

Fertility Requirements of Coastal Bermudagrass and Crimson Clover Grown on Cecil Sandy Loam I. Yield Response to Fertilization

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Coastal Bermuda (*Cynodon dactylon* (L.) Pers.) is one of the most promising summer grasses adapted to the southeastern United States. While it was originally thought to be primarily suited to the sandy soils of the Coastal Plain, interest in Coastal Bermuda in the Piedmont Region (Adams and Stelly, 1958) is increasing rapidly as shown by the fact that at least 140,000 acres of this grass have been planted in the Piedmont of Alabama, Georgia, and South Carolina during the past six years. It is estimated that 60 percent of this acreage is seeded to crimson clover (*Trifolium incarnatum*).

Burton and associates (1948, 1952, 1954) were first to demonstrate the high yield potential of Coastal Bermudagrass. More recently, agronomists in other sections of the southeastern United States have studied this grass and have shown that it is widely adapted and has a high yield potential when properly fertilized and managed (Coats, 1957; Fisher, 1953; Gausman and Crowley, 1954; Johns *et al.*, 1957). Splitting the annual N rates into two or three applications has been suggested as a means of obtaining a better seasonal distribution of growth (Burton and

DeVane, 1952; Coats, 1957) and approximately five weeks has been found to be the optimum clipping interval.

This paper presents the first two years results of a study of fertility requirements of Coastal Bermudagrass when grown in association with crimson clover on a Cecil sandy loam.

Procedure

The experiment was established at Watkinsville, Georgia, on April 10, 1954, on Cecil sandy loam soil of 2 to 3 percent slope with moderate sheet erosion. One ton of Dolomitic limestone,

which was the lime requirement by soil test, was applied broadcast, plowed, and disked into the soil. This treatment raised the pH from 5.3 to 6.0. One hundred pounds per acre of N as ammonium nitrate were applied to all plots in three equal applications at about 30-day intervals during the summer of 1954 to establish a stand.

Bermuda sprigs were planted by hand in 30-inch rows, about 18 inches apart in the row, with a portion of the stem uncovered. Weeds were controlled the first year by one hand hoeing and two cultivations with a spike tooth harrow.

The experiment was a 4 x 4 x 4 factorial with four rates each of N (0, 100, 200, and 400 lbs./a), P₂O₅ (0, 50, 100, and 200 lbs./a), and K₂O (0, 50, 100, and 200 lb./a). The 64 treatments were completely randomized in each of the three blocks. Plots 8 x 20 feet in size were used. Yields were taken by cutting a 34-inch

Table 1. The effect of nitrogen, phosphorus and potassium levels on Coastal Bermudagrass forage production, 1955-56.

Nitrogen N Lbs./A.	Phosphorus P ₂ O ₅ Lbs./A.	Potassium, Lbs./A.				Average T./A.
		0-K ₂ O	50-K ₂ O	100-K ₂ O	200-K ₂ O	
		Coastal Bermudagrass, T./A. ¹				
0	0	2.17	2.31	2.51	2.06	2.26
	50	2.52	2.43	2.18	2.85	2.49
	100	2.28	2.75	2.30	2.62	2.48
	200	2.15	2.47	3.19	2.58	2.59
	Average	2.28	2.49	2.54	2.52	2.45
100	0	4.04	4.06	3.69	4.36	4.03
	50	4.40	4.85	4.53	4.65	4.60
	100	4.20	4.50	4.70	4.38	4.44
	200	4.36	4.88	4.85	4.99	4.77
	Average	4.25	4.57	4.44	4.59	4.46
200	0	4.52	5.05	5.28	5.36	5.05
	50	5.12	5.78	5.78	5.64	5.58
	100	4.77	5.76	5.85	6.12	5.62
	200	5.41	5.40	5.76	6.47	5.76
	Average	4.95	5.49	5.66	5.89	5.50
400	0	4.73	4.63	5.09	5.98	5.10
	50	5.30	6.31	6.39	6.35	6.08
	100	5.32	6.31	6.26	6.56	6.11
	200	5.89	6.38	6.98	7.21	6.61
	Average	5.32	5.84	6.18	6.52	5.97

¹Each entry represents an average of 3 replications. L.S.D. for N, P₂O₅ and K₂O levels: .05 = .12; .01 = .16. C.V. = 7.0%. N x P, N x K, P x K: Highly significant. N x P x K: N.S.

¹Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, and the Georgia Agricultural Experiment Stations.

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Table 2. Efficiency of nitrogen for forage production when applied at different levels to Coastal Bermudagrass, 1955-56.

N - P ₂ O ₅ - K ₂ O Lbs./A.	Average pounds of oven-dry forage		
	Per Acre	Due to N	Per Pound of N
0-200-200	5,160
100-200-200	9,980	4,820	48.2
200-200-200	12,940	7,780	38.9
400-200-200	14,420	9,260	23.1

strip lengthwise through the middle of each plot with a sickle-bar mower. Forage clippings were taken at approximately 5-week intervals, except during drought periods when the clipping intervals was extended.

Crimson clover was seeded on all plots each fall at a rate approximating natural reseeding. Clover was harvested at full bloom stage to prevent regrowth. Thus, the first harvest of Coastal Bermuda each year contained little or no clover.

Nitrogen, in the form of ammonium nitrate, was applied in four equal applications in 1955. The first application followed immediately after clover harvest. The second and third applications followed the first and second grass harvests, respectively. The fourth application was applied about 5 weeks after the third application, although no grass was harvested during the intervening period as a result of dry weather. Annual nitrogen applications were reduced to three in 1956 and were applied as follows: 37.5 percent immediately after clover harvest, 37.5 percent after the first grass harvest, and 25 percent after the second grass harvest. All P₂O₅ and K₂O were applied at clover seeding in the fall immediately following the last grass harvest.

Rainfall during the establishment year from planting to harvest (April-September) was 16.56 inches, which was 6.36 inches less than the 72-year average for the same 6-month period.

Soil samples were taken for chemical analysis from every plot each fall prior to the application of phosphorus and potassium.

Results and Discussion

Forage Production of Coastal Bermuda, 1955-56

The annual forage production of Coastal Bermuda varied widely with treatments, ranging from 2.17 tons per acre with no fertilization to 7.21 tons per acre at the 400-200-200 fertilizer level (Table 1). The two-year average annual production of Coastal Bermuda forage was 2.17 tons per acre with no fertilization. The average forage production of Coastal Bermuda for the 100-50-50, 200-100-100, and the 400-200-200 fertilizer levels was 4.85, 5.85, and 7.21 tons per acre; respectively. The over-all average yields for the 0, 100, 200, and 400 pound nitrogen levels were 2.45, 4.46, 5.50, and 5.97 tons per acre, respectively. The yield increase for each increment of nitrogen was highly significant.

When the supply of other nutrients was adequate, Coastal Bermuda made efficient use of nitrogen. The data in Table 2 show that the efficiency of nitrogen utilization for forage production falls off, however, as the rate of nitrogen increases. Total forage production increased with each increment of nitrogen from 100 to 400 pounds per acre. Even at the highest rate, a ton of hay was produced for each 75 pounds of nitrogen.

Table 3. The average response of Coastal Bermuda to phosphorus and potassium for 1955-56.

Fertilizer:	Pounds of P ₂ O ₅ or K ₂ O Applied Per Acre			
	0	50	100	200
	Tons of oven-dry forage per acre ¹			
Phosphorus(P ₂ O ₅)	4.17	4.69	4.69	4.93
Potassium(K ₂ O)	4.20	4.68	4.71	4.89

¹Each figure is an average of 48 plots.

L.S.D. for P₂O₅ and K₂O levels: .05 = .12; .01 = .16.

The average yield response of Coastal Bermuda to the four levels of phosphorus and potassium are shown in Table 3. These values were calculated in the same manner as the average yield response to nitrogen in Table 1. The data showed a yield response to phosphorus of about 20 percent. Where phosphorus was limiting, but N and K₂O adequately supplied, there was a noticeable reduction in the height of the Coastal Bermuda at harvest.

Potassium deficiency of Coastal Bermuda in this experiment was first observed in the fall of 1956. The plants on all plots with high N and low potassium rates had brown leaf tips. The data in Table 3 show that potassium increased the yield of Coastal Bermudagrass about 15 percent. Interactions N x P, N x K, and P x K were highly significant, but there was no significant N x P x K interaction.

The rate of removal of applied phosphorus and potassium at the zero nitrogen level was not sufficient to make these nutrients limiting. Without N the growth of Coastal Bermudagrass was greatly restricted and the requirement for phosphorus and potassium was very low. As the level of nitrogen fertilization was increased the rate of absorption of phosphorus and potassium was greatly increased.

Forage Production of Crimson Clover, 1955-56

A total of 100 pounds of N per acre annually from ammonium nitrate applied to Coastal Bermuda gave a highly significant increase in the yield of crimson clover grown the following win-

ter over 0, 200, and 400-N levels (Table 4).

Soil tests indicated the extractable potassium at the 0 and 100-N levels was not a limiting factor (Table 6), but there were pronounced potassium deficiency symptoms on crimson clover in 1956 on plots receiving high nitrogen and low potassium. The increased growth of Coastal Bermuda at the 200 and 400-N rates removed the applied potassium and in addition depleted the soil supply to a critically low level.

The average response of crimson clover to the 50-pound level of P_2O_5 (Table 5) was highly significant over the other levels. The 0 and 100- P_2O_5 levels produced more clover than the 200- P_2O_5 level. No explanation at this time can be offered for the decreased growth of crimson clover at the higher phosphorus levels.

Yield response to the 50, 100, and 200-pound rates of K_2O were highly significant over the 0

Table 5. The average response of crimson clover to phosphorus and potassium for 1955-56.

Fertilizer:	Pounds of P_2O_5 or K_2O Applied Per Acre			
	0	50	100	200
Phosphorus (P_2O_5)	.93	1.06	.96	.81
Potassium (K_2O)	.75	1.00	1.00	1.02

¹Each figure is an average of 48 plots. L.S.D. for P_2O_5 and K_2O levels: .05 = .04; .01 = .05.

rate. There were no measurable interactions between nitrogen, phosphorus, and potassium.

Other experiments that are being conducted by the authors indicate that crimson clover will increase the yield of Coastal Bermuda about one-half ton per acre over Coastal Bermuda when grown without clover. The crimson clover itself supplied an average of one ton per acre of forage and would have extended the grazing period from four to six weeks over Coastal Bermuda alone.

Changes in Soil Chemical Properties

Soil acidity increased as the

rate of application of ammonium nitrate increased (Table 6). In only one year the use of 400 pounds of nitrogen as ammonium nitrate produced a very marked increase in soil acidity, from pH 5.7 to 4.9. This is an increasingly serious problem associated with high level production of non-leguminous crops since most of the nitrogen sources being used cause a residual acidity in the soil.

The results presented in Table 6 show that the rate of application of nitrogen also affected the extractable phosphorus and potassium in the soil. The extra growth of forage at the higher nitrogen levels removed larger amounts of both phosphorus and potassium, but the latter was removed much more rapidly. Extractable phosphorus tended to increase at all nitrogen levels since more was being applied than removed by the crop. The increase was greater at the lower levels, however. During the same period there was a pronounced depletion of potassium (Table 6) which was accentuated at the high nitrogen levels.

There was a general accumulation of extractable soil phosphorus at the 50, 100, and 200- P_2O_5 levels between 1954 and 1956 (Table 7). Conversely, there was a marked depletion of the soil potassium at all rates of potassium application. At the zero rate the extractable potassium dropped to only about 50 percent of the initial level. The reduction for the 50, 100, and 200- K_2O rates was 66, 57, and 54 percent, respectively. It is obvious from these results that potassium depletion is a serious

Table 4. The effect of four levels each of nitrogen, phosphorus and potassium on the forage production of crimson clover grown on Coastal Bermudagrass, 1955-56.

Nitrogen Phosphorus		Potassium, Lbs./A.				Average T./A.
N Lbs./A.	P_2O_5 Lbs./A.	O- K_2O	50- K_2O	100- K_2O	200- K_2O	
0	0	.82	.99	1.05	.90	.94
	50	.83	1.12	.98	1.16	1.02
	100	.87	1.11	.95	1.05	.99
	200	.66	.70	.79	.88	.76
	Average	.79	.98	.94	.99	.92
100	0	.88	1.08	1.03	.98	.99
	50	.86	1.21	1.25	1.36	1.17
	100	.69	1.16	1.13	1.02	1.00
	200	.69	1.08	.90	1.02	.92
	Average	.78	1.13	1.07	1.09	1.02
200	0	.74	1.00	1.05	.84	.90
	50	.91	1.09	1.14	1.20	1.08
	100	.78	.91	1.00	1.02	.93
	200	.62	.73	.83	.87	.76
	Average	.76	.93	1.00	.98	.91
400	0	.66	.96	.96	1.01	.89
	50	.67	1.11	1.13	1.06	.99
	100	.77	1.00	.96	1.03	.94
	200	.63	.78	.80	.96	.79
	Average	.68	.96	.96	1.01	.90

L.S.D. for N, P_2O_5 and K_2O levels: .05 = .01; .01 = .05. No significant interactions.

Table 6. The effect of nitrogen rates on soil pH, extractable P₂O₅, and extractable K₂O in 1954 and 1956.

N-rates ¹ Lbs./A.	pH		Extractable P ₂ O ₅ ²		Extractable K ₂ O ²	
	1954	1956	1954	1956	1954	1956
0	6.0	5.7	111	136	115	78
100	6.0	5.5	105	129	105	47
200	6.0	5.3	105	123	106	33
400	6.0	4.9	105	111	110	29

¹Each N rate represents an average of all P₂O₅ and K₂O levels—48 plots.

²Extracted with .075 N. HCl - H₂SO₄

P₂O₅ determined on Colorimeter.

K₂O determined on Perkin-Elmer flame photometer.

problem associated with the production of grass forage under intensive management. When grasses are grown with associated legumes the problem is even more serious.

The preceding discussion relating to the increase in soil phosphorus and potassium depletion raises a question as to the best method for determining the fertilizer requirements for specific crops. The extreme variability of the soils of the southern Piedmont Plateau and the accumulation of phosphorus from cotton and other well fertilized crops indicates that the use of soil tests to determine specific fertilizer needs would be the most reliable approach. In this experiment the 400-200-200 treatment resulted in an accumulation of phosphorus in the soil; however, yield responses were obtained at all phosphorus levels with Coastal Bermuda. At the same time, potassium in the soil has been depleted to such a low

level that pronounced potassium deficiency has been observed on Coastal Bermuda and crimson clover grown at low potassium and high nitrogen levels.

Summary

Yield response of Coastal Bermuda grown in association with crimson clover was measured in a factorial experiment at four N levels ranging from 0 to 400 pounds per acre and four levels each of P₂O₅ and K₂O ranging from 0 to 200 pounds per acre. The results for 1955 and 1956 show that:

1. Coastal Bermuda forage yields ranged from 2.17 tons of dry matter per acre without fertilization to 7.21 tons at the 400-200-200 fertilizer level.
2. Yields were increased markedly by nitrogen fertilization through 400 pounds of N per acre. The 100-pound per acre rate produced the largest number

- of pounds of forage per pound of N.
3. There were highly significant yield responses to both phosphorus and potassium application through the 200-pound rate.
4. Intensified potassium deficiency occurred in Coastal Bermudagrass at high levels of nitrogen fertilization.
5. The soil pH and extractable K₂O decreased sharply as the rate of N was increased.
6. Crimson clover yields were reduced by increasing rates of N applied to the Coastal Bermuda.

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Table 7. The effect of applied P₂O₅ and K₂O upon the extractable P₂O₅ and K₂O in the soil in 1954 and 1956.¹

Applied Phosphorus or Potassium ²	Extractable P ₂ O ₅		Extractable K ₂ O	
	1954	1956	1954	1956
----- (Pounds Per Acre) -----				
0	51	46	60	27
50	75	95	102	35
100	127	165	121	52
200	175	199	162	74

¹See table 6 for method of extraction.

²Each P₂O₅ or K₂O rate is an average of 48 plots

NOTICE

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