1967 TURFGRASS RESEARCH SUMMARY

MICHIGAN STATE UNIVERSITY

East Lansing, Michigan

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NOT FOR PUBLICATION

A-2. RED FESCUE BREEDING. - F. C. Elliott, L. Copeland and J. B. Beard.

Wintergreen red fescue release status. Introduced as P.I. 237182 from the Netherlands and received in 1958. Grown as spaced plants in the introduction nursery. Seven clones were selected in 1959 on the basis of first year vigor, leaf growth habit, and freedom from disease by Dr. Fred Elliott and included in the first polycross. Seed from this polycross was used for the original turfgrass evaluations planted in 1960 at East Lansing by Dr. James Tyson. Seed from a six clone polycross of the same material was planted in 1962 by Dr. James Beard at East Lansing for turfgrass evaluations. Additional plantings were made at Traverse City in 1963 and Iron Mountain in 1966. In the summer of 1963 seed was composited from four clones in the earlier 6-clone polycross which produced seed in East Lansing and the composite was planted at the Oregon Experiment Station in Corvallis for seed increase. This seed increase is the basis for the Wintergreen variety.

Compared to Pennlawn, the best red fescue variety now available, Wintergreen is superior in color, density, uniformity and management requirements. Wintergreen has a deep, dark green color similar to Merion Kentucky bluegrass. The color retention in the winter and late fall is outstanding. The density is very high, twice that of Pennlawn. The growth is upright and very uniform. Compared to Pennlawn, it has had superior turfgrass quality under quite low management regimes (minimum water and nitrogen fertilization).

The range of adaptation of Wintergreen outside Michigan may be limited. Wintergreen is being released specifically for use under the moderate climate and light soil conditions of Michigan. It is relatively weak in rhozomatous growth and therefore is not likely to be used in the commercial sod production industry. The leaf texture is somewhat finer than for Pennlawn. It is slightly slower in rate of establishment in comparison to Pennlawn.

A-3. TURFGRASS EVALUATION.

Bluegrass, red fescue, tall fescue, ryegrass (4 cm. cut) and bentgrass (0.65 cm. cut) evaluations have been in progress 5.5 years at East Lansing and 4.5 years at Traverse City on 91% sand. Specific data will be presented for the year 1966 plus general observations for 1967.

A-3a. BLUEGRASS VARIETY EVALUATIONS - J. B. Beard.

East Lansing - A comparison of overall turfgrass quality and shoot density of 17 Kentucky bluegrass varieties is shown in Table 1. During 1966, Pennstar ranked first in quality, followed by Delft, 16-F, Prato, Merion, and Campus.

Table 1. 1966 BLUEGRASS VARIETY EVALUATIONS
East Lansing

(5 x 9' plots; 3 reps.;
planted July 26, 1962; sandy loam; irrigated; 4 cm. cut)

Variety	Density count 11/10/66 (Shoots per square dm.)	Quality rating* (1-best: 9-poorest)	Multiple comparison test (Based on quality)
Pennstar	293	1.6	a
Delft	223	2.2	a b
16-F	-	2.5	a b
Prato	267	2.7	a b
Merion	264	2.9	a b
Newport	263	3.0	a b
Campus	234	3.0	a b
Cougar	225	3.1	a b c
Windsor[2]	239	3.3	a b c
Delta	225	3.4	a b c
Park	241	3.4	a b c
Fylking[2]	241	3.4	a b c
Z.W.B.	346	3.5	a b c
Common Kentucky	219	4.4	b c d
Brabantia[2]	208	5.3	c d
36622-981[2]	258	5.7	d
Rough Bluegrass	177	5.7	d
Nu Dwarf	-	7.3	e

*Average of Monthly Seasonal Ratings.
[1]Planted August 20, 1963
[2]Planted September 2, 1964

Following a decline in performance in 1965, Pennstar ranked at the top in 1966 and, along with Merion, was one of the top bluegrasses in 1967. An experimental selection, 16-F, continues to rank quite high. Delft and Prato show the most improvement of any bluegrass tested in 1966. Windsor also shows steady improvement through 1967. Cougar has decreased in quality in 1966 and 1967. Z.W.B., Pennstar, Prato, Merion, and 36622-981 continue to show superior density while Common, Brabantia, and Nu Dwarf remain inferior.

Traverse City - Leafspot has not been observed at Traverse City. Ten Kentucky bluegrass varieties are compared in Table 2.

Table 2. 1966 NORTHERN BLUEGRASS VARIETY EVALUATIONS
Traverse City

(5 x 7' plots; 4 reps.; planted May 16, 1963;
loamy sand, 91% sand; irrigated; 4 cm. cut)

Variety	Density count 9/15/65 (Shoots per square dm.)	Quality rating* (1-best 9-poorest)	Multiple comparison test (Based on quality)
Merion	198	3.2	a
Z.W.B.	215	3.5	a b
Newport	173	3.8	a b
Campus	106	3.8	a b
Pennstar	180	3.8	a b
Park	189	4.3	a b c
Cougar	121	4.3	a b c
Common Kentucky	167	4.4	a b c
Upland Bluegrass	169	4.5	a b c d
Delta	166	4.7	b c d
Canada Bluegrass	198	4.8	b c d
Brabantia	202	5.2	c d
Rough Bluegrass	3	5.8	d

* Average of monthly seasonal ratings

Merion, Z.W.B., Newport, Campus and Pennstar ranked as the top five varieties in 1966. Newport and Pennstar showed some improvement over the preceding year while Cougar was definitely inferior as were Park and Common but to a lesser degree. Z.W.B., Brabantia, Merion, and Park ranked highest in density, but when compared to E. Lansing data were considerably less dense. Z.W.B., Pennstar, and Cougar ranked highest under unirrigated conditions because of their superior ability to recover from drouthy conditions.

A-3b. FINE-LEAFED FESCUE EVALUATIONS - J. B. Beard.

East Lansing - Eighteen fine-leafed fescues are compared in Table 3. The top ranking fescue again in 1966 was an experimental selection S-59, followed by Highlight, Oase, and MSU-47-Fr. MSU-47-Fr. continued to show improvement and ranks as the best fescue in 1967. Syn A, chewings, common creeping, and SL-3 continue to be inferior. Golfrood showed marked improvement following a poor performance in 1965. Pennlawn and Rainier rank highest among the commercially available varieties.

Table 3. 1966 FINE-LEAFED FESCUE VARIETY EVALUATIONS
East Lansing

(5 x 9' plots; 3 reps.; planted July 11, 1962;
sandy loam; irrigated; 4 cm. cut)

Variety	Quality rating** (1-best; 9-poorest)	Multiple comparison test (Based on quality)
S-59*	1.6	a
Highlight	1.7	a
Oase	1.8	a
MSU-47-Fr*	2.0	a b
Syn B*	2.2	a b c
Grand Prairie	2.3	a b c d
Golfrood	2.4	a b c d
Pennlawn	2.6	a b c d e
Rainier	2.6	a b c d e
Duraturf	2.7	a b c d e
Olds	3.2	b c d e f
Illahee	3.4	c d e f
Syn A*	3.5	d e f
Chewings	3.5	d e f
Common Creeping	4.2	f g
SL-3*	4.8	g h
Career Sheep Fescue	5.8	h
Hard Fescue	8.7	i

* Experimental selections.
** Average of monthly seasonal ratings.

Traverse City - Thirteen five-leafed fescues are compared in Table 4. This location has a soil containing 91% sand and more severe winter conditions than at East Lansing. No leafspot attacks have occurred to date at this location.

Table 4. 1966 NORTHERN FINE-LEAFED FESCUE VARIETY EVALUATIONS
Irrigated - Traverse City

(5 x 7' plots; 4 reps.; planted May 18, 1963;
loamy sand, 91% sand; irrigated; 4 cm. cut)

Variety	Density count 9/14/66 (Shoots per square dm.)	Quality rating** (1-best; 9-poorest)	Multiple comparison test (Based on quality)
Syn A*	239	3.2	a
Pennlawn	208	3.6	a b
Syn B*	182	3.6	a b
Common Creeping	209	3.7	a b
Highlight	374	3.7	a b
Duraturf	150	3.8	a b
Chewings	191	4.1	a b c
Olds	196	4.2	a b c
Illahee	230	4.4	a b c
Rainier	193	4.4	a b c
MSU-47-Fr	224	4.7	a b c
Career Sheep Fescue	298	4.9	c
Hard Fescue	154	6.4	d

* Experimental selections.
** Average of monthly seasonal ratings.

Syn A, Pennlawn, Syn B, Common Creeping, Highlight, and Duraturf ranked as the top varieties in 1966. Pennlawn performs much better on a comparative basis because of its superior tolerance to drought and low temperature injury. Illahee and Rainier showed a decrease in quality and MSU-47-Fr continued to rank quite low at this northern location because of its susceptibility to low temperature kill. Highlight continues to be the most dense red fescue, followed by Career sheep fescue and Syn A.

Syn A, hard fescue, Pennlawn, Syn B, Duraturf, and Rainier are the leading varieties. Quality and drouth recover of 13 red fescues under unirrigated conditions are listed in Table 5.

Table 5. 1966 NORTHERN FINE-LEAFED FESCUE VARIETY EVALUATIONS
Unirrigated - Traverse City

(5 x 7' plots; 4 reps.; planted May 18, 1963;
loamy sand, 91% sand; unirrigated; 4 cm. cut)

Variety	Drouth Recovery (1-best; 9-Poorest)	Quality rating** (1-best; 9-poorest)	Multiple comparison test (Based on quality)
Syn A*	5.5	4.9	a
Hard Fescue	2.5	5.0	a b
Pennlawn	5.5	5.2	a b
Syn B*	7.7	5.3	a b
Duraturf	5.0	5.3	a b
Rainier	5.5	5.4	a b
Common Creeping	6.7	5.7	a b
Illahee	4.2	5.8	a b
Common Chewings	7.5	6.0	a b
Olds	8.0	6.1	a b
MSU-47-Fr	6.0	6.1	a b
Career Sheep Fescue	9.0	6.4	a b
Highlight	6.2	6.6	b

* Experimental Selections
** Average of Monthly Seasonal Ratings

A-3c. BENTGRASS VARIETY EVALUATIONS - J. B. Beard.

East Lansing - Fourteen bentgrass varieties (Table 6) and seven selections (Table 7) evaluated under putting green conditions. No diseases occurred in 1966 and 1967 except for a limited gray snow mold attack.

Cohansey and Toronto continued to rank highest in turfgrass quality for 1966. Penncross continues to rank as the best of the seeded bentgrasses. Astoria, Evansville, and Washington were inferior for putting greens. Pennlu showed a drastic decrease in quality from 1965. Evansville and Iowa K-13 continue to show objectionable levels of thatch accumulation. The experimental putting green had a severe attack of yellow tufts and puffiness during August, 1967.

Table 6. 1966 BENTGRASS VARIETY EVALUATIONS
East Lansing

(10 x 16' plots; 3 reps.; planted Oct. 25, 1961;
loamy sand, irrigated; 6.5 mm. cut)

Variety	Quality rating* (1-best; 9-poorest)	Multiple comparison test (Based on quality)
Cohansey	2.2	a
Toronto	2.8	a b
C-1 + C-19	3.5	a b c
Penncross	3.6	a b c d
Congressional	3.7	b c d e
Old Orchard	3.8	b c d e
Seaside	4.1	b c d e
Iowa K-13	4.1	b c d e
Arlington	4.1	b c d e
Nimisilla	4.2	b c d e
Pennlu	4.6	c d e
Astoria	4.9	c d e
Evansville	5.1	d e
Washington	5.2	e

* Average of monthly seasonal ratings.

Bentgrass selections showing promise are MSU-28-Ap, Springfield, MSU-24-Ap and Pennpar, while Holfiar, Exeter and Bore have been quite unsatisfactory for putting greens (Table 7).

Table 7. 1966 Bentgrass Selection Evaluations
East Lansing

(4 x 4' plots; 3 reps.; planted Aug. 2, 1962;
loamy sand; irrigated; 6.5 mm. cut)

Variety	Quality rating*** (1-best; 9-poorest)	Multiple comparison test (Based on quality)
MSU-28-Ap	1.5	a
Springfield*	1.5	a
MSU-24-Ap	1.6	a b
Pennpar*	2.6	b c
Holfiar	5.0	d
Exeter*	7.2	e
Bore**	8.6	f

* Planted July 2, 1963
** Planted September 8, 1964
*** Average of monthly seasonal ratings.

Traverse City - Seven bentgrasses are compared for snow mold susceptibility, density, and turfgrass quality at Traverse City (Table 8). Congressional, Cohansey and Penncross ranked high while Seaside and Washington continued to be unsatisfactory.

Table 8. 1966 WINTERKILL, DENSITY, AND QUALITY EVALUATIONS OF BENTGRASS VARIETIES
Traverse City

(8 x 12' plots; 3 reps; planted Aug. 18, 1964; loamy sand, irrigated; 6.5 mm. cut)

Variety	Snow mold (Percent Kill) 4/15	Density count (Shoots/ sq. cm.) 9/15	Quality rating** (1-best; 9-Poorest)	Multiple comparison test (Based on quality)
Congressional	5	2542	1.8	a
Cohansey	35	2170	2.5	a b
Penncross	20	1953	2.6	a b
Toronto	45	2527	3.1	b c
Astoria	0	1566	3.3	b c
Seaside	45	1736	4.0	c
Washington	25	1814	4.5	c

* Typhula snow mold
** Average of monthly seasonal ratings

For the second straight year Astoria and Congressional showed the least snow mold injury. Penncross and Washington were intermediate while Cohansey, Toronto and Seaside were high in susceptibility in 1966. Astoria, Seaside, and Washington were again low in density while Congressional and Toronto were very dense.

A-3d & e. RYEGRASS AND TALL FESCUE VARIETY EVALUATIONS - J. B. Beard.

East Lansing - Six ryegrasses, six tall fescues, and four other grasses are under evaluation (Table 9). Pelo, S-23, and Norlea are the outstanding ryegrasses tested. All five selections rank better than common perennial ryegrass.

MSU-4-Fe was again superior to the other tall fescues. Kentucky 31 continued to show better over-all quality in comparison to Alta. Backafall was inferior.

Evergreen timothy showed a drastic decline in turfgrass quality due to the hot, dry summer. Draylar upland bluegrass continues to perform better than Canada bluegrass under Michigan conditions.

Table 9. 1966 MISCELLANEOUS VARIETY EVALUATIONS
East Lansing

(5 x 9' plots; 3 reps.; planted July 10, 1962;
sandy loam; irrigated; 4 cm. cut)

Variety	Quality rating** (1-best; 9-poorest)	Multiple comparison test (Based on quality
	Perennial Ryegrass	
Pelo	2.1	a
S-23	2.8	a b
Norlea	3.6	a b c
Sceempter*	4.7	c d
Viris*	5.4	d
Common	7.0	e
	Tall Fescue	
MSU-4-Fe	2.8	a
Syn A	3.4	a b
Kentucky 31	3.5	a b
Alta	4.0	a b c
S-170	4.4	b c d
Backafall*	5.9	d e
	Others	
Upland Bluegrass	4.3	a
Redtop	5.9	a b
Canada Bluegrass	6.0	b
Evergreen Timothy	6.5	b c

* Planted September 2, 1964
** Average of monthly season ratings

Traverse City - Tall fescue evaluations show MSU-4-Fe to rank first followed by Kentucky 31 and Alta (Table 10), the same order as at East Lansing. However, there is no significant difference between the three either in quality or density.

MSU-21-Lp ranked higher than common perennial ryegrass; however, both were unacceptable for northern Michigan conditions.

Table 10. 1966 TALL FESCUE AND RYEGRASS VARIETY EVALUATIONS
Traverse City

(5 x 7' plots; 4 reps.; planted May 16, 1963;
loamy sand, 91% sand; irrigated; 4 cm. cut)

Variety	Density count 9/16/65 (Shoots per square dm.)	Quality rating* (1-best; 9-poorest)	Multiple comparison test (Based on Quality)
	Tall Fescue		
MSU-4-Fe	79	4.3	a
Kentucky 31	82	4.5	a
Alta	69	4.7	a
	Perennial Ryegrass		
MSU-21-Lp	101	5.6	a
Common	112	6.6	b

* Average of monthly seasonal ratings.

A-3h. TURFGRASS DROUGHT TOLERANCE EVALUATIONS - J. B. Beard.

Eight Kentucky bluegrass and eight red fescue varieties were planted May 16, 1963, on 91% sand at Traverse City. The plots were irrigated throughout the 1963 and 1964 growing season to insure uniform establishment. During the 1965 and 1966 seasons irrigation was withheld. The only water received by the plots was normal rainfall.

Table 11. 1966 COMPARATIVE DROUGHT TOLERANCE AND RECOVERY OF EIGHT BLUEGRASS VARIETIES
Traverse City

(5 x 7' plots; 2 reps.; planted May 16, 1963; loamy sand; 4 cm. cut)

Variety	Drought recovery 9/15/66*
Pennstar	2.0
Cougar	2.5
Merion	4.2
Brabantia	4.2
Park	5.0
Newport	5.2
Common	6.0
Delta	6.7

* 1-best; 9-poorest

The comparative drought tolerance and recovery of eight Kentucky bluegrasses is shown in Table 11. All varieties were severly thinned by mid-August, especially Brabantia, Pennstar and Cougar. Pennstar and Cougar showed the best recovery capability for a second straight year followed in order by Merion and Brabantia. Newport, common and Delta were inferior in ability to recover from drought.

All eight red fescue varieties showed a similar degree of browning during peak drought stress (Table 12). However, certain varieties had a much better ability to recover from drought. Oustanding in drought recovery was Illahee followed in order by Pennlawn and Rainier. The other five red fescue varieties were inferior.

Table 12. COMPARATIVE DROUGHT TOLERANCE AND RECOVERY OF EIGHT RED FESCUE VARIETIES
Traverse City

(5 x 7' plots; 2 reps.;
planted May 16, 1963; loamy sand; 4 cm. cut)

Variety	Drought recovery 9/15/66*
Illahee	4.2
Pennlawn	5.5
Rainier	5.5
MSU-47-Fr	6.0
Highlight	6.2
Common Creeping	6.7
Chewings	7.5
Olds	8.0

* 1-best; 9-poorest

B-2. SOIL MIXTURES AND MODIFICATIONS - P. E. Rieke

In this study there are 24 soil mixes with 2 replications under Cohansey bentgrass. 1967 quality ratings and double-ring infiltration data are given in Table 13.

Table 13. 1967 QUALITY RATINGS AND DOUBLE-RING INFILTRATION (OCT., 1967) RATES FOR SEVERAL SOIL MIXTURES

Soil mix*	Average quality ratings	Infiltration rate in/hr
0-1-0	1.5	0.7
1-1-1	2.4	7.2
2-1-1	3.5	8.2
3-1-1	3.4	14.9
4-1-1	3.7	18.5
6-1-1	3.8	19.3
8-1-1	5.8	17.5
1-1-2	2.1	1.7
2-1-2	2.7	12.5
3-1-2	4.0	11.7
4-1-2	4.4	17.3
6-1-2	4.5	15.4
8-1-2	5.0	17.0

Table 13. (continued)

1-2-1	1.8	2.5
2-2-1	2.5	4.2
3-2-1	4.3	10.6
4-2-1	4.7	16.4
6-2-1	5.8	18.8
8-2-1	5.4	16.0
3-1-0	6.0	21.3
3-0-1	6.0	20.3
0-1-1(+T)	---	5.0
1-1-1(+T)	---	17.3
0-2-1(+T)	---	2.7

*First number is parts coarse sand; second is parts fine sandy loam; third is parts peat in soil mix. T refers to parts calcined clay in plots established May, 1967.

B-3. SOIL AND TISSUE TESTING - P. E. Rieke

Table 14. SUMMARY OF 1967 TRAVERSE CITY SOIL TESTS FROM IRRIGATED VS UNIRRIGATED PLOTS

		Average soil test values in pounds per acre			
	Median pH	P*	K	Ca**	Mg**
Unirrigated	6.4	110	102	1194	98
Irrigated	7.2	81	93	1559	148

Table 15. SOIL PHOSPHORUS AND POTASSIUM TESTS FOR NITROGEN FERTILIZED AND UNFERTILIZED PLOTS
Traverse City, October, 1967

	Average soil test values in pounds per acre	
	P	K
Fertilized with nitrogen	106	114
No nitrogen	68	72

Soil potassium test values from plots receiving 0, 2, 4, 6 and 8 pounds for 4 years are shown in Table 16. The grass is common Kentucky bluegrass.

Table 16. POTASSIUM SOIL TEST VALUES (IN POUNDS K PER ACRE) BY DEPTH AFTER 4 YEARS OF POTASSIUM FERTILIZATION
October, 1967

K applied annually (lbs per 1000 sq. ft.)	Depth of sampling, inches		
	0-2	2-4	4-6
0	286	206	182
2	472	367	303
4	566	487	419
6	648	577	512
8	752	696	642

These plots also receive nitrogen at rates of 0, 4, 8, 12 and 16 pounds of nitrogen per 1000 sq. ft. annually. After 4 years the median pH values range from 7.4 on the check plots (no nitrogen) to 6.7 on the plots receiving the highest rate of application. Most of this pH affect occurs in the 0-2 inch depth.

Soil test values from similar plots under Merion bluegrass and Toronto bentgrass are not yet available for 1967.

B-5. TURFGRASS FERTILIZATION - P. E. Rieke & J. B. Beard

At Traverse City on sandy soil, under irrigated conditions, 18 fertility treatments have been applied on 3 species of grass for 4 years. A summary of the 1967 quality ratings is given in Table 17.

Table 17. SUMMARY OF 1967 QUALITY RATINGS ON TRAVERSE CITY FERTILITY PLOTS. AVERAGE OF 2 REPLICATIONS EACH OF COMMON KENTUCKY BLUEGRASS, MERION BLUEGRASS, AND PENNLAWN RED FESCUE ON 5 DATES

Treatment*	Average quality rating (1-best; 9-poorest)
Coated urea; spring, fall	2.52
Urea; 1 1/2X, monthly	2.57
Urea; spring, fall	2.80
Urea; monthly	3.12
Milorganite; spring, summer, fall	3.12
Milorganite; spring, fall	3.28
Urea; spring, summer, fall	3.53
Combination; urea, UF, milorganite	3.53
UF; spring, fall	3.70
UF; spring, summer, fall	3.82
Urea; spring only	3.83
N-Serve; spring, fall	3.90
Urea; 1/2X; monthly	4.03
UF; spring only	4.13
Coated urea; spring only	4.23
Milorganite; spring only	4.30
N-Serve; spring only	4.60
Check	6.48

* X rate of application is 8 pounds nitrogen/1000 sq. ft. per year for Merion; 4 pounds for common; 3 pounds for Pennlawn.

N-Serve tends to cause burning of the grass which reduces the quality ratings.

Annual rates of 2, 4, 6 and 8 pounds of nitrogen, applied monthly on Delta, Windsor, and Common Kentucky bluegrass resulted in the highest quality ratings for the 8 pound treatment in all cases. No disease was significant during this first year of treatment.

Pennlawn Red Fescue and an MSU Red Fescue selection received nitrogen rates up to 6 pounds per 1000 sq. ft. with similar results although the difference between the 4 and 6 pounds rates was very small. Again no significant disease infestations were observed.

Table 18. AVERAGE 1967 QUALITY RATINGS (5 DATES) ON MERION BLUEGRASS UNDER SEVERAL NITROGEN CARRIERS. 3 REPLICATIONS ON FINE SANDY LOAM, EAST LANSING. ALL PLOTS RECEIVED 6 POUNDS OF NITROGEN PER 1000 SQ. FT.

Treatment	Average quality rating (1-best; 2-poorest)
Ammonium nitrate; April only	2.63
Ammonium nitrate; May only	2.70
Ammonium nitrate; April, May, Aug.	2.73
Ammonium nitrate; April, Aug., Sept.	3.17
Milorganite; April only	3.47
Ammonium nitrate; May, winter	4.03
Ammonium nitrate; May, Nov.	4.07
Ureaform; 12 pounds; April, May, Aug.	4.13
Milorganite; April, May, Aug.	4.17
Ammonium nitrate; Aug. only	4.33
Ureaform; April only	4.97
Ureaform; April, May, Aug.	5.57

The data in Table 18 are quality ratings for several nitrogen treatments on fine sandy loam at East Lansing. Ammonium nitrate and the spring treatments stand out.

A comparison of nitrogen rates on Merion established from seed as well as from sod has indicated that the nitrogen requirements for sodded Merion are about 2 pounds less for a similar response the first year.

B-7. PESTICIDE SOIL STUDIES - J. Timmerman and P. E. Rieke

Certain pesticides influenced grass growth, soil nitrogen levels or both. In a greenhouse study on Pennlawn Red Fescue, Bay-25141, Diazinon, Tersan-OM, and Caloclor increased clipping weights over the check by 23.0, 16.7, 9.8, and 8.8 percent, respectively, when used at recommended rates over a three-month period. When used at 10 times recommended rate increases of 13.0, 47.5, 73.5, and 31.5 percent for the same compounds. The Bay-25141 had begun to turn the grass brown at the end of the second month which reduced the total clipping weights. Dyrene and Acti-dione thiram reduced clipping weights. Cadminate, Dieldrin, and Chlordane had little or no effect. Soil nitrogen levels were increased by some of these materials, especially B-25141 and Acti-dione thiram when used at the 10 times rate.

Bay-25141 tended to increase nitrogen content of Cohansey bentgrass clippings under field conditions, Tersan-OM applied at 10X recommended rate increased nitrogen content of the clippings 15 percent over clippings from the nontreated plot. No outstanding interaction was apparent between pesticide applied and nitrogen carrier under these conditions.

C-3. TURFGRASS MIXTURE ECOLOGY STUDY ON SANDY SOIL - J. B. Beard

The eighteen mixtures included in the study ranked well through 1963 and 1964. No significant low temperature injury occurred in the winter of 1963-64 due to the extensive snow cover. During the winter of 1964-65, severe kill of ryegrasses was observed. In mixtures containing ryegrass, 90 to 95% loss of turf was notes. As a result, mixtures containing ryegrass performed poorly throughout 1965 and 1966 (Table 19).

Table 19. PERFORMANCE OF FIVE SELECTED TURFGRASS MIXTURES
Traverse City

(5 x 7' plots; 4 reps.; planted May 16, 1963; loamy sand, 91% sand; irrigated; 4 cm. cut)

Percent composition on a seed number basis			Turf quality rating* (1-best; 9-poorest)			Multiple comparison test
Kentucky bluegrass	Red fescue	Perennial ryegrass	1964	1965	1966	
75	25	0	3.1	3.8	4.5	a
25	75	0	3.2	3.9	4.7	a
50	50	0	3.4	4.2	5.0	a b
60	20	20	3.6	7.7	5.8	b c
33	33	33	3.3	8.0	6.6	c

* Average of monthly ratings.

The detrimental effects of ryegrass in bluegrass-red fescue mixtures is much more striking in northern Michigan on sandy soils than at East Lansing. The dryer soil conditions favor ryegrass establishment which in turn suppresses the permanent establishment of bluegrass and red fescue. Under these conditions the resultant composition of the turf is 80 to 95 percent ryegrass which subsequently winterkill.

Mixtures containing redtop, rough bluegrass or tall fescue were definitely inferior in turfgrass quality and density.

D-2a. CAUSES OF INDIRECT HIGH TEMPERATURE GROWTH STOPPAGE IN TURFGRASSES - D. T. Duff and J. B. Beard

Some effects of above optimum temperature upon the growth of Toronto creeping bentgrass were investigated. The amount of dry matter produced as measured by weekly harvests of leaf tissue decreased slightly from the 20-10 C regime through the 25-15 and 30-20 C. When the temperature was increased further to 35-35 C, a sharp decrease in dry matter production took place. At 40-30 C, very little new leaf tissue was produced between harvests.

Reduction in dry matter production came about through the action of three separate effects: leaf length, leaf width, and leaf weight per unit area. Decrease in leaf width was the most important at the lower temperature regimes. The effect was nearly countered by increased leaf dry weight per unit area. At the higher temperatures of 35-25 and 40-30 C there was a precipitous decrease in leaf length. Dry weight per unit area continued to increase at these temperatures but was overshadowed by the large decrease in leaf length. The dry weight percentage of leaf tissue increased slightly as temperature was increased above 20-10 C until at 40-30 C a large and highly significant increase took place. Dry weight per unit area trended upward linearly from the lowest temperature to the highest.

The amount of 85 percent ethanol soluble carbohydrate and water soluble carbohydrate remained essentially the same at 20-10, 25-15 and 30-20 C. A slight increase was noted in both fractions at 35-25 C. A highly significant increase was found in both carbohydrate fractions at 40-30 C. The content of water soluble carbohydrate present in leaf sheath, stem and stolon tissue was on the same order of magnitude as that found in leaf tissue grown at the same temperature.

When leaves grown at 20-10, 30-20 and 40-30 C were tested for cumulative O_2 and CO_2 production in the Warburg apparatus at the light period temperatures under which they were grown, activity ranked as 40>30>20 C for both. When leaves grown at 20-10 C were tested at 20, 30 and 40 C, the ranking was 30>40>20 for photosynthetic rate and 40>30>20 for respiratory rate. Leaves grown at 40-30 C exhibited the same ranking of activity.

Comparison of relative photosynthetic rates of leaves grown at 20-10 C with those produced at 40-30 C and tested at 20, 30 and 40 C indicated that quantitative and qualitative changes were taking place within the leaf tissue. These changes indicated that adaptive mechanisms influenced the photosynthetic rate per unit area in leaf tissue grown at the highest temperature level.

Although ample carbohydrate was found in leaf tissue grown at the highest temperature, and adaptive mechanisms for photosynthetic rate per unit area were indicated, plants died at the highest temperature. These data indicate that turfgrass growth stoppage and death at high temperature is not due to carbohydrate exhaustion caused by respiration exceeding photosynthesis or by interference in carbohydrate translocation.

D-2a. DIRECT HIGH TEMPERATURE KILL OF ANNUAL BLUEGRASS - J. A. Fischer and J. B. Beard.

The effects of high temperature on Poa annua were studied in a specially designed wind tunnel chamber. Wind speed in the chamber was 11.4 mph and the relative humidity approximately 100 percent. The temperature treatments ranged from 38 to 45°C. with exposure times varying from ten minutes to twelve hours. Injury was evaluated by grass observations and a histological technique. High temperature resulted in a systematic injury to the Poa annua plant tissue. Injury occurred first at the junction of the leaf sheath and the leaf blade of all affected leaves. The root crown tissue, the youngest leaf and the apical meristem, in that order, were the least susceptible to lethal high temperatures. Exposure to high temperature hastened aging of leaves. The order of cellular changes observed was protoplasmic granulation, protoplasmic coagulation, cell wall breakdown, and total cell collapse. At any one temperature treatment, the degree of kill increased proportionally with exposure time. Kill of Poa annua at 100 percent relative humidity occurred after only a one hour exposure to a temperature of 42°C. Kill of annual bluegrass occurred at a surprisingly low temperature. This suggests that some midsummer kill which is attributed to other causes may, in fact, be the result of high temperatures, especially if transpirational cooling has been impaired.

D-3c. TEMPERATURE-FLOODING TOLERANCE INTERACTION STUDIES - D. P. Martin and J. B. Beard

Four turfgrass species were submerged in water for sixty days at water temperatures of 10, 20, and 30° C. The order of flooding tolerance among the four species was: Toronto creeping bentgrass (most), Merion Kentucky bluegrass, annual bluegrass and Pennlawn red fescue (least). The flooding tolerance decreased as the temperature was increased. Water temperatures above 20° C. greatly reduced the duration of flooding tolerance. One hundred percent kill at 30° C. occurred at the following time periods: Toronto - 20 days, Merion - 8 days, annual bluegrass - 5 days, and Pennlawn - 4 days.

E-1. MOWING INVESTIGATIONS - J. B. Beard

Reel and rotray mowers are being compared under four heights of cut: 1.3, 2.6, 3.9 and 5.2 cm. The study was initiated in the fall of 1962. Visual differences have been observed for five years with the rotary mowed plots having a browned appearance for 3 to 4 days after mowing, particularly during active growth periods in late fall. Significant differences have not been found in density between the two types of mowers. Density was increased as the mowing height was lowered. This is a joint study with Ohio State University.

E-3. THATCH FORMATION STUDIES - J. B. Beard

A continuing long term study of management factors involved in thatch formation. A management system is desired which will minimize thatch build-up and the associated disease problems. Factors under evaluation include height (2.5 vs 5 cm.); clipping return vs. removal; mechanical thatch removal vs. none; and nitrogen rates compared in all possible combinations.

The amount of thatch removed by a vertical dethatching machine over a four year period is shown in Table 20. The thatch removed is greater at higher heights of cut or where clippings are returned. There is a general decline in the amount of thatch removed as the turf ages.

Table 20. AMOUNT OF THATCH REMOVED OVER A FOUR YEAR PERIOD FROM FOUR MANAGEMENT COMBINATIONS

(7 x 21' plots in 3 reps.; irrigated Merion)

Cutting Height (cm)	Clipping Treatment	Pounds per acre of thatch removed				
		1963	1964	1965	1966	Sum
2.5	Removed	207	432	144	227	1010
2.5	Returned	976	800	509	425	2710
5	Removed	485	469	328	371	1653
5	Returned	1138	766	538	548	2990

During 1966 and 1967 the turfgrass quality of plots where the clippings are returned has been significantly lower than where clippings are removed. The return of clippings at adequate or high N levels also reduces the turfgrass density as shown in Table 21.

Table 21. 1966 DENSITY COUNT OF SELECTED TREATMENTS IN THE MERION THATCH STUDY

Clippings	Pounds of Nitrogen Per 1,000 sq. ft.		
	4	6	8
Returned	247	222	202
Removed	222	260	253

NOT FOR PUBLICATION

G-1. MULCH EVALUATION STUDIES - D. P. Martin and J. B. Beard

Sixteen mulches were established on a roadside fill slope in early September of 1966. Only the (a) soil retention mat, (b) loose excelsior, and (c) wood chips gave an acceptable level of soil stabilization and grass establishment comparable to the standard of straw (2 tons) plus asphalt. Glass-roots, Silvafiber, Conwed pulp fiber, and an experimental pulp fiber were unacceptable.

G-2. THE ROOTING CAPABILITY OF KENTUCKY BLUEGRASS SOD PRODUCED ON ORGANIC AND MINERAL SOIL - J. W. King and J. B. Beard

The sod was laid on (a) clay subsoil and (b) on an 8 cm layer of a 1:1 mix of sandy loam topsoil and subsoil placed over clay subsoil in 25 x 25 x 45 cm boxes. The soil was either wet to field capacity or air dry when the sod was laid. Daily watering rates of from 15 to 65 mm per week were used. After three weeks all roots growing below the sod piece were collected and ashed to determine new root growth.

Organic grown sod produced more root organic matter than mineral grown sod. In all except two of the seven studies the difference in favor of organic sod was statistically significant. Incorporating topsoil into the clay subsoil resulted in greater root production than subsoil alone. No difference in root production between soil-incorporated or sod surface fertilizer placement was found. Cutting sod at a 2 cm depth was clearly superior to the 1 cm depth of cut in root organic matter production. Dry subsoil resulted in less root production than moist subsoil, particularly with mineral grown sod. Watering rate was more critical with mineral than organic grown sod and where laid on subsoil alone, but no recommendation as to optimum water rate can be made on the basis of these investigations. In a moisture retention study, organic grown sod lost significantly more water per day than mineral sod. Nevertheless, the mineral grown sod showed severe wilting one day earlier.

Table 22. ROOT ORGANIC MATTER PRODUCTION (9)

Sod Type	July 22 to Aug. 9	Aug. 14 to Aug.30	June 29 to July 24	Aug. 9 to Aug.30	Sept.6 to Sept. 27
Mineral Sod	0.95*	0.45***	0.53**	1.10**	1.21***
Organic Sod	2.72	1.30	1.21	1.70	1.96

Significant at * 5% level; ** 1% level; *** 0.05% level.

G-3. GRASSES AND MIXTURES FOR SOD PRODUCTION - J. B. Beard

A sod strength measuring apparatus was used to evaluate the comparative sod strengths of certain turfgrass varieties and mixtures. The average sod strengths of five varieties in decreasing order were: Merion, Delta, Common, and Newport Kentucky bluegrass, followed by Pennlawn red fescue.

G-3. SOD PRODUCTION - P. E. Rieke

Merion bluegrass was planted May, 1967 on Houghton muck. Nitrogen was applied in July, August and September at rate shown in Table 23.

Table 23. EFFECT OF RATE OF NITROGEN APPLICATION ON SOD STRENGTH (WEIGHT TO TEAR 16 INCH SOD PIECE). Data taken Oct. 4, 1967. Average of 3 replications.

Pounds nitrogen per month	Weight to tear sod, pounds
0	31.9
15	60.0
30	64.7
45	59.3
60	65.7

Merion bluegrass, established on sandy loam in May, was fertilized according to the schedule in Table 24. In October, sod strength measurements were taken. It is apparent that although the nitrogen rates were low, the September applications were particularly important for developing sod according to the October data.

Table 24. SOD STRENGTH OF MERION BLUEGRASS ON OCT. 4 ON SANDY LOAM SOIL. AVERAGE OF 3 REPLICATIONS.

Treatment (lbs/1000 sq. ft.)	Total N	Sod Strength (Pounds to tear 16" sod piece)
No nitrogen	0	0
1/3 lb. July, Aug., Sept. 1	1	22.8
2/3 lb. July, Aug., Sept. 1	2	26.0
1 lb. July, Aug., Sept. 1	3	30.0
1 1/3 lb. July, Aug., Sept. 1	4	44.3
1/3 lb. July, Aug. 1; 2/3 Sept. 1	1.3	27.4
2/3 lb. July, Aug. 1; 1 1/3 Sept. 1	2.7	38.0

G-3. CAUSES OF SOD HEATING DURING SHIPMENT - J. W. King and J. B. Beard

A technique has been developed for duplicating the sod heating process under experimental conditions. The lethal temperature range is from 95 to 99° C. when held in 2 x 2 x 3 ft. boxes for 24 to 36 hours. Sod management and harvesting factors which will minimize the rate of sod heating are now under investigation.

A-1. TURFGRASS BREEDING PROGRAM - K. T. Payne

The red fescue breeding program will be expanded. Primary goals are the development of shade tolerant, leaf spot and drouth resistant varieties with a more vigorous creeping habit. At present the sod industry is in need of such a variety and none are available. Several lines of ryegrass have been isolated that have excellent winter-hardiness and turf quality. Additional evaluation of these will be made and seed increase will be initiated for the most promising. Consideration is being given to establishing a breeding program for improved bentgrasses. While strains for potential use on greens will not be ignored, the main emphasis will be toward bents needed for other areas.

A & B. UPPER PENINSULA TURFGRASS INVESTIGATIONS - D. J. Reid, P. E. Rieke, and J. B. Beard

Bluegrass, red fescue, ryegrass and tall fescue variety, mixture, and management studies; plus nitrogen rate, carrier and frequency of application studies being conducted at Iron Mountain, Michigan. Soil on the site is a loamy sand. All studies are being maintained under irrigated and non-irrigated conditions.

B-4b. PLANT NUTRIENT REMOVAL STUDY - J. B. Beard and P. E. Rieke

The total leaf production of Toronto creeping bentgrass, common Kentucky bluegrass, and Pennlawn red fescue has been collected and is being analyzed for both major and minor essential element content. The study has been underway three full growing seasons.

B-4b. MANAGEMENT REQUIREMENTS OF THE MSU RED FESCUE POLYCROSS - P. E. Rieke

A study of the cutting height and nutritional requirements of an improved red fescue polycross, Wintergreen.

B-4c. NITROGEN-POTASSIUM FERTILITY STUDIES - J. B. Beard and P. E. Rieke

Nitrogen rates of 0, 4, 8, 12 and 16 pounds per 1000 square feet per year and potassium rates of 0, 2, 4, 6 and 8 pounds are being applied in all combinations to Toronto creeping bentgrass and Kentucky bluegrass. Objectives of this study are to evaluate the effects of these treatments on low temperature survival, wear tolerance, and turf quality.

C-3. THE ECOLOGY OF ANNUAL BLUEGRASS GROWTH AND DEVELOPMENT. W. J. Rahling and J. B. Beard

The optimum, minimum and maximum levels of various environmental and soil factors on the growth and developments of annual bluegrass are being studied. Also, of concern is the hereditary variability.

D-2a. CAUSES OF HIGH TEMPERATURE GROWTH STOPPAGE IN GRASSES I. H. Stoin and J. B. Beard

Effect of high temperatures on nitrogen metabolism of turfgrasses. Of particular concern are the effects on the ammonia levels, certain keto-acids, and the amidea reserves. The possibility of ammonia toxicity at high temperature is under detailed investigation.

D-2a. CAUSES OF HIGH TEMPERATURE GROWTH STOPPAGE IN GRASSES II - K. Vallieu and J. B. Beard

The temperature activity curves of certain key enzymes are under investigation. The dehydrogenases are receiving detailed study.

D-2b. MANAGEMENT FACTORS IN WINTERKILL - J. B. Beard and P. E. Rieke

The influence of various types of nitrogen carriers, nitrogen rates, time of nitrogen application and potassium level on low temperature kill of turfgrasses. The effects of cutting height and thatch are also being studied.

D-3b. WINTER DESICCATION CONTROL - J. B. Beard

Four widely different means of winter desiccation control on turf are under study.

F-2. CAUSES AND PREVENTION OF FUSARIUM BLIGHT - R. Scheffer and N. A. Smith

Causes of the Fusarium blight type symptoms found in Michigan are being investigated. Also, underway are comparisons of turfgrass species and variety susceptibilities. Future work will encompass means of control.

F-2b. TYPHULA SNOW MOLD AND ITS CONTROL - J. B. Beard

The effect of nitrogen carriers, rates and times of application on the incidence of Typhula snow mold. Several new fungicides are also being evaluated for control.

F-4. NEMATODES EFFECTS IN SOD PRODUCTION - R. Itam and J. A. Knierim

A survey of the types of species and comparative populations of nematodes in organic grown sod are being investigated as well as the effects of production of a crop and utilization on the consumer's site.

NOT FOR PUBLICATION

F-1. EFFECT OF PRE-EMERGENCE HERBICIDES ON DESIRABLE TURFGRASS SPECIES - W. F. Meggitt and J. B. Beard

Ten pre-emergence herbicides were applied to two year old sods of Merion Kentucky bluegrass, common Kentucky bluegrass and Pennlawn creeping red fescue in May, 1964. In 1965 a second treatment was applied to those treated in 1964 and additional plots were established to provide single treatments in 1965. The objective of this study is to evaluate the effects of these herbicides on desirable grasses. These studies include treatments made in a single year as well as repeated applications in subsequent years. Of concern is the immediate effects of these materials, and the ultimate effect on density of desirable species.

G-1. HIGHWAY TURF ESTABLISHMENT STUDIES - D. P. Martin, J. B. Beard and P. E. Rieke

A second three-year study of mulch, turf mixture, and fertilization practices was initiated in July of 1966. A third three-year study of seed mixtures, fertilization practices, date of seeding, and seedbed preparation and seeding methods, was initiated in September, 1967, on a sandy site.

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