feet by 6 feet with 3 replications. Sustane, an organic fertilizer produced from turkey waste, gives a quicker response than Milorganite but the length of response was of shorter duration than Milorganite. IBDU responded slowly as expected but provided excellent longevity.

The study outlined in Table 6 was initiated on July 6. Turf quality ratings for the Kentucky bluegrass turf indicated considerable variability in the data caused reduced significance in the data taken July 19 and August 5. On August 15 and September 26 turf quality reflected the effect of nitrogen rate with few differences caused by carrier. Roots were washed from soil samples taken in September, then dried and weighed. Samples were also taken in September to determine the amount of thatch in each plot. Data are shown in Table 7. There was a tendency for lower root weights with higher rate of nitrogen application and with higher rate of potassium application but differences were not consistent. No differences occurred in the amount of thatch as a result of these treatments.

WETTING AGENT EVALUATIONS

Several wetting agent treatments were applied to a Penncross creeping bentgrass putting green at the Hancock Turfgrass Research Center to evaluate effects on localized dry spots, dew and frost formation and phototoxicity. Plot size was 4 feet by 6 feet. Plots were not irrigated to determine the potential for phytotoxicity. Data in Table 8 indicate Hydroflo L (liquid) and LescoWet were more phytotoxic than AquaGro liquid. While some minor injury was detected with the higher rate of Hydro Wet this proved the safest of the liquid materials evaluated. The Hydroflo and AquaGro granular materials resulted in no injury to the turf. LescoWet II was considerably less injurious than LescoWet. In terms of dew reduction the order of effectiveness was Hydroflo L > LescoWet > AquaGro > HydroWet = LescoWet II > AquaGro granular = Hydroflo G.

A second wetting agent study was begun October 6 to evaluate wetting agent effects on formation on dew and frost. Data are given in Tables 9 and 10 for dew and frost ratings, respectively. Generally, Hydroflo was most effective in reducing dew formations followed by LescoWet and AquaGro. Other materials reduced dew compared to the check on some dates. Granular wetting agents responded slowly and over the month of this study did not prove of longer effect than liquid applications. Effects of wetting agents on frost formation (Table 10) were less clearly defined although good differences occurred on the October 20 rating date.

One of the objectives of these studies was to evaluate the effect of wetting agents on preventative or curative effects on localized dry spots on putting greens on sandy soils. Although treatments were applied, no significant development of localized dry spot developed adequately to permit separation of treatment effects. A modest problem with localized dry spot began to develop in mid-July but rains promptly corrected the condition.

GREENS TOPDRESSING STUDIES

The long term sand topdressing study begun in 1982 was continued through 1988. Treatments shown in Table 11 give the quality ratings taken during the year. As observed in the past the higher nitrogen (6 pounds N per 1000 sq ft

Table 11. Effect of topdressing and nitrogen fertility programs on the turfgrass quality ratings of a Penneagle creeping bentgrass green. Treatments initiated in 1982. Hancock Turfgrass Research Center. Averages for three replications.

Topdress Treatment	N Rate (lbs/1000)	Date of Rating (1988)y			
		7/12	8/8	9/26	10/26
12 cu. ft. Spring/Fall 2:1 Sand Soil Mix	3	6.0cde*	6.0c	5.0de	7.0bc
12 cu. ft. Spring/Fall Sand	3	5.7de	6.0c	5.3de	6.7c
3 cu. ft. every 3 weeks Sand	3	6.7bcd	7.0b	5.7cd	6.3c
6 cu. ft. every 6 weeks Sand	3	7.0abcd	7.0b	6.0bcd	7.0bc
Check	3	5.0e	5.0d	4.0e	4.0d
12 cu. ft. Spring/Fall 2:1 Sand Soil Mix	6	8.0ab	8.0a	7.0abc	8.3ab
12 cu. ft. Spring/Fall Sand	6	7.3abc	8.0a	7.3ab	8.3ab
3 cu. ft. every 3 weeks Sand	6	8.0ab	8.0a	8.0a	9.0a
6 cu. ft. every 6 weeks Sand	6	8.3a	8.0a	7.3ab	8.3ab
Check	6	7.3abc	6.7b	6.0bcd	6.3c

* - Means followed by the same letter are not significantly different at the 1% level using Duncan's Multiple Range Test.
y - 9 = excellent 1 = poor

annually) resulted in higher quality ratings than the lower N rate (3 pounds). The non-topdressed plots (check) ranked significantly lower than where topdressing treatments were applied. The check plots have developed a significant thatch layer which results in a lower quality turf. Using the surface hardness tester developed by John N. Rogers, III at Pennsylvania State University with Don Waddington, the non-topdressed plots were found to be considerably harder than where topdressing was applied. The impact readings were in the range of 71-74 on topdressed plots compared to an average value of 86 on the check plots. In spite of the thatch layer on non-topdressed plots, the soil below the thatch has become highly compacted while topdressed plots exhibit more resilience.

After three years of topdressing with sand or sand mixes it has become apparent that putting green turf quality ratings are improved after topdressing (Table 12). Peak turf quality occurs on plots topdressed in spring and fall after these treatments have been applied while those plots topdressed every 3 weeks tend to have a more consistent quality throughout the growing season. On a few dates topdressing with sand mixes (80% sand, 20% peat or 60% sand, 20% peat, 20% loam topsoil) turf quality ranked better than when sand was used alone. All topdressed plots consistently ranked better than non-topdressed plots.

Applying Sand Aid with sand when topdressing on a Penncross bentgrass putting green resulted in improved turf quality on certain dates during the growing season. Data are given in Tables 13 and 14 for studies established in 1985 on a modified loamy sand and dune sand, respectively. This was particularly evident on the green growing on sand. Interestingly, plots which were cored had less dew on October 17 than plots which were sand topdressed or not treated. This rating was taken during a period of frequent rainfall and low evapotranspiration so differential soil moisture was not considered a factor in the differential in dew formation.

SOIL TEST RESPONSES TO PHOSPHATE AND POTASH

Ongoing studies on Penncross bentgrass putting greens have been continued in 1988. Phosphorus and potassium applications outlined in Tables 15 and 16 have been applied since 1982. On the soil green (loamy texture) in Table 15 it is apparent that 2 pounds of P per 1000 sq ft annually are needed to increase P soil test over the check on this soil that had a very high P level at the beginning of the study in 1982. At such high P levels (375 pounds per acre) it is apparent that P has moved down into the 2-4 inch depth (194 pounds per acre) compared to lower P levels applied. Potassium also accumulates in this loamy soil as indicated by the K soil tests in Table 15.

On the green established on a 80% sand, 20% peat mixture (Table 16) there is some residual potassium in the 0-2 inch depth from applications made during establishment. Some potash has accumulated in the 0-2 inch depth but only at the higher rates of application has much potassium moved into the 2-4 inch depth.

Phosphorus applied to a Penncross creeping bentgrass growing on sand (Table 17) corrected a phosphorus deficiency with as little as 1 pound P applied annually. However, the P soil test of 11 pounds per acre is still considered deficient for good stress tolerance of the turf. It is clear that phosphorus does leach in the sand which has no organic matter added other than what the turf contributes. Regular, light application of phosphorus should

Table 12. Effect of topdressing a Penncross creeping bentgrass green with Great Lakes Minerals topdressing mixes on turfgras quality ratings. Study initiated spring 1986. Hancock Turfgrass Research Center. Averages for 3 replications.

Treatment			Overall Quality Ratings (9 = best)						
Mix[y]	Rate	Frequency	4/26	7/14	7/20	8/8	8/26	10/3	11/1
	cu ft/1000								
TDS-50	3	3 weeks	6.2d	7.7a	7.3c	8.3ab	8.7a	6.7bc	6.7b
	12	Spring/Fall	7.0ab	7.7a	7.3c	8.7a	7.3cd	7.0ab	7.0b
80:20	3	3 weeks	6.3cd	7.7a	8.7ab	8.7a	8.3ab	7.7a	6.7b
	12	Spring/Fall	7.2a	8.0a	7.3c	7.7ab	7.0d	6.7bc	8.3a
60:20:20	3	3 weeks	6.5bcd	8.0a	9.0a	8.7a	8.7a	7.3ab	7.0b
	12	Spring/Fall	6.8abc	7.7a	7.7c	8.0ab	7.7bcd	7.0ab	8.7a
TDS-50 (cored)	12	Spring/Fall	6.2d	7.3a	8.0bc	8.0ab	8.0abc	7.0abc	7.0ab
Check	-	-	4.8e	6.0b	6.3d	6.0d	7.2cd	6.0c	5.0c

* Means in columns followed by same letter are not significantly different from each other using Duncan's Multiple Range test (5%).

[y] TDS-50 is 100% sand; 80:20 is 80% sand, 20% peat; 60:20:20 is 60% sand, 20% peat and 20% loamy topsoil.

Table 13. Effect of Sand Aid treatments on turfgrass quality and dew ratings of a Penncross creeping bentgrass green grown on loamy sand. Hancock Turfgrass Research Center. Treatments initiated in 1985. Quality rating scale of 1-9 with 9 = highest quality turf. For dew ratings 9 = no dew. Averages for three replications.

Treatment		Dew	Quality Rating		
Sand Aid	Auxiliary	10/17	4/26	10/4	11/1
5%	Sand topdress	4.7d*	6.7b	7.0abc	5.3a
10%	Sand topdress	5.0cd	7.3a	7.7a	5.7a
None	Sand topdress	4.3d	6.0c	7.3ab	5.3a
15 lbs	Coring	6.0ab	5.8cd	6.3bc	5.7a
30 lbs	Coring	6.7a	5.8cd	6.0c	6.0a
None	Coring	5.7bc	5.2d	6.3bc	6.0a
None	None	4.0d	5.3d	6.1c	4.0b

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 14. Effect of Sand Aid treatment on turfgrass quality and dew ratings of a Penncross creeping bentgrass green grown on sand. Hancock Turfgrass Research Center. Treatments were initiated in 1985. Quality rating scale of 1 - 9 with 9 = highest quality turf. For dew ratings 9 = no dew. Averages for three replications.

Treatment		Dew	Quality Rating		
Sand Aid	Auxillary	10/17	7/6	7/20	8/8
5%	Sand topdress	4.0c	6.3ab	7.3a	7.3ab
10%	Sand topdress	5.0b	6.7a	8.0a	8.0a
None	Sand topdress	4.3bc	4.0d	5.7c	6.3bc
15 lbs	Coring	7.0a	5.3bc	6.0bc	7.3ab
30lbs	Coring	7.0a	6.7a	7.0ab	8.0a
None	Coring	6.3a	6.3ab	6.0bc	7.3ab
None	None	4.3bc	5.0cd	5.0c	6.0c

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.