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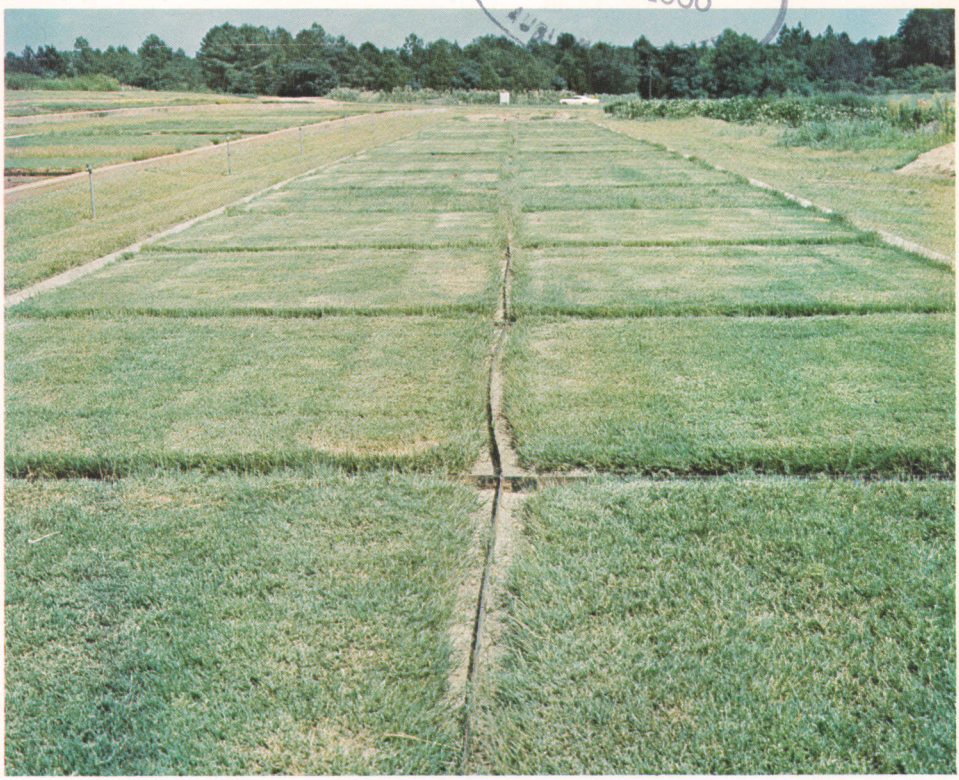

Phosphorus and Potassium on ZOYSIA AND TIFLAWN BERMUDAGRASSES *on Four Soil Types*

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COVER PHOTO. Cover shows overall view of one series of the turf research plots.

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Phosphorus and Potassium on ZOYSIA and TIFLAWN BERMUDAGRASSES *on Four Soil Types*

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Zoysia (*Zoysia matrella,* L, Merr.) and bermuda are the two most extensively used grasses on lawns in Alabama.

Bermudagrass (*Cynodon dactylon,* L, Pers.) is also used extensively on playgrounds, athletic fields, and golf course tees, fairways, and greens. Fertilizer practices for these grasses vary considerably. Research has produced much information relating soil tests to fertilizer needs of field and pasture crops, but very little similar information is available on turf for landscapes and recreational areas. Also, information on relation of soil type to turf growth and response to fertilizer practices is lacking. Some information is available on relation of plant analysis to fertilizer response in turf. Much information on turf fertilization is based on hay or pasture type turf where the main consideration is on growth and yield rather than on appearance. Appearance is of much more importance for lawns and other turf areas than is vegetative growth.

A study was begun at Auburn in 1959 to obtain information on influence of soil type and fertilizer practices on growth, mineral composition, and appearance of turf and soil test values. This report gives results of this study for the 6-year period 1961-66, inclusive.

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EXPERIMENTAL METHODS

A study to determine the P, K, and lime requirements of zoysia matrella P.I. No. 13521 and Tiflawn (Tifton 57) bermuda was conducted at Auburn on four soil types—Decatur clay loam, Hartsells fine sandy loam, Norfolk sandy loam, and Norfolk fine sandy loam. The soil was placed in 18-inch deep concrete bins with steel partitions several years prior to the study. Each bin was 8.5 feet square. The initial fertilizer and lime treatments were applied and mixed with the top 6 inches of soil. Subsequent treatments were applied on the surface. Water was applied as often as needed to keep the plants growing vigorously. The treatments were in duplicate on each of the soil types and on each grass. Results are for the average of the duplicates.

Ammonium nitrate was applied to all treatments at an annual rate of 400 pounds N per acre. Phosphorus and potassium rates varied. Normal 20 per cent super phosphate (9 per cent P) was used to supply P, and 60 per cent muriate of potash (50 per cent K) was used to supply K. One-half of the P and K was applied in the spring before growth began and the other half in the fall, about October 1. Nitrogen at the rate of 60 pounds N per acre was applied in the fall and spring at the time of application of P and K. Nitrogen at the rate of 70 pounds per acre was applied approximately May 1, June 1, July 1, and August 1. Lime (dolomite) was added to bring the pH to about 6.5 on the treatments designated to study rates of P and K. Lime was added annually as needed to maintain the pH at about 6.5 except on the treatment for studying the effect of lime.

The grasses were set in the spring of 1959 and were allowed to grow with an occasional mowing until established. Before growth began in the spring of 1960, all dead vegetation was removed to the soil surface. Clipping treatments were begun in the spring of 1960 and records begun in 1961. The grass was clipped at a height of 1 inch as often as needed (usually every 2 weeks). The clippings from each plot were removed, oven dried, and weighed. Plant samples for analysis were taken on three dates (approximately May 10, July 10, and September 1). Plant samples were taken on the second cutting following N applications. Analysis was made for P, K, Ca, and Mg.

Soil samples were taken at 0-2- and 2-6-inch depths initially and each year before growth started in the spring. Determinations by the methods of Page *et. al* (10) were made for P, K, Mg, pH, and for lime requirement.

Ratings based on appearance were made several times each year. These usually were made to determine earliness, color, and general appearance. Clipping weights were recorded as a measure of vigor. Density and ground cover were not measured independent of appearance.

RESULTS

Effect of Soil Type and Grass Species on Yield

Yields of bermuda and zoysia on each of four soils from various applications of P, K, and lime are shown in Tables 1, 5, and 9. The difference in yields was greatest when no P or K was applied. There was a large difference in the yields of no P and no K treatment among soils. The Hartsells fine sandy loam and the Norfolk fine sandy loam produced lower yields than did Decatur clay loam or Norfolk sandy loam. There was little difference in maximum yield on the various soils; thus, the increases in yields from treatments were greatest on Hartsells and Norfolk fine sandy loam soils.

TABLE 1. AVERAGE TOTAL YIELDS OF DRY MATTER PER ACRE WHEN VARIOUS RATES OF P WERE APPLIED TO ZOYSIA AND BERMUDA ON FOUR SOILS[1]

P applied[2] annually, lb. per acre	Average annual yield, dry matter per acre					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Decatur clay						
0	6,522	4,104	5,313	7,956	6,168	7,062
22	9,426	7,806	8,616	10,032	10,386	10,209
44	9,552	9,126	9,339	10,212	11,022	10,617
88	9,906	9,258	9,582	10,116	10,722	10,419
Hartsells fine sandy loam						
0	3,678	3,126	3,402	5,124	5,580	5,352
22	8,316	7,476	7,896	9,150	10,056	9,603
44	9,054	9,528	9,291	9,504	10,230	9,867
88	9,336	9,498	9,417	9,744	10,476	10,110
Norfolk sandy loam						
0	6,126	3,528	4,827	7,506	5,532	6,519
22	8,622	7,572	8,097	9,630	8,490	9,060
44	8,766	8,988	8,877	10,392	8,988	9,690
88	9,558	8,778	9,168	10,050	8,928	9,489
Norfolk fine sandy loam						
0	2,688	2,010	2,349	4,698	5,640	5,169
22	7,596	7,062	7,329	9,600	9,348	9,474
44	9,576	9,642	9,609	10,602	11,334	10,968
88	9,630	9,984	9,807	10,650	11,118	10,884

[1]The rate of K applied was 166 lb. per acre and dolomite was added as needed.
[2]Rates of P equivalent to 0, 50, 100 and 200 lb. of P_2O_5 per acre respectively.

Effect of Phosphorus on Yield and Mineral Content of Clippings

Both grasses produced near maximum yields at the 44-pound rate of P (100 pounds P_2O_5) on all four soils, Table 1. The largest response per unit of P was from the first 22 pounds. The response from 44 pounds over 22 pounds was relatively small with no appreciable difference in yield for 88 pounds over 44 pounds. These rates are much below those of Juska (5) (6) for Kentucky bluegrass.

Bermuda gave greater response to P than did zoysia. Yields of bermuda on the 0- and 22-pound P plots decreased in the second 3-year period. Bermuda responded to 44 pounds P (100 pounds P_2O_5) on all four soils. Zoysia needed only 22 pounds P (50 pounds P_2O_5) on the Decatur and Hartsells soils, but responded to 44 pounds P (100 pounds P_2O_5) on the Norfolk soils. Need for P would be expected to have been less in all cases at a rate of N lower than the 400 pounds applied to these plots.

These results indicate that many turf areas receive recommendations for a higher rate of P than is needed for growth.

TABLE 2. AVERAGE P CONTENT OF DRY MATTER WHEN VARIOUS RATES OF P WERE APPLIED TO ZOYSIA AND BERMUDA ON FOUR SOILS[1]

P applied[2] annually, lb. per acre	P content of dry matter					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Decatur clay						
0	0.18	0.15	0.16	0.14	0.13	0.13
22	.26	.22	.24	.21	.19	.20
44	.30	.29	.30	.27	.29	.28
88	.35	.35	.35	.33	.36	.35
Hartsells fine sandy loam						
0	.14	.14	.14	.11	.12	.11
22	.21	.21	.21	.18	.18	.18
44	.30	.30	.30	.27	.28	.27
88	.35	.38	.36	.34	.33	.34
Norfolk sandy loam						
0	.12	.13	.12	.16	.13	.14
22	.20	.21	.21	.24	.24	.24
44	.29	.29	.29	.28	.32	.30
88	.31	.34	.33	.32	.39	.36
Norfolk fine sandy loam						
0	.11	.13	.12	.11	.12	.11
22	.18	.20	.19	.16	.19	.17
44	.27	.27	.27	.25	.29	.27
88	.31	.34	.33	.32	.38	.35

[1]The rate of K applied was 166 lb. per acre and dolomite was added as needed.
[2]Rates of P equivalent to 0, 50, 100 and 200 lb. of P_2O_5 per acre respectively.

Applications of P increased the P content of clippings, Table 2. Bermuda and zoysia were similar in P content, although at deficient levels zoysia usually contained a slightly lower percentage P. The critical level of P was about 0.2 per cent for these grasses. Above 0.3 per cent there was little or no growth response, while below 0.2 per cent there was a definite response to P. These figures agree with those of Lunt (7) and Ferguson (3) but are higher than those of Oertli (9). These results, considered together with a higher yield of zoysia than bermuda at zero P, show that zoysia has a lower P requirement than bermuda. The amount of P removed in the clippings from the larger yielding plots was about 30 pounds per acre.

Applications of P increased the K content of both grasses, Table 3, and the K content of both grasses was similar on all soils. These results were from treatments that had received the highest rate of K and therefore should not be regarded as indicating an improvement in the efficiency of K utilization.

Applications of P increased the calcium content of bermuda but had no effect on the calcium content of zoysia. The type of soil had no effect on calcium content. These results were obtained from treat-

TABLE 3. EFFECT OF PHOSPHORUS APPLICATIONS ON AVERAGE K, CA, AND MG CONTENT OF DRY MATTER OF CLIPPINGS ON FOUR SOILS[1]

P applied[2] annually, lb. per acre	K, Ca, and Mg content of dry matter					
	Bermudagrass			Zoysiagrass		
	K	Ca	Mg	K	Ca	Mg
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Decatur clay						
0	1.20	0.42	0.17	1.28	0.35	0.18
22	1.36	.46	.16	1.30	.34	.18
44	1.42	.50	.19	1.40	.35	.18
88	1.40	.48	.18	1.42	.34	.18
Hartsells fine sandy loam						
0	1.08	.44	.17	1.18	.34	.17
22	1.26	.43	.18	1.39	.36	.19
44	1.35	.52	.18	1.35	.36	.18
88	1.24	.50	.18	1.37	.38	.19
Norfolk sandy loam						
0	.95	.41	.16	1.16	.40	.18
22	1.22	.46	.17	1.36	.37	.20
44	1.35	.47	.18	1.30	.37	.18
88	1.27	.54	.19	1.34	.37	.16
Norfolk fine sandy loam						
0	.98	.42	.17	1.12	.35	.17
22	1.27	.48	.17	1.40	.33	.16
44	1.36	.48	.17	1.36	.33	.20
88	1.37	.51	.19	1.36	.34	.19

[1]The rate of K applied was 166 lb. per acre and dolomite was added as needed.
[2]Rates of P equivalent to 0, 50, 100 and 200 lb. of P_2O_5 per acre respectively.

ments that had dolomitic limestone added as needed to maintain soil pH.

Applications of P had little or no effect on magnesium content of either zoysia or bermuda. Neither did soil type affect magnesium content. These results were obtained from treatments that had dolomite as needed to maintain the pH near 6.5; therefore there was an abundant supply of magnesium.

Effect of Phosphorus on Appearance and Earliness

The appearance ratings, Table 4, showed some decrease in appearance of bermuda when no P was applied. Over the years studied the 22-pound rate produced as good an appearance as any other rate. Quite often the bermuda on the high P rate was lighter green in color than that on the low rate. The bermuda on the no P treatments had a dwarfed, stunted appearance and a reddish-purple cast.

TABLE 4. THE EFFECT OF P APPLICATIONS ON APPEARANCE AND EARLINESS OF BERMUDA AND ZOYSIA[1]

P applied annually, lb. per acre	Average annual rating[2]							
	Bermudagrass				Zoysiagrass			
	1965	1966	1967	Av.	1965	1966	1967	Av.
	Appearance in the growing season							
0	8	8	6	7	10	8	8	9
22	9	9	9	9	8	9	9	9
44	8	9	9	9	6	10	9	8
88	9	10	9	9	6	8	6	7
	Earliness in the spring							
0	4	4	7	5	6	7	6	6
22	10	9	8	9	9	9	9	9
44	10	9	8	9	8	9	8	8
88	10	9	8	9	7	7	8	7

[1]The rate of K applied was 166 lb. per acre and dolomite was added as needed.
[2]Rating was done several times each year by 2 or more persons when differences were apparent. Results reported are averages for four soils for all ratings during the year. 10=best, 1=poorest.

Zoysia had a good color in the no P treatments but the plants were dwarfed. These symptoms of P deficiency are in agreement with those described by Morgan (8). The high P treatments produced zoysia that was lighter green and often plants became chlorotic. The colors shaded from dark green to yellowish green as the P treatments went from 0 to 88 pounds per acre. The chlorotic condition could be corrected by spraying with a soluble iron compound such as ferrous sulfate. Therefore, it is assumed that the excess P was producing iron deficiency in zoysia. Bermuda was not sensitive to high P.

Earliness of zoysia and bermuda was affected by P applications. Plants not receiving P were later emerging in the spring. The amount of P applied made little or no difference in earliness of bermudagrass. The 22-pound rate began growth just as early as did the 88-pound rate. As the rate of P increased, early growth of Zoysia was delayed.

Effect of Potassium on Yield and Mineral Content of Clippings

Yields of both grasses were increased by K on all soils, Table 5. Zoysia produced higher yields than bermuda at all rates of K. The differences were greatest at the zero application and bermuda gave

TABLE 5. AVERAGE TOTAL YIELDS OF DRY MATTER PER ACRE WHEN VARIOUS RATES OF K WERE APPLIED TO ZOYSIA AND BERMUDA ON FOUR SOILS[1]

K applied annually,[2] lb. per acre	Average annual yield, dry matter per acre					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Decatur clay						
0	8,268	4,014	6,141	9,858	6,258	8,058
42	9,684	7,920	8,802	10,380	9,726	10,053
83	9,624	8,922	9,273	10,146	10,512	10,329
166	9,906	9,258	9,582	10,116	10,722	10,419
Hartsells fine sandy loam						
0	6,462	2,640	4,551	8,436	4,992	6,714
42	8,748	7,668	8,208	9,780	10,182	9,981
83	9,360	8,946	9,153	9,480	9,930	9,705
166	9,336	9,498	9,417	9,744	10,476	10,110
Norfolk sandy loam						
0	7,470	3,930	5,700	8,862	4,578	6,720
42	8,892	7,098	7,995	9,558	7,596	8,577
83	9,198	8,598	8,898	10,212	8,598	9,405
166	9,558	8,778	9,168	10,050	8,928	9,489
Norfolk fine sandy loam						
0	6,882	3,762	5,322	8,622	3,984	6,303
42	8,922	7,554	8,238	9,948	9,042	9,495
83	10,080	8,580	9,330	10,548	10,464	10,506
166	9,630	9,984	9,807	10,650	11,118	10,884

[1]The rate of P applied was 88 lb. per acre and dolomite was added as needed.
[2]Rates of K equivalent to 0, 50, 100 and 200 lb. of K_2O per acre respectively.

greater response to K than did zoysia. Most of the response was produced by the first 42 pounds of K. Increase in yield from the 166-pound rate over 83 pounds was small. Response to K was greater in the second 3-year period than in the first because yields dropped on the 0 K plots. Response to K was much less on the Decatur clay than on the other three more sandy soils. Application of 42 pounds of K (50 pounds K_2O) was adequate for zoysia on Decatur and Hartsells, but 83 pounds K (100 pounds K_2O) was needed on the

two Norfolk soils. Bermuda gave a good growth response to 83 pounds of K (100 pounds K_2O) on all soils. The amount of K removed in the clippings from the higher yielding plots was about 100 pounds per acre (10,000 pounds at 1 per cent K).

The application of K at the high rate of P and lime increased the K content of bermuda and zoysia, Table 6. Both grasses were similar in K content on all soils. The critical K content of these plants was approximately 1.0 per cent. Below this figure there was a definite response to K applications, but above this there was little response. These results are slightly lower than those of Ferguson (3) but are higher than those of Oertli (9).

TABLE 6. AVERAGE K CONTENT OF DRY MATTER WHEN VARIOUS RATES OF K WERE APPLIED TO ZOYSIA AND BERMUDA ON FOUR SOILS[1]

K applied annually,[2] lb. per acre	K content of dry matter					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Decatur clay						
0	0.67	0.44	0.56	0.65	0.37	0.51
42	.92	.79	.85	.83	.64	.74
83	1.14	1.08	1.11	1.05	.97	1.01
166	1.33	1.46	1.40	1.38	1.46	1.42
Hartsells fine sandy loam						
0	.48	.41	.44	.43	.25	.34
42	.76	.68	.72	.71	.56	.64
83	1.05	1.01	1.03	.99	.89	.94
166	1.10	1.38	1.24	1.29	1.45	1.37
Norfolk sandy loam						
0	.57	53	.55	.52	.34	.43
42	.81	.83	.82	.68	.64	.66
83	1.10	1.03	1.07	1.01	.88	.95
166	1.17	1.37	1.27	1.26	1.43	1.34
Norfolk fine sandy loam						
0	.54	.39	.47	.38	.30	.34
42	.74	.73	.74	.71	.52	.62
83	.92	1.00	.96	.91	.79	.85
166	1.23	1.51	1.37	1.32	1.40	1.36

[1]The rate of P applied was 88 lb. per acre and dolomite was added as needed.
[2]Rates of K equivalent to 0, 50, 100 and 200 lb. of K_2O per acre respectively.

The application of K increased the P content of zoysia and bermuda, Table 7. This is probably associated with the unthrifty condition of the grasses on the zero K treatment.

The application of K did not greatly affect the calcium content, Table 7. Bermudagrass was higher in Ca content than zoysia, but there were no differences between soils.

Fertilization with K decreased the Mg content of both grasses, Table 7. This was most pronounced at the high rate of K.

TABLE 7. AVERAGE P, CA, AND MG CONTENT OF DRY MATTER WHEN VARIOUS RATES OF K WERE APPLIED TO ZOYSIA AND BERMUDA ON FOUR SOILS[1]

K applied annually,[2] lb. per acre	P, Ca, and Mg of dry matter					
	Bermudagrass			Zoysiagrass		
	P	Ca	Mg	P	Ca	Mg
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Decatur clay						
0	0.30	0.48	0.24	0.31	0.41	0.22
42	.33	.46	.24	.33	.40	.20
83	.37	.49	.22	.34	.36	.19
166	.35	.48	.18	.35	.34	.18
Hartsells fine sandy loam						
0	.29	.45	.26	.32	.41	.25
42	.32	.46	.24	.34	.41	.21
83	.35	.48	.22	.35	.40	.20
166	.36	.50	.18	.34	.38	.19
Norfolk sandy loam						
0	.29	.48	.24	.33	.44	.23
42	.32	.49	.23	.35	.42	.21
83	.34	.48	.21	.37	.44	.22
166	.33	.54	.19	.36	.37	.16
Norfolk fine sandy loam						
0	.28	.43	.24	.31	.42	.24
42	.32	.43	.24	.35	.38	.21
83	.34	.47	.25	.35	.38	.19
166	.33	.51	.19	.35	.34	.19

[1]The rate of P applied was 88 lb. per acre and dolomite was added as needed.
[2]Rates of K equivalent to 0, 50, 100 and 200 lb. of K_2O per acre respectively.

Effect of Potassium on Appearance and Earliness

The appearance ratings, Table 8, show a poor appearance for treatments receiving no K. This was true for both zoysia and bermuda. The low rate of K (41.5 pounds per acre) produced plants with less desirable color than did the medium rate (83 pounds) or the high rate (166 pounds).

The plants without K showed typical K deficiency symptoms. The plants were dwarfed, grew slowly, were light green in color, the tips of leaves often died, and the turf appeared dry. Often the plants appeared as if they were suffering from drouth. The deficiency symptoms were similar to those described by Morgan (8).

The initiation of plant growth in the spring was about 2 weeks later on the no K treatments than on those receiving K. A deficiency of K often resulted in winter kill of bermuda during winters of unusually low temperatures. No diseases were prevalent during the studies. Goss (4) has shown K applications reduce the incidence of diseases in turf grasses. Evans (2) found less leafspot present on Coastal bermuda that received high K rates.

PLATE 1. Tiflawn plots in April show browning or rusting typical of K deficiency (top) and sparse early growth caused by P deficiency (center) compared to vigorous green growth from adequate fertilizer.

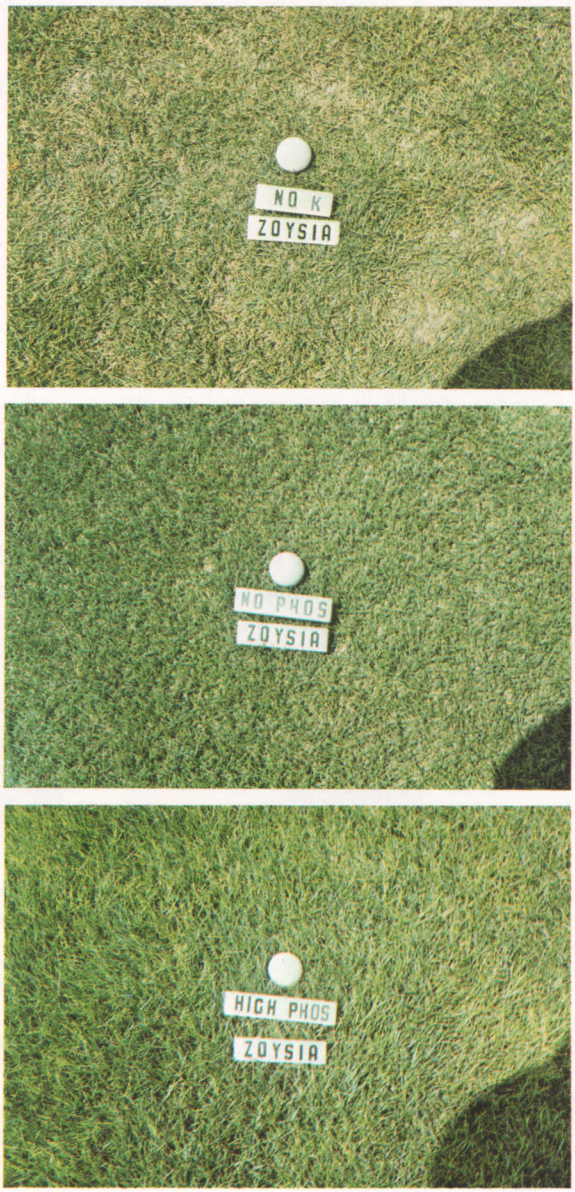

PLATE 2. Zoysia plots in July show symptoms of moderate K deficiency (top) and typical yellowing of iron deficiency caused by excess P (bottom) in contrast with dark green color of plots receiving no P.

TABLE 8. THE EFFECT OF K APPLICATIONS ON APPEARANCE AND EARLINESS OF BERMUDA AND ZOYSIA[1]

K applied annually, lb. per acre	Average annual rating[2]							
	Bermudagrass				Zoysiagrass			
	1965	1966	1967	Av.	1965	1966	1967	Av.
	Appearance in the growing season							
0	1	1	1	1	3	2	1	2
42	6	9	7	7	6	7	7	7
83	7	9	9	8	6	8	8	7
166	7	10	9	9	6	9	7	7
	Earliness in the spring							
0	2	1	1	1	1	1	1	1
42	7	5	6	6	8	7	7	7
83	10	9	9	9	8	8	8	8
166	10	9	8	9	7	7	8	7

[1]The rate of P applied was 88 lb. per acre and dolomite was added as needed.
[2]Rating was done several times each year by 2 or more persons when differences were apparent. Results reported are averages for four soils for all ratings during the year. 10=best, 1=poorest.

Effects of Lime

Application of lime to maintain pH between 6.0 and 6.5 had little or no effect on the yield of bermudagrass on any of the 4 soils tested, Table 9. The yield of zoysia was increased slightly on two of the soils (Norfolk sandy loam and Norfolk fine sandy loam) by application

TABLE 9. THE EFFECT OF LIME ON AVERAGE TOTAL YIELDS OF DRY MATTER PER ACRE ON ZOYSIA AND BERMUDA ON FOUR SOILS[1]

Lime application	Average annual yield, dry mattter per acre					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Decatur clay						
as needed[2]	9,906	9,258	9,582	10,116	10,722	10,419
none	10,080	10,020	10,050	11,274	10,842	11,058
Hartsells fine sandy loam						
as needed[2]	9,336	9,498	9,417	9,744	10,476	10,110
none	9,372	9,678	9,525	9,852	10,236	10,044
Norfolk sandy loam						
as needed[2]	9,558	8,778	9,168	10,050	8,928	9,489
none	9,540	8,970	9,255	9,120	7,554	8,337
Norfolk fine sandy loam						
as needed[2]	9,630	9,984	9,807	10,650	11,118	10,884
none	9,972	9,366	9,669	9,654	8,340	8,997

[1]The rate of P applied was 88 lb. and of K was 166 lb. per acre.
[2]To maintain pH at near 6.5.

of lime but was not affected on the other two soils.

The average annual pH of the soil is shown in Table 10. Soil pH was maintained near 6.5 by applying lime annually as the need was

shown by soil test of samples collected in late winter. The unlimed soil apparently did not reach a level sufficiently low to greatly reduce the growth of the grasses. Zoysia and bermuda grew well at pH as low as 4.7.

TABLE 10. THE EFFECT OF LIME APPLICATIONS ON AVERAGE SOIL pH UNDER BERMUDA AND ZOYSIA ON FOUR SOILS[1]

Lime applied	Average annual pH of soil					
	Bermudagrass			Zoysiagrass		
	1961-63	1964-66	Av.	1961-63	1964-66	Av.
	pH	*pH*	*pH*	*pH*	*pH*	*pH*
Decatur clay						
as needed[2]	5.9	6.4	6.2	5.7	6.4	6.1
none	4.8	4.8	4.8	4.9	4.8	4.9
Hartsells fine sandy loam						
as needed[2]	6.0	6.6	6.3	6.0	6.5	6.3
none	4.6	4.7	4.7	4.7	4.8	4.8
Norfolk sandy loam						
as needed[2]	5.9	6.5	6.2	6.0	6.4	6.2
none	4.7	4.7	4.7	5.0	5.0	5.0
Norfolk fine sandy loam						
as needed[2]	5.8	6.4	6.1	5.9	6.3	6.1
none	4.7	4.7	4.7	4.7	4.7	4.7

[1]The rate of P applied was 88 lb. and of K was 166 lb. per acre.
[2]To maintain pH at near 6.5.

Effect of Lime on Ca, Mg, P, and K Content

Lime (dolomite) application increased the Ca and Mg content of the plants, Table 11. The P content was not affected in bermuda but was increased in zoysia. The K content was lowered by lime in most cases. These data are from treatments that had adequate amounts of P (88 pounds) and K (166 pounds) annually in the fertilizer, thus, the lowering of the K content was of no significance in affecting the growth of the grasses. Under a low K fertilizer program, the lime might have produced poor growth of the grasses as a result of a reduction of K uptake by the plants.

There were no differences in appearance or earliness in bermuda or zoysia attributable to lime treatments.

Soil Test Relationships

The soils data were not different for zoysia and bermudagrass, and the soil test values reported in Tables 12 and 13 are the averages for both grasses. The soil test values for phosphorus, Table 12, are related to rate of annual application. There was little change in soil

TABLE 11. AVERAGE CA, MG, P, AND K CONTENT OF DRY MATTER AS AFFECTED BY LIME[1]

Lime applied	Ca, Mg, P, and K content of dry matter							
	Bermudagrass				Zoysiagrass			
	Ca	Mg	P	K	Ca	Mg	P	K
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Decatur clay								
as needed[2]	0.48	0.18	0.35	1.40	0.40	0.18	0.35	1.42
none	.42	.14	.34	1.54	.32	.12	.31	1.41
Hartsells fine sandy loam								
as needed[2]	.50	.18	.36	1.24	.41	.19	.34	1.37
none	.43	.14	.34	1.46	.33	.16	.30	1.51
Norfolk sandy loam								
as needed[2]	.54	.19	.33	1.27	.42	.16	.36	1.34
none	.44	.13	.33	1.40	.34	.12	.32	1.29
Norfolk fine sandy loam								
as needed[2]	.51	.19	.33	1.37	.38	.19	.35	1.36
none	.42	.13	.31	1.51	.31	.11	.29	1.46

[1]The rate of P applied was 88 lb. and of K was 166 lb. per acre.
[2]To maintain pH at near 6.5.

TABLE 12. SOIL TEST VALUES BY YEARS ON SOIL TYPES AT 4 RATES OF P APPLIED[1]

P applied	Soil Test P					
	1961	1962	1963	1964	1965	1966
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
0 P						
Decatur cl	1	0	0	0	3	1
Hartsells fsl	1	2	1	2	2	3
Norfolk sl	3	2	1	2	3	3
Norfolk fsl	0	0	1	0	2	2
Average	1	1	1	1	2	2
22 P						
Decatur cl	6	5	3	2	4	5
Hartsells fsl	6	6	3	3	5	5
Norfolk sl	12	11	8	8	9	10
Norfolk fsl	3	3	3	1	4	6
Average	7	6	4	3	5	6
44 P						
Decatur cl	17	15	14	12	13	17
Hartsells fsl	15	16	18	16	17	22
Norfolk sl	25	32	26	29	34	40
Norfolk fsl	11	11	11	11	15	20
Average	17	18	17	17	20	25
88 P						
Decatur cl	54	59	61	73	86	93
Hartsells fsl	49	52	70	71	102	107
Norfolk sl	61	68	70	84	118	108
Norfolk fsl	48	56	76	72	110	102
Average	53	59	69	73	104	102

[1]Average zoysia and bermudagrass plots. Treatments applied at ½ rate in fall and ½ rate in the spring. The rate of K applied was 166 lb. per acre. Dolomite was added as needed.

TABLE 13. SOIL TEST VALUES BY YEARS ON SOIL TYPES AT 4 RATES OF K APPLIED[1]

K applied	Soil Test K					
	1961	1962	1963	1964	1965	1966
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
0 K						
Decatur cl	60	44	35	37	33	29
Hartsells fsl	29	19	27	25	30	17
Norfolk sl	24	20	16	24	24	20
Norfolk fsl	18	17	19	24	28	25
Average	32	25	24	26	29	23
42 K						
Decatur cl	73	53	46	42	44	39
Hartsells fsl	50	30	30	31	36	38
Norfolk sl	38	24	22	26	33	31
Norfolk fsl	35	32	24	30	36	37
Average	49	35	30	32	37	36
83 K						
Decatur cl	116	67	66	59	50	54
Hartsells fsl	57	47	50	40	37	37
Norfolk sl	40	50	32	46	45	40
Norfolk fsl	48	48	30	35	44	36
Average	65	53	44	45	44	42
166 K						
Decatur cl	179	175	156	151	148	153
Hartsells fsl	102	93	101	93	115	109
Norfolk sl	55	63	60	68	97	94
Norfolk fsl	66	80	80	79	111	93
Average	100	103	99	98	118	112

[1]Average zoysia and bermudagrass plots. Treatments applied at ½ rate in fall and ½ rate in the spring. The rate of P applied was 88 lb. per acre. Dolomite was added as needed.

test P values over the 6-year period for the 0, 22-, and 44-pound rates. This indicates that approximate equilibrium conditions had been established between amount applied and removed for each rate by the third year of application, 1961. At the 88-pound rate of application, there was a gradual increase of P on all soils.

The soil test values for potassium showed some change over the years and also by soil type, Table 13. On Decatur, the K values decreased at all rates of application. The other soils showed no change or a slight decrease for the 0-, 42-, and 83-pound rates, but an increase for the 166-pound rate.

These data show that 44 pounds of P (100 pounds P_2O_5) and more than 83 pounds of K (100 pounds K_2O) were required to maintain the 1961 levels of P and K in these soils. The highest rate of P, 88 pounds per acre (200 pounds P_2O_5), increased soil test values in all soils. The highest rate of K, 166 pounds per acre (200 pounds K_2O), increased soil test values on the two Norfolk soils. The soil tests of Hartsells

and Decatur did not change appreciably at this rate of application. It should be emphasized that in this study the N rate used was 400 pounds per acre with all clippings removed. Had the N rate been lower and clippings not removed, more buildup is likely to have occurred.

Rouse (11) reported, based on cotton and corn calibration research, that it was necessary to classify soils into at least three different classes to permit pooling data for soil test calibration. The data from this study do not show that this would be necessary for soils on which lawn grasses are grown. This could have been the result of a high rate of P and K removal in the clippings from these high-yielding plots.

The relationship between soil test P and K and the relative yield for all treatments and both grasses are plotted in Figures 1 and 2. It should be pointed out that yields from treatments receiving 22, 44, and 88 pounds of P were influenced by application of the element as well as soil test values. Because an approximate equilibrium condition was established and maintained by the semiannual application of the variable element, Tables 12 and 13, it is considered that any bias would be reflected in slightly higher yield for a given soil test value than would have occurred if the application had not been made.

A curve describing the relationship between soil test value and

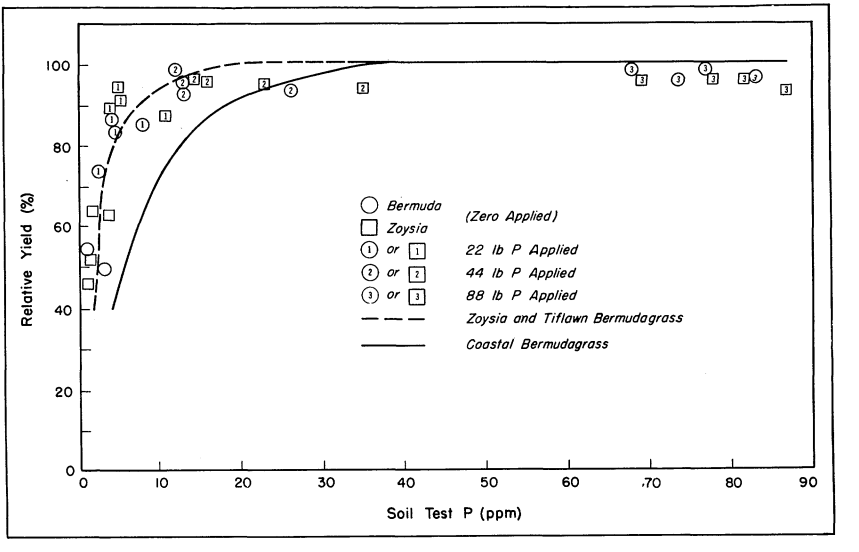

FIGURE 1. Relationship between soil test P in the top 2 inches of soil and relative yields of zoysia and Tiflawn bermudagrasses grown on 4 soil types.

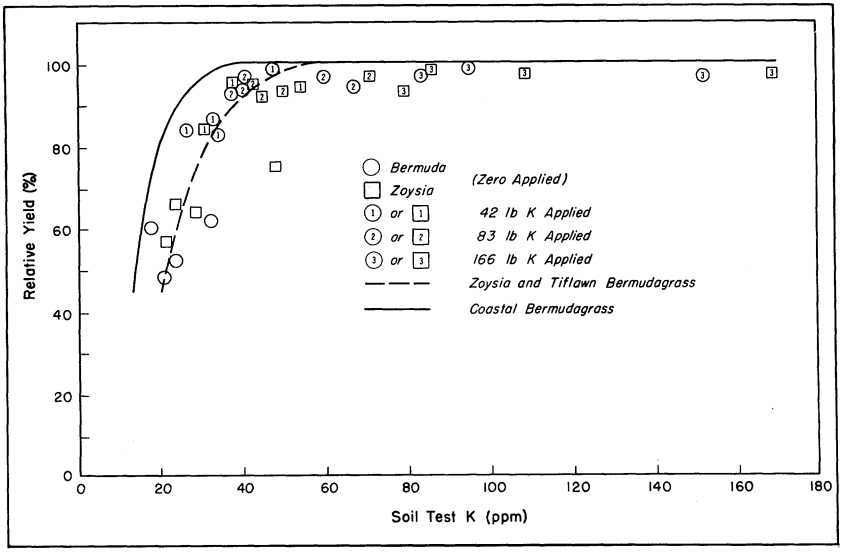

FIGURE 2. Relationship between soil test K in the top 2 inches of soil and relative yields of zoysia and Tiflawn bermudagrasses grown on 4 soil types.

relative yield reported for Coastal bermudagrass by Rouse (11) is also plotted on these graphs. Considering the direction of any bias resulting from an application of the element, it would appear that the relationship determined for Coastal bermudagrass grown for hay on Coastal Plains soils at 200 pounds of N would be valid for these two grasses managed for lawn at 400 pounds of N.

The results show a critical level for soil test value of P of about 15 p.p.m. At this figure and above, there was little response to P applications. At a level of 7 p.p.m. and below, there was a definite deficiency. This is in agreement with the findings of Bingham (1) and Lunt (7).

The critical level of soil test value of K was about 50 p.p.m. Above this figure, there was little response. At 30 p.p.m. or below, there was a definite deficiency.

SUMMARY AND CONCLUSIONS

A study to determine the effect of different rates of phosphorus and potassium and the addition of lime on yield, mineral content, and appearance of zoysia matrella and Tiflawn bermuda showed that soil test values could be used as a guide for the application of phosphorus, potassium, and lime.

Results indicate that fertilizer recommendations given for many turf areas specify larger amounts than are required for good growth and appearance and that soil testing would serve as a valuable guide to the application of phosphorus or potassium more in keeping with the needs of the plant. Soil test values showed a critical level of 15 p.p.m. for P and 50 p.p.m. for K. Above these values, there was little response to applications of these elements in a fertilizer. At a value of 7 p.p.m. or below for P and of 30 p.p.m. or below for K, there was a definite deficiency.

The results indicated that at 400 pounds of N annually with the clippings removed, the application of 44 pounds P (100 pounds P_2O_5) per acre with 83 pounds K (100 pounds K_2O) would be adequate on most soils of Alabama with an initial soil test of low or medium.

Analysis of plants indicates that a P content of 0.3 per cent and a K content of above 1.0 per cent are adequate for plant growth. The critical level of P was 0.2 per cent and K was 1.0 per cent.

Over fertilization with P may produce adverse effects on appearance of zoysia. This occurred at the 88-pound P (200 pounds P_2O_5) application rate when the soil test P level was 75 p.p.m. No evidence of injury from too much K was noticed.

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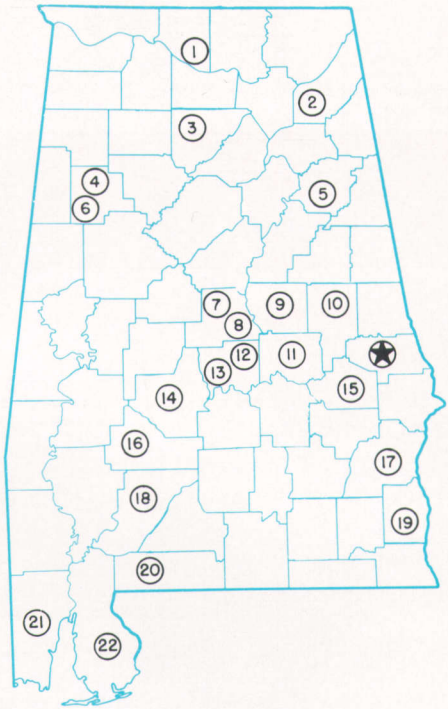

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Alexandria Experiment Field, Alexandria.
6. Forestry Unit, Fayette County.
7. Thorsby Foundation Seed Stocks Farm, Thorsby.
8. Chilton Area Horticulture Substation, Clanton.
9. Forestry Unit, Coosa County.
10. Piedmont Substation, Camp Hill.
11. Plant Breeding Unit, Tallassee.
12. Forestry Unit, Autauga County.
13. Prattville Experiment Field, Prattville.
14. Black Belt Substation, Marion Junction.
15. Tuskegee Experiment Field, Tuskegee.
16. Lower Coastal Plain Substation, Camden.
17. Forestry Unit, Barbour County.
18. Monroeville Experiment Field, Monroeville.
19. Wiregrass Substation, Headland.
20. Brewton Experiment Field, Brewton.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.