in May. As the growing season progresses the turf gradually recovers in plots with marginal phosphorus levels so that symptoms are evident only on the check plot and for the lowest rate of P treatment (August 5 rating date). Then as temperatures cool the turf begins to show deficiency symptoms again. This pattern occurred in both 1993 and 1994.

Phosphorus soil tests (Table 1) indicate that the available P levels are all very low except for treatment 4 which tested at 32 lbs. P per acre after having received 8 lbs. P_2O_5 per 1000 sq. ft. over the 2 year period. Treatment 5, which was treated only in 1993 has a P level about equal to treatment 3 which has received the same P level as treatment 5 after 2 years. These data point out the importance of applying P regularly throughout the year on new sand greens.

The potassium fertilization studies have continued on creeping bentgrass, Kentucky bluegrass and annual bluegrass. Rates of application of K_2O are none (check), 4, 8, and 12 lbs. per 1000 sq. ft. annually which are split into 2 lb. increments spread over the growing season. These studies were initiated in 1990. Plot size is 5 ft. by 7 ft. with 4 replications. Soil samples are collected in early November each year and analyzed for available K levels.

Data for the potassium soil tests on the loamy sand putting green for 1990 through 1994 are given in Tables 2 and 3 for the 0-3 and 3-6 inch depths, respectively. Tests for the check plots have remained consistently low over the years. These K levels are very low and should approach deficiency levels although there has been no evidence of wilting or loss of turf density through the years. It is interesting that the tests for treated plots have fluctuated somewhat from year to year with tests in both the 0-3 and 3-6 inch depths being slightly lower in 1994 than in earlier years. It is assumed there was greater leaching of K as a result of higher than normal rainfall during the growing season in 1994. In spite of the highest rates of application at 60 lbs. K_2O total for the 5 years there is a maximum the soil can hold in this loamy sand green. The excess K is leached from the surface into the 3-6 inch depth and beyond.

Soil K tests for 1990-1993 in the Kentucky bluegrass potassium fertilization study are given in Tables 4 and 5, respectively for the 0-3 and 3-6 inch depths. Note that much higher K levels are found in this loam soil which has a much higher cation exchange capacity. Still, there appears to be a maximum amount of K which the soil will hold with the balance leaching downward in the soil. Similar soil tests were found for the annual bluegrass plots growing on loam soil.

While these soil test correlation studies point out there is a maximum amount of nutrient which can be held in the soil it is important to follow reasonable fertilization programs. Do not use the high rates used in these studies. For sandy loams, loams and other soils with more clay, soil test recommendations should be provide adequate K for the turf. For sands and loamy sands, soil tests are not particularly helpful in predicting needs for K. For these soils we suggest using a ratio between N and K_2O as a basis for determining needs for potassium. If low annual N rates are applied (3 lbs. or less) use a ratio of $1N:1.5K_2O$. That is, if there are 2 lbs. N applied for the year, apply 3 lbs. K_2O annually. For 4-8 lbs. N annually, follow a $1N:1K_2O$. If more than 8 lbs. N are applied annually, use a ratio of $1N:0.75K_2O$.

CULTIVATION STUDIES

A study initiated in 1989 to evaluate the effect of timing of cultivation of an annual bluegrass fairway turf was continued in 1994. At the initiation of the study the grass was predominantly annual bluegrass. The cultivation treatments are given in Table 6. In past years there has been little difference in the quality of turf observed as affected by treatment. In 1994 some differences began to appear. On May 24 the amount of annual bluegrass in the plots was evaluated. Plots which had been aerified just after seedhead production in about mid-June or in late Fall had the highest amount of annual bluegrass. Those plots with the lowest amount of annual bluegrass were the untreated check and plots aerified in the early spring. The reader is cautioned however, that it is not possible to be sure about whether the greater annual bluegrass populations were a result of treatment or random encroachment of bentgrass into the plot area.

In September, several of the plots were exhibiting wilting symptoms. Plots with the most wilting were those which were the untreated check and in mid-September. Normally, the September treatment would have been made by the date of these ratings, but with the wilting symptoms appearing this cultivation treatment was delayed until late September. Treatments with the least wilting were those aerified during high stress in mid-July and after seedhead production in about mid-June. Based on these data it appears that the plots which have been aerified more recently exhibit the least wilting. Whether this hold true in the future will be determined by additional dry down periods in 1995. Even if this response is consistent cultivation during the prime golfing season would be considered unacceptable by many golfers because of surface disruption by core cultivation.

TALL FESCUE FAIRWAY COMPACTION STUDY

In past years we have reported on the study to evaluate the effect of compaction on a tall fescue turf mowed at 3/4 inch and maintained under fairway conditions. Treatments include low traffic (3 passes per week with a vibrating roller filled with water); heavy traffic (6 passes per week); and an uncompacted check. At the initiation of the study

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

Table 5. Kentucky Bluegrass Potassium Study
Potassium soil tests, 3-6" Depth

Pounds of K_2O/M applied annually	Carrier	1990	1991	1992	1993
Check	------	253	69 c	76	78 c
Soil Test Result	KCl	103	109 bc	145	153 bc
4	KCl	116	165 b	229	220 bc
8	KCl	94	177 b	340	455 ab
12	KCl	145	314 a	450	747 a
12	K_2SO_4	149	340 a	506	589 a

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

Table 6. Cultivation Timing Study 1994 Data

Initiated 1989

Treatments	% of Poa May 24th	% of Plot under Wilt Stress		
		September 19	September 21	September 23
Early Spring (Mid-April)	50.0 b	9.0 bcd	10.8 b	16.3 bc
After Seedheads (Mid- June)	80.0 a	7.8 cd	7.5 b	12.0 bc
High Stress (July or August)	65.0 ab	4.8 d	4.0 b	7.8 c
September	65.0 ab	16.3 ab	16.3 ab	22.5 ab
Late Fall	77.5 a	12.5 bc	5.5 b	14.5 bc
Check plot	57.5 b	22.5 a	27.5 a	30.8 a
probability	.0116	.0017	.0517	.0120

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

Table 7. Tall Fescue Compaction Study

Initiated 1992

Treatment	10 cm tension table	20 cm tension table	40 cm tension table	.1 bar	.33 bar	1 bar
Low compaction	5.3 a	8.3 ab	11.3 b	33.7 ab	28.14 b	32.8 b
High compaction	3.9 a	6.9 b	9.8 b	30.6 b	25.15 b	30.1 b
Check	6.5 a	10. a	14.2 a	38.2 a	35.7 a	39.0 a

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

Low compaction treatments were rolled three times per week
while the high compaction treatments were rolled six times per week.