a nitrification inhibitor with urea showed small improvement in readings compared to urea alone particularly from the fall applications. Again, as was observed in the summer studies the sulfur-coated urea from CIL responded somewhat more rapidly than that from Lakeshore, especially with the spring applications.

The data from a similar study at the Country Club of Lansing (Table 4) are consistent with those observed at the Walnut Hills site. It is perhaps most striking that the nitrogen responses from the late fall applications carried through and were observable even into mid-July. With the reduced growth response observed from fall applications compared to spring applications, and with the relative longevity of response, even from soluble nitrogen sources (but particularly from those which contain some slow released nitrogen), it is apparent that spring applications of nitrogen can be delayed when a late season nitrogen program has been followed. The time of application in the late spring can be delayed as far as into June in some cases, depending on soil, turf and season.

The use of urea as a nitrogen source in fall and late fall applications was evaluated on Nugget Kentucky bluegrass at East Lansing in the fall of 1979. The fall turfgrass quality responses are shown in Table 5. As would be expected, in October a very quick response to the September application of urea was very apparent. Three weeks after the October 1 application, the response was not quite as great as to the September applications but was still very marked. Further, the October applications resulted in higher quality readings in mid-November than those applied in September. The nitrogen from the early September application was obviously becoming dissipated.

A companion study evaluating nitrogen sources applied at different times on Nugget Kentucky bluegrass is outlined in Table 6. As would be expected, those materials which are more readily available give the faster response than the more slowly available IBDU. This was especially apparent for those applications made later in the season when the soil is cooler and the response to the slowly available nitrogen source is more limited. Spring responses to these treatments applied as outlined in Tables 5 and 6 will be evaluated during the spring of 1980.

The lawn care industry is concerned about the potential for foliar burn from nitrogen fertilizer application. A study was initiated to evaluate the foliar burn potential of several nitrogen sources on September 19 at East Lansing (Table 7). The treatments were applied on Penncross creeping bentgrass which is quite susceptible to foliar injury. The plots were rated 5 days after application for foliar burn. It is interesting to note that urea applied as high as 1.5 lbs of nitrogen per 1000 square feet gave no detectable injury while at 3 lbs serious injury occurred. The product from the Ashland Company, Formolene, was apparently quite safe to use in that no injury occurred even at the 3 lb nitrogen rate. Folian from Allied did give significant foliar burn, however, at both 1.5 and 3 lb rates. The Amway fertilizer which is comprised of all soluble nitrogen sources, likewise gave very serious burn at both rates. The Methylolurea from Georgia Pacific was quite safe as well. Although we have not observed any long-term benefit of the use of the Methylolurea products, they are clerly saver to use and are less likely to cause foliar burn of the turf.

There have been reports of injury from the use of sulfur on various turfs when the sulfur is applied at rates high enough to reduce soil pH. A study was initiated in the fall of 1978 at Traverse City on the sandy soil at that site (Table 8). The sulfur sources used were powdered (flowers of sulfur) and a ground sulfur which was composed of relatively larger particles of crystalline sulfur. The pH change was quite marked, particularly for the powdered form, at all rates of application. It is apparent that the 20 lb application rate gave a very significant reduction in pH down to 4.6. As can be seen by turf quality readings, serious turf injury also occurred as observed in September, 11 months after application. Interestingly, the pH decreased even in the 4 to 6 inch depth indicating that the acid was being moved downward somewhat in the very sandy soil by leaching. In contrast, the pH effects from the ground sulfur applications were not as marked nor was there any injury apparent on the turf, even at the 20 lb application rate. Thus, it is very important to consider the type of sulfur being applied when determining the rate of application.

One should always use caution in applying the powdered form of sulfur. A maximum annual rate of 4 to 5 lbs per 1000 square feet is suggested when this is used. pH change on finer-textured soils or soils which have considerable amounts of free calcium carbonate and have pH as well above 7 would be much slower than observed here, of course. More sulfur would be needed to bring about a similar pH change so the treatment period would need to be extended over a period of years. As is clear, the ground sulfur which has larger particles gives much slower pH change but the effect would last longer. There are some products on the market which are granular in nature but when they are put in water, they break down to fine particles and give relatively quick pH change again. Let me stress the importance of using sulfur very carefully to reduce soil pH.

Studies on the effect of using core cultivation on soils have proven very interesting. Marty Petrovic completed his Ph.D. on this study in the past year and now is the turf specialist at Cornell University in New York. He utilized the Computerized Axial Tomography scanner (CAT Scanner) in the Medical School here at Michigan State University to evaluate the density of soil over very small distances. With this piece of equipment, he was able to determine that core cultivation does, in fact, cause zones of compaction both parallel to the sides of the tines and in the soil right at the bottom of the coring hole. Based on greenhouse studies, we feel that the compaction on the sides of the coring holes is minimal and with tiem these walls tend to sluff into the opening and in fact provide improvement in aeration and associated responses such as rooting. The bottom of the coring hole, however, presents a different problem. After several months of growing the cores in the greenhouse, the soil at the bottom of the coring hole still exhibited a marked increase in compaction as a result of the core cultivation. It is apparent that with continued use over a period of yers coring to the same depths can cause a type of coring pan, or compaction zone below the surface.

How serious is this problem? We really do not know the long-term detriment of this effect. Perhaps with freezing and thawing we may get improvement of the compaction layer such that it will not be noticeable. Should one consider not using core cultivation in the future? Definitely, we would say that core cultivation should be practiced where needed. If the surface compaction problem is such that core cultivation is necessary, this is an essential practice. But it might be well to consider coring to different depths to be sure there is not one depth that is reached with your coring tine every time this is practiced. Naturally, the coring depth will vary as there are changes in soil moisture content, the amount of sand in a particular green, how compacted the soil is for particular greens, and the length of the tines at the time the coring is done. It may be well to not always follow the same routine when starting with new tines. That is, do not core number 18 first and proceed in a set pattern. By varying the depth of coring, one then can vary the depth to which this compaction might occur.

The basic conclusion from these studies is not that we should cease coring operations, but that we should evaluate carefully the objectives for such practices and then determine that they are, in fact, giving us the improvement in turf conditions which is desired. If we just stop to think about it, anything that creates a hole where there was not one will have to cause compaction due to the downward motion. For example, spiking surely causes some compaction in the surface inch or so of soil under a green. Is spiking giving use the improvement in maintenance conditions desired? There are some clear advantages of spiking,

Table 7. Foliar burn effects of N fertilizers applied on Penncross bentgrass September 19, 1979 at East Lansing. Plots rated September 24. Average of 3 replications.

Treatment		
Carrier	N Rate lbs/1000	Foliar burn injury rating (9 = none)
None	-	9.0a*
Urea	1.5	8.8a
Urea (2 lbs Dwell/A)	1.5	8.8a
Urea	3.0	6.0c
Formolene (Ashland)	1.5	9.0a
Formolene	3.0	8.7a
Folian (Allied)	1.5	6.8bc
Folian	3.0	6.3c
Amway	1.5	7.3b
Amway	3.0	4.3d
Methylolurea (Ga. Pacific)	1.5	9.0a
Methylolurea	3.0	8.7a

*Numbers in columns followed by the same letter are not significantly different from each other at the 5% level.

Table 8. Sulfur effects on soil pH and Kentucky bluegrass injury. Treatments applied to Kalkaska sand in October, 1978. Ratings taken in 1979.

Treatment		Soil pH (11/79)		Turf Quality Rating (9 = best)	
Source	Rate lbs/1000	0-2 inch	4-6 inch	Sept 13/79	Dec 11/79
None	-	6.9	6.6	9.0a*	6.3a*
Powder	5	6.4	6.2	9.0a	7.0a
Powder	10	5.4	6.0	6.5b	5.7b
Powder	20	4.6	5.8	1.0c	2.0c
Ground (Chip)	5	6.5	6.3	9.0a	6.7ab
Ground (Chip)	10	6.6	6.6	9.0a	6.7ab
Ground (Chip)	20	6.0	6.2	9.0a	6.7ab

*Numbers in columns followed by the same letter are not significantly different from each other at the 5% level.