1979 TURFGRASS RESEARCH SUMMARY

UNIVERSITY OF ILLINOIS

AT URBANA-CHAMPAIGN

(NOT FOR PUBLICATION)

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A. 2. a. Kentucky bluegrass cultivar evaluation.
J. E. Haley and A. J. Turgeon.

The intraspecific variability of Kentucky bluegrass has allowed the development of many cultivars and experimental selections that differ widely in their color, texture, density, environmental adaptation disease susceptibility, and other factors. There are 52 cultivars plus 10 blends and 4 mixtures from an April 1972 planting. Plots measure 6 x 8 foot and each variety is replicated 3 times. Fertilizer is applied 4 times per year to supply a total of 4 lb. N/1000 sq. ft. using a 10-6-4 analysis fertilizer. Mowing is performed 2 to 3 times per week at 1.5 inches. The turf is irrigated as needed to prevent wilt. The basis for these efforts is that improvements in the characteristics and adaptation of a turfgrass reduce its dependency on cultural practices designed to compensate for its weaknesses. Thus turfgrass management is made simpler and higher turfgrass quality is obtainable with the use of improved cultivars.

Due to an extremely dry spring, May and June quality data are not as high as would be anticipated. There was no incidence of striped smut disease, presumably due to the below average rainfall. Incidence of Helminthosporium leaf spot was not severe although some cultivars were affected by it (Campina, K158, Kenblue, Park). August quality data reflected cultivar susceptibility to dollar spot disease (Table 1).

Comparison of blend quality with that of the components alone shows the mitigating effects of the cultivars upon each other as in previous years. For example, July dollar spot data for the Nugget-Glade blend is intermediate between that observed for Nugget and Glade alone. Similar comparisons can be made for other blends in the study.

A. 2. a. Expanded Kentucky bluegrass selection evaluation.
J. E. Haley and A. J. Turgeon

With the introduction of many new experimental selections, an additional series of Kentucky bluegrass plots were planted in September, 1974, to determine their performance in central Illinois. Plot size was 5 x 6 ft. and each selection was planted at 2 lb./1000 sq. ft. in three replicate plots. Cultural practices are conducted as in the Kentucky bluegrass cultivar evaluation.

Due to an extremely dry spring little disease was evident. Quality level varied with Kentucky bluegrass selection and time during the growing season (Table 2). Several selections from Warren's Turf Nursery (WTN) were particularly outstanding as was a selection from Princetown Sod Farms in New Jersey (Princetown 104).

Table 1. Quality of Kentucky bluegrass cultivars in 1979.

Cultivar	Spring Green-up 3/27/79	Helminthosporium[1] Leaf Spot 5/15/79	Dollar Spot 7/30/79	Seed[2] Heads	Quality[3] 10/9/78	Quality[3] 11/2/78	Quality[3] 5/15/79	Quality[3] 6/28/79	Quality[3] 8/13/79	Quality[3] 10/12/79
A-20 (seeded)	4.0	2.0	2.0	1.0	3.0	3.0	2.3	1.3	2.3	1.0
A-20 (veg)	4.7	2.0	2.0	1.3	3.0	3.3	3.0	2.0	2.0	1.3
A-34	4.3	2.3	3.7	1.0	4.0	3.0	2.7	2.3	3.7	1.3
A-20-6	5.7	2.3	3.3	1.0	3.7	2.7	2.7	1.0	3.0	1.3
Adelphi	4.0	2.0	1.3	1.0	2.7	2.7	3.0	2.7	2.7	2.7
Ba 61-91	5.0	2.0	3.7	4.0	4.7	4.3	3.3	3.0	4.3	2.3
Ba 62-55	4.0	2.3	1.7	3.3	4.0	3.3	3.0	4.0	2.7	3.0
Baron	4.3	2.0	3.0	4.3	3.7	3.0	3.0	4.0	4.0	2.7
Bonnieblue	3.7	2.0	3.3	1.3	5.0	4.3	3.7	3.3	4.3	3.0
Brunswick	4.0	2.0	3.0	1.0	4.3	3.3	2.3	2.3	4.0	3.0
Campina	4.3	4.0	2.3	2.0	5.0	4.7	4.7	4.0	3.7	3.3
Cheri	4.3	2.3	3.0	2.3	3.7	3.3	2.7	3.0	3.3	2.7
Delft	4.0	3.3	2.3	1.7	5.0	3.7	4.0	3.7	4.0	2.7
Enmundi	4.0	2.3	3.0	1.0	4.3	3.7	3.0	2.7	3.7	3.3
EVB-305	4.3	2.7	3.3	2.0	6.0	4.7	3.3	3.0	4.3	3.3
Entopper	5.0	2.3	3.0	2.7	4.3	4.3	4.3	4.0	4.7	3.7
Enoble	4.7	2.3	4.0	1.3	4.0	3.7	3.3	3.3	4.7	3.0
Fylking	4.3	3.3	3.3	1.7	5.7	4.0	3.7	3.3	4.3	3.7
Galaxy	4.0	2.3	4.0	2.0	4.7	3.7	3.7	4.0	5.0	3.3
Geronimo	4.7	3.0	3.0	2.0	5.3	4.7	3.0	3.7	3.7	3.3
Glade	3.7	2.7	2.3	1.3	3.7	3.0	3.7	3.3	4.0	3.3

Table 1 (con't.)

Cultivar	Spring Green-up 3/27/79	Helminthosporium[1] Leaf Spot 5/15/79	Dollar Spot 7/30/79	Seed[2] Heads	Quality[3]					
					10/9/78	11/2/78	5/15/79	6/28/79	8/13/79	10/12/79
K1-131	4.0	2.7	3.3	1.0	4.7	4.0	3.3	2.0	5.0	3.3
K1-132	4.0	2.3	4.3	1.3	4.3	4.0	3.7	2.7	5.7	3.0
K1-133	3.7	2.7	2.3	1.0	4.7	4.0	3.0	3.0	5.0	3.0
K1-138	4.3	3.0	2.3	1.3	5.3	4.3	4.0	4.3	4.3	3.3
K1-143	3.7	2.3	2.7	1.0	5.0	4.0	3.7	3.0	4.3	3.0
K1-157	4.7	3.7	2.3	1.3	6.0	5.0	5.0	4.0	4.3	3.7
K1-158	4.0	5.3	1.0	1.0	3.7	3.0	4.7	3.3	2.7	2.3
K1-187	3.7	2.7	1.7	1.0	5.0	3.7	3.3	3.7	3.3	3.0
Kenblue	4.7	5.7	3.0	1.0	4.3	4.0	5.3	4.0	3.7	2.3
IL-3817	5.0	2.7	3.0	3.7	4.7	4.0	4.0	3.7	4.3	3.0
Majestic	4.0	2.0	1.0	1.3	4.3	4.3	3.3	3.0	3.0	3.7
Merion	5.7	3.3	3.3	3.3	4.3	3.7	3.7	4.0	4.7	3.0
Monopoly	4.3	2.7	4.3	3.0	4.3	4.0	3.3	3.3	4.7	3.7
Nugget	7.0	2.0	5.3	2.0	5.3	4.7	5.3	3.0	5.3	3.3
P-59	3.7	2.0	2.3	2.3	4.0	2.3	3.3	3.0	3.0	3.0
P-140	3.3	2.3	5.0	1.0	3.0	3.3	3.7	2.3	6.0	2.3
Parade	3.3	2.0	2.3	3.3	3.7	3.0	3.3	3.3	3.3	2.7
Park	4.3	4.0	3.5	1.0	5.3	4.5	4.0	3.5	3.5	3.5
Pennstar	4.3	2.7	2.3	2.7	5.0	4.0	4.0	3.7	3.3	3.3
Plush	4.0	2.3	2.0	1.0	4.0	3.3	3.3	2.3	3.0	2.3
PSU-150	5.0	2.7	3.7	1.0	3.3	3.0	3.7	2.3	5.0	2.0

Table 1 (con't.)

Cultivar	Spring Green-up 3/27/79	Helminthosporium[1] Leaf Spot 5/15/79	Dollar Spot 7/30/79	Seed[2] Heads	Quality[3]					
					10/9/78	11/2/78	5/15/79	6/28/79	8/13/79	10/12/79
PSU-169	5.0	2.3	3.3	1.3	4.3	4.7	4.0	2.7	3.7	3.0
PSU-190	4.7	2.0	4.0	2.0	5.0	4.3	4.0	4.0	5.3	3.7
PSU-197	4.7	3.0	3.7	2.3	5.4	4.7	3.3	4.0	5.3	3.0
Ram #1	4.0	2.3	2.7	1.0	4.7	3.3	3.0	3.0	3.7	3.0
Ram #2	3.7	2.7	2.7	1.0	4.7	3.7	3.0	3.0	4.7	3.3
Rugby	4.0	2.0	2.7	3.0	4.3	3.3	3.3	3.7	3.7	2.7
Sodco	4.3	2.3	1.3	1.0	2.3	2.7	3.0	2.7	2.0	2.3
Sydsport	4.7	2.3	4.0	1.7	3.3	3.7	3.0	2.7	4.7	2.3
Touchdown	3.3	2.0	3.7	1.0	3.0	2.3	3.0	3.3	4.3	2.0
Vantage	4.3	2.2	2.0	1.3	3.7	3.3	3.0	2.5	2.5	2.5
Victa	4.3	2.0	3.0	3.7	3.7	4.0	3.7	3.7	4.3	3.0
Windsor	4.7	3.3	2.5	1.0	5.0	4.0	4.0	3.0	4.5	2.7
. . . . Blends										
Merion + Kenblue	4.0	5.3	2.0	2.3	5.0	4.0	5.0	3.7	3.0	2.7
Merion + Pennstar	5.7	3.3	2.0	3.7	5.3	4.0	3.7	3.0	3.3	3.3
Merion + Baron	4.3	2.7	3.0	4.0	5.3	4.3	4.0	3.3	3.3	3.3
Nugget & Pennstar	6.3	2.3	7.3	2.0	5.0	4.3	4.7	2.0	6.3	3.3
Nugget + Park	5.3	2.7	5.7	1.0	5.7	4.7	4.0	3.3	6.0	3.3
Nugget + Glade	4.3	3.0	4.0	1.0	4.3	4.0	3.7	3.3	5.0	3.0

Table 1 (con't.)

Cultivar	Spring Green-up 3/27/79	Helminthosporium[1] Leaf Spot 5/15/79	Dollar Spot 7/30/79	Seed[2] Heads	Quality[3]					
					10/9/78	11/2/78	5/15/79	6/28/79	8/13/79	10/12/79
Nugget + Adelphi	5.0	2.0	3.0	2.0	4.7	3.7	3.7	2.7	4.3	2.3
Victa + Vantage	4.7	2.3	5.0	3.7	4.7	4.0	3.0	3.0	4.7	3.0
P-59 + Brunswick	3.7	2.0	2.0	2.0	4.3	4.0	2.3	2.7	3.0	2.0
Blend 38	4.3	2.0	2.0	1.0	3.0	2.7	2.7	2.0	3.3	2.0
. . . . Mixtures.										
Fylking + Jamestown (RF)	4.0	2.3	3.0	2.3	4.7	4.0	3.7	3.0	4.3	2.7
Fylking + Pennlawn (RF)	4.7	3.3	3.7	2.7	5.0	4.7	4.0	4.0	4.0	3.3
Fylking + C-26 (RF)	4.0	4.0	2.0	1.3	5.3	5.3	4.7	4.0	4.0	3.0
Fylking + Pennfine (RF)	3.3	2.7	3.0	1.0	5.3	5.0	5.7	4.7	5.7	3.0

[1]Disease ratings were made using a scale of 1 through 9 with 1 representing no apparent disease and 9 representing complete necrosis of the turf.

[2]Seedhead ratings were made using a scale of 1 through 9 with 1 representing no visible seedheads and 9 representing complete coverage of the plot with seedheads.

[3]Quality ratings were made using a scale of 1 through 9 with 1 representing best quality and 9 representing very poor quality turf.

Table 2. Expanded Kentucky bluegrass cultivar and experimental selection evaluation.

Selection	Quality[1]			
	4/13/79	5/18/79	5/5/79	10/23/79
Adiker A214	5.0	4.0	4.7	4.3
Adiker K1096	4.0	3.3	4.7	3.3
Burl D517	4.0	4.3	4.3	4.0
Burl F1086	4.0	3.3	4.7	4.0
Burl F1145	4.3	3.0	4.0	3.0
Burl F2039	4.7	4.7	5.0	4.3
Calturf P-143	4.0	5.0	5.0	4.3
Green K860	4.0	4.3	4.7	3.7
GWSH #2	4.7	4.7	4.3	3.7
NK P154	3.3	5.0	4.0	3.3
P-3N	3.7	3.3	3.7	3.0
P-167	4.0	4.0	4.7	4.0
Princetown 104	3.0	2.3	2.3	1.7
Princetown 164	3.7	3.3	3.7	3.0
K1-80	3.7	6.0	6.0	4.7
K1-88	4.7	4.7	5.7	5.3
K1-121	4.0	5.3	5.3	4.3
K1-122	4.3	6.0	5.7	4.3
K1-136	3.3	5.3	5.3	4.5
K1-140	3.7	4.7	4.7	3.7
K1-144	3.7	4.0	3.7	4.7
K1-152	3.3	3.0	4.3	4.0
K1-153	3.3	5.0	5.0	4.3
K1-154	3.7	4.0	4.0	3.0
K1-159	3.0	4.3	4.0	3.3
K1-165	2.7	4.7	4.7	4.0
K1-189	4.0	4.0	4.3	4.3
K2-200	3.3	4.7	4.7	4.3
K3-162	3.3	4.7	4.7	3.3
K3-164	4.0	4.3	4.0	4.0
K3-166	3.7	2.7	3.3	3.7

Table 2 (con't.)

Selection	4/13/79	5/18/79	5/5/79	10/23/79
K3-168	3.3	4.3	5.0	4.0
K3-169	4.0	5.3	5.0	3.7
K3-170	3.7	4.3	5.0	3.3
K3-171	3.0	4.0	3.5	3.0
K3-172	3.0	4.3	4.7	4.3
K3-174	3.7	3.3	3.3	3.0
K3-178	3.7	3.0	4.0	3.0
K3-179	3.7	4.3	3.7	3.0
K3-180	3.3	3.3	3.7	4.0
K3-181	3.0	3.0	4.3	3.0
K3-182	3.3	5.7	5.3	4.3
K3-222	3.7	5.7	5.3	4.7
K8-176	3.7	3.7	4.0	4.0
WTN-A20-6	4.3	3.0	2.7	3.0
WTN-A29-10	3.7	2.7	2.3	2.3
WTN-H-11	3.0	2.7	3.3	3.0
WTN-I-13	2.3	2.7	3.0	2.7
WTN-N-1	3.0	3.0	2.7	3.3
WTN-N-37	5.0	3.7	3.7	3.7
WTN-0-39	4.3	4.3	4.0	3.7
WTN-0-758	3.7	3.0	3.7	3.3
Newport	4.0	5.3	5.0	4.7
Park	4.0	6.0	5.7	5.3
Aquilla	4.7	4.3	4.3	4.0
. . . . Blends				
#1 WTN	3.7	3.0	3.0	2.3
#2 WTN	3.0	2.7	3.0	3.7
Prato-Fylking-Pennstar	4.0	4.0	4.0	4.7
Adelphi-Aquilla-Parade-Nugget	4.3	4.0	4.3	3.7
Adelphi-Aquilla-Parade	4.7	4.0	4.3	4.0

Table 2 (con't.)

Selection	4/13/79	5/18/79	5/5/79	10/23/79
Majestic-Nugget	5.7	4.0	5.0	3.7
Adelphi-Baron	3.3	3.7	3.7	3.3
Bonnieblue-Brunswick-Parade	3.3	2.3	3.0	2.3
Baron-Nugget	5.3	4.0	4.3	3.7
Pennfine-Majestic	3.3	5.7	6.0	4.3
Sydsport-Majestic	3.0	3.3	3.0	3.7

[1]Quality ratings were made using a scale of 1 through 9 with 1 representing best quality and 9 representing very poor quality.

A. 2. b. Creeping bentgrass cultivar evaluation.
J. E. Haley and A. J. Turgeon.

Creeping bentgrass cultivars were established in May, 1973 in plots measuring 6 by 8 ft. with three replications of each. Mowing height is 0.25 in. and the plots receive a total of 4 lb. N/1000 sq. ft. annually. Irrigation is performed as needed to prevent wilting. A preventative fungicide program was followed from June through September.

The cultivars varied widely in their quality ratings due to the differences in texture, color, density, annual bluegrass invasion, and disease incidence (Table 3). One of the poorest cultivars was Toronto which deteriorated severely in 1974 due to red leaf spot disease. Annual bluegrass invasion decreased from last year possibly due to heat and drought stress during May and June. Good turfgrass quality has been observed with Penncross, Pennpar, Old Orchard, Morrissey, and the experimental selections MSU-AP-18, MSU-AP-28 and MSU-AP-38.

A. 2. d. Perennial ryegrass cultivar evaluation.
J. E. Haley and A. J. Turgeon.

Perennial ryegrass is usually considered a temporary lawn or nurse grass in seed mixtures. In Illinois deterioration during the summer months has prevented perennial ryegrass from becoming an important permanent turfgrass. Improved varieties with better color, density, mowing quality and disease resistance have challenged the traditional image of perennial ryegrass.

Perennial ryegrass plots were established in September, 1972. Plots measured 6 x 8 ft. and each cultivar was replicated 3 times. Mowing, fertilization and irrigation were performed as for the Kentucky bluegrass cultivars.

Due to an extremely dry spring and summer quality data are not as high as would be anticipated (Table 4). All cultivars deteriorated rapidly under drouthy conditions. Cooler night temperatures and frequent precipitation early in October stimulated growth so that by mid-October all cultivars had recovered from the stressful spring and summer. Pennfine, Manhattan, NK200 and K8-137 maintained good quality except under extreme drouth. Common and K-8-142 held up very poorly under drouthy conditions.

Table 3. Quality of bentgrass cultivars in 1979.

Cultivar	Snow Mold[1]	% Poa annua	Quality[2]		
	3/20/79	5/18/79	5/18/79	7/17/79	10/15/79
Seaside	6.0	13.3	5.3	3.7	3.3
Penncross	4.0	3.0	3.7	2.7	2.3
Washington	3.3	7.3	4.7	3.3	3.7
Toronto	4.3	18.3	6.0	5.0	5.3
Cohansey	5.7	4.0	5.3	3.7	4.0
Pennpar	3.0	6.0	4.3	3.0	3.0
Pennlu	5.3	21.7	6.7	4.0	5.0
Arlington	5.7	15.0	5.3	3.0	4.3
Emerald	5.0	21.7	5.7	3.3	5.0
Congressional	5.7	23.3	6.0	3.7	4.3
Old Orchard	5.3	9.3	5.0	3.0	2.7
Metropolitan	5.0	11.7	5.3	4.0	5.0
Collins	4.3	15.0	5.7	3.3	3.3
Nemisilla	6.3	13.3	6.0	2.7	7.3
Morrissey	3.7	4.0	3.7	3.3	3.0
MSU-AP-18	3.7	10.0	5.3	2.7	3.7
MSU-AP-28	2.3	5.7	5.0	2.7	3.0
MSU-AP-38	2.7	.7	3.7	2.7	2.3

[1]Snow Mold disease ratings were made using a scale of 1 through 9 with 1 representing no apparent disease and 9 representing complete necrosis of the turf.

[2]Quality ratings were made using a scale of 1 through 9 with 1 representing best quality and 9 representing very poor quality.

Table 4. Perennial ryegrass cultivar evaluation.

Cultivar	Quality[1]			
	5/14	7/17	8/8	10/18
Pelo	4.0	5.0	6.0	3.0
NK-100	4.3	5.0	5.3	3.0
NK-101	4.0	5.3	6.3	3.0
NK-200	4.3	5.0	4.7	3.3
Manhattan	3.0	4.0	5.7	2.0
Pennfine	4.3	3.0	5.0	2.3
Common	6.7	5.7	6.3	4.0
K8-137	4.0	4.3	6.0	2.7
K8-142	4.0	5.7	7.0	3.7

[1]Quality ratings were made using a scale of 1 through 9 with 1 representing best quality and 9 representing very poor quality.

A. 3. Kentucky bluegrass-perennial ryegrass mixtures.
A. J. Turgeon and Rich Burns.

Mixtures of Kentucky bluegrass and perennial ryegrass have been used to combine the advantages of rapid estalishment and persistence of the turf under a wide range of environmental conditions. A traditional concern over combining these species has been the potential domination of perennial ryegrass if seeded too heavily or if it comprises too much of the mixture by weight. The purpose of this study was to determine the effect of different percentages of perennial ryegrass, by seed weight, on the species composition of a mixed turf using two perennial ryegrass and two Kentucky bluegrass cultivars.

Four combinations of two Kentucky bluegrass (Fylking and A-34) and two perennial ryegrass (Citation and Pennfine) cultivars were planted in May, 1975. The perennial ryegrass component of each cultivar combination was 5, 10, 15, 20, 25 or 50 percent of the seed mixture, by weight. Plots measured 1.5 by 1.8 m and each seed mixture was replicated three times in a randomized complete block design. The seeding rate for all mixtures was 30 g/plot. Establishment and maintenance were as in A. After two years, two 5 by 5-cm plugs were extracted from all replications of plots planted with 5, 10, 15, 20, 25, and 50% perennial ryegrass, for determining the distribution of Kentucky bluegrass and perennial ryegrass by shoot counts.

Combinations of Kentucky bluegrass and perennial ryegrass at different percentages of seed weight yielded significantly different proportions of the two species in plots, depending upon the cultivars selected (Figure 1). A-34 Kentucky bluegrass was more competitive than Fylking, while Pennfine perennial ryegrass was more competitive than Citation. These differences are most striking at the five-percent level of perennial ryegrass in the seed mixtures; after three years, the Pennfine-Fylking mixture was nearly 50 percent perennial ryegrass based on shoot counts while the Citation-A-34 mixture was less than five percent.

Since the rapid germination and vigorous seedling growth of perennial ryegrass makes it desirable in seed mixtures for rapid soil cover, but undesirable where it becomes the dominant component of the turf, the selection of appropriate cultivars of these species is important in achieving the seemingly opposing objectives of rapid cover and a predominantly Kentucky bluegrass turf.

Turf quality generally decreased as the percent ryegrass increased (Table 5). This reflected the differential growth rate of the two species during cool weather, and the reduced quality of the perennial ryegrass during warmer periods.

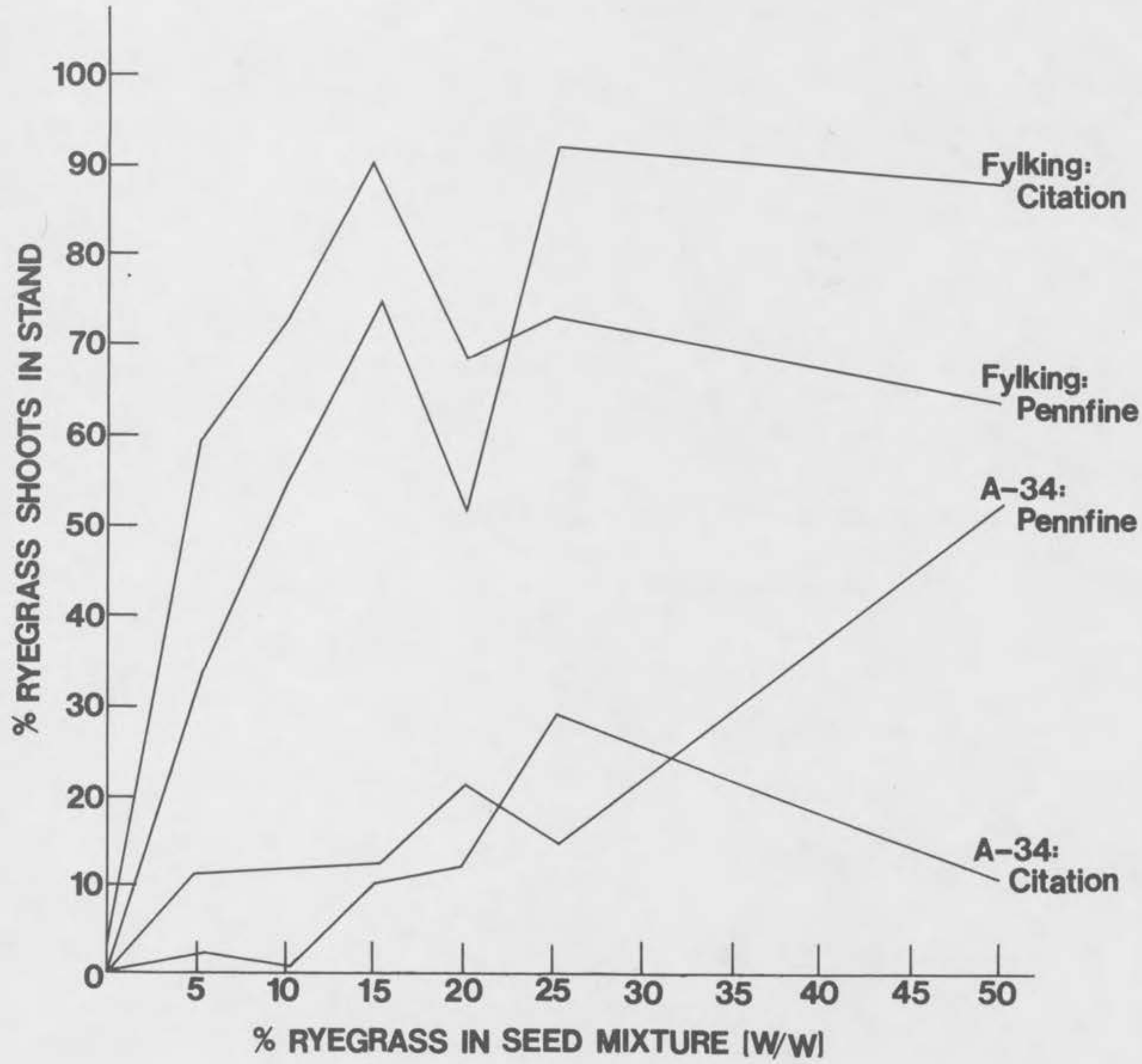

Figure 1. Effects of cultivars and percent ryegrass seed by weight on the ryegrass component in ryegrass-Kentucky bluegrass communities.

Table 5. Kentucky bluegrass-perennial ryegrass mixtures.

% Perennial Ryegrass in Seed Mixture		% Kentucky Bluegrass in Seed Mixture		Quality[1]			
				5/14	7/17	8/10	10/19
Pennfine	0	Fylking	100	3.7	2.7	2.7	2.3
	5		95	5.3	3.3	4.0	3.0
	10		90	5.3	3.7	3.7	4.0
	15		85	6.0	3.0	4.3	3.0
	20		80	5.3	3.7	4.0	3.7
	25		75	5.0	4.0	4.0	3.0
	50		50	5.3	4.3	5.0	3.0
Pennfine	0	A-34	100	3.7	3.0	3.0	2.0
	5		95	3.0	3.0	3.0	2.3
	10		90	3.7	3.0	3.0	2.7
	15		85	3.7	3.0	3.0	2.7
	20		80	4.0	3.0	3.0	2.3
	25		75	4.0	3.0	3.3	2.7
	50		50	4.7	3.0	3.0	2.7
Citation	0	Fylking	100	4.0	3.3	3.3	2.7
	5		95	5.0	3.3	4.3	3.3
	10		90	5.3	3.0	4.7	2.7
	15		85	5.0	3.0	4.7	2.7
	20		80	5.3	3.0	4.7	3.0
	25		75	5.7	3.3	4.7	3.3
	50		50	5.3	4.0	5.0	3.0
Citation	0	A-34	100	4.3	2.3	2.3	2.3
	5		95	3.0	2.3	2.3	2.3
	10		90	3.3	2.3	2.3	2.3
	15		85	3.3	2.3	2.7	2.3
	20		80	3.0	2.7	2.3	2.7
	25		75	3.7	2.7	3.0	2.0
	50		50	3.0	3.0	3.0	2.3

[1]Quality ratings were made using a scale of 1 through 9 with 1 representing best quality and 9 representing poor quality.

B. 2. b. Investigations of the edaphic properties of thatch and thatch-like derivatives in turf.
T. K. Danneberger and A. J. Turgeon

In situations of excessive thatch accumulation problems develop with regard to increased susceptibility of turf to inserts, disease, and environmental stresses. Some thatch is desirable though, in that it provides resiliency to the turf. The objectives of these studies were to determine the properties of pure thatch as a growing medium and how modification of the thatch layer by soil inclusion can change the measurable features of the resultant thatch-like derivatives.

Pure thatch was found to have a high cation exchange capacity (CEC) on a weight basis but a very low CEC on a volume basis (Table 6). The volume measurement is probably the more meaningful comparison since a turfgrass community grows in a volume of medium and not a weight of medium. The CEC of thatch was also found to be highly pH-dependent (Figure 2). Associated with an increase in pH, there was an increase in CEC.

Field studies were initiated on Penncross creeping bentgrass to determine the effect of soil inclusion on the thatch layer (Tables 7 and 8). Core cultivation and vertical mowing were the treatments done to incorporate soil into the thatch layer. Results showed thatch to have a lower pH and bulk density than the underlying soil but, by soil inclusion, the pH and bulk density increased. Regarding CEC, thatch was higher than the soil on a weight basis. As mentioned previously, the expression of CEC on a volume basis is more appropriate. Calculating CEC on a volume basis is readily done by multiplying CEC times bulk density. The inclusion of soil into the thatch layer increased CEC on a volume basis (CECBD). The term used to describe the mixing of thatch and soil is a "thatch-like derivative". It appears by core cultivation and vertical mowing a mixing of thatch and soil can be accomplished thus taking the desirable properties of each and providing a favorable growing medium for the turfgrass community.

Table 6. The cation exchange capacity of Kentucky bluegrass thatch as influenced by mechanical grinding using four extracting reagents.

Reagent	Sample[1]	CEC, me /100 g	CEC, me /100 cc
1N NH_4OAc	u	76.24	7.12
	g	79.67	7.52
1N BaOAc	u	58.12	5.41
	g	57.51	5.15
1N NaOAc	u	46.49	4.14
	g	47.64	4.11
1N CaOAc	u	42.94	3.87
	g	40.88	3.74

[1] u-unground-sample
g-ground-sample

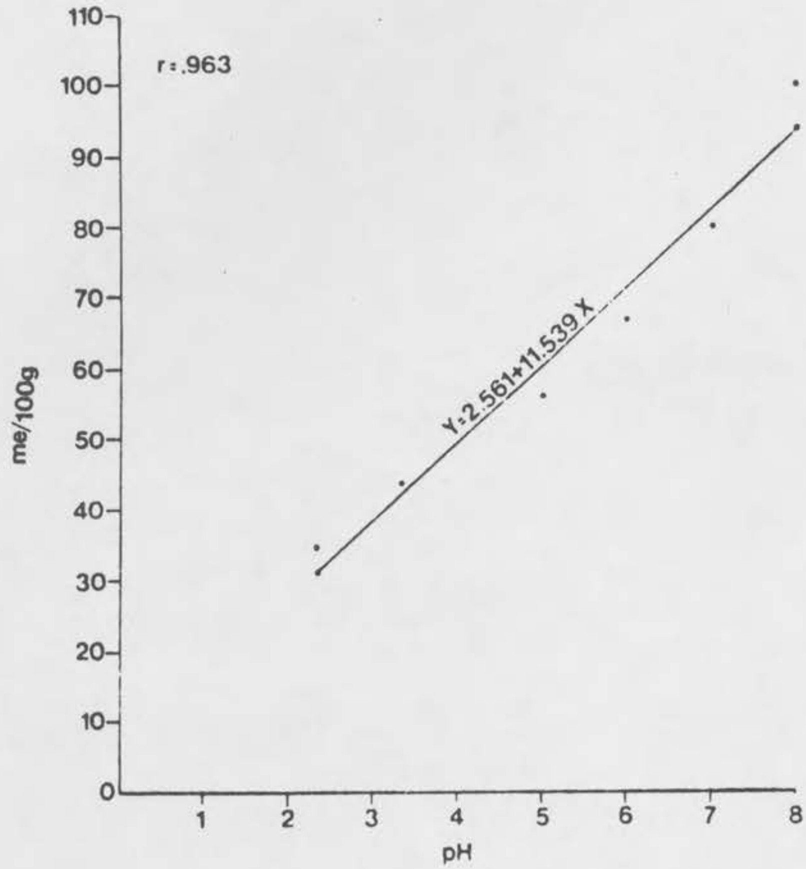

Figure 2. Influence of pH on the CEC of pure thatch from a Kentucky bluegrass turf.

Table 7. The effect of soil inclusion on seven different properties of thatch and thatch-like derivatives for September (1978)-treated 'Penncross' creeping bentgrass.

Treatment[1]	Turf Quality	Poa Annua %	pH	O.M. %	B.D. g/cc	CEC me/100g	CEC-BD me/100cc
untreated	1.0d[2]	0	6.27c	55.83a	.260h	63.10a	16.40e
ICC/RI	2.0d	2.0	6.40bc	28.50b	.320g	56.30ab	17.97de
3CC/NRI	4.0c	1.3	6.47b	27.27b	.410t	49.50bc	20.27be
3CC/RI	4.0c	2.0	6.53b	24.30b	.520d	40.80cd	21.17bcd
VM	5.3bc	10.7	6.57b	28.30b	.443ef	45.63bcd	20.17be
VM & ICC/RI	5.7b	16.7	6.50b	24.80b	.463e	41.77cd	19.33cde
VM & 3CC/NRI	6.3ab	15.0	6.47b	21.87b	.573c	39.80cd	22.63bc
VM & 3CC/RI	7.3a	15.0	6.77a	14.57c	.740b	33.03ed	24.43ab
Soil	___	___	6.90a	6.73d	1.200a	23.47e	28.17a

[1] cc=core cultivation; RI = reincorporated cores; NRI = cores removed; VM = vertical mowed.

[2] Means within columns followed by unlike letters are significantly different at 5% level by Duncans multiple range test.

Table 8. The effect of soil inclusion on seven different properties of thatch and thatch-like derivatives for April (1979)-treated 'Penncross' creeping bentgrass.

Treatment[1]	Turf Quality	Poa Annua %	pH	O.M. %	B.D. g/cc	CEC me/100g	CEC-BD me/100cc
untreated	1.0d[2]	6.3	6.20e	54.07a	.287e	59.60a	17.03d
ICC/NRI	1.0d	5.0	6.27e	49.43b	.353de	58.00a	20.50cd
ICC/RI	1.3d	11.0	6.30e	28.77d	.440d	53.10ab	22.70bc
3CC/NRI	2.3cd	9.0	6.27e	39.60c	.420d	50.10b	20.97bcd
3CC/RI	2.7c	18.3	6.57cd	25.50de	.650c	38.67c	25.13b
VM	3.3c	18.3	6.53d	26.40de	.570c	42.47c	23.87bc
VM+1CC/RI	6.0b	23.3	6.60cd	24.57de	.550c	41.47c	22.97bc
VM+3CC/NRI	6.7ab	25.0	6.67c	23.87e	.543c	42.73c	23.07bc
VVM+3CC/RI	8.0a	51.7	6.80b	17.30t	.843b	29.70d	25.00bc
Soil	___	___	6.97a	6.93g	1.187a	25.10d	29.77a

[1]cc= core cultivation; RI = reincorporated cores; NRI = cores removed; VM = vertical mowed.

[2]Means within columns followed by unlike letters are significantly different at 5% level by Duncans multiple range test.

C. 1. <u>Mulching mower study.</u>
J. E. Haley, A. J. Turgeon, and W. A. Torello

Conventional rotary mowers are typically used with a bagger to catch clippings and thus avoid the accumulation of leaf debris on the turf's surface with each mowing. In recent years, various "mulching" mowers have been introduced which by virtue of their closed housings, do not require a bagger. Clippings are repeatedly chopped and returned to the turf to recycle nitrogen and other nutrients. The primary objectives of this study are to determine the long-term influence of "mulching" mowing compared to conventional rotary mowing with and without clipping removal. Secondary objectives include: determination of the effects of mowing frequency and fertilization rate on annual clipping production and clipping quality (crude protein concentration, digestibility, and feeding quality in poultry); and determination of the influence of clippings on the nitrogen status of a Kentucky bluegrass turf.

The study was initiated on a one-year-old stand of 'Baron' Kentucky bluegrass in April, 1979. Main-plot treatments are: mowing at 5 cm with a mulching mower, or with a conventional rear-bagger rotary mower with and without clipping removal, at 1, 2, or 4 times per 2-week period. Subplot treatments are fertilization with 10-6-4 to supply 0, 3, or 6 lb. N per 1000 ft^2 per year in equal increments supplied in April, June, and September. Subplots measured 10 x 6 ft. and each treatment combination was replicated 3 times in a randomized complete block design.

Estimates of turf quality and seedhead production were first made on June 1, 1979 (Table 9). Seedheads were most numerous in plots mowed with the conventional mower with clippings removed. The plots mowed with the mulching mower had the fewest seedheads. Seedhead production was inversely related to mowing frequency; the fewest seedheads occurred in plots mowed once every two weeks. Increasing fertilization resulted in decreasing seedhead production. Comparing seedhead and turf quality data, a conclusion is that adequate fertilization in spring coupled with infrequent mowing and returned clippings results in the best turf quality and fewest seedheads.

Turf quality in July and August was significantly influenced by mowing frequency and fertilization rate. Generally, frequent mowing and increasing fertilization rate resulted in best quality. One casual observation was that, where clipping production was heavy, the mulching mower tended to produce unsightly clumps of clippings when turning while the conventional mower (clippings returned) did not. An important point of clarification is that the discharge chute of the Toro rear-bagger mower is closed off when the bagger is removed; thus, clippings are not discharged onto the turf but, rather, are contained within the housing for additional chopping.

Total clipping yield for the 1977 growing season increased in response to increasing nitrogen fertilization rate, (1.0 to 1.6 to 2.4 tons/acre from 0, 3, and 6 lb. N/M/yr, respectively) and decreasing mowing frequency (1.3 to 1.6 to 2.0 tons/acre from 2/wk, 1/2 wk, and 1/2 wk respectively) (Table 10). However, trends varied during the growing season, especially in response to mowing frequency.

Table 9. Comparison of the Toro mulching and conventional mowers on 'Baron' Kentucky bluegrass turf.

Treatment	Fusarium[2] 9/5	Seedheads[3] 6/1	Quality[4] 6/1	7/12	8/9	9/5	10/8
Mowing System[1]							
Mulching Mower	2.0	2.7	4.9	3.9	3.6	3.7	3.4
Conv. Mower C-Ret	1.5	4.0	3.6	3.4	3.0	3.1	3.3
Conv. Mower C-Rem	1.7	5.0	3.6	3.5	3.5	3.5	4.3
Mowing Frequency							
2/wk	1.8	5.3	4.2	3.3	2.9	3.3	3.4
1/wk	1.9	4.1	4.2	3.4	3.4	3.5	3.6
1/2 wk	1.4	2.3	3.7	4.1	3.8	3.5	3.9
Fertilization							
0 lb N/M/Yr	1.7	5.2	5.0	4.6	3.7	3.9	4.1
3 lb N/M/Yr	1.7	3.9	4.0	3.5	3.4	3.4	3.6
6 lb N/M/Yr	1.7	2.6	3.2	2.7	3.0	3.1	3.2

[1]Mowing systems include: 21" Toro Mulcher Deluxe; conventional 21" Toro Rear Bagger mower with clippings returned (C-Ret); and conventional mower with clippings removed (C-Rem).

[2]Fusarium ratings were made using a scale of 1 through 9 with 1 representing no apparent disease and 9 representing complete necrosis of the turf.

[3]Seedhead ratings were made using a scale of 1 through 9 with 1 representing no seedheads and 9 representing complete coverage of the plot area based upon visual estimates.

[4]Quality ratings were made using a scale of 1 through 9 with 1 representing excellent quality and 9 representing poor quality.

Table 10. Influence of nitrogen fertilization and mowing frequency on clipping yield from Baron Kentucky bluegrass turf.

Treatment	Date of Collection															
	5/10	5/24	6/7	6/22	7/5	7/19	8/3	8/16	8/31	9/7[1]	9/21	10/5	10/18	11/1	11/5[2]	Total
	(clipping dry weight, g.)															
Fertility Level (lb N/M/Yr)																
0	147.0	279.1	158	96.6	44.3	59.8	104.0	116.3	87.4	61.5	38.7	27.7	14.2	10.5	8.6	1253.6
3	235.0	389.9	196.5	130.9	119.6	161.6	205.5	163.3	117.8	78.8	47.4	35.6	17.9	37.4	22.3	1959.5
6	386.5	598.7	178.4	200.5	242.7	309.4	312.4	237.1	147.1	105.6	62.3	42.4	22.8	84.3	49.2	2979.4
Mowing Frequency																
2/wk	331.9	343.6	106.2	78.0	98.6	139.2	206.1	121.8	80.8	57.3	34.5	15.6	5.7	44.8	7.0	1671.1
1/wk	236.7	424.7	158.8	131.2	135.7	173.5	215.8	187.4	101.5	67.8	60.7	32.8	18.1	48.1	24.6	2017.4
1/2 wk	199.8	499.4	268.0	215.7	172.3	218.1	199.9	207.4	170.0	120.6	53.2	52.3	32.2	39.2	48.5	2496.6

[1] These numbers reflect one week's accumulation of turf clippings.

[2] Final mowing.

C. 1. Evaluation of growth retardants on Kentucky bluegrass.
T. C. Rogas, J. E. Haley, and A. J. Turgeon.

Chemical growth retardants are used on low maintainence turfs to reduce mowing requirements. This not only reduces labor and equipment costs but also reduces the danger of mowing in hazardous areas (i.e. steep slopes, along heavily trafficked highways). Their use has been limited in the past by inadequate control of vertical growth and by unacceptable phytotoxicity in treated turfs. Consequently, evaluations are conducted to find new materials that would reduce leaf growth without sacrificing color or density.

Several materials were applied to a mature stand of Kentucky bluegrass (Fylking-Pennstar-Prato blend), infested with a small population of annual bluegrass, on May 5, 1979. Embark was applied at 0.3 and 0.6 lb. a.i./acre. An experimental compound from the Eli Lilly Company, EL72500, was applied as a wettable powder and in granular formulation at rates of 0.5, 1.0, 1.5, 2.0 and 3.0 lb. a.i./acre. In addition, maleic hydrazide was applied at 4 lb. a.i./acre. Liquid formulations were applied with a CO_2-propelled back-pack sprayer at a spray volume of 28 gal/acre. Granular materials were applied by hand. Plot size was 5 x 6 ft., and each treatment was replicated three times. The turf had been mowed to the height 1.5 inches two days prior to treatment. The weather was unseasonably hot and dry throughout May and June. Embark most effectively reduced leaf growth, and inhibited seedhead formation (Table 11). It also proved to be the most phytotoxic to Kentucky bluegrass (Table 12). It is uncertain whether the phytotoxic effects were caused directly by the chemical or by reduced resistance to Helminthosporium melting out disease. EL72500 from Eli Lilly was less effective in controlling leaf growth, but less phytotoxic than Embark. There was no apparent difference between the wettable powder and granular formulations. In this study mallic hydrazide reduced leaf growth and inhibited seedhead development without any apparent loss in turf quality.

Table 11. Effects of chemical growth retardents on the top growth of a Kentucky bluegrass blend.

Treatment	Rate lb/A	Leaf Height 2	4	Weeks After Treatment 5	6	7	9	Seedhead Height 4	6
Embark 2 lb/gal	0.3	6.0	6.8	6.0	5.7	14.0	15.0	0	0
	0.6	6.3	6.5	6.5	6.0	13.0	14.3	0	0
El 72500 50WP	0.5	7.3	10.0	12.0	17.6	22.6	25.3	20.6	29.0
	1.0	7.6	9.5	10.3	13.6	17.0	22.6	19.3	27.0
	1.5	6.8	8.5	9.0	10.3	13.3	17.6	14.0	23.0
	2.0	7.8	8.2	8.5	8.0	9.3	13.6	11.3	17.0
	3.0	6.6	8.2	8.0	7.8	8.5	12.3	10.0	12.6
untreated		8.3	13.0	22.0	26.6	34.0	36.3	22.6	35.0
MH 2 lb/gal	4.0	7.2	7.6	11.0	14.3	16.0	18.3	11.6	17.3
EL 72500 1G	0.5	8.2	10.8	14.3	16.0	20.0	22.6	20.6	29.0
	1.0	7.3	9.7	12.8	13.0	18.7	20.6	16.0	28.0
	1.5	7.8	8.3	9.5	10.3	12.3	15.6	12.0	20.6
	2.0	7.6	9.6	10.6	11.0	11.6	15.3	10.5	20.3
	3.0	7.6	7.3	7.6	8.8	9.3	11.0	10.0	13.6

Table 12. Phytotoxic effects of chemical growth retardants on a Kentucky bluegrass blend.

Treatment	Rate	Kentucky Bluegrass Phytotoxicity[1]						Annual Bluegrass Phytotoxicity[1]				
		Weeks After Treatment										
	lb/A	2	4	5	6	7	9	4	5	6	7	9
Embark 2 lb ai/gal	.3	1.0	4.3	5.6	8.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	.6	1.0	4.6	6.3	7.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EL 72500 50 wp	.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.6	1.0	1.0	1.0	1.0
	1.5	1.0	1.6	2.0	1.3	1.0	1.0	3.3	3.0	3.0	1.0	1.0
	2.0	1.2	2.3	3.3	3.0	1.0	1.0	3.8	4.0	2.5	1.3	1.0
	3.0	1.3	3.0	3.6	3.3	2.0	1.3	3.8	4.0	3.0	1.0	1.0
untreated		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MH 2 lb ai/gal	4.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EL 72500 1G	.5	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.2	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.3	3.0	1.0	1.0
	1.5	1.0	1.0	1.0	1.3	1.0	1.0	2.0	2.0	2.0	1.0	1.0
	2.0	1.0	1.3	1.6	1.6	1.0	1.0	3.3	3.0	3.3	1.0	1.0
	3.0	1.0	1.6	2.3	3.0	1.3	1.3	3.5	3.3	4.1	1.0	1.0

[1] Phytotoxicity ratings are made on a scale of 1 through 9 with 1 representing no damage to the turf and 9 representing complete necrosis.

C. 3. Volatilization and leaching of nitrogen from various carriers applied to turf.

A. J. Turgeon, J. R. Street, J. E. Haley, and V. S. Batte

Previous work indicated that soluble (urea) and slowly soluble (IBDU) carriers differed in their susceptibility to leaching and volatilization losses from turf cores under laboratory conditions. The purpose of this study was to compare several slowly available nitrogen carriers, including IBDU, sulfur-coated urea (SCU), and two formulations of urea-formaldehyde (UF) with urea, under conditions similar to those used in previous work, to determine how much nitrogen leaching and volatilization would occur.

Turf cores composed of thatch (upper 1 inch) and Flanagan silt loam (lower 1 inch) were extracted from a Kentucky bluegrass lawn and placed in a specially designed apparatus constructed from plexiglass and porous ceramic plates to measure nitrogen leaching in the controlled environment chamber. Under continuous suction, the cores drained in a fashion similar to that expected in the field. Leachates from the cores were collected and analyzed daily for nitrogen.

Results showed that over 25 percent of the nitrogen applied as urea leached through the cores during the 15-day experiment (Table 13). This compared to about 14 percent leaching of the applied nitrogen as SCU, 13 percent from IBDU, and 2 percent from UF.

For the volatilization studies, turf cores were placed in glass chambers in which air flow carried ammonia (NH_3) gas from the cores to a trapping flask containing basic acid solution. Analysis of the trapping solution for nitrogen provided an accurate measure of nitrogen volatilization as NH_3 from the various nitrogen carriers. Results showed that, while approximately 25 percent of the urea nitrogen was lost through volatilization, only about 5 percent of the SCU nitrogen volatilized, and less than 1 percent of the nitrogen applied as IBDU or UF volatilized (Table 14).

These studies suggest that considerable amounts of nitrogen can be lost through leaching and volatilization from turf fertilized with urea, and that much of this loss can be reduced through the use of slowly available nitrogen carriers, especially UF and IBDU.

Table 13. Influence of nitrogen carrier on leaching of nitrogen through turf cores 15 days after treatment with 55.8 mg of actual nitrogen.

Nitrogen Carrier	Leachate Nitrogen	
	Inorganic	Total
Urea	14.9	15.9
SCU	10.4	9.5
IBDU	7.4	8.8
UF (Powder Blue)	1.7	2.4
UF (Blue Chip)	1.6	2.8
Untreated	1.3	1.6

Table 14. Influence of nitrogen carrier on volatilization of nitrogen from turf cores for 8 days following treatment with 55.8 mg of actual nitrogen.

Nitrogen Carrier	Days Following Treatment			
	2	5	8	Total
Urea	11.8	2.1	0	13.9
SCU	3.2	1.8	0	5.0
IBDU	0	0	0.5	0.5
UF (Powder Blue)	0	0	0.5	0.5
UF (Blue Chip)	0	0	0.7	0.7
Untreated	0	0	0	0

C. 3. Nitrogen fate studies in turf.
W. A. Torello and A. J. Turgeon.

A microecosystem has been developed to observe the fate of agricultural chemicals in closed, controlled environments, closely mimicking the natural system. These systems enable the researcher to develop a "balance sheet" for nitrogen, accounting for all avenues of N-loss within the system. It is well known that only 50% or less of applied N is taken up by the plant under most circumstances. Overemphasis has been placed upon leaching losses of NO_3, N-immobilization, and plant uptake after which the remainder of N-loss is assumed to be gaseous loss. The recent development of more sensitive analytical tools has renewed interest in directly measuring gaseous loss. These findings indicate that gaseous N-losses have been greatly underestimated and, in some cases, may be as high as 40% of the applied nitrogen. The newly developed microecosystems should enable quantitative recovery of applied N-losses through NO_3 leaching, ammonia volatilization, and denitrification as well as accounting for immobilized-N in the soil.

The turf microecosystem developed at the University of Illinois consists of a brass base fitted with a porous ceramic plate elevated 1/8 inch above the bottom to allow natural flow of leachate which will be vacuum pumped into a leachate flask for continuous N analysis. Water movement stimulated by the continuous suction closely approximates turf field conditions. Acetylene (C_2H_2) will be continuously flushed through the turf slab from perforated copper tubing placed directly under the turf. A 1.0 - 5.0% concentration of C_2H_2 in the soil will inhibit the reduction of N_2O to N_2 and thus allow complete trapping and quantitative analysis of gaseous N evolved through denitrification.

An atmospheric chamber constructed from plate glass and measuring approximately one cubic foot is placed on each brass base forming a tight seal. Holes drilled near its base allow air movement into the chamber and over the turf. Suction of 1 liter/min originating at the top of the chamber will pull out all incoming air as well as gaseous nitrogen effluxes from the turf slabs into various chemical traps to capture water vapor, CO_2, NH_3, and N_2O. Ammonia and N_2O evolving from the turf slab will be analyzed during every 24 hour period. Periodic sampling of thatch, underlying soil, and turf clippings will provide data on N-immobilization and N-uptake. Automatic irrigation is provided at predetermined frequencies to the systems through solid-cone irrigation nozzles positioned in the topmost portion of the chambers.

A total of six systems will be placed within a large controlled environment chamber so that temperature and light can be controlled for each experiment. The turf microecosystem represents a significant advance in systems for monitoring the fate of nitrogen as well as other agricultural chemicals.

Initial studies to determine nitrogen fate in turf will begin in January, 1980. Preliminary investigations using a more primitive but similar system were performed to determine % N-loss from turfgrass clippings.

Samples consisting of 15 Kentucky bluegrass clippings alone or mixed in soil were incubated under gas trapping chambers for 14 days. The chambers were continuously swept with ambient air into 3.0% boric acid to capture ammonia (NH_3). Results are shown in Table 15. Ammonia losses increased to a maximum at 10 days after which a slow decline was observed. Clippings mixed with soil exhibited lower N-losses (8.6%) compared to clippings placed on top of soil (24%). These results suggest that turfgrass clippings may not return all of their nitrogen to the soil, but may lose appreciable amounts to the atmosphere as ammonia and, possibly, other nitrogen-containing gases. Further analysis using the turf microecosystems should provide more insight into this problem.

Table 15. Evolution of ammonia (NH_3) from decomposing clippings taken from a Baron Kentucky bluegrass turf.[1]

Source	Incubations time, days						Total
	3	7	10	11	12	14	
	(mg nitrogen)						
Clippings above soil	3.48	12.35	18.83	4.56	5.48	2.29	46.99
Clippings/ soil mixture	0	2.24	10.23	0	0	4.35	16.82

[1]Kjeldahl analysis of the clippings revealed that they contained 5.3 percent nitrogen on a dry weight basis.

C. 3. Nitrogen Fertilizer Materials and Program Evaluation.
J. R. Street and A. Yust

Good turfgrass growth is dependent on an adequate supply of all essential elements, as well as on other environmental and cultural factors. Nitrogen is the essential element that receives the most attention in turfgrass fertilization programs. One reason for emphasis on nitrogen is that grasses give a good response to nitrogen fertilization. The behavior of nitrogen, both in the plant and in the soil, place it in the position of being the control element. Supplies of other elements are kept at adequate levels and the turf manager regulates growth by adding or withholding nitrogen.

A number of nitrogen-containing fertilizers are presently available on the market for turfgrass fertilization: water-soluble, slowly-soluble, and slow-release. These materials vary considerably in their chemical and physical properties. Slow-release products such as ureaformaldehyde (UF) and milorganite (natural organic) have been available for years. Others such as isobuylidene diurea (IBDU) and methylene ureas are newer, while sulfur-coated ureas are just now becoming important in the industry. Since slow-release and slowly-soluble nitrogen sources are important components of commercial turf fertilizers, it is important that performance of existing products versus new products are constantly monitored. Safety, efficiency, initial plant response, residual response, and cost among other factors are key considerations in developing and utilizing fertilizers and instituting fertilization programs.

The objectives of this study are to evaluate several slowly-soluble and slow-release nitrogen sources on a 'Baron' Kentucky bluegrass turf (Table 16). The Kentucky bluegrass area was planted in the spring, 1978 and treatments were initiated on May 2, 1979. Treatments consist of 15 nitrogen carriers or combinations applied at various rates and application frequencies. Each treatment was replicated three times with 5 x 6 ft plots in a completely randomized block design. Mowing is performed 2 or 3 times weekly at 1.5 in and clippings are returned. Irrigation is performed as needed to prevent wilt.

Fertilizer materials are evaluated on the basis of color and visual density ratings and plant height measurements at 2-week intervals during the growing season. Plant height measurements are made 3 to 4 days following mowing. All nitrogen fertilizers showed improved color and overall quality with Programs II and III compared to Program I, 3 to 4 weeks following initial applications (Table 17). With the second 1 lb N application under Program I (applied May 30), color and overall quality were comparable with Programs II and III with most nitrogen sources at 8 weeks. A higher initial application rate (i.e. 1 1/2-2 lbs. N/M) of IBDU and SCU (CIL, Lakeshore and TUA) appears to be necessary to produce a desirable early response. UF produced a low quality turf compared to other treatments throughout the spring and summer under Programs I and II. UF applied at the 4 lb N rate under Program III was comparable in quality to other treatments throughout the spring and summer periods. The poor response to low rates of UF supports the low recovery of nitrogen reported by other researchers during the initial years of UF usage.

The single spring application (4 lb N/M) showed a much greater growth response with all nitrogen sources as indicated by plant height measurements (Table 18). Urea and Scotts SCU produced the most rapid initial growth response. Only slight differences in plant growth response were evident between Programs I and II for most nitrogen sources.

All nitrogen fertilizers showed improved color and overall quality with Program I and II compared to Program III 2 weeks following the August applications (Table 17). Program II provided better quality than Program I until after the second 1 lb N application under Program I (October 1). Plant height measurements were greater for Program II compared to Program I. Program I and II showed superior quality to Program III for all fertilizer sources during the late summer-fall period.

Table 16. Nitrogen sources, rates, and application frequencies.

Fertilizer	Analysis	lb N/M	Application Dates
1. Scotts 1.9/1 Methylene Urea	39-0-0	1.0	April, May, Aug., Sept.
		2.0	April, August
		4.0	April
2. Hercules UF	38-0-0	"	April, May, Aug., Sept.
3. Milorganite	6-2-0	"	" " " "
4. Swifts IBDU Coarse	31-0-0	"	" " " "
5. Canadian Industries Limited - SCU	32-0-0	"	" " " "
6. Lakeshore SCU	36-0-0	"	" " " "
7. Lakeshore Fairway	28-3-9	"	" " " "
8. Scotts - SCU	38-0-0	"	" " " "
9. Urea	45-0-0	"	" " " "
10. Tennessee Valley Authority - SCU	36-0-0	"	" " " "
11. IBDU, TVA-SCU, Urea 24%, 57%, 19%	_____	"	" " " "
12. IBDU, CIL-SCU, Urea 37%, 43%, 20%	_____	"	" " " "
13. IBDU, TVA-SCU, Urea 39%, 40%, 20%	_____	"	" " " "
14. IBDU, CIL-SCU, Urea 22%, 60%, 18%	_____	"	" " " "
15. Urea Plus Extend	45-0-0	"	" " " "

Table 17. Color and density ratings for various nitrogen fertilizers on Kentucky bluegrass.[1]

Fertilizer	Program I, 1 lb N/M: April, May, August, September											
	Color									Density		
	5/16/79	5/28/79	6/25/79	7/13/79	7/28/79	8/12/79	9/7/79	9/26/79	10/31/79	5/16/79	7/13/79	9/7/79
Scotts 1.9/1 Methylene Urea	3.3	4.0	3.0	2.3	4.0	5.0	4.0	4.3	4.0	5.7	2.3	3.0
Swifts IBDU Coarse	4.7	4.7	3.7	1.7	2.0	3.3	4.3	4.6	4.0	5.7	1.7	3.7
Hercules UF	4.0	4.7	4.7	3.7	4.0	5.0	4.3	5.3	6.0	5.7	3.0	3.5
Milorganite	4.7	4.7	3.3	2.7	4.3	5.0	4.0	4.3	4.0	6.0	2.0	3.0
CIL - SCU	3.7	3.7	3.0	2.0	3.7	4.7	3.7	3.0	4.0	5.0	1.3	2.0
Lakeshore SCU	3.7	4.0	3.0	2.0	3.3	4.7	3.7	3.0	4.0	5.7	2.0	2.0
Lakeshore Fairway	3.7	4.0	3.0	2.0	2.7	4.7	3.7	3.0	4.0	5.3	2.0	2.0
Scotts SCU	3.0	3.3	2.3	2.0	4.0	5.0	3.7	3.3	4.0	4.7	1.7	3.0
Urea	3.0	3.0	3.0	2.0	4.0	4.7	3.7	4.3	4.0	5.0	2.0	2.7
TVA-SCU	3.7	4.0	3.0	2.0	3.7	5.0	3.5	3.0	4.0	5.3	2.0	3.7
IBDU 24%, TVA-SCU 57%, Urea 19%	3.7	4.0	2.7	2.0	3.3	4.7	4.0	3.0	4.0	5.0	2.0	2.0
IBDU 37%, CIL-SCU 43%, Urea 20%	3.7	4.0	3.0	2.0	3.7	4.7	3.7	4.0	4.3	5.3	2.0	2.0
IBDU 39%, TVA-SCU 40%, Urea 20%	4.0	4.7	3.0	2.0	3.3	4.7	4.0	3.3	4.0	5.0	2.0	2.3
IBDU 22%, CIL-SCU 60%, Urea 18%	4.0	4.0	3.0	2.0	3.3	4.0	4.0	3.0	4.0	5.0	1.7	2.0
Urea plus Extend	3.0	3.3	3.0	2.0	4.0	5.0	4.0	4.3	4.0	5.0	1.7	3.7
Check	5.0	5.7	6.0	5.7	5.3	5.0	5.0	6.0	7.0	5.7	5.0	4.7

[1] Color and density ratings were made on a scale of 1 through 9 with 1 representing best and 9 representing poorest. Fertilization dates were May 2 and May 30.

Table 17. (Continued) Color and density ratings for various nitrogen fertilizers on Kentucky bluegrass.[1]

Fertilizer	Program II 2 lb N/M											
	April					August					September	
	Color									Density		
	5/16/79	5/28/79	6/25/79	7/13/79	7/28/79	8/12/79	9/7/79	9/26/79	10/31/79	5/16/79	7/13/79	9/7/79
Scotts 1/9/1 Methylene Urea	3.0	3.0	3.3	3.0	5.0	5.0	3	3	5.0	5.0	2.3	2.7
Swifts IBDU	4.3	3.7	3.0	1.7	3.0	4.3	4.7	3.0	4.0	5.7	1.7	3.7
Hercules UF	4.0	4.0	4.3	5.0	5.0	5.0	4.3	5.6	6.0	5.0	3.0	3.5
Milorganite	4.0	4.0	3.3	3.0	4.7	5.0	3.0	3.0	4.6	5.7	3.0	3.3
CIL-SCU	2.7	2.7	3.0	2.7	4.7	5.0	3.0	2.0	4.0	5.0	1.7	2.0
Lakeshore SCU	3.0	2.7	3.0	2.7	4.0	5.0	3.0	2.0	4.0	5.0	2.0	2.3
Lakeshore Fairway	3.0	3.0	3.0	2.0	4.3	5.0	3.3	2.0	4.6	4.7	2.0	2.0
Scotts SCU	2.7	2.3	2.6	2.3	4.3	5.0	3.0	2.3	5.3	4.0	2.0	3.0
Urea	2.7	2.3	3.0	2.7	4.7	5.0	3.0	3.0	5.6	4.0	2.0	3.3
TVA-SCU	3.0	2.7	3.0	2.3	3.7	5.0	3.0	2.0	4.0	4.3	1.7	3.3
IBDU 24%, TVA-SCU 57% Urea 19%	3.3	3.0	2.7	2.0	4.0	5.0	3.0	2.3	4.0	5.0	2.3	2.5
IBDU 37%, CIL-SCU 43% Urea 20%	3.0	3.3	2.7	2.0	4.0	5.0	3.0	2.6	5.0	4.7	2.0	2.0
IBDU 39%, TVA-SCU 40% Urea 20%	3.7	3.3	3.0	2.3	3.3	5.0	3.3	2.0	4.0	4.3	2.0	2.3
IBDU 22%, CIL-SCU 60% Urea 18%	3.3	3.0	3.0	2.7	4.3	4.7	3.0	2.0	4.0	5.0	2.0	2.0
Urea plus Extend	2.0	2.0	3.0	2.0	4.3	5.0	3.0	3.0	5.0	4.0	2.0	3.3
Check	5.0	5.7	6.0	5.7	5.7	5.0	5.0	6.0	7.0	5.7	5.0	4.7

[1] Color and density ratings were made on a scale of 1 through 9 with 1 representing best and 9 representing poorest.

Table 17. (Continued) Color and density ratings for various nitrogen fertilizers on Kentucky bluegrass.[1]

Fertilizer	Program III 4 lb N/M April											
	Color									Density		
	5/16/79	5/28/79	6/25/79	7/13/79	7/28/79	8/12/79	9/7/79	9/26/79	10/31/79	5/16/79	7/13/79	9/7/79
Scotts 1.9/1 Methylene Urea	2.3	2.0	2.0	2.0	3.0	4.0	4.7	4.3	6.0	4.0	1.0	3.0
Swifts IBDU	4.0	3.3	2.0	1.7	2.0	3.3	3.7	3.6	4.6	5.3	1.0	3.3
Hercules UF	3.0	3.0	3.7	3.3	3.0	4.0	3.7	4.0	6.0	4.7	1.3	3.0
Milorganite	3.7	3.0	2.7	2.3	3.0	4.3	5.0	3.6	5.6	5.0	1.0	3.0
CIL-SCU	2.3	2.0	2.0	2.0	3.0	4.7	4.7	4.3	6.0	4.0	1.0	2.0
Lakeshore SCU	2.0	2.0	2.0	2.0	3.0	4.0	4.5	4.3	5.6	4.0	1.0	1.6
Lakeshore Fairway	2.0	2.0	2.0	2.0	3.0	4.0	4.7	4.3	5.6	3.7	1.3	2.3
Scotts SCU	2.0	2.0	2.3	2.0	3.0	4.0	4.7	4.0	6.0	3.3	1.3	3.7
Urea	2.0	2.0	2.0	2.0	3.0	4.0	4.7	4.6	6.0	3.0	1.0	3.3
TVA-SCU	2.0	2.0	2.0	2.0	3.0	4.0	4.7	4.3	6.0	3.7	1.3	4.0
IBDU 24%, TVA-SCU 57% Urea 19%	2.0	2.0	2.3	2.0	3.0	4.0	5.0	4.3	5.6	4.0	1.0	2.5
IBDU 37%, CIL-SCU 43% Urea 20%	2.0	2.3	2.0	2.0	3.0	4.0	4.7	4.6	5.6	4.0	1.0	3.5
IBDU 39%, TVA-SCU 40% Urea 20%	2.7	2.7	2.0	2.0	3.0	4.0	4.3	4.3	6.0	4.3	1.0	3.7
IBDU 22%, CIL-SCU 60% Urea 18%	2.3	2.3	2.0	2.0	3.0	4.0	4.0	4.0	5.6	4.0	1.0	4.0
Urea plus Extend	___	___	___	___	___	___	___	___	___	___	___	___
Check	5.0	5.7	6.0	5.7	5.3	5.0	5.0	6.0	7.0	5.3	4.7	4.3

[1]Color and density ratings were made on a scale of 1 through 9 with 1 representing best and 9 representing poorest.

Table 18. Plant height for various slowly-soluble and slow-release nitrogen fertilizers on Kentucky bluegrass.[1]

Fertilizer	Program I 1 lb N/M					Program II 2 lb N/M					Program III 4 lb N/M				
	5/21	6/18	7/16	8/6	10/2	5/21	6/18	7/16	8/6	10/2	5/21	6/18	7/16	8/6	10/2
Scotts 1.9/1 Methylene Urea	4.7	5.8	6.4	5.5	5.1	5.0	5.3	6.3	5.7	5.4	8.0	7.4	7.2	6.8	5.2
Swifts IBDU Coarse	4.3	5.5	6.7	6.3	4.8	4.4	5.7	6.5	5.8	6.0	5.1	6.8	6.1	6.4	5.4
Hercules UF	4.3	5.0	5.7	5.7	4.5	4.1	4.5	6.0	5.7	5.4	5.1	5.7	7.0	6.2	5.1
Milorganite	4.5	5.6	6.1	5.9	4.6	4.6	5.5	5.9	5.4	5.6	5.6	6.0	6.4	5.8	4.3
CIL-SCU	4.9	5.3	6.9	6.0	5.6	5.4	5.6	6.4	5.8	5.8	6.8	6.4	7.4	6.6	4.6
Lakeshore SCU	5.4	6.1	6.2	6.1	5.0	5.7	5.7	5.8	5.8	5.8	7.9	6.6	7.1	6.6	5.1
Lakeshore Fairway	5.0	6.9	5.6	5.7	5.0	6.0	6.4	6.4	5.7	5.6	8.1	7.6	7.0	6.5	4.6
Scotts SCU	6.2	6.6	5.9	5.8	4.4	7.7	6.8	5.9	5.5	5.3	8.4	7.4	7.7	6.5	5.8
Urea	6.9	6.7	6.4	6.3	5.0	6.9	7.2	7.2	5.7	5.3	8.9	7.9	7.5	6.2	5.3
IBDU 24%, TVA-SCU 57% Urea 19%	5.2	5.5	6.6	6.2	5.2	5.8	5.6	6.3	5.8	5.6	6.9	7.1	7.3	6.2	5.2
IBDU 37%, CIL-SCU 43% Urea 20%	5.3	6.1	7.3	5.7	4.9	5.4	5.8	6.3	5.5	5.6	7.8	6.9	7.3	7.0	4.8
IBDU 39%, TVA-SCU 40% Urea 20%	5.5	6.2	6.6	5.8	4.9	6.3	6.8	6.8	5.7	5.2	7.6	7.6	7.5	6.3	4.9
IBDU 22%, CIL-SCU 60% Urea 18%	6.1	6.4	6.8	5.3	5.4	5.9	6.9	6.9	6.0	5.6	7.5	7.3	7.3	7.0	5.0
TVA-SCU	5.6	6.5	6.8	6.3	4.8	7.1	7.1	7.1	5.6	6.2	7.3	7.6	6.7	6.3	5.8
Urea plus Extend	5.7	7.1	6.5	5.5	5.2	5.7	6.4	5.9	5.2	5.1	___	___	___	___	___
Check	4.2	4.9	4.8	5.7	3.6	4.3	4.9	5.2	5.2	3.9	4.4	4.2	5.2	5.9	3.7

[1]Plant height measurements are given in centimeters. Values taken 3 to 4 days following mowing.

C. 3. Putting green nitrogen fertility.
J. E. Haley, J. R. Street, and A. J. Turgeon.

In April 1976 a study was established to evaluate different nitrogen sources and rates of application on an established Penncross creeping bentgrass turf. The turf area was maintained at 0.25 in mowing height, received fungicide applications June through September, and was irrigated as needed. Plot size was 5 x 6 ft, and each treatment was replicated 3 times. Materials were applied by hand.

Quality varied with nitrogen source and the season (Table 19). Generally, the plots receiving ammonium sulfate were superior in color and density. Presumably, this reflects the response to the sulfur contained in this fertilizer. Incidence of annual bluegrass was appreciably higher in Milorganite-treated plots, possibly due to the substantial amounts of phosphorus (4 percent) contained in this product.

C. 3. Effect of nitrogen rate, form, and application method on Kentucky bluegrass.
J. R. Street

The predominant forms of nitrogen fertilizer utilized by the lawn care industry today are urea, ureaform, IBDU, and sulfur-coated urea. The most economical material strictly from a cost analysis standpoint is urea. The major disadvantages to soluble urea are high potential to burn, rapid growth surges following application, and short residual response resulting in loss of green color prior to follow-up applications. Slowly-available nitrogen sources are substituted to some extent in soluble sources by the lawn care industry to reduce the potential in some of these latter problems. A new nitrogen source, liquid slow-release (Formolene 25) is now available on the market which claims to exhibit slowly-available characteristics. In addition to nitrogen source, some concern also exists within the industry as to the merits of dry versus liquid application techniques. Thus, various nitrogen sources under liquid and/or dry application programs were evaluated for improving turfgrass growth and residual response.

Urea, ureaform, and Formolene 25 were applied under liquid and/or dry application techniques on a mature "Common-type" Kentucky bluegrass turf (Tables 20 and 21). Nitrogen rates were 1/2, 1, and 2 lb N per 1000 ft^2 for each nitrogen source. The Kentucky bluegrass area was maintained at 4 lb N/1000 ft^2 and a 1.5 in mowing height prior to initiation of treatments on September 1, 1979. Each treatment was replicated three times with 5 x 6 ft plots in a completely randomized block design. Mowing was performed once weekly at a 2 in height following initiation of treatments and clippings were removed. Clipping yield and quality ratings were taken for a total of 8 weeks. Clippings were taken at weekly intervals by making a single swatch across the center of each plot using a Scott's silent (push) mower. Foliar burn was evoluted several days after fertilization (9-5-79) and overall quality ratings were made at approximately weekly intervals. Liquid applications were made at the rate of 5 gallons of water per 1000 ft^2 using a CO_2-compressed air sprayer.

Table 19. Creeping bentgrass response to different nitrogen fertilizers.

Fertilizer	Rate[1] lb N/M	% Annual Bluegrass 5/18/79	Thatch depth (cm)	Quality[2] 5/18/79	Quality[2] 7/10/79	Quality[2] 11/2/79	P[1] (lb/A)	K (lb/A)	Ca (lb/A)	Mg (lb/A)
Ammonium Nitrate	1	4.7	1.8	3.3	3.0	2.7	52.3	278	4333.3	717.3
Ammonium Nitrate	1/2	1.3	1.9	3.3	3.7	4.0	73.3	308	4370.0	653.3
Urea	1	7.0	2.2	3.7	3.0	2.3	66.0	286	4793.3	738.3
Urea	1/2	2.3	2.0	3.3	3.7	3.3	75.3	256.7	4543.3	674.7
Ammonium Sulfate	1	2.7	2.1	3.3	2.3	2.3	56.3	248.0	4230.0	689.0
UF	1	3.7	1.8	3.7	3.0	4.3	61.7	275.3	4403.3	703
IBDU	1	10	2.0	4.3	2.7	4.0	49.7	253.7	4300.0	674.7
Milorganite	1	20	2.3	5.0	2.3	5.0	108.3	309.7	4436.7	717
UF + Urea	1/2 + 1/2	7.3	2.0	3.7	3.0	3.0	72.7	234.3	4543.3	688.7
UF + Urea	1/4 + 1/4	3.0	1.9	4.3	4.0	4.3	77.7	298.0	4720.0	703

[1]Fertilizer applications made four times annually in May, June, August and September.

[2]Quality ratings were made on a scale of 1 through 9 with 1 representing the best and 9 representing the poorest.

Table 20. Effect of liquid and dry fertilization on quality and foliar burn of Kentucky bluegrass.

Fertilizer Treatment	Rate lb N/M	Foliar Burn[1]	Quality[2]							
			9/5	9/11	9/19	9/25	10/3	10/13	10/23	10/31
Urea, liquid	1/2	1	2.6	4.2	4.3	4.7	4.7	5.7	6.3	7.3
	1	1	2	3.0	3.3	3.3	3.7	5.0	5.3	7.0
Formolene 25	2	3.3	2	2.0	2.3	2.3	3	4.0	4.0	6.0
	1/2	1	2.6	4.0	4.0	4.7	4.3	6.0	6.6	7.3
	1	1	2.2	3.0	3.0	3.0	3.3	5.3	5.3	7.3
	2	4	2.2	2.0	2.0	2.0	2.3	4.0	4.0	5.6
Urea, dry	1/2	1	3.0	4.0	4.0	4.0	4.0	6.0	6.0	7.6
	1	1	2.0	3.0	3.0	3.0	3.0	5.0	5.0	7.0
	2	4	2.0	1.3	2.0	2.0	2.3	4.0	4.0	6.0
	1/2	1	5.6	5.7	5.7	5.7	5.3	6.3	7.0	8.0
	1	1	5.0	5.0	5.0	5.0	4.3	6.0	6.3	7.6
	2	1	3.3	4.0	4.0	4.0	3.7	5.3	5.0	6.6
UF, powder (liquid)	1/2	1	5.0	5.3	5.3	5.3	4.7	6.0	7.0	7.6
	1	1	5.0	4.3	4.3	4.7	4.6	5.7	6.3	7.6
	2	1	2.8	3.0	3.0	3.0	3.0	4.7	4.3	5.6
Untreated		1	5.8	5.9	5.9	5.9	5.4	6.6	7.0	7.8

[1]Foliar burn was measured using a scale of 1 through 9 with 1 representing no injury and 9 representing complete necrosis of the plot.

[2]Quality was rated using a scale of 1 through 9 with 1 representing the best and 9 representing the poorest.

Table 21. Effect of liquid and dry fertilization on clipping yield of Kentucky bluegrass.

Fertilizer Treatment	Rate lb N/M	Clipping yield[1]								
		9/13	9/19	9/25	10/3	10/9	10/17	10/24	10/31	Total
		(g dry wt/plot)								
Urea, liquid	1/2	16.0	6.6	8.7	7.4	3.6	2.0	2.0	.21	46.51
	1	23.6	11.7	10.6	10.9	4.7	2.6	2.7	.56	76.36
	2	28.1	15.8	14.2	14.9	6.5	3.8	4.0	.69	87.99
Formolene	1/2	15.8	5.6	7.3	5.9	2.9	1.8	1.6	.45	41.35
	1	25.4	9.5	9.6	7.0	4.1	2.5	2.5	.53	61.13
	2	26.8	17.0	16.8	18.2	6.7	4.6	4.6	.80	95.5
Urea, dry	1/2	17.2	7.9	8.5	8.0	3.2	4.0	2.4	.29	51.49
	1	26.0	11.1	11.3	10.3	5.8	3.0	3.3	.47	71.27
	2	30.3	47.4	15.9	15.9	7.8	4.4	4.0	.56	126.26
UF, dry	1/2	10.0	4.7	5.8	5.0	2.2	1.8	1.7	.32	31.52
	1	10.8	5.5	6.1	5.7	2.7	2.0	1.9	.29	34.99
	2	14.2	6.9	7.3	6.8	4.7	2.4	2.3	.30	59.10
UF, liquid	1/2	11.8	5.5	6.3	7.7	3.0	2.0	1.7	.36	38.36
	1	12.5	5.0	6.8	6.2	3.7	1.8	1.8	.32	38.12
	2	20.3	9.1	10.4	10.9	5.3	3.4	3.4	.65	63.45
Untreated		9.7	4.8	4.8	5.5	2.7	1.7	1.8	.24	31.24

[1]Clipping yield is based on one complete swath across the center of each plot with a Scott's silent mower.

Foliar burn was moderate where the fertilizer treatment consisted of 2 lb N/1000 ft^2 as urea (dry application), urea (liquid application), and Formolene 25. Turfgrass quality was usually higher and residual response was longer at the higher nitrogen rates. Urea and Formolene 25 at the 1/2 lb N rates provided acceptable quality for only 14-20 days following application. These same sources provided acceptable quality for 5-6 weeks at the 1 lb N/1000 ft^2 rates. Initial color response was similar to urea (dry application), urea (liquid application) and Formolene 25. Ureaform (powder or blue chip) provided quality comparable to the lower rates of Formolene or urea. Turfgrass quality ratings indicate a better response from powder blue than blue chip.

Clipping yield was greater as nitrogen fertilizer rates increased for all nitrogen sources. All urea and Formolene 25 treatments outyielded all ureaform treatments at equivalent rates. Little difference was apparent in seasonal clipping yield of urea compared to Formolene 25. Clipping yield of ureaform (powder blue or blue chip) was only slightly greater than the untreated plots suggesting a rather low recovery during the initial year of use.

C. 3. <u>Effect of liquid and dry applications of several nitrogen fertilizers on quality and growth of Kentucky bluegrass</u>.
J. R. Street.

A number of nitrogen-containing fertilizers are presently available on the market for turfgrass fertilization including: water-soluble, slowly soluble, and slow-release. These materials vary considerably in their chemical and physical properties. Slowly soluble products such as urea-formaldehyde (UF) and milorganite have been available for many years. Others, such as isobutylidene diurea (IBDU) and methylene ureas are newer, while sulfur-coated urea (SCU) and liquid slow-release nitrogen are just now becoming important in the industry. For lawn care, some of these products can be applied via bath liquid and dry application techniques, whereas others like sulfur-coated urea are limited to only dry application. There have been some questions raised as to the advantages of liquid versus dry applications of nitrogen fertilizer. The purpose of this study was to evaluate the performance of several nitrogen fertilizers applied at various application rates in liquid or dry form on Kentucky bluegrass.

The study was initiated on a one-year-old stand of 'Baron' Kentucky bluegrass on May 29, 1979. Temperature was 87-89° when treatments were applied and no irrigation was performed until 3 days following treatment. Liquid applications were made using a water volume of 5 gallons per 1000 ft^2. Nitrogen was applied at 1,2 and 4 lbs. per 1000 ft^2 for each nitrogen source. Each treatment was replicated 3 times in a randomized complete block design. Foliar burn was evaluated several days after fertilization (6-1-79) and overall quality ratings were made at approximately 2 week intervals for 12 weeks. Clipping yield was taken at weekly intervals by making a single swath across each plot using a reel mower with catcher.

Kentucky bluegrass quality and clipping yield are provided in Table 22 and 23. Fertilizer burn under these conditions was moderate to severe from liquid urea, urea + Extend (liq.), and Formolene 25. The burn caused considerable foliar discoloration, but almost complete recovery was evident within 7-10 days after treatment. Urea (granular application) and ureaform (liquid application) did not cause any noticeable burn. Kentucky bluegrass quality and clipping yield were higher with urea (dry application) and Formolene 25 than with urea (liquid application) at the 1 lb N rate. UF produced a low quality turf compared to the other treatments at the 1 and 2 lb. N rates. Higher rates of all the nitrogen sources usually resulted in higher quality ratings and clipping yield. The poor performance of urea (liquid application) relative to Formolene 25 may be due to greater leaching and volatilization losses of nitrogen from urea. Volatilization losses have been shown to be a significant pathway for potential loss of nitrogen from granular, surface applied urea in previous studies by Nelson, Turgeon and Street (M.S. thesis, University of Illinois, 1978).

C. 5. Soilless sod on sand and silt loam.
A. J. Turgeon.

One of the presumed advantages of soilless (washed) sod is the elimination of the potentially troublesome interface effect that results where the soil carried with the sod (muck) differs substantially in its physical properties from the underlying medium at the transplant site. Spomer and Turgeon (vertical soil water retention is newly sodded, drained turfgrass sites. Commun. in Soil Sci. and Plant Anal. 8:417-423, 1977) reported substantially higher water retention in the muck and silty clay loam sod-soil layers than in the underlying sand medium 48 hours following irrigation. These differentials in surface and subsurface moisture can adversely affect initial rooting and subsequent turfgrass growth.

Field studies by Turgeon (comparative advantages of soilless sod for Kentucky bluegrass propagation. Rasen Gruflachen Bergrunungen 8:13-15, 1977) showed that soilless sod roots faster than conventional sod under moderate temperatures, but is more prone to desiccation under conditions of high-temperature stress. Where sand and silt loam media were both tested, rooting was more rapid in the sand as long as desiccation did not occur. In another study, Turgeon, Berns, and Warren (A mechanized washing system for generating soilless sod. Agronomy Journal 70:349-350, 1978) reported that reductions in sod strength of 'A-20' Kentucky bluegrass accompanying successive washings were due to the addition of moisture rather than from the removal of soil. Thoroughly washed sod (4 times) was comparable in sod strength when dry to dry, unwashed sod. When saturated, however, both washed and unwashed sod had significantly lower sod strengths.

The current field study was initiated in September, 1976, to determine the long-term results from the use of soilless and conventional sods of muck-grown 'A-20' Kentucky bluegrass planted on silt loam and sand media. Observations to date indicate that: (1) irrigation and fertilization requirements of both sod types (especially soilless) are considerably greater on sand compared to silt loam soil; (2) thatching tendency was greater on sand than on soil, presumably due to the abundance of earthworms and other organisms within the soil and their relatively low numbers or absence in sand; and (3) core cultivation is less effective in sand than in soil for cycling the

Table 22. Effect of liquid fertilization on quality of Kentucky bluegrass.

Fertilizer Treatment	Rate lb N/M	Fertilizer[1] burn 6/1	Quality[2] 6/17	6/26	7/13	7/31	8/12	9/7
Urea, dry	1	1.0	2.8	3.5	3.8	4.7	4.7	5.0
	2	1.0	2.0	3.0	3.0	4.0	3.7	5.7
	4	1.0	2.0	2.0	2.0	3.0	3.0	5.0
Urea, liquid	1	2	3.6	3.6	5.0	5.0	4.7	5.3
	2	3	2.6	2.6	3.3	4.0	4.3	5.0
	4	6.3	2.0	2.0	2.0	3.0	3.0	5.0
Urea & Extend	1	2.6	2.6	3.6	4.6	5.0	5.0	5.0
	2	4.3	2.0	3.0	3.0	4.0	4.0	5.0
	4	7.0	2.0	2.0	2.0	3.0	3.0	5.0
Ureaform	1	1.0	5.0	4.6	5.3	5.2	5.0	5.0
	2	1.0	3.6	4.0	3.6	4.2	4.0	5.0
	4	1.0	3.0	3.3	3.0	3.0	3.0	5.0
Formolene 25	1	2.6	3.0	3.3	3.8	4.5	4.5	5.0
	2	4.3	2.3	3.0	3.0	4.0	4.0	5.0
	4	6.6	2.0	2.0	2.0	3.0	3.0	5.0
Untreated		1.0	7.0	7.0	7.0	6.0	6.0	6.0

[1]Foliar burn was measured using a scale of 1 through 9 with 1 representing no injury and 9 representing complete necrosis of the plot.

[2]Quality was rated using a scale of 1 through 9 with 1 representing the best and 9 representing the poorest.

Table 23. Effect of liquid fertilization on clipping yield of Kentucky bluegrass.

Fertilizer Treatment	Rate lb N/M	Clipping yield[1] grams dry wt./plot								
		6/11	6/19	6/26	7/3	7/10	7/17	7/27	8/3	8/14
Urea, dry	1	26.3	23.7	9.5	21.7	16.3	19.3	30.2	18.4	14.6
	2	32.0	29.9	17.9	24.6	22.4	21.7	25.6	16.6	14.1
	4	34.7	38.6	26.6	45.1	31.7	33.2	38.2	23.0	14.2
Urea, liquid	1	14.9	14.6	9.2	15.6	11.1	15.7	16.5	12.5	8.3
	2	17.5	21.7	13.9	20.2	15.9	17.5	27.2	14.7	11.8
	4	30.6	37.5	25.5	45.4	33.1	32.8	38.1	22.5	16.4
Urea & Extend	1	23.9	18.3	11.7	18.8	13.7	18.2	23.5	14.9	11.1
	2	31.3	31.2	20.2	30.0	23.0	19.8	27.7	17.4	13.3
	4	29.1	38.4	31.9	51.2	39.4	38.8	44.4	26.7	17.3
Ureaform	1	8.6	8.2	6.9	12.3	9.5	11.6	16.5	7.9	9.0
	2	10.8	16.0	9.7	20.0	21.3	18.7	24.5	18.2	13.1
	4	24.1	26.6	18.3	34.0	31.2	35.5	48.6	30.7	20.8
Formolene 25	1	31.2	24.7	17.1	28.0	20.4	17.3	26.6	16.5	14.4
	2	21.4	23.3	17.2	25.6	19.0	23.2	26.5	16.8	11.4
	4	27.5	33.4	25.2	44.7	34.7	32.4	36.7	24.4	19.1
Untreated		8.7	8.0	6.0	4.1	3.1	5.4	6.5	4.9	4.7

[1] Clipping yield based on one complete swath across each plot with a Scott's silent mower. All clippings were removed from plots.

media underlying the sod for incorporation into the thatch layer. Thus, where sod is planted to a sand base, sand topdressing may be necessary to fully integrate the sod and subsequently developed thatch into the sand medium.

C. 6. Kentucky bluegrass cultivar management.
J. E. Haley and A. J. Turgeon.

Twenty-one cultivars of Kentucky bluegrass were planted in 15 replicate plots in September, 1974. Twelve replications of the cultivars were planted in the northwest section of the OHRC turfgrass experimental site and 3 replications were located north of the east west road leading into OHRC. In 1975, five different cultural intensities were imposed so that 3 replications of each cultivar were maintained under one of the following programs: 0.75-in mowing with 4 lb. N/1000 sq. ft. /yr, 0.75-in mowing with 8 lb N/1000 sq. ft./yr, 1.5-in mowing with 4 lb N/1000 sq. ft./yr., 1.5-in mowing with 8 lb N/1000 sq ft./yr and 3-in mowing with 116 N/1000 sq ft./yr. In the spring of 1979 the replications at 3-in mowing with 1 lb N/1000 sq ft./yr were discontinued. On the remaining replications mowing was performed 2 or 3 times per week at 0.75 or 1.5 in. Fertilization was performed in 1 or 2 lb N increments in April, May, August and September. Irrigation was performed as needed to prevent wilting. Plots measured 5 by 6 ft and cultivars within cultural level were arranged in a randomized complete block design.

Consistent with reports from observations made during the previous growing seasons, three of the cultivars (Brunswick, A-34, Touchdown) sustained at the highest cultural intensity (mowing at 0.75 in; 8 lb N/M/Yr) have resisted invasion by annual bluegrass while nearly all of the other cultivar plots had converted to predominantly annual bluegrass (Table 24).

Incidence of dollar spot disease was associated with nitrogen fertilization levels. The plots maintained at 4 lb N/1000 sq. ft./yr showed more evidence of the disease than did the plots receiving 8 lb N/1000 sq ft./yr.

General quality of the turf varied with cultivar, time of year, fertilization rate, mowing height and amount of annual bluegrass within the plot. It is clear that the cultivars vary widely in their adaptation to different cultural intensities. Most of the cultivars performed well at the intermediate intensity of culture (1.5 in mowing height; 4 lb N/M/yr) which is characteristic of lawn turf.

Table 24. Kentucky bluegrass cultivar management study.

Cultivar	Cultural[1] Intensity	Annual bluegrass% 4/16	Dollar Spot[2] 7/30	Quality[3] 5/18	7/5	8/10	10/23
A-20	M .75, F4	13.3	2.7	4.3	4.0	4.7	4.3
	M .75, F8	45.0	1.7	4.7	3.7	6.0	6.0
	M 1.5 , F4	2.3	1.0	4.0	3.3	2.3	3.7
	M 1.5 , F8	8.0	1.7	5.3	3.3	4.0	3.7
A-34	M .75, F4	8.3	3.0	4.0	3.7	4.3	3.7
	M .75, F8	14	1.3	5.3	3.0	4.7	4.0
	M 1.5 , F4	1.7	1.7	2.7	3.3	2.7	2.7
	M 1.5 , F8	5.0	1.3	4.3	3.0	4.0	3.3
Adelphi	M .75, F4	11.7	3.3	5.0	6.0	6.0	5.5
	M .75, F8	46.7	1.7	5.7	4.0	6.0	5.3
	M 1.5 , F4	5.7	1.7	4.3	4.0	3.3	4.7
	M 1.5 , F8	11.7	1.0	5.3	4.3	4.0	5.7
Aquilla	M .75, F4	10.0	3.7	5.0	4.7	5.3	5.0
	M .75, F8	51.7	1.3	4.7	4.3	7.7	6.3
	M 1.5 , F4	1.7	2.0	4.0	4.3	3.3	3.7
	M 1.5 , F8	8.3	1.3	5.3	3.3	3.5	5.7
Baron	M .75, F4	10.0	2.7	4.3	4.0	5.3	5.3
	M .75, F8	65.0	1.3	5.0	4.0	8.0	6.3
	M 1.5 , F4	2.3	1.7	4.0	3.7	3.3	3.3
	M 1.5 , F8	12.3	1.0	4.7	3.3	4.3	5.7
Birka	M .75, F4	10.0	3.0	4.7	4.0	5.7	4.0
	M .75, F8	41.7	1.7	5.3	4.0	7.0	6.0
	M 1.5 , F4	0	1.3	3.3	3.7	3.3	3.7
	M 1.5 , F8	1.7	1.0	4.3	3.0	3.7	3.7

Table 24. Kentucky bluegrass cultivar management study. (continued)

Cultivar	Cultural[1] Intensity	Annual bluegrass% 4/16	Dollar Spot[2] 7/30	Quality[3] 5/18	7/5	8/10	10/23
Bonnieblue	M .75, F4	11.7	2.7	5.0	4.3	4.7	4.0
	M .75, F8	35.0	1.7	5.0	4.3	7.3	4.7
	M 1.5 , F4	1.3	1.7	4.0	4.3	3.7	3.7
	M 1.5 , F8	7.3	1.0	5.0	4.0	4.7	4.5
Brunswick	M .75, F4	4.0	2.0	4.0	2.7	3.0	2.7
	M .75, F8	20.0	1.0	4.7	2.7	5.0	2.7
	M 1.5 , F4	0.7	1.3	2.3	3.0	2.7	2.3
	M 1.5 , F8	3.3	1.3	4.0	2.3	3.0	2.0
Cheri	M .75, F4	23.3	2.7	5.0	3.7	5.0	5.0
	M .75, F8	48.3	1.3	5.0	4.3	7.3	6.7
	M 1.5 , F4	2.3	1.3	4.0	4.0	3.0	3.7
	M 1.5 , F8	9.0	1.0	4.3	4.0	4.3	4.3
Code 95	M .75, F4	30.0	2.7	5.0	4.7	5.7	6.0
	M .75, F8	2.0	2.0	5.3	3.7	7.3	7.7
	M 1.5 , F4	0	1.0	5.7	4.3	3.7	3.7
	M 1.5 , F8	6.7	1.0	5.7	4.3	3.7	6.3
Glade	M .75, F4	4	2.7	4.3	3.7	5.0	4.0
	M .75, F8	28.3	1.0	5.0	4.0	6.7	6.3
	M 1.5 , F4	0	1.0	3.3	3.3	2.7	3.0
	M 1.5 , F8	1.3	1.0	4.0	3.0	3.0	3.0
Rugby	M .75, F4	21.6	4.0	5.0	5.0	6.3	5.5
	M .75, F8	66.7	1.7	5.0	4.7	7.3	6.7
	M 1.5 , F4	1.7	1.0	3.3	4.3	3.3	3.7
	M 1.5 , F8	4.0	1.0	4.7	3.7	3.7	4.0

Table 24. Kentucky bluegrass cultivar management study. (continued)

Cultivar	Cultural[1] Intensity	Annual bluegrass% 4/16	Dollar Spot[2] 7/30	Quality[3] 5/18	7/5	8/10	10/23
Majestic	M .75, F4	33.3	3.7	5.5	5.0	6.7	7.0
	M .75, F8	51.7	2.0	5.0	4.3	7.0	7.3
	M 1.5 , F4	7.3	2.0	5.3	6.0	5.5	4.0
	M 1.5 , F8	19.0	1.3	5.3	4.7	4.7	5.3
Merion	M .75, F4	39.5	2.3	5.3	5.3	4.0	5.5
	M .75, F8	43.3	2.0	5.3	4.3	7.0	6.7
	M 1.5 , F4	0.7	1.0	4.3	4.0	2.5	3.5
	M 1.5 , F8	5.3	1.3	5.0	3.7	3.7	4.7
Nugget	M .75, F4	8.3	3.3	4.7	4.0	5.0	4.3
	M .75, F8	76.7	2.0	4.7	4.0	7.7	6.3
	M 1.5 , F4	3.3	3.7	5.0	3.7	5.3	4.0
	M 1.5 , F8	5.0	1.0	4.3	3.3	4.3	4.0
Touchdown	M .75, F4	0.7	2.3	3.7	3.0	4.3	2.7
	M .75, F8	16.7	1.3	5.7	3.3	5.3	3.0
	M 1.5 , F4	0	1.7	3.0	3.3	3.0	2.3
	M 1.5 , F8	2.7	1.0	4.3	3.0	3.3	3.0
Yorktown	M .75, F4	16.7	5.3	6.0	5.0	7.3	5.3
	M .75, F8	46.7	1.6	6.0	4.7	8.0	6.0
	M 1.5 , F4	5.0	4.0	6.0	6.3	7.3	4.3
	M 1.5 , F8	12.3	1.0	6.0	5.3	7.7	5.0
Parade	M .75, F4	21.7	2.7	5.0	3.0	5.0	3.0
	M .75, F8	58.3	1.3	5.3	4.3	6.7	6.7
	M 1.5 , F4	3.7	1.3	4.7	4.5	3.0	2.5
	M 1.5 , F8	2.0	1.0	5.0	3.5	4.5	4.0

Table 24. Kentucky bluegrass cultivar management study. (continued)

Cultivar	Cultural[1] Intensity	Annual bluegrass% 4/16	Dollar Spot[2] 7/30	Quality[3]			
				5/18	7/5	8/10	10/23
Pennstar	M .75, F4	30.0	3.7	5.0	5.0	6.0	5.0
	M .75, F8	87.7	2.3	5.0	5.0	7.0	6.7
	M 1.5 , F4	2.3	2.0	4.3	5.3	4.0	4.0
	M 1.5 , F8	9.0	1.0	5.7	4.3	5.5	5.3
Sydsport	M .75, F4	7.3	1.7	4.3	3.7	4.3	4.0
	M .75, F8	58.3	1.7	5.3	3.7	7.0	6.0
	M 1.5 , F4	1.7	1.3	3.3	3.3	3.3	3.7
	M 1.5 , F8	8.3	1.3	5.0	3.7	4.3	4.7
Vantage	M .75, F4	50.0	3.3	5.5	5.0	6.0	6.5
	M .75, F8	60.0	1.7	5.0	4.7	7.0	7.3
	M 1.5 , F4	8.3	2.0	5.3	5.3	4.5	4.7
	M 1.5 , F8	15.0	1.0	5.0	4.0	4.5	6.5
Victa	M .75, F4	10.0	3.7	4.3	3.0	5.0	4.7
	M .75, F8	53.3	1.3	5.3	4.3	7.7	7.0
	M 1.5 , F4	5.0	2.0	3.3	3.3	3.7	3.3
	M 1.5 , F8	8.3	1.0	4.7	3.3	4.7	4.7

[1] Cultural intensities: mowing at 0.75 in (M .75) and 1.5 in (M 1.5); fertilization with 10-6-4 to supply an annual total of 4 lb N/1000 sq ft (F4), or 8 lb N/1000 sq ft (F8), with equal increments applied in April, May, August and September.

[2] Disease ratings were made using a scale of 1 through 9 with 1 representing no disease and 9 representing complete necrosis of the turf.

[3] Quality ratings were made using a scale of 1 through 9, with 1 representing perfect quality and 9 representing very poor quality.

C. 6. Annual bluegrass cultural studies.
A. J. Turgeon and J. E. Haley.

Many intensively cultured golf turfs have substantial populations of annual bluegrass mixed with other cool-season turfgrasses. In some cases, the fairway turfgrass is predominantly, or exclusively, annual bluegrass. Yet, research emphasis has always been on "controlling" annual bluegrass while attempting to increase populations of other "desired" turfgrass species. Recently, J. M. Vargas at Michigan State University determined that the decline of annual bluegrass during midsummer stress periods was due, at least in some instances, to anthracnose disease, and that an effective fungicide application program plus adequate nitrogen fertilization were important for sustaining annual bluegrass during stress periods. The purpose of these studies is to determine how several cultural variables, including fertilization and fungicide treatments, influence the quality and disease susceptibility of annual bluegrass turf.

The first experiment was arranged in a split-plot design with fungicide treatment (weekly rotation of Tersan 1991 @ 1 oz/M and Daconil 2787 @ 3 oz/M versus no fungicides) as the main plots, and nitrogen (urea) - potassium (KCl) fertilization treatments as the subplots. The second experiment was organized the same way except that subplot treatments were different levels of phosphorus fertilization with a uniform treatment of urea (3 lb. N/M/yr) and KCl (1.5 lb K_2O/M/yr) across the plot area. The third experiment involved applications of several fertilizer materials at different rates to annual bluegrass receiving the weekly Tersan 1991-Daconil 2787 fungicide rotation. In all experiments, plots measured 6 x 5 ft. with three replications per treatment. Mowing was performed three times per week at 0.75 in. and the turf was irrigated as needed to prevent wilting.

Results to date indicate that the fungicide program is essential for sustaining the annual bluegrass at an acceptable level of quality (Table 25). Deterioration of the plots not receiving fungicides appeared to be due to climatic stress as the typical anthracnose disease symptoms were not always evident. There was some indication that the nitrogen-treated plots were better than the unfertilized plots; however, no consistent beneficial effect from potassium fertilization has been observed to date. The phosphorus fertilization experiment has not shown any difference among phosphorus treatments to date but, as in the first experiment, fungicide treatment clearly resulted in superior turfgrass quality (Table 26). Some differences among fertilizer materials were evident in experiment 3; Country Club 18-5-9 has generally resulted in slightly better turf during the summer months, but results are rather inconclusive at this time (Table 27). These experiments will be continued through 1980, and additional field studies are planned.

Table 25. Effects of different nitrogen and potassium fertilization levels on the quality of an annual bluegrass turf sustained with and without weekly fungicide treatments.[1]

Treatment	Rate lb/M/Yr	Fungicide[2]								No Fungicide[2]							
	N or K_2O	4/5	5/17	6/28	7/17	8/13	8/23	9/24	10/19	4/5	5/17	6/28	7/17	8/13	8/23	9/24	10/19
Urea	3	4.0	4.7	4.7	2.7	2.7	2.3	2.7	2.0	3.7	5.0	4.3	3.3	4.3	4.0	4.3	2.0
Urea + K	3 + 1.5	4.0	4.7	4.3	3.0	2.3	2.3	3.0	2.0	4.0	4.7	4.3	3.3	5.0	3.7	4.0	2.3
Urea + K	3 + 3	3.7	4.7	5.0	3.3	2.7	2.7	2.7	1.7	4.0	4.3	4.7	3.7	4.0	3.0	4.3	2.3
Urea	6	3.3	5.0	5.0	2.3	3.3	3.0	2.3	1.0	3.0	6.3	4.0	2.3	5.7	4.3	3.3	1.3
Urea + K	6 + 3	3.3	5.7	4.7	2.0	3.0	2.3	2.7	1.0	4.0	5.3	3.7	2.3	5.3	4.7	3.3	1.0
Urea + K	6 + 6	3.3	6.0	4.7	2.0	4.0	3.7	3.0	1.0	3.3	5.7	3.3	2.3	6.0	5.0	4.0	1.3
K		5.7	5.3	6.3	4.7	3.7	4.0	4.0	4.0	5.0	5.3	6.0	5.3	5.3	4.7	5.3	4.7
Untreated		5.0	4.7	6.3	4.3	3.3	3.7	4.0	4.0	5.3	5.7	6.3	5.3	5.0	4.7	5.0	5.0

[1]Quality ratings were made using a scale of 1 to 9 with 1 representing best quality and 9 representing poor quality.

[2]Fungicide treatments included a weekly rotation of Tersan 1991 @ 2 oz/M and Daconil @ 3 oz/M.

Table 26. Effects of phosphorous fertilization levels on the quality of an annual bluegrass turf with and without weekly fungicide treatments.[1]

Treatment	Rate lb/M/Yr	Fungicide[2]								No Fungicide							
		4/5	5/17	6/28	7/17	8/13	8/23	9/24	10/19	4/5	5/17	6/28	7/17	8/13	8/23	9/24	10/19
0-46-0	1	5.0	4.8	6.3	4.3	3.0	3.0	4.0	3.0	4.3	5.5	6.3	5.5	4.5	4.3	4.8	3.3
0-46-0	2	4.5	4.5	6.0	4.8	3.3	3.3	4.5	3.0	5.5	6.5	5.8	5.3	5.5	4.5	5.3	4.0
0-46-0	4	5.3	5.0	6.3	4.8	4.0	3.5	4.3	3.5	5.0	6.3	6.8	6.0	5.5	4.8	5.3	4.0
Control	0	4.5	4.5	6.3	4.3	4.0	3.5	4.3	3.3	5.0	6.3	6.3	5.5	4.8	4.8	4.8	3.8

[1]Quality ratings were made using a scale of 1 to 9 with 1 representing best quality and 9 representing poor quality.

[2]Fungicide treatments included a weekly rotation of Tersan 1991 @ 2 oz/M and Daconil @ 3 oz/M.

Table 27. Effects of different nitrogen fertilizer carriers on the quality of an annual bluegrass turf.[1]

Fertilizer	Rate lb N/M/Yr	Quality 4/16	5/15	6/28	7/17	8/10	9/19	10/18
IBDU	3.0	3.3	4.0	5.7	2.3	5.3	5.7	4.0
IBDU	6.0	2.0	4.3	4.3	2.0	6.3	4.0	1.7
UF	3.0	4.7	4.0	5.3	3.0	5.0	5.0	3.7
UF	6.0	4.7	4.0	5.3	2.3	5.3	3.7	2.0
SCU 32-0-0	3.0	4.7	4.0	5.7	3.0	5.3	5.3	3.0
SCU 32-0-0	6.0	2.7	5.7	6.0	2.3	5.0	4.3	1.0
Urea	3.0	3.7	5.0	5.3	3.0	5.3	5.3	3.0
Urea	6.0	2.0	5.7	4.3	3.0	5.0	3.7	1.0
Urea	2.0	5.0	4.7	5.3	4.0	5.0	4.3	3.7
Urea	4.0	3.0	5.7	4.7	3.0	5.3	4.0	2.0
SCU 20-5-10	2.0	4.7	3.3	6.3	3.3	5.0	4.3	3.3
SCU 20-5-10	4.0	3.7	4.7	5.7	3.0	5.3	4.3	2.0
Milorganite	2.0	5.3	4.0	6.0	3.0	4.7	5.7	4.0
Milorganite	4.0	4.0	3.7	5.3	2.7	5.3	4.7	3.0
Country Club	2.0	4.7	4.7	4.3	3.0	3.3	4.7	3.7
Country Club 18-5-9	4.0	4.0	4.0	4.3	3.0	4.0	3.7	3.0
Par Ex 27-3-9	2.0	4.7	3.7	5.3	3.0	4.0	4.3	3.7
Untreated	0	5.0	4.7	5.0	5.0	4.0	5.3	6.0

[1]Quality ratings were made using a scale of 1 to 9 with 1 representing best quality and 9 representing poor quality.

D. 1. b. <u>Development of Microecosystems for studying the fate of pesticides in turf.</u>
B. E. Branham and A. J. Turgeon.

Microecosystems have been shown to be effective in measuring the biological fate of pesticides in the environment. Radioactive compounds can be employed which allow a balance sheet approach to pesticide fate. Metabolites which have been volatilized, leached or degraded can be easily measured.

The Turf Microecosystem developed at the University of Illinois consists of a media base, atmospheric chamber, automatic irrigation, analytical trapping devices, thermocouples and a data logger for continuous environmental monitoring. The media base is constructed of brass and includes a 1/2" thick porous ceramic plate supporting a turf slab measuring 12 x 12 x 12 (l x w x d) inches. A drainage tube connects the 1/8-inch free space beneath the filter to a leachate flask, and to a vacuum pump. Under continuous suction, water movement thru the turf slab will approximate that occurring in field turf. Periodic sampling of the turf slab followed by sectioning and analysis will enable us to monitor the movement and metabolism of topically applied pesticides over time.

The atmospheric chamber, constructed from plate glass and measuring approximately 1.2 cubic feet, sits atop the media base. Holes drilled near its base and at the top allow air movement into and out of the chamber. A 3/8" teflon tube brings the airstream out of the chamber and through a $CaSO_4$ trap to remove any water vapor in the airstream. A flowmeter is used to measure and regulate the volume of air leaving the chamber.

The analytical trapping system consists of a U-tube immersed in a dewar cold trap and two bubblers filled with sodium hydroxide solution. The U-tube will condense any volatilized pesticide or its metabolites while the bubblers will trap any CO_2 released from complete metabolism of the pesticide. Each microecosystem has two analytical trapping systems to allow continuous monitoring without interruption for sampling. Thermocouples positioned within the microecosystem continuously monitor soil and air temperatures. All thermocouples are connected to a Fluke 2240B datalogger for measurement and recording of temperature and moisture data.

Four systems will be placed inside a large growth chamber to provide environmental control. Initial studies to determine the fate of Dacthal and other preemergence herbicides will begin in January, 1980.

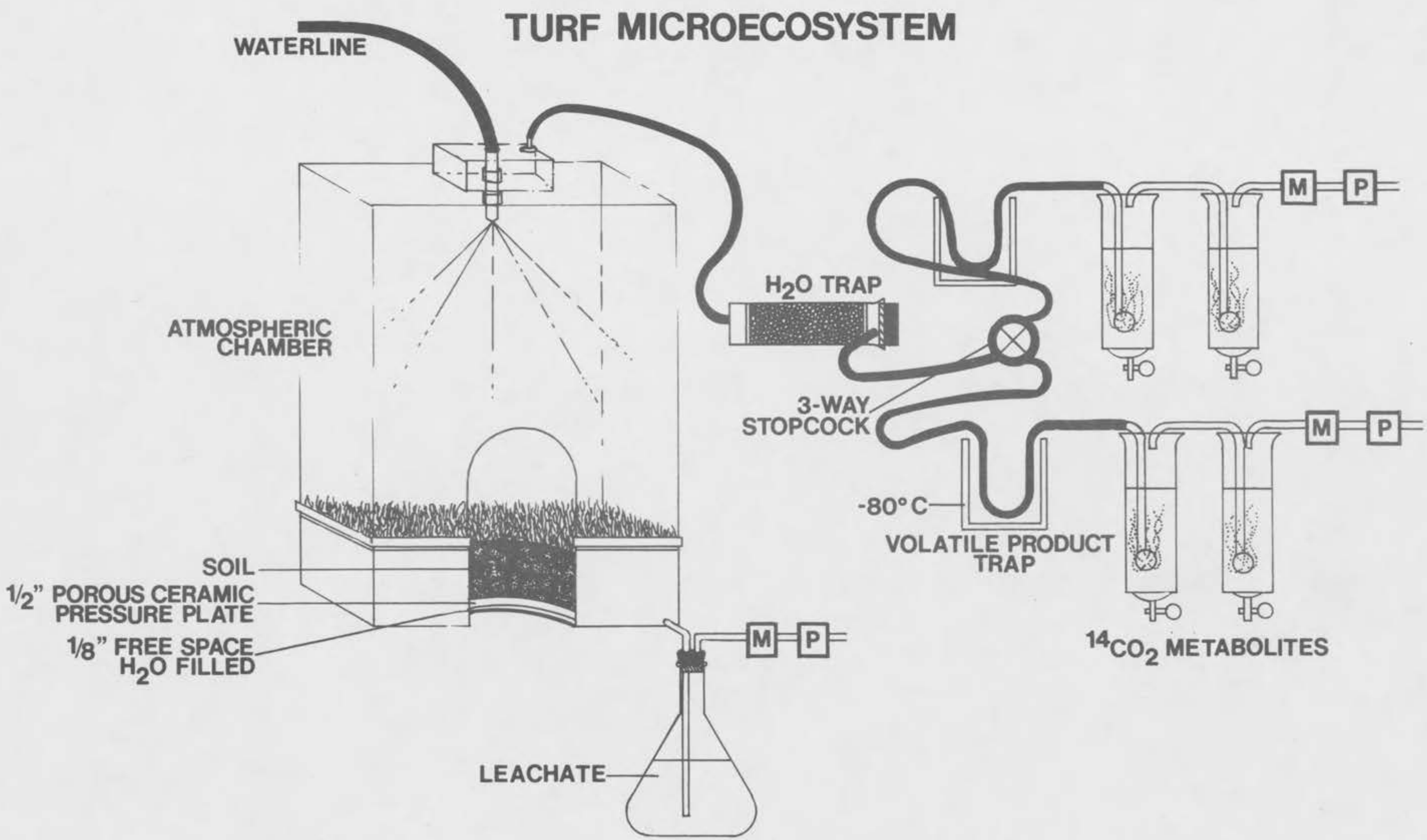

Figure 3. Illustration of the Turf microecosystem developed at the University of Illinois.

D. 1. c. Preemergence crabgrass herbicide evaluation.
J. E. Haley and A. J. Turgeon.

Preemergence herbicides were applied May 9, 1979 to an established Kentucky bluegrass turf that had been spiked and overseeded with crabgrass. Three commercially available materials were evaluated. Dacthal 75 WP and Dacthal 5 G were applied at rates of 10.5 lb ai/acre and 10.5 lb ai/acre with a later application of 7.5 lb ai/acre six weeks later. Pre San EC (formulation 4 lb ai/gal) and Pre San 7 G were applied at rates of 7.5 lb ai/acre, 11.25 lb ai/acre, and 7.5 lb ai/acre with a second a second application of 7.5 lb ai/acre made six weeks later. Treatments of Balan 2.5G were made of 2 lb ai/acre and 2 lb ai/acre with a second treatment six weeks later of 2 lb ai/acre. Granular formulations were applied by hand. Liquid formulations were made with a CO_2-propelled back-pack sprayer (spray volume 28 gal/acre). Plot size was 5 x 6 ft, and treatments were replicated three times.

Granulars generally exhibited less control than liquid formulations (Table 28). Generally, a lower percentage of crabgrass was found in plots receiving a second application of herbicide six weeks after the first application. No phytotoxic effects in Kentucky bluegrass were apparent in any of the herbicide treatments.

Table 28. Efficiency of preemergence herbicides applied to Kentucky bluegrass for crabgrass control.

Material	Rate lb/A	8/23	9/5	9/25	10/9
Dacthal 75 WP	10.5	2.0	2.0	2.0	2.0
Dacthal 75 WP	10.5 + 7.5[1]	0	5.0	3.0	0
Dacthal 5 G	10.5	5.0	14.0	17.0	5.0
Dacthal 5 G	10.5 + 7.5	0	1.0	1.0	0
Pre San EC	7.5	2.0	5.0	7.0	0
Pre San EC	11.25	1.0	5.0	3.0	0
Pre San EC	7.5 + 7.5	0	0	1.0	0
Pre San 7 G	7.5	1.0	6.0	5.0	4.0
Pre San 7 G	11.25	1.0	1.0	1.0	2.0
Pre San 7 G	7.5 + 7.5	0	0	1.0	0
Balan 2.5 G	2	5.0	10.0	12.0	7.0
Balan 2.5 G	2 + 2	1.0	1.0	1.0	0
Check		15.0	20.0	25.0	25.0

[1] Second application was made approximately 6 weeks after the first.

D. 1. c. Effects of irrigation and mowing height on the efficacy of preemergence herbicides for annual grass control in Kentucky bluegrass.
B. E. Branham and A. J. Turgeon.

In the second year of this study, data were obtained on both crabgrass and annual bluegrass invasion. On September 3, 1978 and September 10, 1979, the plot area was overseeded with annual bluegrass at a rate of 0.25 lb/1000 sq. ft. The herbicides - DCPA, benefin and bensulide - were applied to 4 x 8 ft plots in the granular form at the standard rates of 12, 3, and 10 lbs ai/acre, respectively, on May 1, 1978, September 4, 1978, May 8, 1979, and September 4, 1979. The area was overseeded with crabgrass at a rate of 0.5 lb/1000 sq. ft. on May 15, 1978, June 16, 1978 and May 1, 1979. Seven irrigation schedules, and mowing heights of 1.5 and 0.75 inches, were selected with each treatment combination being replicated three times.

Data on annual bluegrass invasion showed that this species was adequately controlled in the 1.5-in plots with only trace amounts occurring in any of the herbicide-treated plots (Table 29). In the untreated plots, annual bluegrass populations ranged from 1 percent in unirrigated, 1.5-inch-mowed turf, to 40 percent in 0.75-inch-mowed turf receiving light, daily irrigations.

This year the climate has not been as favorable for crabgrass germination and growth as last year. This fact has led to some interesting differences in the efficacy of the herbicides between 1978 and 1979. Benefin, which last year exhibited the least control, gave excellent control this year; the most crabgrass in any benefin-treated plot was 18.7 percent (Table 30). This was quite different from last year's results which showed crabgrass populations of up to 80 percent in some benefin-treated plots. In contrast, bensulide did not provide the same high level of control this year as it did in 1978. DCPA showed better control this year with a maximum crabgrass invasion of 36.7 percent, compared to 76 percent last year. Manufacturers of DCPA and benefin both recommend a supplemental application in late May if crabgrass pressure is severe.

These results clearly shows that, regardless of the herbicide selected, better annual grass control is obtained with less frequent irrigation and higher mowing heights.

Table 29. Effect of mowing height and irrigation regime on the percent annual bluegrass cover in overseeded Kentucky bluegrass turf.

Irrigation Treatment	Mowing Height, in. 1.5 in.				.75 in.			
	Herbicide Treatment							
	Benefin	DCPA	Bensulide	Untreated	Benefin	DCPA	Bensulide	Untreated
	May 31, 1979							
.02 in/day	1.0	1.0	1.0	8.3	3.0	5.3	4.3	40.0
.04 in/day	1.0	1.0	1.0	3.0	1.7	4.3	3.0	25.0
.08 in/day	1.0	1.0	1.0	1.7	1.3	1.7	1.7	18.3
.14 in/3.5 days	1.0	1.0	1.0	6.0	2.7	3.7	2.0	33.3
.29 in/7 days	1.0	1.0	1.0	3.7	1.7	4.0	1.0	31.7
.59 in/14 days	1.0	1.0	1.0	3.3	1.7	3.7	1.0	18.3
Unirrigated	1.0	1.0	1.0	1.0	1.0	1.0	1.0	9.0

Table 30. Effect of mowing height and irrigation regime on the percent crabgrass cover in overseeded Kentucky bluegrass turf.

Irrigation Treatment	Mowing Height, in. — 1.5 in.				.75 in.			
	Herbicide Treatment							
	Benefin	DCPA	Bensulide	Untreated	Benefin	DCPA	Bensulide	Untreated
				July 23, 1979				
.02 in/day	1.0	1.0	1.0	21.6	1.7	4.0	1.7	33.3
.04 in/day	1.0	1.0	1.7	18.3	1.0	4.0	1.7	30.0
.08 in/day	1.0	1.0	1.7	16.7	1.0	5.3	1.0	31.7
.14 in/3.5 days	1.0	1.0	1.0	5.3	1.0	1.7	1.0	11.7
.29 in/7 days	1.0	1.0	1.0	8.3	1.0	1.0	1.0	28.3
.59 in/14 days	1.0	1.0	1.7	5.3	1.0	1.0	1.0	10.0
Unirrigated	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3
				August 8, 1979				
.02 in/day	1.0	5.3	1.0	40.0	2.3	15	4.0	66.6
.04 in/day	1.0	2.3	5.3	43.3	2.3	13.3	8.6	65.0
.08 in/day	1.0	1.0	4.0	33.3	2.3	16.6	12.0	68.3
.14 in/3.5 days	1.0	2.3	1.0	26.6	2.3	10.0	4.0	43.3
.29 in/7 days	1.0	1.0	1.0	40.0	1.0	6.3	1.0	60.0
.59 in/14 days	1.0	3.0	1.0	21.6	1.0	3.6	1.0	40.0
Unirrigated	1.0	2.3	1.0	12.0	1.0	4.6	1.0	25.0

Table 30. (continued)

Irrigation Treatment	Mowing Height, in. / Herbicide Treatment							
	1.5 in.				.75 in.			
	Benefin	DCPA	Bensulide	Untreated	Benefin	DCPA	Bensulide	Untreated
	August 22, 1979							
.02 in/day	1.0	11.7	2.3	50.0	5.7	23.3	8.3	73.3
.04 in/day	1.0	4.3	13.3	55.0	2.3	21.7	18.3	70.0
.08 in/day	1.0	5.0	10.7	40.0	2.3	21.7	21.7	80.0
.14 in/3.5 days	1.0	4.3	1.7	33.3	3.0	13.3	1.7	51.7
.29 in/7 days	1.0	4.0	2.3	31.7	2.3	13.3	3.7	68.3
.59 in/14 days	1.0	3.7	1.0	23.3	1.0	10	2.3	41.7
Unirrigated	1.0	1.0	1.0	15.3	1.0	5.3	1.0	16.7
	September 22, 1979							
.02 in/day	2.3	21.7	8.3	56.7	18.3	36.7	21.7	81.7
.04 in/day	1.0	15.0	33.3	66.7	7.7	33.3	46.7	76.7
.08 in/day	3.7	10.0	28.3	65.0	7.3	33.3	43.3	83.3
.14 in/3.5 days	1.0	15.0	4.0	31.7	4.7	25.0	4.7	71.7
.29 in/7 days	1.0	11.7	11.7	46.7	2.3	23.3	10.0	76.7
.59 in/14 days	1.0	10.0	3.0	38.3	3.7	21.7	3.7	55.0
Unirrigated	1.0	10.3	1.0	25.0	1.0	18.7	1.0	30.0

D. 1. c. Controlled-release preemergence herbicide formulations for annual grass control in Kentucky bluegrass.
David Chalmers and A. J. Turgeon.

Results from past field studies with controlled-release herbicide formulations suggested that some of these materials can provide effective control of crabgrass while reducing the potential for phytotoxicity to Kentucky bluegrass. These results are dependent upon the herbicide release rate, under field conditions, that is sufficient to control target weed species, but not so fast that marginally safe herbicides cause injury to desired turfgrasses. Controlling the bio-available concentration of a pesticide also acts in controlling those avenues through which biologically active herbicides can lose effectiveness (such as spray drift, volatilization, leaching, sorption by organic matter as well as chemical, photo-chemical, and microbial degradation).

Formulations used for these studies were provided by USDA formulation chemist B. Shaska, from the Northern Regional Research Center in Peoria. The control-release carrier under study (starch xanthide) is a granular material formed from cornstarch. The starch xanthide formulation physically encapsulates the pesticide within a granular porous matrix; release is due to diffusion through the pores and decomposition of the starch matrix.

The 1979 studies include a continuation of the 1978 studies where three preemergence herbicides (benefin, oxadiazon, and prosulfalin) were encapsulated within three formulations of starch xanthide of varying release properties (fast, medium, and slow). The resulting granules were screened to separate them into three mesh sizes, including 14-20 mesh (coarse), 20-40 mesh (medium), and 40-60 mesh (fine). Three new control-release studies were initiated in 1979, concentrating on only one herbicide (benefin). These studies included: a) a comparison of relative performance of different starch xanthide-benefin formulations; b) evaluation of different combinations of starch xanthide (SX) and commercial formulations (CF) of benefin; and c) evaluation of the requirements of a control-release preemergence herbicide system in Kentucky bluegrass turf using varying CF application sequences of benefin.

Plots measured 6 x 10 ft for the medium-textured sx granules and commercial formulations. The fine and coarse-textured sx granules were applied to 6 x 5 ft plots as were those studies initiated in 1979. Each treatment plus control were replicated three times in a randomized complete block design. The turf was a Kenblue-type Kentucky bluegrass maintained at a mowing height of 1.5 inches, fertilized with a 10-6-4 ($N:P_2O_5:K_2O$) water-soluble fertilizer and irrigated as needed to prevent wilting of the untreated (control plots). The plot area was overseeded 3 times with 0.5 lb crabgrass seed per 1000 sq. ft. to ensure weed pressure. The herbicide formulations were applied to all studies on May 5, 1979. The multiple herbicide studies received 3 lb. a.i./acre while the benefin only studies received 4 lb. a.i./acre. The benefin-sx formulation study also received a 2 lb. a.i./acre rate. One-half of the 10 x 6 ft. plots received a second application of herbicides on August 30, 1979 when annual bluegrass was overseeded. Data were collected periodically during the season to evaluate phytotoxicity to the turfgrass and weed control.

Results from all benefin-treated plots did not vary appreciably in phytotoxicity while being most severe for prosulfalin formulations. (Tables 31 and 32). Comparison of phytotoxicity data for varying mesh sizes of SX formulations indicated finer textured granules release faster than the coarser textured granules. Crabgrass control did not appear to correlate with projected controlled-release properties, but did appear to be influenced by particle size and type of encapsulated herbicide. Control using encapsulated benefin and prosulfalin appeared greatest when the finer particle size was used regardless of formulation. Oxadiazon formulations in the same study exhibited a response that varied with both particle size and formulation.

Comparison of six SX formulations of benefin showed greater crabgrass control at 4 lb a.i./acre than at 2 lb a.i./acre (Table 33). SX-benefin formulations differed slightly in their control of crabgrass from preemergence applications but results did not agree with predicted release characteristics.

Benefin (commercial formulation) applied at various rates and frequencies in an effort to simulate a controlled-release system in the field, provided excellent crabgrass control for all treatments (Table 34). Insufficient crabgrass pressure in 1979 probably accounts for the lack of substantial differences in control observed in this study.

Combinations of SX and CF formulations of benefin, as well as the SX formulation alone, showed a slight advantage over identical quantities of CF alone (Table 35). Also, higher rates of the herbicide provided generally better crabgrass control. Otherwise, very small differences were observed from this year's field trials.

In future research, experiments will be conducted to study factors affecting herbicide release rates of the herbicide from the SX granule. Studies will include the use of radiolabeled benefin to determine the influence of temperature, moisture, microbial populations, and herbicidal properties on herbicide release.

Current research also includes micromorphological investigations to determine relationships between internal and external SX structure and how these properties might affect release of the active ingredient from the starch xanthide granule.

Table 31. Performance of preemergence herbicides encapsulated in starch xanthide (sx) as compared to their commercial formulations (CF).

Herbicide Formulation	Release Property	% Annual bluegrass 6/19 S	S+F[2]	Phytotoxicity[1] 5/30[3]	6/19 S	6/19 S+F	6/29 S	6/29 S+F	7/23 S	7/23 S+F	8/8 S	8/8 S+F	8/22 S	8/22 S+F	9/7 S	9/7 S+F	9/21 S	9/21 S+F	% Crabgrass[3] 7/23	8/8	8/22	9/7	9/21
Benefin																							
CF		4.0	8.3	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	3.0	7.0	10.0
SX_1	Fast	8.3	8.7	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.1	4.5	9.2
SX_2	Medium	5.3	6.7	1.7	1.0	1.0	1.0	1.0	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.5	6.7	10.9
SX_3	Slow	6.7	8.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.5	4.0	8.3
Oxadiazon																							
CF		8.3	6.7	1.7	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	3.9	6.7
SX_1	Fast	6.7	8.7	2.0	1.3	1.3	1.0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	2.0	4.0	6.7	10.9
SX_2	Medium	5.0	2.7	1.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	4.2	4.5
SX_3	Slow	8.3	5.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	4.2	7.5
Prosulfalin																							
CF		5.3	5.0	2.7	2.7	3.0	2.7	2.0	1.7	1.7	1.0	1.3	1.3	1.3	1.0	1.0	1.0	2.0	1.0	3.0	6.7	10.0	20.8
SX_1	Fast	6.7	2.3	1.7	2.3	2.3	2.0	2.0	1.7	2.0	1.0	1.3	1.0	1.7	1.0	1.0	1.0	1.7	0	2.0	4.2	8.3	13.4
SX_2	Medium	5.0	1.0	1.7	2.0	2.7	1.7	2.0	2.0	2.3	1.7	1.7	1.7	1.7	1.0	1.0	1.0	1.7	1.0	1.5	3.3	5.5	10.8
SX_3	Slow	11.7	8.7	2.0	2.7	3.3	2.0	2.3	2.3	2.7	1.7	2.0	1.0	2.0	1.0	1.0	1.0	2.0	1.0	5.5	7.2	12.5	17.5
Untreated Check		10.7	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.3	10.2	18.5	21.7	25.9

[1] Phytotoxicity ratings were made using a scale of 1 through 9 with 1 representing no injury and 9 representing complete necrosis of the turf.

[2] S=plots receiving spring applications only; S+F = plots receiving spring and fall (Sept. 1, 1978) applications.

[3] Values are averages of S and S+F applications.

Table 32. Performance of preemergence herbicides encapsulated in starch xanthide as influenced by formulation and mesh size.

Herbicide Formulation	Release Property	Mesh Size	Phytoxocity[1]								% Crabgrass				
			5/30	6/19	6/29	7/23	8/8	8/22	9/7	9/21	7/23	8/8	8/22	9/7	9/21
Benefin															
SX_1	Fast	14-20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	4.3	5.3
SX_1	Fast	40-60	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.7	1.7	5.0	8.3
Sx_2	Medium	14-20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.5	3.0	5.0
SX_2	Medium	40-60	1.7	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.7	6.7	13.3
SX_3	Slow	14-20	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	3.7	6.7	10.0
SX_3	Slow	40-60	1.7	1.3	1.0	1.0	1.0	1.3	1.0	1.0	0	1.0	2.7	6.7	13.3
Oxadiazon															
SX_1	Fast	14-20	3.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.3	2.3	2.3	6.0	10.0
SX_1	Fast	40-60	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.7	3.7
SX_2	Medium	14-20	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	4.3	10.0
SX_2	Medium	40-60	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.5	5.0	7.5
SX_3	Slow	14-20	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	5.0	5.0
SX_3	Slow	40-6	1.3	1.5	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.7	3.7
Prosulfalin															
SX_1	Fast	14-20	1.3	2.0	1.0	1.7	1.0	1.3	1.0	1.0	1.3	5.0	6.7	10.0	16.7
SX_1	Fast	40-60	1.3	2.7	2.0	1.7	1.3	1.5	1.0	1.0	0	1.0	1.5	4.0	7.5
SX_2	Medium	14-20	1.0	2.3	1.7	1.7	1.3	1.0	1.0	1.0	0	1.0	3.5	5.0	10.0
SX_2	Medium	40-60	1.3	3.7	2.3	2.3	1.7	1.7	1.0	1.0	0	1.0	3.3	6.0	10.0
SX_3	Slow	14-20	1.0	2.3	1.7	1.7	1.3	1.3	1.0	1.0	0	2.3	3.7	8.3	13.3
SX_3	Slow	40-60	2.3	4.7	3.3	2.7	2.0	1.7	1.0	1.0	0	1.0	3.3	3.7	6.7
Untreated Check			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	0.0	8.3	11.7	15.0

[1] Phytotoxicity ratings were made using a scale of 1 through 9 with 1 representing no injury and 9 representing complete necrosis of the turf.

Table 33. Comparison of relative performance of different starch xanthide-benefin formulations for the control of crabgrass in Kentucky bluegrass turf.

		Phytotoxicity[1]																% Crabgrass										
Herbicide Formula-tion	Release Property	5/30		6/19		6/29		7/23		8/8		8/22		9/7		9/22		7/23		8/8		8/22		9/7		9/22	
		2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#	2#	4#
Benefin																											
SX_1	Fast	1.0	1.0	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	3.0	1.0	5.0	1.7	8.3	3.7
SX_2	↑	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	2.3	6.0	3.0	10.0	6.0
SX_3	Inter-	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.3	2.7	5.7	3.0	6.7	4.7
SX_4	med-iate	1.0	1.0	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	2.3	9.3	5.3	11.7	4.7
SX_5	↓	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	6.7	2.3	8.3	3.7
SX_6	Slow	1.0	1.0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3	3.0	3.7	3.0	5.0	3.0
Untreated Check		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	7.0	6.0	11.7	11.7	15.0	16.7	18.3	20.0

[1] Phytotoxicity ratings were made using a scale of 1 through 9 with 1 representing no injury and 9 being complete necrosis of the turf.

Table 34. Evaluation of the requirements of a control-release preemergence herbicide system in a Kentucky bluegrass turf using varying CF application sequences.

Benefin (CF) Applied (lbs/per acre	Application Rates and Frequencies	Phytotoxicity[1]								% Crabgrass				
		5/30	6/19	6/29	7/23	8/8	8/22	9/7	9/21	7/23	8/8	8/22	9/7	9/21
4	2 lbs, 2x	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	2.7
4	1 lb., 4x	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	2.7
4	0.5 lb, 8x	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.0	1.3
4	2 lb, 1x;0.67lb,3x	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.7	2.3
4	2 lb, 1x;0.33lb,6x	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	1.0
4	1 lb, 1x;0.5 lb,6x	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	0	1.0	1.0	1.0
Untreated check		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	7.0	15.0	36.7	40.0

[1] Phytotoxicity ratings were made using a scale of 1 through 9 with 1 representing no injury and 9 being complete necrosis of the turf.

Table 35. Evaluation of different combinations of starch xanthide (SX) and commercial formulations (CF) of Benefin for crabgrass control in a Kentucky bluegrass turf.

Total Benefin Applied (lbs./Acre)	Carrier Application Rates (lbs/A)		Phytotoxicity[1]								% Crabgrass				
	SX	CF	5/30	6/19	6/29	7/23	8/8	8/22	9/7	9/21	7/23	8/8	8/22	9/7	9/21
4	4	0	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	4.7	8.3
4	3	1	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.3	6.0	6.7
4	2	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	4.3	5.7
4	1	3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	4.3	6.7
4	0	4	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.7	5.7	7.3
3	3	0	1.3	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.7	5.0	6.7
3	2.25	0.75	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.3	3.7	7.0
3	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.7	4.3	10.0
3	0.75	2.25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	3.0	2.7	7.7	11.7
3	0	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	3.0	5.3	9.3	13.3
2	2	0	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	2.0	3.7	6.7
2	1.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	3.7	6.0	9.3
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1	3.0	4.0	11.7	15.0
2	0.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	2.0	3.0	6.7	10.0
2	0	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	2.0	2.3	7.7	7.7
Untreated Check			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	7.0	10.0	20.0	30.0

[1]Phytotoxicity ratings were made using a scale of 1 through 9 with 1 representing no injury and 9 representing complete necrosis of the turf.

D. 1. c. Annual bluegrass control in creeping bentgrass, perennial ryegrass and Kentucky bluegrass with Nortron.
J. E. Haley and A. J. Turgeon.

On May 23 a study was initiated to evaluate the efficacy of Nortron, a Fison Corporation herbicide used to selectively control annual bluegrass. Two rates, 0.25 lb ai/acre and 0.5 lb ai/acre, were applied in three programs - spring, summer and fall - with three applications in each program. Nortron was applied to annual bluegrass that had been established the previous fall as 4 in. plugs (3 per plot) in three established turfs: Baron Kentucky bluegrass, perennial ryegrass and Penncross creeping bentgrass. The herbicide was applied with a CO_2-propelled back-pack sprayer (spray volume 28 gal 1 acre). Plots measured 5 x 6 ft, and each treatment was replicated 3 times.

A later study was established in Kentucky bluegrass and perennial ryegrass turfs that supported natural populations of annual bluegrass. Nortron was applied once at rates of 0.5, 1.0, 2.0 and 4.0 lb ai/acre. Linuron, a granular product from O. M. Scott, was tested at 1.0, 2.0 and 4.0 lb ai/acre. Plot size and liquid application were as in the earlier study. Linuron was applied by hand.

No consistent control of annual bluegrass was apparent with Nortron at rates of 0.25 through 2.0 lb ai/acre. Some control was exhibited with Nortron at 4 lb ai/acre, and with Linuron at 2 and 4 lb ai/acre. These tests will be repeated in 1980, but with higher application rates of the herbicides to determine if they can be used in programs for controlling annual bluegrass in turf.

D. 1. c. Efficacy of MK-616 in controlling crabgrass in Kentucky bluegrass at various application rates and spray volumes.
A. A. Pondel, J. E. Haley, and A. J. Turgeon.

Studies were initiated in April, 1979, to evaluate the efficacy of MK-616, a preemergence herbicide from Japan, for controlling crabgrass in turf. Application rates were 1,2,3,4,6, and 8 lb ai/acre in spray volumes of 28, 54, 174, and 261 gal. (water)/acre. The plot area was overseeded with crabgrass three times during the growing season at 0.5 lb/1000 sq ft each time. Plots measured 5 x 6 ft, and each treatment was replicated three times.

Crabgrass germination was slow at the test site with observable populations developing only in late August. Very small differences in percent crabgrass cover were observed among either application rates of spray volumes (Table 36). Results from this study were inconclusive.

Table 36. Effects of application rate and spray volume on the efficacy of MK-616 for preemergence control of crabgrass in Kentucky bluegrass.

Treatment	Crabgrass cover			
	8/30	9/7	9/18	9/25
		%		
Application rate (lb a.i./acre)				
1	4.1	5.3	7.8	13.8
2	3.8	7.0	8.2	13.2
3	3.3	5.2	7.4	12.5
4	4.2	6.4	7.9	13.6
6	2.6	4.5	6.0	11.1
8	3.4	5.2	6.9	12.1
Spray volume (gal/acre)				
28	2.9	5.0	6.4	11.8
54	2.4	5.3	6.8	10.7
174	5.1	6.9	8.2	17.1
261	3.8	5.3	8.0	11.3

D. 2. c. <u>1979 turf fungicide trials.</u>
Guy L. Fagiolo, M. C. Shurtleff, and R. A. Wilson.

Three fungicide trials were conducted in 1979: (1) A fungicide compatibility study involving the Noram fungicide SN66752 (Previcur), Daconil 2787, and Dyrene for control of Sclerotinia dollar spot on mixed bentgrass; (2) An evaluation of old and new products to control Rhizoctonia brown patch and Pythium blight on Penncross creeping bentgrass; and (3) The control of Helminthosporium leaf spot and melting-out on a mixture of common Kentucky bluegrasses.

In all experiments the fungicides were applied with a CO_2 sprayer at 40 psi using 3 gallons/1000 sq ft. The compatibility and Penncross fungicide studies were applied weekly beginning June 21 and August 2, respectively. The Kentucky bluegrass applications were sprayed at two-week intervals starting on May 10. All experiments were continued through the first week of September.

Four replications were used in the compatibility and Kentucky bluegrass experiments, and five in the Penncross study. The 5 x 5' treatment plots were all randomized in a complete block design.

I. Fungicide compatibility study on mixed creeping bentgrass

Two rates each of Previcur, 2 and 4 fl oz; Daconil 2787, 3 and 6 oz; and Dyrene, 3 and 6 oz were applied alone and in all possible combinations. There were a total of 15 treatments, including the untreated check (Table 37).

By comparing the percent change of disease between the untreated check and the various treatments, the effectiveness of the various fungicides and combinations in controlling Sclerotinia dollar spot were ranked:

Rank	Treatment	Rate oz/1000 sq ft
1	Dyrene + Previcur	6 + 2 fl
2	Daconil 2787	6
3	Dyrene	6
	Daconil 2787	3
4	Dyrene	3
5	Previcur	2 fl
6	Daconil 2787 + Previcur	3 + 2 fl
7	Daconil 2787 + Previcur	6 + 2 fl
	Dyrene + Previcur	3 + 2 fl
	Daconil 2787 + Previcur	3 + 4 fl
8	Dyrene + Previcur	3 + 4 fl
	Dyrene + Previcur	6 + 4 fl
	Daconil 2787 + Previcur	6 + 4 fl
9	Previcur	4 fl

Table 37. Fungicide compatibility study involving Previcur, Daconil 2787, and Dyrene on mixed creeping bentgrass

Treatment	Rate oz/1000 square feet	Notes taken on 6/18	6/21	6/28	7/5	7/12	7/19	7/27	8/10	8/16	8/24
Dyrene	3	3*	3	2	1	.1	1	.8	1	2	1
Dyrene	6	7	3	5	2	.2	.6	3	.9	1	2
Daconil 2787	3	6	4	3	2	1	.8	2	3	2	3
Daconil 2787	6	6	2	2	1	.5	2	.9	3	3	5
Previcur	2 fl	6	3	3	2	.4	2	2	4	3	4
Previcur	4 fl	2	3	2	2	.4	1	2	5	4	5
Dyrene + Previcur	3 + 2 fl	4	4	2	1	.5	1	4	3	3	4
Dyrene + Previcur	3 + 4 fl	3	3	3	1	.8	.6	2	3	2	4
Dyrene + Previcur	6 + 2 fl	11	5	4	2	.5	2	2	3	1	1
Dyrene + Previcur	6 + 4 fl	2	2	1	1	.2	.6	.6	1	1	2
Daconil 2787 + Previcur	3 + 2 fl	9	6	5	3	.4	.5	5	3	1	1
Daconil 2787 + Previcur	3 + 4 fl	5	5	5	1	.4	.6	1	3	1	3
Daconil 2787 + Previcur	6 + 2 fl	3	2	2	1	.1	.2	3	2	2	1
Daconil 2787 + Previcur	6 + 4 fl	1	1	.6	.5	2	.4	.4	1	1	2
Check	---	6	3	4	2	1	3	3	4	6	8

* Percent plot area affected by Sclerotinia dollar spot.

Effective early season control occurred with Dyrene (6 oz) + Previcur (2 fl oz), Daconil 2787 (3 oz) + Previcur (2 fl oz), and Daconil 2787 (3 and 6 oz). Daconil did well at the season's start, but later lost its advantage to Dyrene. Poor early control was noted with Previcur (4 fl oz), Dyrene (3 oz) + Previcur (4 fl oz), and Daconil 2787 (3 oz) + Previcur (4 fl oz). These treatments all have the higher Previcur rate in combination with the lower rate of Dyrene and Daconil.

The use of Previcur with Dyrene or Daconil showed an inhibiting effect in all combinations but one. Previcur alone or in various combinations had the nine lowest rankings. The lowest involved the higher concentration of Previcur (4 fl oz). No chemical "burn", or other evidence of phytotoxicity was seen during the season, discounting the possibility of chemical injury by the higher rate of Previcur. Studies in 1978 also showed the decreased effectiveness of Dyrene and Daconil 2787 when combined with Previcur.

Dyrene provided the best control of Sclerotinia dollar spot in this experiment, taking three of the top five rankings. It is assumed that the high level of Dyrene (6 oz) was able to overcome the "incompatibility" or loss of effectiveness caused by the low (2 fl oz) rate of Previcur. In fairness, it should be pointed out that Previcur is not registered for the control of Sclerotinia dollar spot. It is, however, an excellent fungicide for use against Pythium blight.

II. Fungicide trial on Penncross creeping bentgrass

This study was conducted on a new creeping bentgrass area cut to a 1/4 inch height. Sprays were begun after Rhizoctonia brown patch and Pythium blight had been active for about one week. There were a total of 18 treatments in the experiment, including the untreated check (Table 38).

Table 38. Fungicide evaluation for control of Rhizoctonia brown patch on Penncross creeping bentgrass

Treatment	Rate oz/1000 square feet	Notes taken on 8/2	8/10	8/16	8/24	8/31	9/6
Bromosan	6	54*	57	42	19	6	.2
Spectro	4	67	65	29	22	3	1
Daconil 500F	9 fl	62	65	33	28	8	4
Dyrene	4	68	63	39	23	4	1
Kromad	4	68	65	35	19	4	2
Acti-dione TGF	.69	62	59	32	18	5	3
Acti-dione TGF + Acti-dione RZ	.34 + .55	48	51	20	11	3	2
Acti-dione TGF + ferrous sulfate	.24 + 2	53	46	28	14	2	.2
DPX 4424	2	57	63	32	19	2	0
Boots 40% EC bnf 8099	7.5 fl	68	63	34	23	6	3
CGA 64251	1 fl	67	65	32	18	2	.3
Chipco RP 26019 (Iprodione)	2	60	61	40	25	2	2
Chipco RP 26019 (Iprodione)	4	60	57	35	25	3	2
Fore	6	54	60	38	19	3	2
Tersan LSR	4.5	62	62	34	21	5	1
Tersan 1991 + Tersan LSR	2 + 4	64	60	39	20	5	.2
Kalo (KL-491-94-79) (experimental)	6	75	68	35	18	3	3
Check	---	62	61	39	19	4	1

* Percent plot area affected with Rhizoctonia brown patch.

It should be noted that the disease level in the untreated check dropped steadily throughout the season, bringing it near zero by the season's end. Using the percent change of the check plots as a norm, comparison of the levels of brown patch on the treated plots resulted in these rankings:

Rank	Treatment	Rate oz/1000 sq ft
1	Kalo (KL-491-94-79) (experimental)	6
2	CGA 64251	1 fl
3	Spectro	4
	Dyrene	4
4	Kromad	4
5	Boots 40% EC bnf 8099	7.5 ft
6	Tersan 1991 + Tersan LSR	2 + 4
7	Daconil 500F	9 fl
	Chipco RP 26109 (Iprodione)	4
	Tersan LSR	4.5
8	Acti-dione TGF	.69
9	Chipco RP 26109 (Iprodione)	2
10	DPX 4424	2
11	Bromosan	6
12	Acti-dione TGF + ferrous sulfate	.24 + 2
13	Fore	6
14	Acti-dione TGF + Acti-dione RZ	.34 + .55

By August 16, the following fungicides showed a significant reduction of 30 percentage points or more in the amount of Rhizoctonia brown patch. Kalo experimental, Spectro, CGA 69251, Boots 40% EC bnf 8099, Dyrene, Kromad, and Acti-dione TGF. These fungicides all did well with only Acti-dione TGF losing some ranking. Chemicals which improved less than the control early in the season were Chipco RP 26019 (2 oz), Fore, and Bromosan.

The Kalo experimental produce performed best over-all for reducing the effects of Rhizoctonia brown patch. A combination of Tersan 1991 and Tersan LSR was more effective than Tersan LSR alone, whereas combinations of Acti-dione TGF with ferrous sulfate or Acti-dione RZ were less effective than Acti-dione alone. When comparing the two Chipco RP 26019 levels (2 and 4 oz), both had similar degrees of control, despite doubling the rate.

Control of Pythium Blight

Bromosan, Acti-dione TGF + Acti-dione RZ, and Boots 40% EC bfn 8099 all reached zero disease levels for Pythium blight by August 10. All three fungicides showed excellent control, often keeping the disease level at zero. Other good early performers were Chipco RP 26019 (4 oz) and Acti-dione TGF + ferrous sulfate. Later, Pythium blight could be found in the Acti-dione TGF + ferrous sulfate and Tersan LSR plots. Poor performers in this "recovery test" were Chipco RP 26019 (2 oz), CGA 64251, and Acti-dione TGF. During the season Pythium blight increased 4 to 7% in these plots (Table 39).

The Tersan 1991 + Tersan LSR plots again showed better control than Tersan LSR alone. However, unlike its activity against Rhizoctonia brown patch, Acti-dione TGF gave better control in combination with Acti-dione RZ and ferrous sulfate than it did alone.

As with the Rhizoctonia brown patch, the check plots for Pythium blight also steadily decreased though no treatments were applied. The following rankings were made:

Rank	Treatment	Rate oz/1000 sq ft
1	Acti-dione TGF + Acti-dione RZ	.34 + .55
2	Bromosan	6
3	Kalo (KL-491-04-79	6
4	Chipco RP 26019 (Iprodione)	4
5	Kromad	4
6	Fore	6
	Spectro	4
	Daconil 500F	9 fl
	DPX 4424	2
	Tersan 1991 + Tersan LSR	2 + 4
7	Acti-dione TGF	.69
8	Acti-dione + ferrous sulfate	.24 + 2
9	Tersan LSR	4.5
10	Dyrene	4
	CGA 64251	1 fl
11	Boots 40% EC bfn 8099	7.5 fl
12	Chipco 26019 (Iprodione)	2

Table 39. Fungicide evaluation for control of Pythium blight on Penncross creeping bentgrass

Treatment	Rate oz/1000 square feet	Data 8/2	8/10	8/16	8/24	8/31	9/6
Bromosan	6	6*	0	0	0	5	1
Spectro	4	8	2	7	2	3	.3
Daconil 500F	9 fl	8	4	5	6	3	.4
Dyrene	4	3	.6	3	2	3	.2
Kromad	4	10	5	6	6	4	4
Acti=dione TGF	.69	7	3	13	4	9	1
Acti-dione TGF + Aci-dione RZ	.34 + .55	5	0	0	1	1	0
Acti-dione TGF + ferrous sulfate	.24 + 2	5	1	1	3	4	0
DPX 4424	2	8	1	6	3	5	.6
Boots 40% EC bfn 8099	7.5 fl	2	0	2	4	4	0
CGA 64251	1 fl	5	2	6	7	9	2
Chipco RP 26019	2	6	4	10	3	10	4
Chipco RP 26019	4	10	6	5	1	5	1
Fore	6	5	1	2	.6	1	.2
Tersan LSR	4.5	3	4	9	0	1	0
Tersan 1991 + Tersan LSR	2 + 4	8	1	4	4	5	.3
Kalo (KL-491-04-79) (experimental)	6	11	2	9	.2	5	.4
Check	---	10	5	6	4	3	.4

* Percent plot acre affected with Pythium blight.

III. Common Kentucky bluegrass trial

The experiment contained a total of 17 treatments, including the untreated check. The leaf spot phase of Helminthosporium leaf spot had been active over a month and the disease had progressed into the crowns (melting-out) before the spraying program was started.

Only treatments in the top three rankings lessened the effect of Helminthosporium. Chemicals ranking from the 4th to 11th positions showed increases in disease levels from one to 11 percentage points. The lower rate of Chipco RP 26019 (Iprodione) (2 oz) controlled the disease best while the higher rate (4 oz) was the least effective treatment. There was no explanation of this phenomenon as there was no evidence of phytotoxicity.

It was concluded that to be effective against Helminthosporium leaf spot and melting out, it is necessary to begin treatment early in the leaf spot phase, prior to its advancement into the crowns.

The results are presented in Table 40.

Rank	Treatment	Rate oz/1000 sq ft
1	Chipco RP 26019 (Iprodione)	2
	Kalo (KL-491-04-79) (experimental)	6
2	Bromosan	6
	Daconil 500F	9 fl
3	Acti-dione TGF	.69
	Acti-dione TGF + Acti-dione RZ	.34 + .55
	Boots 40% EC bfn 8099	7.5 fl
4	Acti-dione TGF + ferrous sulfate	.24 + 2
	Kromad	4
5	Dyrene	4
	Acti-dione RZ + ferrous sulfate	.55 + 1
	CGA 64250	1 fl
6	Tersan LSR	4.5
7	Daconil 500F	6 fl
8	DPX 4424	2
9	Spectro	4
10	Acti-dione RZ	.55
11	Chipco RP 26019 (Iprodione)	4

Table 40. Fungicide evaluation for control of Helminthosporium leaf spot and melting out (H. spp.) on common Kentucky bluegrass

Treatment	Rate oz/1000 square feet	Notes taken on 8/24	8/31	9/6
Bromosan	6	6*	6	4
Spectro	4	3	7	9
Tersan LSR	4.5	15	13	18
Kromad	4	2	4	5
Dyrene	4	11	11	13
Daconil 500F	6 fl	7	8	11
Daconil 500F	9 fl	11	8	9
Acti-dione TGF	.69	13	11	12
Acti-dione TGF + Acti-dione RZ	.34 + .55	7	7	6
Acti-dione TGF + ferrous sulfate	.24 + 2	8	8	9
Acti-dione RZ + ferrous sulfate	.55 + 1	13	11	15
Acti-dione RZ	.55	2	3	9
DPX 4424	2	4	7	11
Boots 40% EC bfn 8099	7.5 fl	5	3	4
CGA 64250	1 fl	13	13	15
Chipco RP 26019 (Iprodione)	2	8	7	5
Chipco RP 26019 (Iprodione)	4	2	5	13
Kalo (KL-491-04-79) (experimental)	6	8	7	5
Check	---	12	12	13

* Percent plot area affected with Helminthosporium leaf spot and melting out.