in 1992 there was a small population of annual bluegrass in the plots. Our hypothesis was that with compaction there would be an increase in the annual bluegrass population. Data from Fall, 1993 showed a trend for an increase in annual bluegrass, but the differences were not significant. Surface hardness as measured with Clegg meter were higher on the compacted plots as would be expected. Soil cores were sampled in late Fall, 1993 and taken into the laboratory to measure the effect of compaction on water holding capacity. Data in Table 7 points out that compaction consistently decreased the water holding capacity over the range of 20 cm moisture tension (high moisture content) to 1 bar (medium moisture content). These moisture tension levels are in the range of soil moisture which is most available to the turf that occurs in the larger soil pores. This result is not surprising because compaction causes the loss of the largest soil pores through which drainage and aeration take place. These plots will be subjected to moisture stress dry down periods in 1995 to determine if there is any difference in susceptibility to wilt.

WETTING AGENT EFFECTS ON SOIL WETTABILITY

A study of an experimental wetting agent from the AquaTrols Corporation was conducted in 1993 and repeated in 1994. Treatments were applied to a Penncross creeping bentgrass green growing on a loamy sand soil. Treatments shown in Table 7 were applied on July 13, August 15 and September 17, 1994. AquaGro-L is the present liquid formulation of wetting agent which has been used in the industry for many years. The ACA 864 is an experimental wetting agent. All treatments were watered in immediately after application. Plot size was 4 ft. by 10 ft. with 4 replications. Because of regular rainfall in 1994 there were few differences in turf quality observed among treatments. In September there was a 2 week period during which there was no rain, permitting visual differences among treatments. All treated plots had less localized dry spot apparent on Sept 7 and 14. Color and quality ratings gave similar results.

Soil core samples were collected about one month after each treatment to determine if there was any effect of wettability of the soil at different depths. This measurement entails drying the soil cores for 1 month, then placing a water droplet on the soil at selected depths. The time for the water droplet to disappear is a measure of how wettable the soil is. The longer the time for the drop to penetrate the soil, the more hydrophobic is the soil. Data in Table 8 indicate that the experimental wetting agent applied at the rates of 4 or 6 oz. per 1000 sq. ft. on July 13 resulted in a decreased time for a water droplet to disappear when placed on the soil surface. Below the surface there was no influence of treatment as all shallow depths (1-3 cm) had relatively hydrophobic conditions.

For the second application date in August (Table 9) the highest rate gave faster water penetration at the 1 and 3 cm depths while no other treatment showed any benefit at those depths. It is interesting to note that all treatments had greater wettability than the check at the 5 cm depth. No treatment had a significant effect on wettability of the surface layer, although there was a trend for reduced times with the higher rates of the experimental material. Interestingly, there was a trend for reduced times deeper in the profile. Apparently, within one month the effect of the wetting agent on the surface layer had dissipated.

For the third application the two highest rates of the experimental resulted in greater wettability at the 1 and 2 cm depths of soil (Table 10). The experimental wetting agent appears to be an effective material for improving wettability of soil and reducing localized dry spot incidence. On several dates after application dew ratings were taken. AquaGro is much more effective than ACA864 in reducing dew. The experimental had some dew reduction effect for about 4 days while the effect of AquaGro lasted 5 to 8 days.

GREENS ROLLING STUDY

A study to evaluate the effects of rolling and mowing height on ball roll and turf quality was initiated during the summer of 1993 and continued in the summer of 1994. Plot size was 15 ft. by 5 ft. 4 in. with 4 replications. The treatments shown in Table 11 included rolling with an Olathe roller 3 times per week; a Jacobsen roller at 3 or 5 times a week; an unrolled check plot; and a treatment which received double mowing. All these treatments were mowed 6 times a week at 5/32 inch. One additional plot was mowed at 3/16 inch and rolled with the Jacobsen roller 3 times per week.

On three dates ball roll was measured the same day as treatments were applied utilizing the Stimpmeter. Rolling 3 times per week with the Olathe roller gave the highest ball roll numbers on the 3 dates analyzed as shown in Table 11. Over a period of months double mowing with no rolling was nearly equal to the Olathe treatment. Rolling 5 times per week with the Jacobsen roller outperformed 3 times per week on only 1 of the 3 dates analyzed. When rolled with the Jacobsen roller and mowed at 5/32 inch the Stimpmeter reading was better than when rolled and mowed at 3/16 on only one date (Aug. 1).

The seasonal average for all dates evaluated for these treatments was 9 ft., 10.5 in. for the Olathe, rolled 3 times per week; 9 ft., 7 in. for the Jacobsen, rolled 5 times; 9 ft., 4 in. for the Jacobsen, rolled 3 times; 8 ft., 9 in. for the check; and 8 ft., 7 in. for the treatment rolled with the Jacobsen 3 times and mowed at 3/16 in. To date these data substantiate

observations on the effects of rolling from research in North Carolina and conducted by Beard and golf course superintendents in northern Michigan. The benefits of rolling and double mowing are obvious in increasing ball roll. Double mowing had rather inconsistent responses, giving increasing numbers as the season progressed. The increase in ball roll may have resulted from a decrease in turf density with continued double mowing. Double mowing should not be considered as a regular practice. This study will continue in 1995.

MULCHING TREE LEAVES INTO TURF

A separate report on this study was presented at the turf conference last year and the study will be continued through the 1995 growing season. The fifth annual treatment of tree leaves was applied in October, 1994. As in the past there has been no detrimental effect on the turf of mulching the leaves. In the studies we have conducted the leaves decompose within a few weeks with no apparent leaf material by the next spring. A report from Virginia Tech indicated there was some detrimental effect of the tree leaves on turf when very high rates of leaves were mulched. It is important to be sure the grass leaves are not buried by the leaf material so they are exposed to sunlight so photosynthesis can take place during the fall.

This study received wide spread exposure in the Fall of 1994. With the ban on yard wastes being sent to land fills many are looking for other alternatives for disposal of leaves. Presently many golf course and parks superintendents are mulching the leaves into the turf with no problem. For good success, the leaves should be dry, the area should be mowed frequently, and the rotary mower blade should be sharp so the leaf particles are fine enough to fall into the thatch layer and give little shading effect on the grass.

HYDROJECT STUDIES

Evaluation of the Hydroject as a cultivation and injection tool continued in 1994. Chris Miller completed his M.S. degree and moved on to gain experience in golf course management. Doug Karcher, a graduate from Ohio State University is continuing this research.

As we continue to conduct research and visit with golf course superintendents, there are varying patterns of use which superintendents are following. The following comments are based on research, discussions with superintendents, and a survey conducted by the Toro Co. Typical use for those who own their own Hydroject are treating from 4 to 10 times per year with an average of about 6 treatments per year. This use is normally concentrated during the summer months when other cultivation would not be feasible due to intensity of play. About half of the courses are using the Hydroject on sandy greens and half on native soil greens although the latter were not described. As we have stated in the past, the best cultivation program for a given turf depends on the soil problems which need to be addressed. So, the appropriate frequency of use of the Hydroject depends on these same problems.

Some superintendents have utilized the Hydroject for frequent treatment of special problems such as localized dry spots or high compaction areas. Such areas may be treated every 1 to 2 weeks when needed. A high traffic area such as where there is concentrated traffic on or off greens or on tees. Some have even used it on smaller areas of fairways which are compacted or subject to localized dry spots.

The other area of use of the Hydroject is injection of nutrients, wetting agents or insecticides. We have demonstrated that phosphorus and potassium can be placed deeper in the soil with the Hydroject. Sometimes the levels of these nutrients deeper in the rootzone are very low because deeper roots extract the nutrients at that depth, while fertilizers are placed on the surface. This is especially true for finer-textured soils with higher cation exchange capacities. Even though there were very low levels of K deeper in the root zone we did not see any increase in the amount of roots growing in that zone when potash were injected with the Hydroject. There was even some tendency for lower root weights when high rates of phosphorus were injected deeper in the rootzone.

The Hydroject is very useful for treating localized dry spots. In some cases injecting water alone can correct a dry spot. If the condition is more severe, injection of a wetting agent has increased the wettability of the soil and reduced the severity of the dry soil condition.

Among the studies conducted by Doug Karcher was one to examine the effects of injecting nitrogen with the Hydroject on fairway and putting green turf. Treatments included three rates of urea, either injected or surface applied. Plots that received subsurface injections of urea had consistently quality and color ratings than plots receiving surface applications. Injected plots had consistently higher clipping yields and nitrogen content in plant tissues than surface applied plots. This difference in response could be a result of volatilization of ammonia from the surface applications of urea. This could have occurred in spite irrigating the plots shortly after application. Interestingly, plots which received surface applications were more susceptibility to wilting than those receiving injected treatments.

Table 11. Greens Rolling Study 1994

Stimpmeter Readings After Rolling - All Treatments Applied

Treatment	July 22	Aug. 1	Aug. 8
3x/week Olathe @5/32	9.2 a	9.6 a	10.0 a
3x/week Jacobsen @ 5/32	8.7 ab	8.9 cd	9.2 bc
Double cut @ 5/32	9.1 a	9.0 bc	9.6 ab
5x/week Jacobsen @ 5/32	9.2 a	9.5 ab	9.2 bc
3x/week Jacobsen @ 3/16	8.3 b	8.0 e	8.8 cd
Check cut @ 5/32	8.3 b	8.4 de	8.4 d

Means followed by the same letter are not significantly different at the 5% level using the LSD mean separation test.