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Response of Guinea, Pangola, and Coastal Bermuda Grasses To Different Nitrogen Fertilization Levels Under Irrigation in The Lajas Valley of Puerto Rico

L. Rivera Brenes, J. Torres Más, and J. A. Arroyo[1]

INTRODUCTION

The Lajas Valley comprises around 35,000 acres of land on the southwest corner of the Island of Puerto Rico. Most of the land is in range pasture and sugarcane. The rainfall varies from 35 to 60 inches annually with a long dry period from October to May. An irrigation project has been under way there and by the end of 1959 around 12,000 acres were already under irrigation.

Foreseeing the impact that water for irrigation was to have on the agricultural pattern of the Valley, an experiment was outlined to determine the effects of fertilizer on Guinea grass, the prevailing one in the area, as well as on Pangola and Coastal Bermuda, both of which exhibit good potentialities.

Fertilization of pasture grasses is very seldom practiced in the Valley, because it is believed that beneficial fertilizer effects are apparently lost due to the prolonged dry periods. The senior author had performed grazing experiments with heavy fertilization and no irrigation. His results gave no support to this belief (*5*).[2]

With water for irrigation available in the Valley it is assumed that pasture-management practices will become more efficient and intensified. Information on pasture-management practices under irrigation was lacking.

A report on the first observations made on response to nitrogen applications under irrigation in the Lajas Valley follows.

[1] Animal Husbandman, Head of Animal Husbandry Department; Research Assistant at the Lajas Substation; and Assistant Chemist at the Animal Husbandry Department, respectively, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

[2] Italic numbers in parentheses refer to Literature Cited 145–6.

PROCEDURE

The experiment was performed in Santa Isabel clay, one of the major soil types of the Valley. This soil is similar to Aguirre clay, to Guánica clay, and to Fraternidad (*3*). There is little risk in considering these soils as of practically the same value for pasture production.

The experimental design was a split-plot one in which the grasses were tested in the large plots and the fertilizer levels in the small plots (20 x 20 feet). The grasses under test were Guinea (*Panicum maximum*), Pangola (*Digitaria decumbens*), and Coastal Bermuda (*Cynodon dactylon*). The nitrogen levels were 200, 400, 800, and 1,200 pounds of N per year, apportioned in six applications at 60-day intervals. Four replications for grasses were used. The grasses were cut every 60 days. A total of 12 cuttings were made.

The following data were taken: 1, Yields of green roughage and dry matter per acre per year; 2, hay yields per acre per year, standardized to 20-percent moisture; 3, gross-energy values; 4, percentage protein and total protein per acre per year; 5, leaf-to-stem ratio.

Plot yields were weighed carefully and samples were obtained for dry-matter, crude-protein, and gross-energy determinations. Chemical analyses were made according to the Official Methods and gross-energy determinations were made in a Parr oxygen-bomb calorimeter.

During the first year of the experiment hay was made artificially from all the grasses. An all-crop dryer was used for that purpose. Field-cured hay was made also. Hay yields were standarized to 20-percent moisture for comparison. Uncontrolled palatability tests were made with the hays using goats and cows. Not enough hay was produced from the plots for a controlled experiment.

Irrigation was applied whenever needed, as indicated by a tensiometer installed in the center of the plots. Special perforated pipes were used and water applications equivalent to 2 inches per acre per irrigation were made.

For supplementary information, samples of soil from each plot were taken, at 8 to 12 inches of depth at the beginning and at the end of the 2-year period, to ascertain the effects of the application of large amounts of ammonium sulfate on soil acidity.

The leaf-to-stem ratio was determined by gathering a bunch of more than 100 culms from each plot at harvesttime; then, the leaves and stems were separated by hand.

Treatments were checked separately.

The data—statistically analyzed and measured—were designed to provide information on:

1, Effects of nitrogen level on yield of green roughage and of dry matter of hay, on gross energy, and on percentage of protein and total protein per acre; 2, seasonal effects on yield; 3, comparison of the grasses in their response to the different N treatments.

LITERATURE REVIEW

The use of fertilizer nitrogen to improve both the quality and quantity of forage grasses is recommended worldwide, as attested by the very large amount of literature on the subject issued in agricultural journals during the past 10 years.

In Puerto Rico, the Agricultural Experiment Station and the Agricultural Research Service have been jointly working to determine the response of the principal grasses to different nitrogen fertilization levels in the various climatic regions of the Island.

Rodríguez (*6*), working in the north humid region, found that 200 pounds of nitrogen a year more than doubled the yield of Guinea grass as compared to the no-nitrogen application, when a harvest interval of about 60 days was used. Similar results were obtained with Napier and Pará grasses.

Rivera Brenes (*4*) studied the same three grasses in the same north humid section in a Vega Alta clay loam of pH 5.3, and a Sabana Seca clay, of pH 5.8, with one application of 40 pounds of nitrogen and no liming. The grasses were harvested at 40, 90, and 120 days of age. Yearly productions for Guinea grass of 19,800, 14,000, and 13,740 pounds of dry matter per acre for the 40, 90, and 120 days of age, respectively, were estimated.

Vicente and Figarella (*7*) found that, in the semiarid region of Coamo on a nonirrigable Coamo clay, the application of 100 pounds of nitrogen per acre to Guinea grass toward the end of the wet season markedly increased the dry-matter yield from 3,555 to 5,520 pounds and protein from 238 to 486 pounds per acre. Heavier applications of nitrogen tended to increase protein yields and the protein content of the forage, but not the yields of dry matter.

Unpublished data of Smith and Vicente, cited by Vicente and Rivera Brenes *et al.* (*9*), show that the application of 300 pounds of nitrogen per acre per year markedly increased the yields of irrigated Guinea grass from 12,400 to 21,500 pounds of dry matter per acre. The quantity of irrigation water applied was not mentioned.

Little, Vicente, and Abruña (*2*) worked in the semiarid south section of Santa Isabel, in a San Antón sandy clay loam of pH 7.5. They tested five levels of nitrogen fertilization (0, 200, 400, 800, 1,600 pounds of N per acre per year) under irrigation for 2 years, and reported the following results: Grasses cut while 30 to 60 days old had dry-matter yields per acre of 37,000 to 59,000 for Napier, 16,000 to 43,000 for Guinea, and 7,000 to

20,000 pounds for Pangola. Percentages of protein varied from 7.7 to 11.4 for Napier, from 6.4 to 11.2 for Guinea, and from 6.5 to 12.6 for Pangola. Total protein in pounds per acre ranged from 2,893 to 6,751 for Napier, from 1,041 to 4,881 for Guinea, and from 474 to 2,642 for Pangola grass. The protein content of all grasses increased with the nitrogen level. They found that yields of Napier and Guinea grasses responded strongly to nitrogen applications up to 800 pounds per acre yearly, but Pangola responded strongly only to the 200-pound level. Heavy applications of ammonium sulfate affected soil pH as expected. The application of 800 pounds of nitrogen reduced the pH of the upper 6 inches of soil from 7.7 to 6.8; the application of 1,600 pounds of nitrogen per acre per year further reduced it to 5.2.

Vicente, Silva, and Figarella (*8*) worked at Río Piedras, in the north humid section of the Island, on the effect of nitrogen fertilization and frequency of cutting on the yield and composition of Napier, Guinea, and Pará grasses. Nitrogen fertilization levels of 0, 200, 400, 800, 1,200, 1,600, and 2,000 pounds per acre and harvest intervals of 40, 60, and 90 days were used. Soil was limed to about pH 7 and 300 pounds of P_2O_5 and 600 pounds of K_2O per acre were applied as "blanket additions."

The 1,600-pound level was not used for Napier, nor the 1,200-pound level for Guinea or Pará grasses. The Napier grass experiment was established in a Toa clay loam alluvial soil and the Guinea and Pará grasses experiments on a Fajardo clay, a deep red soil.

The findings reported were: Yields increased with harvest interval, but at 60 days, dry-matter yields per acre per year according to nitrogen level were from 15,000 to 46,000 for Napier grass, 10,000 to 34,000 for Guinea grass, and from 7,000 to 32,000 pounds for Pará grass. There was a rapid increase in yield for all grasses up to the 800-pounds-of-nitrogen treatment. The protein content of all grasses increased with nitrogen fertilization up to the highest level. For Napier from 6.5 to 13.8; for Guinea from 6.2 to 12.4; and for Pará from 6.4 to 12.1 percent.

A marked seasonal effect on yields was demonstrated in this work. There is a period of high production from April through August and a sharp decline occurs from then on. Results presented showed a tendency for yields to follow somewhat the rainfall pattern throughout the year.

The application of 800 pounds of nitrogen reduced the pH from 7.0 to 4.1 in the first 6 inches of soil in the Toa soil, and from 6.7 to 4.6 in the Fajardo clay.

RESULTS

Yields of green forage, dry matter, total protein, percentage of protein, and gross energy; pounds of dry matter per pound of nitrogen applied;

and cost per pound of dry matter according to nitrogen applied are presented in table 1 for the three grasses studied. Table 2 presents the data on hay yields per acre, standardized to 20-percent moisture.

TABLE 1.—*Yields per acre per year of green forage, dry matter, crude protein, and gross energy for Guinea, Pangola, and Coastal Bermuda grasses*[1]

Treatment No.	N per acre	Green forage	Dry matter	Protein[2]	Total protein	Dry matter per pound of N applied	Cost per pound of dry matter considering only cost per pound of N applied[3]	Gross energy
				Guinea grass				
	Pounds	*Tons*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Cents*	*Cal./gm.*
2	200	28.03	17,376.87	8.10	1,408.37	86.88	0.17	4.02
4	400	33.32	20,010.38	9.93	1,986.75	50.02	.30	4.02
8	800	36.24	21,527.88	12.94	2,786.38	26.91	.50	4.07
12	1,200	39.05	22,049.13	14.06	3,099.88	18.37	.80	4.03
				Pangola grass				
2	200	16.27	11,284.00	6.93	781.87	56.42	0.26	4.00
4	400	24.24	15,509.75	8.02	1,243.50	38.77	.39	4.02
8	800	34.63	19,896.37	11.09	2,206.00	24.56	.61	4.09
12	1,200	41.21	22,889.62	12.06	2,761.62	19.07	.78	4.10
				Coastal Bermuda grass				
2	200	14.33	10,946.38	7.20	788.00	54.73	0.27	4.23
4	400	15.24	14,874.75	8.33	1,239.75	37.18	.40	4.29
8	800	19.96	18,149.00	10.37	1,881.50	22.69	.66	4.35
12	1,200	24.08	22,240.13	11.30	2,512.25	18.53	.81	4.36

[1] Average of 2 years. Pounds of dry matter per pound of nitrogen applied and cost per pound of dry matter produced under the different nitrogen treatments.

[2] Percentage protein = average for 48 samples for each nitrogen level.

[3] Cost of 1 pound of N from ammonium sulfate = 15 cents.

The data for the 2 years of the experiment were analyzed statistically with the following results.

GUINEA GRASS

For yield of green forage from Guinea grass, treatment 12 was significantly better at the 1-percent level only than treatment 2. No significant difference was found between treatments 8, 4, and 2. At the 5-percent level treatments 12 and 8 were significantly better than treatment 2. Analysis of variance expressed in hundredweights per acre for 2 years follows:

Treatment No.	Treatment mean, green forage	Treatments outyielded at—	
		1-percent level	5-percent level
12	1,561.96	2	2
8	1,449.51	—	2
4	1,333.45	—	—
2	1,121.33	—	—

$s_{\bar{x}}$ = 73.28; error d.f. = 9

Yields were low for Guinea grass at all levels of nitrogen fertilization. This low production may have been caused by several things, such as too much water of irrigation, slow drainage even if the water of irrigation was not excessive, water table too close to the roots, and needs for phosphorus, potash, and other elements. A detailed consideration of available data not presented here indicates that the low levels of available phosphorus and potash may have been the most important factors in this connection.

For dry-matter yields no difference was found between treatments at the 1-percent level, but at the 5-percent level treatment 12 was significantly better than treatment 2 only (fig. 1). Analysis of variance of dry matter yield in hundredweights per acre for 2 years follows:

Treatment No.	Treatment mean, dry matter	Treatments outyielded—	
		1-percent level	5-percent level
12	440.98	—	2
8	430.56	—	—
4	400.21	—	—
2	347.54	—	—

$s_{\bar{x}}$ = 21.14; error d.f. = 9

Guinea grass responded very well to the nitrogen applications in total protein per acre. Treatment 12 was significantly better than treatments 2 and 4 at the 1-percent level, but not significantly better than treatment 8. Treatment 8 was better than treatments 4 and 2, and treatment 4 better than treatment 2. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	Treatment mean, total protein	Treatments outyielded at 1-percent level
12	62.00	2, 4
8	55.73	2, 4
4	39.74	2
2	28.17	—

$s_{\bar{x}}$ = 2.19; error d.f. = 9

TABLE 2.—*Calculated hay yields per acre of the 3 grasses at different nitrogen levels adjusted to 20-percent moisture for purposes of comparison*

Grass	Nitrogen level[1]	Yield in tons per acre per year
Guinea	2	10.86
	4	12.50
	8	13.45
	12	13.78
Pangola	2	7.05
	4	6.69
	8	12.49
	12	14.30
Coastal Bermuda	2	6.84
	4	9.30
	8	11.68
	12	13.90

[1] See table 1 for explanation.

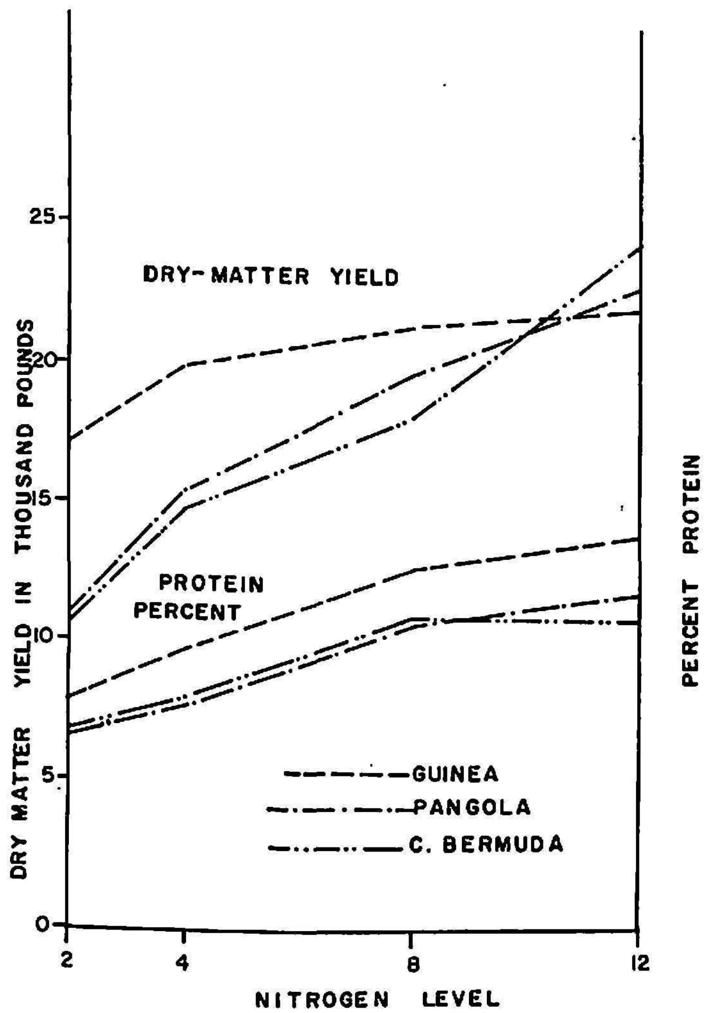

FIG. 1.—Dry-matter yield per acre per year and percentage protein content of Guinea, Pangola, and Coastal Bermuda grasses when grown at different nitrogen levels.

Hay was made from all the grasses under test as explained in Procedure. Because of the variability of the moisture left in the grasses the production of hay was calculated based on 20-percent moisture, table 2. For Guinea grass the yield of hay for treatment 12 was significantly better at the 5-percent level than that of the other treatments. No significant difference was found among the other treatments. Analysis of variance for hay in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, hay yield*	*Treatments outyielded at 5-percent level*
12	551.25	2
8	538.20	—
4	500.28	—
2	434.44	—

$s_{\bar{x}}$ = 26.43; error d.f. = 9

Analysis of variance for gross energy for Guinea grass follows:

Treatment No.	*Treatment mean*
12	4.07
8	4.04
4	4.07
2	4.02

$s_{\bar{x}}$ = 0.01806; error d.f. = 9

No significant difference in gross energy was found between treatments. Actually, utilizable energy has to be measured as digestible energy in digestion trials, but not enough roughage was produced to run a digestion trial for any of the grasses.

PANGOLA GRASS

Pangola grass responded very well to the different nitrogen levels. For yields of green forage treatment 12 was better at the 1-percent level than treatments 4 and 2, and at the 5-percent level than treatment 8. Treatment 8 was better than treatments 4 and 2 at the 1-percent level and treatment 4 better than treatment 2 at the 1-percent level. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, green, forage*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	1,648.48	2, 4	2, 4, 8
8	1,385.27	2, 4	2, 4
4	969.73	2	2
2	650.76	—	—

$s_{\bar{x}}$ = 69.90; error d.f. = 9

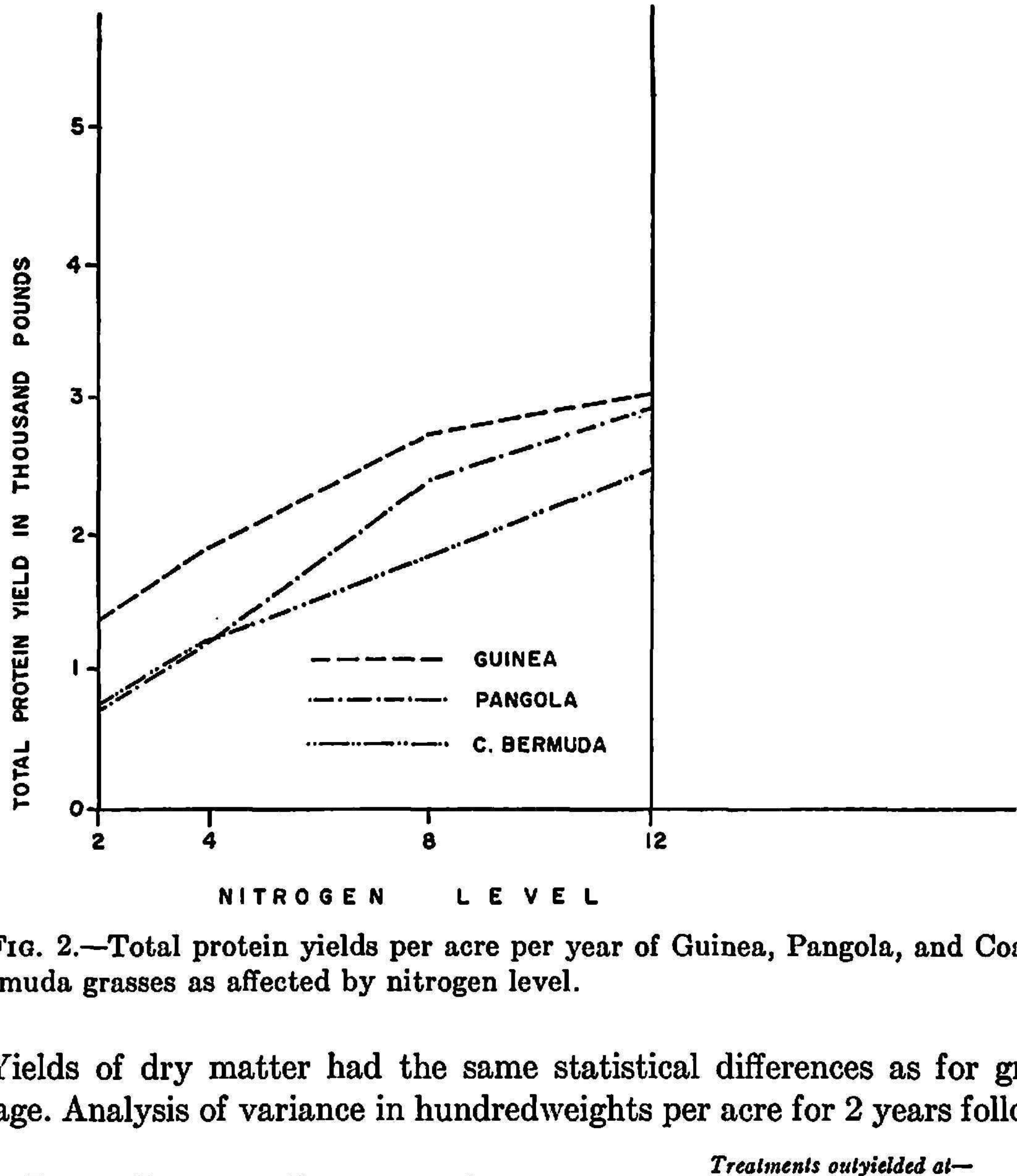

FIG. 2.—Total protein yields per acre per year of Guinea, Pangola, and Coastal Bermuda grasses as affected by nitrogen level.

Yields of dry matter had the same statistical differences as for green forage. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, dry matter*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	457.79	2, 4	2, 4, 8
8	397.93	2, 4	2, 4
4	310.20	2	2
2	225.68	—	—

$s_{\bar{x}}$ = 18.13; error d.f. = 9

Statistical analysis for total protein yield per acre demonstrated the following differences: Yields for treatment 12 were significantly higher than those of treatments 2, 4, and 8 at the 1-percent level; for treatment 8 they were significantly higher at the 1-percent level than for treatments 2 and 4, and for treatment 4 higher than for treatment 2 at the 1-percent level (fig. 2). Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, total protein*	*Treatments outyielded at 1-percent level*
12	55.23	2, 4, 8
8	44.12	2, 4
4	24.87	2
2	15.64	—

$s_{\bar{x}}$ = 1.56; error d.f. = 9

Treatment 12 produced hay yields per acre higher at the 1-percent level than did treatments 2 and 4, but not better than did treatment 8. Yields under treatment 8 were significantly higher at the 1-percent level than for treatments 2 and 4, and for treatment 4 significantly higher, at the 1-percent level, than for treatment 2. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, hay yields per acre*	*Treatments outyielded at 1-percent level*
12	572.12	2, 4
8	499.52	2, 4
4	387.70	2
2	282.13	—

$s_{\bar{x}}$ = 22.92; error d.f. = 9

Some differences were found between treatments in gross energy in Pangola grass. Analysis of variance per gram of dry matter follows:

Treatment No.	*Treatment mean*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	4.10	2	2, 4
8	4.09	—	2, 4
4	4.02	—	—
2	4.00	—	—

$s_{\bar{x}}$ = 0.016; error d.f. = 9

COASTAL BERMUDA GRASS

Coastal Bermuda grass also responded to the different nitrogen levels, although not so well as Pangola. For yield of green forage, treatment 12 was significantly better at the 1-percent level than treatments 2 and 4, but no difference was found with treatment 8. Treatment 8 was significantly better at the 4-percent level than treatments 4 and 2. No difference was found between treatments 2 and 4. Analysis of variance for green forage in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, green forage*	*Treatments outyielded at—*	
		1-7ercent level	*5-percent level*
12	963.06	2, 4	2, 4
8	798.32	—	2, 4
4	609.62	—	—
2	573.17	—	—

s_{x} = 54.25; error d.f. = 9

In producing dry-matter yield per acre treatment 12 was significantly better than treatments 4 and 2 at the 1-percent level and than treatment 8 at the 5-percent level. Treatment 8 was better than treatment 2 at the 1-percent level, but not better than treatment 4. Treatment 4 was better than treatment 2 at the 5-percent level. Analysis of variance for yield of dry matter per acre for 2 years follows:

Treatment No.	*Treatment mean, dry matter*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	444.80	2, 4	2, 4, 8
8	362.98	2	2
4	297.50	—	2
2	218.93	—	—

$s_{\bar{x}}$ = 21.11 error d.f. = 9

For the production of total protein per acre Coastal Bermuda grass under treatment 12 was significantly higher than under treatments 8, 4, and 2 at the 1-percent level; treatment 8 was better at the 1-percent level than treatments 4 and 2; and treatment 4 was better than treatment 2 at the 5-percent level. Analysis of variance for total protein per acre for 2 years follows:

Treatment No.	*Treatment mean, total protein per acre*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	50.25	2, 4, 8	2, 4, 8
8	37.63	2, 4	2, 4
4	24.79	—	2
2	15.76	—	—

$s_{\bar{x}}$ = 2.11; error d.f. = 9

For hay yield treatment 12 was better than treatments 2 and 4 at the 1-percent level and better than treatment 8 at the 5-percent level. Treatment 8 was better than treatment 2, but not better than treatment 4 at the 1-percent level. Treatment 4 was better than treatment 2 at the 5-percent level. The analysis of variance for hay yield per acre for the 2 years follows:

Treatment No.	*Treatment mean, hay yield*	*Treatment outyielded at—*	
		1-percent level	*5-percent level*
12	556.02	2, 4	2, 4, 8
8	467.35	2	2
4	372.03	—	2
2	273.68	—	—

$s_{\bar{x}}$ = 27.73; error d.f. = 9

For the production of gross energy treatment 12 was significantly better than treatment 2, but not better than treatments 4 and 8 at the 5-percent level. Treatment 8 was better than treatment 2 at the 5-percent level, but not better than treatment 4. No significant difference was found between treatments 4 and 2. The analysis of variance for gross energy at the different nitrogen fertilization levels follows:

Treatment No.	*Treatment mean, gross energy*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	4.36	2	2
8	4.35	2	2
4	4.29	—	—
2	4.23	—	—

$s_{\bar{x}} = 0.0272$; error d.f. = 9

For the production of gross energy treatment 12 was significantly better than treatment 2 at the 5-percent level, but not better than treatments 4 and 8. Treatment 8 was better than treatment 2 at the 5-percent level, but not better than treatment 4. No significant difference was found between treatments 4 and 2.

The grasses were compared by adding the yields of the four treatments for the 2 years and submitted to an analysis of variance (table 3).

In spite of the fact that its yields are considered low, as said before, Guinea grass outyielded the other two in all other aspects but gross energy. Pangola and Coastal Bermuda grasses were similar in yields except for gross energy, in which Coastal Bermuda also excelled Guinea grass.

Figure 1 shows the response of the three grasses to the different nitrogen levels as to yield of dry matter and percentage protein. Figure 2 shows the response of the grasses as to total protein yields under the different nitrogen levels.

The data on rainfall and amount of water of irrigation are presented in table 4 and the pH values found before and after 2 years of experiment are given in table 5. The pH values were taken in only two plots as only a check was sought on the possibility of any drastic change due to ammonium sulfate fertilization. Apparently 2 years were not enough to bring drastic changes in this soil under these fertilizing schedules.

The factors previously mentioned as adversely influencing the Guinea grass yields apparently affected more acutely the results at the high-nitrogen levels; the low-nitrogen levels of 200 and 400 pounds per acre produced yields which were higher than those obtained by Little *et al.* (*2*) at Aguirre and Vicente *et al.* (*8*) at Río Piedras.

DISCUSSION

PANGOLA GRASS

Yields of Pangola grass were good and compared favorably with yields obtained by others (see Literature Review). Higher yields could probably

TABLE 3.—*Comparison of results with Guinea, Pangola, and Coastal Bermuda grasses with analyses of variance to show differences among them*

Grasses, factors compared $s_{\bar{x}}$, and error d.f.	Adjusted mean yields	Results at 1-percent level	Results at 5-percent level
Individual treatments			
	Cwt./A.		
Green matter			
Guinea	5,652.10	Guinea better than Bermuda	Guinea better than Bermuda and Pangola, and Pangola better than Bermuda
Pangola	4,426.48		
Bermuda	2,986.06		
$s_{\bar{x}}$ = 224.68, error d.f. = 4			
Dry matter			
Guinea	1,664.62		Guinea better than Pangola and Bermuda
Bermuda	1,349.77		
Pangola	1,320.70		
$s_{\bar{x}}$ = 51.39, error d.f. = 4			
Hay 20-percent moisture			
Guinea	2,084.57		Do.
Bermuda	1,701.81		
Pangola	1,648.44		
$s_{\bar{x}}$ = 64.40, error d.f. = 4			
Total protein			
Guinea	188.36	Guinea better than Bermuda and Pangola	Do.
Pangola	135.14		
Bermuda	130.43		
$s_{\bar{x}}$ = 3.70, error d.f. = 4			

All treatments added

Grasses, factors compared, $s_{\bar{x}}$, and error	Adjusted mean yields	Results at 1-percent level	Results at 5-per cent level
	Cal./gm.		
Gross energy			
Bermuda	17.26	Bermuda better than Pangola and Guinea	Bermuda better than Pangola and Guinea
Guinea	16.20		
Pangola	16.13		
$s_{\bar{x}}$ = 0.0103, error d.f. = 4			

TABLE 4.—*Rainfall and water-of-irrigation (inches) data from October 1956 to September 1958 inclusive, by months*

Month	1956		1957		1958	
	Rainfall	Irrigation	Rainfall	Irrigation	Rainfall	Irrigation
October	10.45	—				
November	6.08	2.0				
December	3.38	—				
January			2.12	4.0	2.97	2.0
February			.85	2.0	.25	2.0
March			.31	4.0	.31	4.0
April			1.20	2.0	4.62	2.0
May			1.40	2.0	2.97	2.0
June			.86	4.0	4.52	2.0
July			.36	6.0	6.81	—
August			5.27	2.0	5.80	—
September			10.43	—	9.48	—
October			6.18	—		
November			2.83	2.0		
December			3.50	2.0		
Total	19.91	2.0	35.31	30.00	37.55	18.0
Total water	21.91		65.31		55.55	

TABLE 5.—*pH values prior to the start of the experiment and after 2 years of experiment according to nitrogen level for one Pangola and Guinea grass plot*

Soil sample No.	Values prior to experiment		Grass and plot No.	Values 2 years after		
	Depth in inches	pH		N level	Depth in inches	pH
U 285 x	0–8	6.7	Guinea 24	2	0–8	8.0
	8–24	7.9		2	8–15	7.4
				4	0–8	7.6
V 285	0–8	6.5		4	8–15	7.8
	8–24	7.7		8	0–8	7.0
				8	8–15	7.0
				12	0–8	5.8
				12	8–15	6.9
V 286	0–8	7.8	Pangola 17	2	0–8	7.6
	8–24	7.8		2	8–15	7.3
				4	0–8	7.8
				4	8–15	8.4
				8	0–8	6.2
				8	8–15	6.9
				12	0–8	5.7
				12	8–15	6.9

have been obtained had phosphorus and potash been used together with nitrogen. Present experiments in the same plots hint toward that assumption.

Aphids presented no problem under the irrigation and cutting-interval management system used.

Pangola grass is very easy to establish and permits very little competition from weeds. The stands reach cutting or grazing condition in 3 to 6 months. Except for one or two weedings a year, it needs very little care.

Although lower in yield than Guinea, it is believed that Pangola will find acceptance in the Lajas Valley under irrigation because of its easy management, its resistance to rough treatment, and its palatability, aggressiveness, and fast recovery period.

The results presented demonstrate that Pangola responds very well to increasing nitrogen applications; further research is needed to determine the proper quantity to recommend for Lajas Valley conditions.

COASTAL BERMUDA GRASS

Coastal Bermuda grass was similar in yield to, and better in dry-matter content and gross energy than Pangola. However, the following factors make Coastal Bermuda impractical and uneconomical under Lajas Valle conditions:

1. It takes too long to cover the ground and be ready to cut or graze.
2. It is not as aggressive as Pangola and weeds compete favorably with it. Large expenditures of time and money had to be made to keep the plots free of weeds and in good condition.

HAY

Hay made from the three grasses was tested for palatability with goats and cows. The best hay yields per pound of nitrogen applied were obtained from Guinea grass at the lower nitrogen levels (table 2). However, it was very poorly accepted by the animals.

Artificially cured hay, using an all-crop dryer, and field-cured hay were made. The stem of Guinea grass is relatively thick and takes too long to dry conveniently, requiring 4 or 5 days of good sunshine for field curing and 2 to 3 days on the dryer, after wilting for a few hours in the field.

It took so long for the moisture in the stems to reach a satisfactory level that the leaves were practically without moisture and almost completely bleached. The hay was very coarse and brittle. The use of a crusher might improve the quality, but there is no certainty that this would improve the palatability.

Coastal Bermuda produces a very good palatable hay. Field-cured hay takes less than 2 good-weather days to make. Artificially cured hay requires from 8 to 10 hours in the dryer after being wilted for a few hours in the field. This grass contains much more dry matter per pound of green material than either Guinea or Pangola, a fact that cuts the time needed to reduce the moisture properly.

Coastal Bermuda grass produces a very palatable hay; both goats and cows relish it. Pangola grass also produces good, very palatable hay, similar to Coastal Bermuda hay, although of a little darker color.

Pangola hay, either for farm use or for commercial use by race horses and calves, can be produced in Lajas Valley by the proper use of dryers. Actually, the importation of timothy hay and a small amount of alfalfa hay runs to over $1,000,000 a year, with costs of from $70 to $80 a ton at the farm.

PERCENTAGE PROTEIN CONTENT

Pangola and Coastal Bermuda responded similarly in percentage protein content to the level of nitrogen applied. Guinea grass had a little higher protein content, probably due to a larger proportion of leaves to stems (*4*).

Table 1 shows the pounds of dry matter produced and the cost thereof per pound of nitrogen applied, according to nitrogen level. Dry matter can be produced cheaper with the lower levels of nitrogen application. The yield data seem to be in line with what should be expected from the law of diminishing returns.

Experiments are under way to seek additional information on this point. Results show that Pangola responded to all levels of nitrogen applications, 1,200 pounds being better than 800, 400, and 200; 800 pounds better than 400 and 200; and 400 better than the 200 pounds.

Coastal Bermuda acts similarly, except that no difference was found between the 400- and 800-pound nitrogen levels.

Fertilizer is a costly item in pasture management in Puerto Rico. As we do not have good legumes and must strive for top production, both in quality and in quantity, large quantities of fertilizer materials must be applied. That is one of the reasons it is so important to determine the economic amounts to recommend. In the meantime, quantities between 300 and 400 pounds of nitrogen per acre can be used, depending on the fertility of the soil.

Table 6 presents the calculated carrying capacities of the grasses under the different nitrogen treatments tested and using the factors of standard cow-days for dairy and beef cows.

The estimated average weight for dairy cows in Puerto Rico is about 900 pounds (equivalent to 350 pounds, or 14 *arrobas* of beef). Assuming an average daily consumption of 15 pounds of dry matter (corresponding to 7.5 pounds of digestible nutrients) to be enough for maintenance, these grasses will carry the number of cows per acre that appear in table 7, according to treatment. See table 1 for yields of dry matter.

These figures are presented for comparison only and allowance must be made for the kind of cattle on a particular farm, lactating cows, pregnant cows, and growing stock. For beef cows calculations should include both cow and calf.

TABLE 6.—*Carrying capacity of Pangola, Coastal Bermuda, and Guinea grasses, assuming 50-percent T.D.N. in the dry matter and that all the forages produced are consumed*

Grass	Average T.D.N. yield per acre per day according to N level under treatment No.—				Dairy cow (16 pounds of T.D.N. per day)[1] under treatment No.—				Beef cow (12 pounds of T.D.N. per day)[1] under treatment No.—			
	2	4	8	12	2	4	8	12	2	4	8	12
Pangola	15.5	21.2	27.2	31.5	0.97	1.33	1.70	1.97	1.29	1.97	2.27	2.63
Coastal Bermuda	14.99	20.37	24.86	30.46	.94	1.27	1.55	1.90	1.25	1.70	2.07	2.54
Guinea	23.8	27.41	29.49	30.20	1.49	1.71	1.84	1.89	1.98	2.28	2.46	2.52

[1] Standard cow-days.

TABLE 7.—*Carrying capacity of the 3 grasses assuming a 900-pound cow and 15 pounds of dry-matter consumption daily*

Grass	Number of cows under treatment No.—			
	2	4	8	12
Pangola	2.00	2.83	3.67	4.18
Coastal Bermuda	2.00	2.73	3.33	4.00
Guinea	3.20	3.67	3.93	4.00

SEASONAL VARIATION

A marked seasonal variation in yield was observed by Vicente *et al.* working on Napier, Pará, and Guinea grasses in the north humid section of the Island (*8*) with high production from April through August, and a sharp decline from then on.

A similar seasonal variation was observed in the present work. The high production starting in March attained a peak in September, followed by a sharp decline from then on (figs. 3, 4, and 5.) Statistical analysis of the data shows that this seasonal variation is cyclic. This finding is very important both for proper management of the grasses and feeding the cattle.

In the dry southwestern section of the Island, where the available water was controlled by irrigation, it was not possible to equate yields throughout

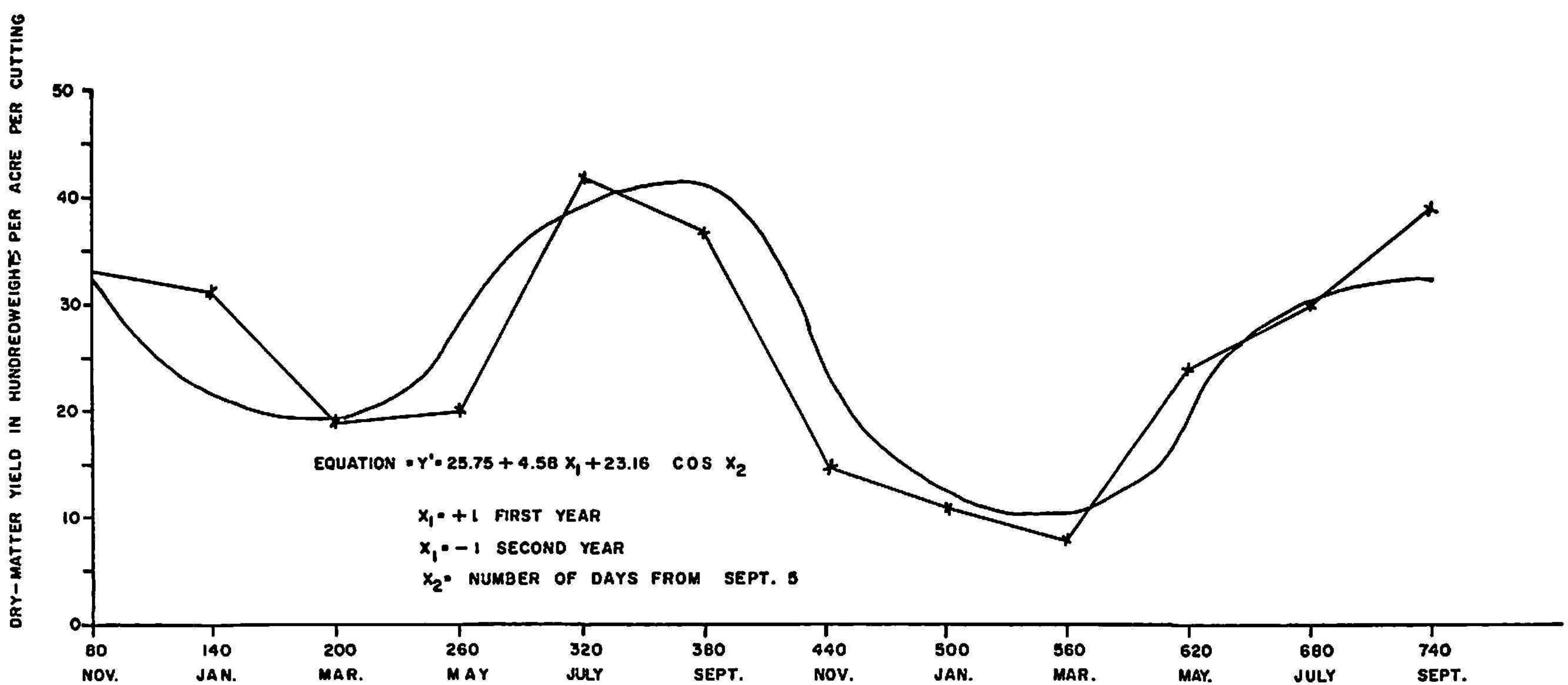

FIG. 3.—Seasonal variation in dry-matter content of Pangola grass during 2-year experiment.

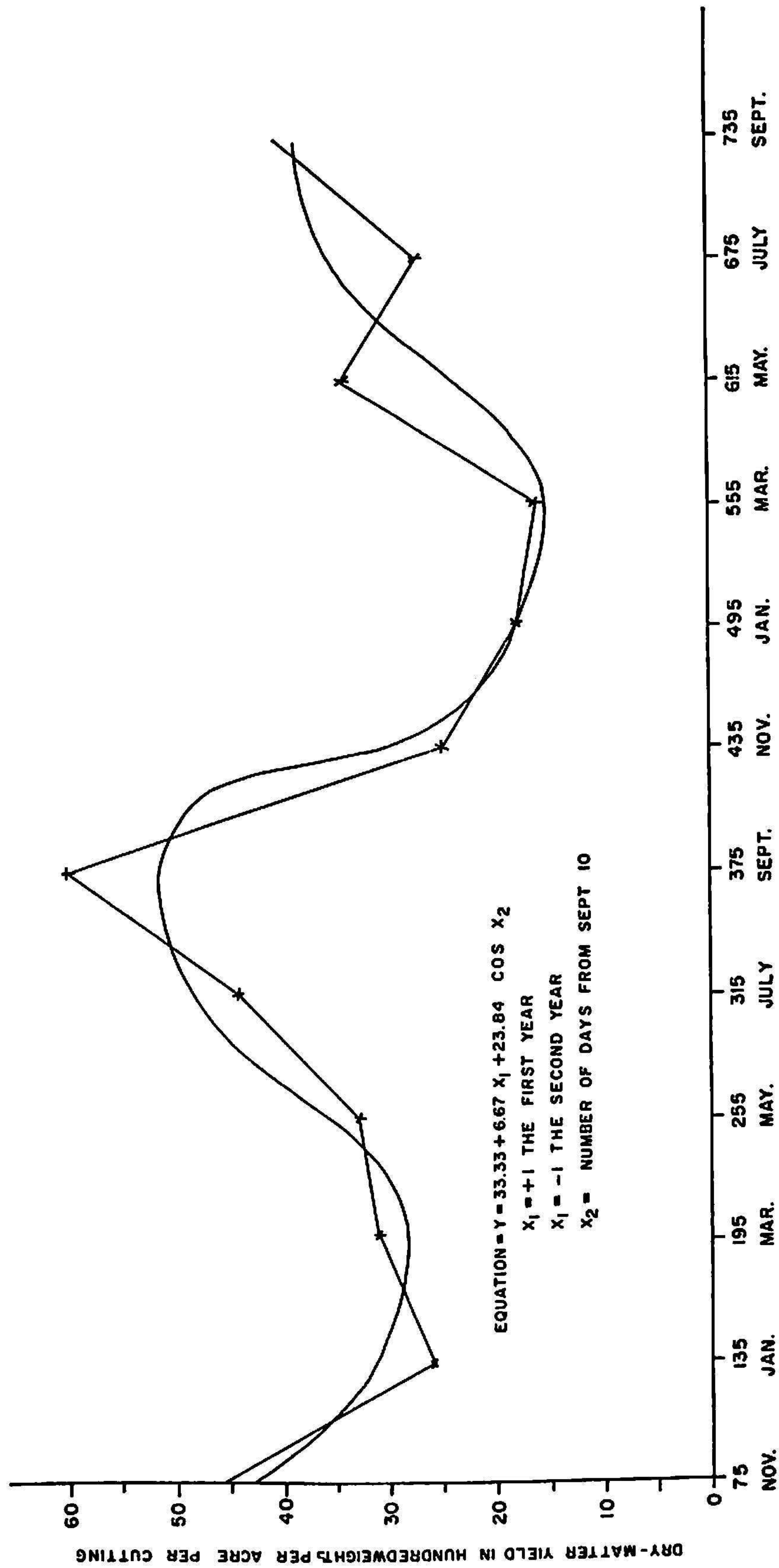

FIG. 4.—Seasonal variation in dry-matter content of Guinea grass during 2-year experiment.

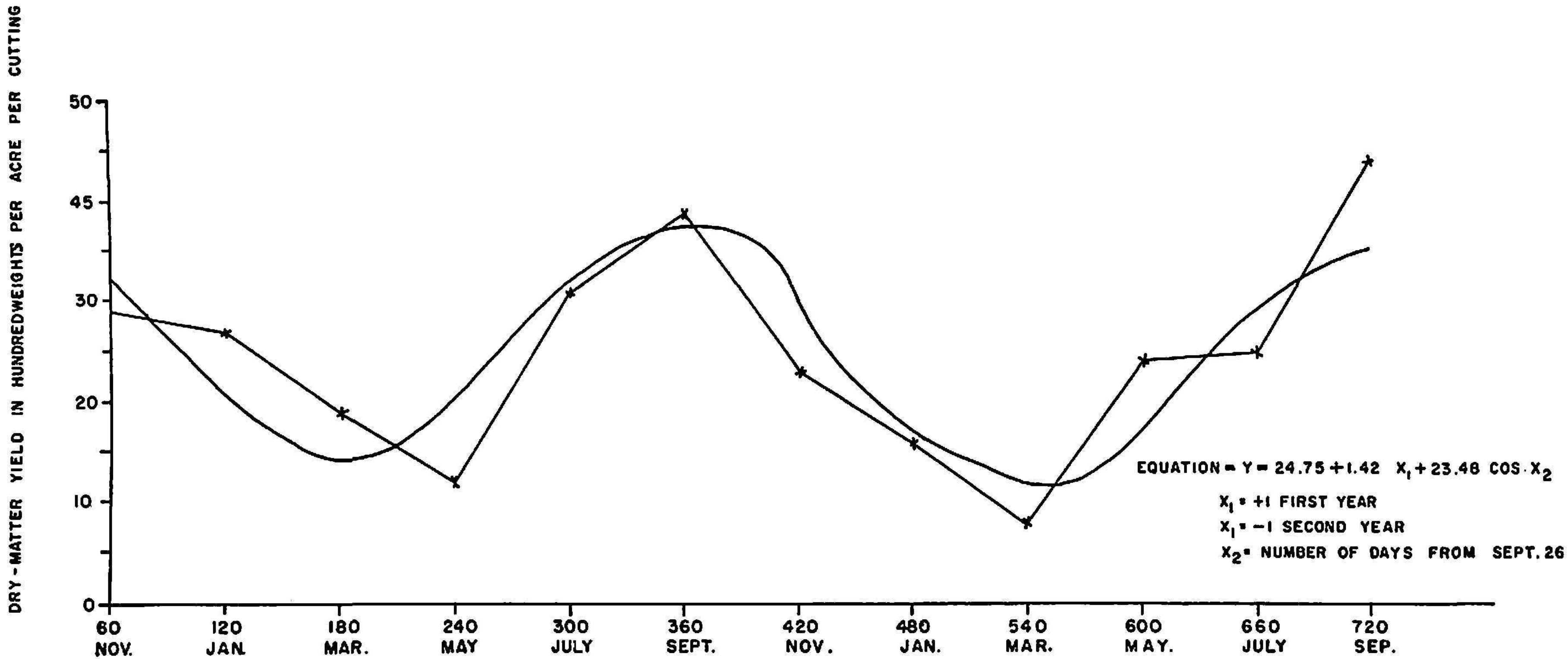

FIG. 5.—Seasonal variation in dry-matter content of Coastal Bermuda grass during 2-year experiment.

the year. The same holds true in the north humid section, which has a period of low production from November to February or March, when days are short and temperatures low.

In the north humid section it is probably more economical to ensile the excess roughage produced during May through September than to establish an irrigation system for use during the period of slow growth. In the Southwest, where dry periods are long and the amount of water during the rainy season uncertain and poorly distributed, irrigation of pastures is necessary.

There is a marked annual variation in yields of Pangola and Guinea grasses.

TABLE 8.—*Average dry-matter yields (pounds) for the first- and second-year harvests of the 3 grasses*

Grass	First year, average of 6 cuttings	Second year, average of 6 cuttings
Guinea	4,000	2,670
Pangola	3,051	2,118
Coastal Bermuda	2,625	2,331

TABLE 9.—*Average percentages of leaves and stems for the 3 grasses according to nitrogen level*[1]

Grass	Results at nitrogen level indicated—							
	200 lb.		400 lb.		800 lb.		1,200 lb.	
	Stem	Leaves	Stem	Leaves	Stem	Leaves	Stem	Leaves
Guinea	28.44	71.56	26.65	73.35	29.94	70.06	29.22	70.78
Pangola	67.09	32.91	66.84	33.16	67.49	32.51	64.96	35.04
Coastal Bermuda	48.24	51.76	50.24	49.76	48.65	51.35	49.98	50.02

[1] Average of 9 samples under each treatment.

Much better yields were obtained the first year than the second. Coastal Bermuda was more uniform in production from one year to the other.

Table 8 presents the average yields of dry matter for the first and second six cuttings corresponding to the first and second year for the three grasses. The effects of year, cutting, and cutting interval all have to be determined. Some of these grasses are best adapted only for grazing, and frequent cuttings affect the life of the stand. An experiment now going on in the same plots, to last 4 years, will probably shed additional information on some of these questions.

The leaf and stem percentages of the grasses are presented in table 9. The nitrogen treatments did not appreciably affect these percentages for any of the grasses.

Guinea grass proved to be superior in leaf:stem ratio to Pangola and Coastal Bermuda. This was found previously by Rivera Brenes (*4*) when Guinea grass was compared with Napier and Pará grasses. Coastal Bermuda is better than Pangola in this trait also. These facts are very important, as most of the nutritional value of a forage grass is in its leaves.

There is no doubt of the superiority in yield and probably in total nutritive value of Guinea grass to Pará, Pangola, molasses, and molasses-kudzu for grazing, due possibly to a higher percentage of leaves. Guinea is the grass to recommend if it is properly managed with adequate fertilization, if rotational grazing is used to minimize "kill-out" of bunches, and if it is mowed at least once a year. This keeps bunches down to at least 8 inches, enabling Guinea to benefit from the high percentage of leaves. At least one field a year should be left to reseed itself. Proper weed control is assumed in all cases.

Most farmers want a forage grass that is easy to handle and not so exacting of good management as is Guinea. These conditions are met by Pangola grass for the humid sections of Puerto Rico and on irrigated areas. There is no choice at present but Guinea grass under good management; for the Southern and Southwestern Regions, without water of irrigation. Otherwise weeds and competing grasses soon smother it.

SUMMARY

An experiment was established at the Lajas Substation to measure the response of Guinea, which is the prevailing grass of the Valley, Pangola, and Coastal Bermuda grasses to fertilization with nitrogen at the levels of 200, 400, 800, and 1,200 pounds of nitrogen in six equal applications per year for two consecutive years under irrigation. A split-plot design was followed with four replications, grasses being tested in the large plots and nitrogen in the subplots.

The grasses were cut every 60 days and the following classes of data were taken for comparisons: 1, Yields of green and dry matter per acre per year; 2, hay yields per acre, using an all-crop dryer and adjusting yields to 20-percent moisture for uniformity; 3, gross-energy values as affected by treatment; 4, percentage of protein and total protein per acre as affected by treatment; 5, leaf-to-stem ratio; 6, observations on palatability of the hays produced; 7, other observations.

Generally speaking, and with few exceptions, highly significant differences were found in yield per acre of green forage, dry matter, hay, and total protein for all three grasses between the high and lower nitrogen treatments. No differences were found between the two high-nitrogen treatments.

Seasonal variation was measured. There was an increase in yield for the three grasses, starting in April with a peak in September, and a reduction starting in late October with the lowest yield in January no matter how much water and fertilizer was applied. Tentative recommendations are made. Further work is being carried on, however.

RESUMEN

Se estableció un experimento en el Valle de Lajas con el propósito de medir los efectos de distintas aplicaciones de nitrógeno (200, 400, 800 y 1,200 libras por cuerda al año) en las yerbas Guinea (predominante en el Valle), Pangola y Bermuda de Costa bajo riego controlado. Este trabajo se llevó a cabo durante dos años consecutivos. Las yerbas se cortaron cada 60 días y las parcelas se abonaron, después de cada corte, con una sexta parte del abono a aplicarse durante el año. Se usó un diseño que comprendía parcelas divididas con cuatro replicaciones y en el cual las yerbas se compararon en las parcelas grandes y las cantidades de nitrógeno en las parcelas pequeñas.

Se estudiaron los siguientes detalles:

1. Rendimiento de materia verde y materia seca por cuerda por año.
2. Producción de heno por cuerda, ajustando la humedad a un 20 por ciento para las comparaciones. Se usó una secadora pequeña de cosechas.
3. Energía bruta de cada una de las yerbas y cómo fue afectada por los distintos tratamientos.
4. Porcentaje de proteína total por cuerda, según los tratamientos.
5. Medidas de los efectos de las variaciones estacionales sobre la producción.
6. Efecto de los tratamientos en cuanto a la proporción de tallos a hojas.
7. Observaciones en cuanto a la aceptación por cabras y vacas de los henos producidos de las distintas yerbas.

Se incluye además una discusión sobre la capacidad de estas yerbas, según cada tratamiento, para sostener cabezas de ganado.

También se discuten otras observaciones de importancia sobre estas yerbas.

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