consistent treatment trends were not evident. The remaining part of the study reveals no treatment differences. When all clippings were totaled, as seen in Table 6, the accumulated top growth was not influenced by any treatment.

Gypsum applied at various rates to the surface or incorporated into the soil did not improve root growth (Table 7). Dry Aqua-Gro increased root growth in the surface 2 inches of the soil as compared to the vermiculite check but was not significantly different from the mixed check. Total root growth, shown in Table 6, was unaffected by the various treatments.

Oxygen diffusion rates (ODR), used to measure soil aeration, are found in Table 8. At the 2" soil depth, the ODRs generally were above the range of 5-20$_g$

$O_2 \times 10^{-8}$ min^{-1} which has been shown to limit normal root growth of Kentucky bluegrass (1). Several isolated treatments were significantly different from each other, but in general no treatment trends occurred. At the 4" soil depth ODRs were slightly less than at the 2" depth and bordered on the upper limit of the range limiting root growth. Treatments had little affect on ODR at this depth.

Gypsum Field Studies

Four field experiments were initiated in 1976. In 1977 one-half of each plot was retreated at the same rate as in 1976. An outline of the studies are found in Table 9. The Dearborn Country Club, Bay County Golf Course and Oakland County Grounds were mature turfs so gypsum was surface applied. The Southgate site was under construction, so applications were incorporated into the top 4" of the soil prior to seeding. The plot sizes were 5' x 7' for the established sites and 9' x 15' at Southgate.

A description of the soils from the 4 field studies is as follows: The Dearborn Country Club 13th men's tee is a clay loam to clay subsoil; Oakland County Grounds soil is a clay loam subsoil; Bay County Golf Course is a loam to clay loam surface soil and the Southgate Golf Course is a clay loam surface soil with 35% silt.

Since initial applications were made in mid summer of 1976, only limited data was collected that fall. Table 10 contains quality ratings from Bay County Golf Course and Dearborn Country Club. Gypsum applied at the recommended rate of 1 to 2 ton/acre at either site did not improve turf quality within the short period following application. Higher gypsum rates showed similar results.

For 1977 quality ratings were taken just prior to the 1977 treatments and in late fall. The Dearborn Country Club site was only rated on 11/22/77 (Table 11) because of damage from an algicide leak and gypsum application did not improve or dramatically decrease the turf quality.

Quality rating at both Bay County Golf Course and Oakland County Grounds revealed a consistent decrease in quality with increasing application rates of gypsum (Table 12 and 13). Normally a quality rating of 1 to 3 is considered acceptable quality turf. Higher values indicate the turf quality is not as good. Ratings made at Bay County in October (Table 12) indicated that gypsum applied at rates 8 ton/A and higher resulted in somewhat poorer quality turf. In November, gypsum rates higher than 1 ton/A gave reduced quality.

The Oakland County Grounds plots are typical of many low or no maintenance areas such as roadsides and parks. Quality rating higher than approximately 6 on such sites would indicate poor turf quality from both aesthetic and soil stabilization standpoints. Quality ratings taken in November, 1977 (Table 13) indicated the following: (1) gypsum applied at rates of 8 tons/A or higher in 1976 resulted in poorer quality turf (2) when applied in both 1976 and 1977, gypsum at a rate as low as 1 ton/A gave poor quality turf and (3) in general the two application (1976-1977) plots were of lower quality than plots only treated once (1976). Gypsum did not influence % cover at this date. August quality ratings from both the Bay County and Oakland County sites showed no treatment responses.

Data was collected only in July, 1977 at the Southgate Golf Course. Table 14 contains turf quality ratings and plant density (% cover). In general the entire experimental site was of low quality due to a poor initial establishment of the previous fall seeding and weed infestation. No improvement of quality was observed as a result of gypsum or VAMA applications and turf density was also unaffected by the treatments.

The lower quality of turf observed on gypsum plots was a result of the development of a yellowing of the turf, not a decrease in density of plants. This

is believed to be caused by an induced magnesium (Mg) deficiency as a result of an imbalance between calcium (Ca) and Mg although foliar nutrient levels were not determined.

Soil samples were taken in November, 1977 from the Bay County, Dearborn and Oakland County sites. Soil test results from Bay County are shown in Table 15. Two trends were very apparent. First, increasing rates of gypsum caused a slight decrease in pH and potassium (K) and a marked decrease in the magnesium (Mg) content of the soil. Second, is that gypsum must be applied at a rate of 8 ton/A or larger to significantly increase the calcium (Ca) content on this soil. Phosphorus (P) levels were not affected by gypsum. The initial Ca levels were very high and Mg was high. The Oakland County soil tests revealed similar trends (Table 15) with the exception of K which did not change with the addition of gypsum.

The soil tests from Dearborn, shown in Table 15, are not consistent with the previous two studies. Except for one isolated case, pH, Mg and Ca were not influenced by gypsum. This is believed to be a result of the removal of gypsum from the turf surface by mowing. This tee is mowed at 3/8" cutting height with clippings being removed. Even though the site was watered following the treatments, a sizeable amount of gypsum was removed during the mowing operation. The initial Ca level at all 3 sites are very high.

Table 16 contains infiltration rates from the Bay County site, taken 11/18/77 and Dearborn Country Club from the fall of 1976. The initial gypsum treatments and the repeat applications did not significantly alter the infiltration rates.

Soil strength plays a major role in the ability of plant roots to grow and function normally in soils. Although specific values limiting turfgrass root growth are not known, values in the range of 150 to 225 psi have been shown to limit seedling emergence of corn, switchgrass and rye (4) which can serve as a basis for comparison.

Soil strength measurements were made by a depth monitoring penetrometer. Each plot received 10 probes to a depth of 4" and average values were obtained for comparison. Penetrometer readings from the Dearborn site were taken in the fall of 1976 and 1977. No observable differences were noted for the treatments in 1976 (Table 18). However, in 1977 (Table 18) several results were observed. First, at a 1" depth of measurement gypsum applied at the rate of 8 ton/A showed a lower penetrometer reading than the check, however, this was not seen at the lower sampling depths. Penetrometer values were lower at 2, 3 and 4 inch measurements with a 4 ton/A gypsum treatment. Repeated treatments did not affect the soil strength.

As seen from Table 19, gypsum at the rate of 8 ton/A or more caused an increase in soil strength at the 1, 2 and 3 inch depths at Bay County. The repeated treatments also resulted in higher penetrometer values in the surface 3 inches as compared to the one 1976 application.

Soil strength determination at Oakland County (Table 20) were not affected by any of the treatments.

Conclusions

Gypsum was found not to affect the turf quality when applied at the manufacturers recommended rate of 1 to 2 ton/A on established turf as seen from the 4 field experimental studies in Michigan. When the recommended rates of gypsum application was exceeded, poorer quality turf resulted. Therefore, one is cautioned not to exceed the manufacturers recommended rate of 1 to 2 ton/A on established turf. The soil structure was also not influenced to any great extent by gypsum as seen from infiltration rates and soil strength measurements. Initial

sod rooting was unaffected by gypsum. It should be pointed out that the exchangeable Ca level of the natural soils of the 4 field sites and in the greenhouse study was very high, which is true for most of the fine textured soils of lower Michigan (3). A soil test should be taken to confirm a low exchangeable Ca level before a gypsum application is deemed necessary.

Gypsum can also be used as a source of sulfur. A sulfur response on turfgrass has not been observed in Michigan (2) but has been reported in Washington and Florida.

LITERATURE CITED

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Table 1. An outline of creeping bentgrass Cultivation Study, M.S.U. Crops Farm - 1977.

Type of Cultivation	Cultivation unit	Tine Size	Time of Application	Topdressing (1/4")*
Coring	Ryan	1/4", 3/8" 1/2", 5/8"	Spring, fall	+, -
Coring	Dedoes	1/2"	Spring, fall	+, -
Coring	Hahn	1/2"	Spring, fall	+, -
Spiking	Power Spiker		Weekly	-
Spiking	Maple Lane Spiker		Weekly	-

* + refers to topdressed plots, - refers to plots that were not topdressed.

Table 2. Visual turfgrass quality ratings (1 = best) as influenced by coring, topdressing, spiking and compaction from creeping bentgrass Cultivation Study, M.S.U. Crops Farm.

Cultivation Treatment	Topdressing†	Date of rating					
		Aug. 31		Oct. 14		Nov. 21	
		compaction*					
		+	-	+	-	+	-
Check	-	1.5	1.7	1.8	2.2	2.0	2.5
Check	+	1.5	1.5	1.5	1.8	2.3	2.5
Ryan 1/4"	-	1.7	1.8	2.3	2.8	2.5	3.3
Ryan 1/4"	+	1.5	1.5	1.7	2.2	1.8	2.0
Ryan 3/8"	-	1.5	1.7	2.0	2.7	2.2	3.2
Ryan 3/8"	+	1.7	1.5	1.8	2.0	2.2	2.3
Ryan 1/2"	-	2.3	2.3	2.5	3.0	2.7	3.5
Ryan 1/2"	+	1.5	1.7	1.7	1.7	1.8	2.3
Ryan 5/8"	-	3.2	2.8	2.3	3.2	2.7	3.3
Ryan 5/8"	+	2.5	2.5	1.7	2.0	1.8	2.3
Dedoes 1/2"	-	1.7	1.8	2.0	2.0	2.3	2.7
Dedoes 1/2"	+	1.7	1.7	1.7	2.0	1.5	1.5
Hahn 1/2"	-	1.7	1.7	1.7	2.0	2.3	3.2
Hahn 1/2"	+	1.7	1.7	1.8	1.7	1.5	1.9
Power Spiker	-	2.7	3.8	2.3	3.0	2.5	3.3
Maple Lane Spiker	-	3.5	2.8	2.2	2.8	2.2	2.8

* + refers to compacted plots, - refers to uncompacted plots; †refers to 1/4" topdressing, spring and fall, - refers to no topdressing.

Table 3. Dry root weights as influenced by coring, topdressing, spiking and compaction from creeping bentgrass cultivation study at M.S.U. Crops Farm.

Cultivation Treatment	Topdressing*	Compaction + Soil depth (cm) 0-4	4-8	Total	Compaction - Soil depth (cm) 0-4	4/8	Total
		mg					
Check	-	190	100	290	293	136	429
Check	+	230	154	384	337	143	480
Ryan 1/2"	-	257	110	367	282	156	438
Ryan 1/4"	+	177	80	257	336	130	497
Ryan 3/8"	-	215	141	356	246	138	384
Ryan 3/8"	+	181	110	291	204	122	326
Ryan 1/2"	-	224	140	364	243	153	396
Ryan 1/2"	+	187	121	308	337	152	529
Ryan 5/8"	-	229	113	342	261	165	426
Ryan 5/8"	+	147	84	231	191	118	309
Dedoes 1/2"	-	253	135	388	166	80	246
Dedoes 1/2"	+	285	271	556	266	130	396
Hahn 1/2"	-	237	143	380	234	150	384
Hahn 1/2"	+	174	128	302	267	106	373
Power Spiker	-	250	155	405	262	153	415
Maple Lane Spiker	-	154	88	242	294	121	415

* + with 1/4" topdressing, spring and fall; - is no topdressing.

Table 4. Clipping yields taken 7 and 16 days after sodding from Gypsum - Wetting agent greenhouse study - Winter, 1977.

Material Applied	Rate of Application	Days after sodding: 7 — Application method: Surface	7 — Mixed	16 — Surface	16 — Mixed
		mg/column			
Check	-	209 *	229 *	164 *	204 *
Check, Verm	640 oz/M	-	235	-	176
Gypsum	1 ton/A	220	211	154	165
Gypsum	4 ton/A	203	209	110	152
Gypsum	8 ton/A	187	243	150	142
Gypsum	16 ton/A	197	200	147	155
Aqua-Gro(dry)	640 oz/M	-	196	-	118
Aqua-Gro	16 oz/M	197	-	154	-
Aqua-Gro	32 oz/M	225	-	133	-
Hydro-Wet	16 oz/M	258	-	207	-
Hydro-Wet	32 oz/M	215	-	145	-

* No statistical differences were observed among treatments on clipping yield taken 7 and 16 days following sodding.

Table 5. Clipping yields taken 23, 31 and 39 days after sodding from Gypsum - Wetting agent greenhouse study - Winter, 1977.

Material Applied	Rate of Application	Days After Sodding: 23 — Application Method: Surface	23 — Mixed	31 — Surface	31 — Mixed	39 — Surface	39 — Mixed
Check	-	162 abcd*	201 ab	247 a	280 a	298 a	327 a
Check, Verm	640 oz/M	-	185 abcd	-	198 a	-	258 a
Gypsum	1 ton/A	170 abcd	159 abcd	241 a	233 a	258 a	307 a
Gypsum	4 ton/A	153 abcd	194 abc	203 a	227 a	266 a	289 a
Gypsum	8 ton/A	115 d	175 abcd	182 a	219 a	247 a	293 a
Gypsum	16 ton/A	179 abcd	155 abcd	207 a	212 a	250 a	236 a
Aqua-Gro (Dry)	640 oz/M	-	171 abcd	-	199 a	-	253 a
Aqua-Gro	16 oz/M	127 bcd	-	224 a	-	252 a	-
Aqua-Gro	32 oz/M	164 abcd	-	208 a	-	262 a	-
Hydro-Wet	16 oz/M	217 a	-	281 a	-	312 a	-
Hydro-Wet	32 oz/M	152 abcd	-	202 a	-	273 a	-

* Values followed by the same letter do not differ significantly at the 5% level.

Table 6. Total accumulated clipping yield and total root growth from Gypsum - Wetting Agent Greenhouse Study* - Winter, 1977.

Material Applied	Rate of Application	Total clipping yield		Total root growth	
		Application Method			
		Surface	Mixed	Surface	Mixed
		mg/column			
Check	-	1093*	1244*	43*	58*
Check, Verm.	640 oz/M	-	1061	-	52
Gypsum	1 ton/A	1043	1072	44	55
Gypsum	4 ton/A	927	1058	51	82
Gypsum	8 ton/A	890	1072	72	66
Gypsum	16 ton/A	973	945	57	89
Aqua-Gro(Dry)	640 oz/M	-	947	-	89
Aqua-Gro	16 oz/M	943	-	44	-
Aqua-Gro	32 oz/M	995	-	49	-
Hydro-Wet	16 oz/M	1284	-	60	-
Hydro-Wet	32 oz/M	978	-	52	-

* No statistical differences were observed among treatments on total accumulated clipping yield or total root growth.

Table 7. Dry weight of roots in the surface 2 inches of soil, 2 to 4 inches and 4 to 8 inches from the Gypsum - Wetting agent greenhouse study - Winter, 1977.

Material Applied	Rate of Application	Soil Depth (Inch) 0 - 2 Application Method: Surface	0 - 2 Mixed	2 - 4 Surface	2 - 4 Mixed	4 - 8 Surface	4 - 8 Mixed
		mg/column					
Check	-	28.7 bc*	33.1 abc	9 a	19 a	7 a	9 a
Check, Verm.	640 oz/M	-	22.3 c	-	14 a	-	8 a
Gypsum	1 ton/A	24.5 c	28.5 bc	8 a	10 a	10 a	13 a
Gypsum	4 ton/A	28.3 bc	44.1 abc	15 a	17 a	8 a	25 a
Gypsum	8 ton/A	33.6abc	37.1 abc	13 a	21 a	14 a	11 a
Gypsum	16 ton/A	32.1 bc	58.5 ab	13 a	16 a	15 a	11 a
Aqua-Gro(dry)	640 oz/M	-	64.1 a	-	18 a	-	10 a
Aqua-Gro	16 oz/M	25.9 c	-	9 a	-	8 a	-
Aqua-Gro	32 oz/M	37.9abc	-	8 a	-	6 a	-
Hydro-Wet	16 oz/M	32.1 bc	-	14 a	-	18 a	-
Hydro-Wet	32 oz/M	36.3abc	-	10 a	-	7 a	-

* Values within the same soil depth followed by the same letter do not differ significantly at the 5% level.

Table 8. Oxygen diffusion rates (ODR) at 2 and 4 inch soil depths from Gypsum-Wetting agent greenhouse study - Winter, 1977.

Material Applied	Rate of Application	Soil Depth: 2 inch, Application Method: Surface	Soil Depth: 2 inch, Application Method: Mixed	Soil Depth: 4 inch, Application Method: Surface	Soil Depth: 4 inch, Application Method: Mixed
		g O_2 x 10^{-8} cm^{-2} min^{-1}			
Check	-	17.1* c	30.2 abc	10.9 a	23.1 a
Check, Verm.	640 oz/M	-	21.6 bc	-	18.9 a
Gypsum	1 ton/A	26.8 abc	29.8 abc	20.2 a	18.7 a
Gypsum	4 ton/A	22.6 bc	36.4 a	16.0 a	19.3 a
Gypsum	8 ton/A	20.7 bc	21.9 bc	17.0 a	17.8 a
Gypsum	16 ton/A	30.3 abc	27.9 abc	18.8 a	21.4 a
Aqua-Gro(Dry)	640 oz/M	-	30.7 abc	-	17.0 a
Aqua-Gro	16 oz/M	28.3 abc	-	17.3 a	-
Aqua-Gro	32 oz/M	26.2 abc	-	17.0 a	-
Hydro-Wet	16 oz/M	31.5 ab	-	18.4 a	-
Hydro-Wet	32 oz/M	27.7 abc	-	17.2 a	-

* Values within the same soil depth followed by the same letter do not differ significantly at 5% level.

Table 9. Outline of four gypsum field studies on fine textured soils initiated in the summer of 1976.

Site Location	Rate of Gypsum Applied	Application Method	Dates of Application
	---- Ton/A ----		
Dearborn C. C.	1,2,4,8,16	surface	07/07/76, 07/11/77
Bay County G. C.	1,2,4,8,16	surface	07/14/76, 08/01/77
Southgate Municipal G. C. *	1,2,4,8,16	incorporated	09/23/76, 08/01/77
Oakland County Grounds	1,2,4,8,16	surface	07/09/76, 08/01/77

* VAMA was also included (160 lbs/A).

Table 10. Turf Quality rates from Bay County Golf Course and Dearborn Country Club-Gypsum Study, Fall, 1976.

Material	Rate of Application	Dearborn C. C.	Bay County G.C.
		Turfgrass Qual. Rating (1=best; 9=poor)	
Check		2.7 *	3.6
Gypsum	1 ton/acre	2.7	4.0
Gypsum	2 ton/acre	2.7	4.0
Gypsum	4 ton/acre	2.2	4.0
Gypsum	8 ton/acre	2.2	3.5
Gypsum	16 ton/acre	2.2	4.0

* No significant differences were observed among treatments.

Table 11. Turfgrass quality ratings taken 11/22/77 from the Dearborn Country Club

Treatment	Rate	Application Date: 1976	Application Date: 1976, 1977
		Turfgrass Qual. Rating (1=best; 9=poor)	
Check	-	2.0 a*	2.0
Gypsum	1 ton/A	2.5	2.5
Gypsum	2 ton/A	2.0	2.0
Gypsum	4 ton/A	2.0	1.7
Gypsum	8 ton/A	2.7	2.8
Gypsum	16 ton/A	2.2	2.0

* No significant differences were observed among treatment means.

Table 12. Turfgrass quality ratings from the 18th fairway, Bay County Golf Course.

		Date of Rating: 8/01/77	10/14/77	11/18/77	
		Application Date: 1976	1976, 1977	1976	1976, 1977
Treatment	Rate				
		Turfgrass Quality Rating (1=best; 9=poor)			
Check	-	6.2 a*	1.0 a	2.8 a	2.8 a
Gypsum	1 ton/A	6.7 a	1.3 a	3.2 ab	3.5 b
Gypsum	2 ton/A	6.3 a	1.7 a	3.5 bc	3.8 bc
Gypsum	4 ton/A	6.3 a	2.5 b	4.2 de	4.3 c
Gypsum	8 ton/A	6.7 a	3.2 b	4.0 cd	4.5 c
Gypsum	16 ton/A	6.3 a	3.3 b	4.8 e	5.3 d

* Values within columns followed by the same letter do not differ significantly at the 5% level.

Table 13. Turfgrass quality rating and stand density (% cover) from Oakland County Grounds.

		DATE				
		8/1/77	11/22/77			
		Turfgrass Qual. Rating (1=best; 9=poor)			% Cover	
		Date	Date of Application			
Treatment	Rate	1976	1976	1976 1977	1976	1977
					------%--------	
Check	-	7.5 a	5.2 a	5.7 a	65 a	65 a
Gypsum	1 ton/A	7.3 a	5.5 a	6.2 ab	73 a	68 a
Gypsum	2 ton/A	7.5 a	5.7 ab	6.5 bc	60 a	68 a
Gypsum	4 ton/A	7.5 a	6.0 ab	6.7 bc	63 a	65 a
Gypsum	8 ton/A	7.3 a	6.5 bc	7.0 c	58 a	65 a
Gypsum	16 ton/A	7.2 a	7.0 c	7.8 d	65 a	68 a

* Values within columns followed by same letter do not differ significantly at 5% level.

Table 14. Turfgrass quality ratings and stand density (% cover) from number one fairway, Southgate Golf Course (7-11-77).

Treatment	Rate	Quality* Rating	% Cover
Check	-	5.0 a+	90 a
Gypsum	1 ton/A	6.5 a	67 a
Gypsum	2 ton/A	7.0 a	60 a
Gypsum	4 ton/A	7.2 a	67 a
Gypsum	8 ton/A	6.2 a	70 a
Gypsum	16 ton/A	7.0 a	57 a
VAMA	160 lb/A	7.0 a	67 a

* 1 = best, 10 = poor, + values within columns followed by same letter do not differ significantly at the 5% level.

Table 15. Soil test results from the Bay County Golf Course, Oakland County Grounds and Dearborn Country Club.

Treatment	Rate	pH	P	K	Ca	Mg
			lbs/A			
Bay County Golf Course, 18th Fairway						
Check	-	7.9 a*	73 a	384 a	6,489 c	493 a
Gypsum	1 ton/A	7.8 a	48 a	368 a	7,022 c	392 b
Gypsum	2 ton/A	7.9 a	72 a	368 a	6,844 c	369 b
Gypsum	4 ton/A	7.8 a	59 a	344 ab	7,333 c	241 c
Gypsum	8 ton/A	7.5 b	82 a	316 b	11,778 b	170 c
Gypsum	16 ton/A	7.6 b	92 a	308 b	17,315 a	167 c
Oakland County Grounds						
Check	-	7.9 a	8 a	231 a	6,489 bc	281 a
Gypsum	1 ton/A	7.9 a	7 a	226 a	6,311 c	249 ab
Gypsum	2 ton/A	7.8 a	3 a	239 a	6,489 bc	205 b
Gypsum	4 ton/A	7.8 ab	3 a	227 a	7,004 bc	198 bc
Gypsum	8 ton/A	7.6 bc	6 a	253 a	9,360 b	143 c
Gypsum	16 ton/A	7.5 c	3 a	231 a	15,672 a	146 c
Dearborn Country Club, 13th tee						
Check	-	7.8 *	6 a	345 a	8,000 a	645 a
Gypsum	1 ton/A	7.7 a	13 a	328 a	7,440 a	589 a
Gypsum	2 ton/A	7.7 a	22 a	340 a	7,840 a	560 a
Gypsum	4 ton/A	7.7 a	21 a	348 a	8,560 a	662 a
Gypsum	8 ton/A	7.6 a	25 a	320 a	10,640 a	573 a
Gypsum	16 ton/A	7.5 a	24 a	311 a	8,000 a	510 a

* Values within columns followed by same letter do not differ significantly at the 5% level.

Table 16. Infiltration rates from 18th fairway, Bay County Golf Course (11/18/77), and 13th tee Dearborn Country Club (fall, 1976).

Treatment	Rate	Bay County		Dearborn
		Application Date		
		1976	1976 1977	1976
		inches/hr		
Check	-	0.1 a*	0.4 a	0.05 a
Gypsum	1 ton/A	0.6 a	1.6 a	0.08 a
Gypsum	2 ton/A	0.2 a	0.5 a	0.02 a
Gypsum	4 ton/A	0.8 a	1.8 a	0.02 a
Gypsum	8 ton/A	0.8 a	0.7 a	0.08 a
Gypsum	16 ton/A	1.1 a	0.6 a	0.05 a

* Values within columns followed by the same letter do not differ significantly at the 5% level.

Table 17. Penetrometer readings for the 13th tee, Dearborn Country Club, 1976.

Treatment	Rate of Application	Soil depth (inch)			
		1	2	3	4
		psi			
Check	-	233 a*	327 a	380 a	400 a
Gypsum	1 ton/A	226 a	320 a	355 a	377 a
Gypsum	2 ton/A	249 a	326 a	373 a	395 a
Gypsum	4 ton/A	202 a	257 a	304 a	335 a
Gypsum	8 ton/A	229 a	293 a	348 a	382 a
Gypsum	16 ton/A	229 a	273 a	302 a	340 a

* Values within columns followed by the same letter do not differ significantly at the 5% level.

Table 18. Penetrometer reading from the 13th tee, Dearborn Country Club, 1977.

Treatment	Rate of Application	Number of Applications	Soil depth (inch) 1	2	3	4
			psi			
Check	-	1*	183 bc†	265 bc	294 a	306 a
		2	161 a	248 a	280 a	303 a
Gypsum	1 ton/A	1	191 c	272 b	295 a	315 a
		2	169 a	233 a	265 a	286 a
Gypsum	2 ton/A	1	142 a	255 ab	276 a	294 a
		2	187 a	248 a	266 a	287 a
Gypsum	4 ton/A	1	163 ab	212 a	241 a	263 a
		2	131 a	201 a	229 a	250 a
Gypsum	8 ton/A	1	124 a	226 ab	267 a	278 a
		2	139 a	234 a	268 a	285 a
Gypsum	16 ton/A	1	173 a	213 a	260 a	275 a
		2	180 a	222 a	241 a	255 a

* 1 refers to treatment in 1976 only, 2 refers to treatment in both 1976 and 1977.

† Averages within columns with the same number of applications followed by the same letter are not significantly different at the 5% level.

Table 19. Penetrometer readings for Bay County Golf Course, 1977.

Treatment	Rate of Application	Number of Applications	Soil Depth (inch) 1	2	3	4
			psi			
Check	-	1*	148 ab†	166 a	201 a	244 a
		2	146 a	175 a	194 a	218 a
Gypsum	1 ton/A	1	142 a	176 a	199 a	218 a
		2	155 a	182 a	201 a	237 a
Gypsum	2 ton/A	1	143 a	172 a	197 a	229 a
		2	163 a	190 ab	206 a	215 a
Gypsum	4 ton/A	1	155 abc	179 a	203 a	193 a
		2	166 a	189 ab	221 ab	238 ab
Gypsum	8 ton/A	1	178 c	204 a	227 a	234 a
		2	174 ab	216 bc	246 bc	267 bc
Gypsum	16 ton/A	1	171 bc	195 a	220 a	230 a
		2	202 b	241 c	260 c	275 c

* 1 refers to treatment in 1976 only, 2 refers to treatment in both 1976 and 1977.

† Averages within columns with the same number of applications followed by the letters are not significantly different at the 5% level.

Table 20. Penetrometer readings from the Oakland County Grounds, 1977.

Treatment	Rate of Application	Number of Applications	Soil Depth (inch) 1	2	3	4
			psi			
Check	-	1*	161 a†	189 a	239 a	285 a
		2	153 a	194 a	286 a	378 a
Gypsum	1 ton/A	1	169 a	186 a	241 a	289 a
		2	197 c	226 a	269 a	325 a
Gypsum	2 ton/A	1	155 a	216 a	269 a	353 a
		2	158 ab	194 a	245 a	315 a
Gypsum	4 ton/A	1	151 a	199 a	272 a	320 a
		2	160 ab	191 a	243 a	304 a
Gypsum	8 ton/A	1	175 a	186 a	240 a	318 a
		2	174 ab	207 a	265 a	339 a
Gypsum	16 ton/A	1	155 a	191 a	259 a	334 a
		2	181 bc	224 a	266 a	316 a

* 1 refers to treatment in 1976 only, 2 refers to treatment in both 1976 and 1977.

† Averages within columns with the same number of applications followed by the letters are not significantly different at 5% level.