more growth so more potassium is removed in the clippings. Second, the higher nitrogen rate likely results in more cations, probably from the production of hydrogen ions through nitrification. These hydrogen ions can replace the weakly held potassium ions increasing the potential to leach the potassium. This further supports the importance of regular soil testing and the light, frequent applications of potash on sand greens. The 8 lb. nitrogen rate is higher than recommended even for sand greens, but it is clear that higher N rates are needed on sand greens than for those having any appreciable amount of silt and clay.

Table 7. Putting Green Root-Zone Mix Fertility Study Soil sample test results from October 1998 regarding nitrogen rate and green root-zone mix.

Root-Zone Mix	1998 Nitrogen Rate	Pounds of Potassium per Acre	Annual $K_2 0$ Recommendation*
85% sand 15% peat	**6 lbs.**	39 e	6.0 lbs.
85% sand 15% peat	**3 lbs.**	41 e	6.0 lbs. .
80% sand 10% peat 10% soil	**6 lbs.**	53 d	6.0 lbs.
80% sand 10% peat 10% soil	**3 lbs.**	66 c	6.0 lbs.
Sandy Clay Loam	**6 lbs.**	175 b	4.0 lbs. .
Sandy Clay Loam	**3 lbs.**	208 a	3.0 lbs.
probability		0.00	
LSD @ 0.05		9.47	

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

* Rates are in lbs. / 1000 sq. ft. For greens, tees, athletic fields, and establishment based on soil K test(neutral normal ammonium acetate extractable) at the Michigan State University Soil Testing Laboratory.

Table 8. Putting Green Root-Zone Mix Fertility Study Clipping weights in grams from 5 May 1998 regarding nitrogen rate and green root-zone mix.

Root-Zone Mix	1998 Nitrogen Rate (lbs/1000 sq. ft.)	Clipping Weights
85% sand 15% peat	**6 lbs.**	22.76 a
85% sand 15% peat	**3 lbs.**	14.22 d
80% sand 10% peat 10% soil	**6 lbs.**	22.91 a
80% sand 10% peat 10% soil	**3 lbs.**	16.46 c
Sandy Clay Loam	**6 lbs.**	23.55 a
Sandy Clay Loam	**3 lbs.**	18.15 b
probability		0.01
LSD @ 0.05		1.54

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

Clippings were collected on 4 dates during the growing season. There were no significant differences among soils. However, there was an interaction between soil mix and nitrogen level on May 5 (Table 8). There was no significance in the amount of clippings on the greens that received 6 lbs. N annually. However, at 3 lbs. N annually there were differences among the three root-zones. These data suggest that 3 lbs. of nitrogen is not adequate for the 85:15 and 80:10:10 mixes while the native soil green has adequate levels of natural organic matter that provided some additional nitrogen. Likewise, the soil in the 80:10:10 mix provided a small amount of nitrogen that resulted release of a small amount of nitrogen compared to the 85:15 mix.

Sand Topdressing On Greens Constructed With Three Different Root-Zone Mixes

In the spring of 1995 a sand-topdressing study was initiated on greens constructed with the three different root-zone mixes described above: an 85% sand, 15% peat green built to U.S.G.A. specifications; an 80% sand, 10% peat, 10% soil green with a perched water table; and a native soil push-up green (sandy clay loam) with no perched water table. There are three replications of each soil treatment. Each soil type measures 40 feet by 40 feet. The grass was Penncross creeping bentgrass and it was mowed on the average of six times per week throughout the growing season at 5/32 inch. The plots have been topdressed every two to three weeks throughout the growing season..

Light-frequent sand-topdressing of putting greens has become a widely adopted practice. One major objective was to smooth the putting surface as mowing heights decreased. One of the stated objectives in the early years was a potential decrease in disease based on the theory that the surface would be dryer as the sand layer accumulated. In 1995 before the fertility was initiated, data were collected that concluded that with higher sand content in the root-zone mix there was more dollar spot. Inversely, there was more yellow tuft disease in the soil green. This seemed logical as dollarspot will be more active when there is less nitrogen available, and yellow tuft will be more active in wet soils. Additional statistically significant data collected in 1998 indicate the same trends are evident. There is more dollarspot on the sand green and more yellow tuft on the natural soil green in spite of a sand topdressing layer of about 1.25 inches that has accumulated since 1995. Furthermore, from root data collected in June of 1998 approximately 54% of the roots were growing in that topdressing layer, regardless of the original green root-zone mix. This study will continue through the year 2000.

Other Studies

The Alternative Golf Spike Study is a project that was a team effort in the summer of 1998. Thom Nikolai initiated this work beginning in 1995. Research efforts have continued as more shoe and spike companies have become involved. In 1998, with the collaboration of Dr. John Rogers III and his staff, the 1998 Traveling Golf Spike Study was held at six different golf courses. Data analysis was done by Doug Karcher. The report for this work appears elsewhere in these proceedings (see Rogers report). Thom will be less involved in this project in the future as he pursues completion of his Ph.D.

Two leaf mulch studies were also continued in 1998. Soil samples have been collected and are yet to be analyzed. Results continue to be positive as reported in the past. More thorough analyses are planned in 1999 as we prepare an article for publication in a scientific journal. The light-weight greens rolling study also continued in 1998 with results consistent with previous observations.

A study to compare irrigation and fertilization effects on three species of grass was initiated in 1998. Irrigation treatments were begun in late summer; nitrogen treatments in November. The grasses are Kentucky bluegrass, perennial ryegrass, and tall fescue. The study is located in open sun at the Hancock Center. The three irrigation regimes were: 0.1 inch per day; irrigation upon the appearance of wilt, and no irrigation. This study is in cooperation with David Gilstrap. During the fall, dry weather was conducive to development of rust disease. As expected, the perennial ryegrass plots had more rust than the other two species. However, plots receiving daily irrigation had little rust compared to the other treatments. This suggests that during a dry fall, some irrigation will reduce susceptibility to rust disease. Adequate nitrogen will also reduce rust symptoms as well, of course.