At this point, we cannot say that there is enough evidence to recommend this timing of cultivation as a standard practice. However, based on other studies we believe that fall is a very appropriate time to consider cultivation. The maximum root production period for cool season grasses is in the spring. Loosening the soil by cultivation in the fall to late fall should provide maximum opportunity for good root growth the next spring.

The objective of another cultivation study is to determine the effect of several cultivation treatments on turf quality and thatch accumulation on Ram-I Kentucky bluegrass. This study was initiated in 1987 on a turf which had about 1 inch of thatch. Treatments include the Verti-Drain with hollow and solid tines, Toro greens aerifier used once and 3 times annually, a vertically operating tine aerifier which is set to penetrate to only 1 inch and an untreated check. The solid tine treatment brings no soil to the surface so there is no mixing of soil with the thatch. As a result, the solid tine treatment has had little effect on thatch accumulation. The shallow treatment is purposely set so there is very little soil brought to the surface to simulate what happens when an ineffective aerifier is used on a thatch site. There have been no differences in turf quality ratings taken, so no data are presented here. This study will continue in 1992.

EFFECT OF HIGH POTASSIUM RATES ON TURF AND SOIL TESTS

In recent years there has been a dramatic increase in the use of potash in fertilizing turfs, especially in high traffic and/or stress situations. This has occurred as a result of recent data indicating that greater wear tolerance has resulted from potash applications above those recommended based on soil tests and the generally accepted view that higher potassium will enhance stress and disease tolerance of turfgrasses. Some turf specialists are concerned that the rates being used by become excessive due to nutrient imbalances and/or high salt levels. The studies reported here were initiated in 1990 in cooperation with J.N. Rogers at the Hancock Turfgrass Research Center, one each on Bristol Kentucky bluegrass growing on loam soil, an annual bluegrass fairway height turf growing on loam soil and a creeping bentgrass green growing on a loamy sand soil. Treatments were applied at 0, 4, 8, and 12 lbs. K_20 (as potassium chloride) per 1000 sq. ft. annually in 2 lb. increments during the growing season. There was also a 12 lb. K_20 treatment applied as potassium sulfate. Each study also had a treatment based on soil tests as recommended by the Michigan State University Soil Testing Lab. Clippings were returned on the Kentucky bluegrass and annual bluegrass studies, but removed from the bentgrass green. Plot size was 4 ft. by 6 ft. with 3 replications.

There were no observable differences in turf quality in any of the 3 studies as reported last year. Soil samples were collected in November and tested for potassium, calcium and magnesium. The soil samples were separated into thatch, 0-3 inch and 3-6 inch depths for analysis. Data are shown in Tables 3, 4 and 5 for the Kentucky bluegrass, creeping bentgrass and annual bluegrass studies, respectively. The rates of K_20 applied for the soil test based treatments were: Bristol Kentucky bluegrass 3.0 lbs. in 1990 and 0.5 lb. in 1991; Penncross creeping bentgrass green - 5.5 lbs. in 1990 and 4.5 in 1991; annual bluegrass fairway - 3.5 lbs. in 1990 and 4.0 in 1991.

Soil test results indicate there are some differences in the responses observed to the potash applications. The higher K soil tests in the check plot on the Kentucky bluegrass study is reflected in the higher K tests at each rate of K_20 application compared to that observed in the annual bluegrass study, even though both are growing on loam soil. In both these studies, the downward movement of K at the higher rates of application is very apparent. As the K level in the surface layer becomes high, there is a natural leaching downward, even in these loam soils. At the excessive rates of 12 lbs. K_20, this would be expected to occur even when clippings are returned.

Table 3 High Potassium Study, 1991
Bristol Kentucky bluegrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11, 1991
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	493 E*	2880A	478A	134 D	2340A	503A	69 C	1769	298AB
KCL-K20	Soil Test-.5	890 D	2479AB	426 B	269 CD	1962AB	336AB	109 BC	2493	306AB
KCL-K20	4	1165 C	2300 B	434AB	361 C	1800 B	370AB	165 B	1616	324A
KCL-K20	8	1204 C	2267 B	418 B	526 B	1725 B	356AB	177 B	1548	308AB
KCL-K20	12	1432 B	2166 B	400 B	736A	1663 B	330 B	314A	1433	282 B
K2S04-K20	12	1617A	2131 B	394 B	882A	1764 B	338 B	340A	1410	288 B

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

Table 4 High Potassium Study, 1991
Penncross creeping bentgrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	192 D*	1969	308	53 D	1074	260A	34 D	899	196A
KCL-K20	Soil Test 4.5	318 BC	1983	348	149 C	1047	196AB	89 C	910	190A
KCL-K20	4	292 CD	2070	363	146 C	1088	216AB	76 C	821	178AB
KCL-K20	8	374ABC	1972	362	204 B	1047	206AB	127 B	781	176AB
KCL-K20	12	462A	2069	349	290A	1087	208AB	200A	870	166 B
K2S04-K20	12	405AB	1881	340	272A	1052	190 B	217A	935	158 B

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

Table 5

High Potassium Study, 1991
Annual bluegrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	156 D*	1659	408A	87 D	1407	391A	62 D	953 B	345A
KCL-K20	Soil Test 4.0	342 BC	1600	375 B	261 C	1660	375AB	130 BC	1406AB	328AB
KCL-K20	4	337 C	1563	357 B	242 C	1621	361 BC	114 CD	1238AB	330AB
KCL-K20	8	412 B	1565	363 B	386 B	1599	351 CD	169 B	1427AB	318 B
KCL-K20	12	498A	1621	358 B	494A	1621	336 D	269A	1387AB	289 C
K2S04-K20	12	508A	1623	379 B	562A	1621	352 CD	316A	1528A	314 B

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

On the loamy sand green, the K soil tests are not as high as in the loam soil at each rate of application. This is to be expected because of the low cation exchange capacity in the sandy soil. Typically, available K soil test levels are not high on sandy soils in spite of high rates of application. Because of the low cation exchange capacities and susceptibility to leaching of potash found in sands, it is necessary to apply potash more frequently and at lighter rates than on finer textured soils.

Based on the data generated thus far, we are reasonably confident in the potash recommendations made by our M.S.U. Soil Testing Lab. The levels of K maintained by the soil test based treatments as found in the 0-3 inch depth is holding about where we expect them to be. Recommendations for fertilizer applications should be based on soil samples taken from the top 3 inches or so of soil. In order to effectively compare soil tests from one year to another, always sample to the same depth and at the same time of year. Note that the soil K tests in the thatch layers are much higher than in the 0-3 inch soil depth in all 3 studies as would be expected. Thatch has lower density than soil.

One area of concern with very high levels of K is the potential for causing an imbalance between potassium and magnesium. In these studies, there is evidence that the magnesium soil test levels in the 0-3 and 3-6 inch soil depths are lower with high rates of application of potash. It is not yet a problem on these soils for 2 reasons: the level of magnesium in the soil is naturally high and the irrigation water used at the Hancock Turfgrass Research Center is very high in both calcium and magnesium. With each irrigation the turf receives a small amount of both calcium and magnesium. Many water sources in Michigan are high in calcium and magnesium, but some are not. Turf managers are urged to monitor magnesium soil test levels carefully if using high rates of potash on sites were magnesium tests are low or when the irrigation water is low in magnesium. Secondly, apply reasonable rates of potash. Most soil test recommendations for potash are acceptable. For heavy use turf areas, one might consider using 1 or 2 pounds of potash annually over that recommended based on soil tests. For maximum protection against the salt effects of potash carriers, we suggest application of only 1 lb. K_20 per 1000 sq. ft. per application when applied in dry form and watered in. One might go as high as 1.5 lbs under "safe" conditions of lower temperature and low relative humidity. The salt effects from fertilizers can cause the visual symptoms of foliar (and crown) burn, but could also be harmful to roots and soil biological activity. We do not have any proof of the latter under normal use of soluble fertilizers, but we do suggest care in not applying excessive rates at one time. It is essential to limit soluble fertilizer applications when the turf is in significant moisture stress. Fertilizers should never be applied when the turf is wilting.

Some agronomists are also concerned about getting the nitrogen to potassium ratio too wide. As a general rule, the higher the rate of nitrogen applied on high use turfs, the higher the rate of potash should be used. This should be related to soil test, of course. For example, if a golf course superintendent is using 5 pounds N per 1000 sq. ft. annually on a putting green and soil tests recommend 3.5 pounds potash, one could use 4.5 to 5.0 pounds potash annually if applications are made throughout the year. Watch magnesium soil tests, of course. However, if one is using only 2.5 pounds N annually and soil tests call for 3.5 pounds potash, the range of 3.5 to 4 pounds potash annually would be more appropriate. We have observed in other studies that with higher rates of N, there is greater loss of potassium. Some of this would come through leaching and some would be lost through greater clipping removal when clippings are not returned to the turf.

EFFECT OF FERTILIZER APPLICATION WITH THE HYDROJECT

A prototype of the Hydroject aerifier developed by the Toro Co. was used to inject phosphorus and potassium into turf soils. These studies were initiated in 1990 and continued in 1991. The phosphorus treatments were established on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Phosphorus treatments were as shown in Table 6: untreated check; Hydroject aerification alone; a surface application of 2.5 lbs. P_20_5 per 1000 sq. ft.; phosphorus applied at 2.5 or 5.0 lbs. P_20_5 per 1000 sq. ft.