THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, for the publication of articles by members of its personnel, or others, dealing with any of the more technical aspects of scientific agriculture in Puerto Rico or the Caribbean Area.

Vol. XXXIII July, 1949 No. 3

THE UTILIZATION OF GRASSES, LEGUMES AND OTHER FORAGE CROPS FOR CATTLE FEEDING IN PUERTO RICO

II. COMPARISON OF FERTILIZED GUINEA GRASS, PARA GRASS AND TROPICAL KUDZU AND TROPICAL KUDZU ALONE AS PASTURE CROPS

LUIS RIVERA BRENES,[1] FRANCISCO J. MARCHÁN[2] AND JOSÉ I. CABRERA[3]

INTRODUCTION

The improvement of the pasture and soiling crops is vital to the dairy cattle industry in Puerto Rico. The high importation of concentrate feeds which in 1947–1948 was around 6 million dollars (2) is due principally to the poor quality roughage consumed by our livestock. There is no doubt about the fact that there is no need for cattle, in general, consuming a high quality forage, especially grass-legume mixtures, to consume large quantities of concentrate feed in order to meet their requirements for maintenance, gain in weight, milk production and reproduction. This, at the same time, reduces the cost of production considerably because the cow has been fitted by nature to be an efficient user of roughage which is the cheapest part of the ration.

LITERATURE REVIEW

It was found in this Station (11) that heifers pasturing in a mixture of Para grass-Kudzu gained consistently more in weight than those that were pasturing in Para grass or Guinea grass alone. Significantly larger amounts of T.D.N. were also produced by the mixture; the carrying capacity was approximately 1 head per acre for the mixture; 1/2 for Para grass alone and 1/2 for Guinea grass alone. No fertilizer was applied in this experiment.

It was also found (11) that the grass growing with the legume had a higher protein content than when grown alone.

It has been proved that the use of fertilizer, especially nitrogenous

[1] Acting Head Animal Husbandry Department.

[2] Assistant Chemist, Animal Husbandry Department.

[3] Assistant Animal Husbandman, Animal Husbandry Department.

fertilizer, besides increasing the total yield also increases the protein content of the grasses; thus improving the nutritive value and increasing the carrying capacity.

In South Africa, Weinman (15) found that fertilization increased the contents of N, P and K in the herbage, also the yield was augmented considerably. Lavvorn (9) found the response of Dallis and Carpet grasses to nitrogen fertilizer to be very great. The yields in pounds of air-dry matter per acre in a fine sandy loam were as follows:

	No Treatment	*Fertilized with N.P.K.*
Dallis	917.0 lbs.	2158.0 lbs.
Carpet	731.0 lbs.	1695.0 lbs.

To find out the effects and efficiency of nitrogen fertilization in sugar cane, Borden in Hawaii (4) used Para grass (*Panicum barbinode*) in pots as an indicator crop. He found that increasing the amount of nitrogen from 0.275 up to 2.2 grams per pot increased the dry weight from 119 to 337 grams as compared to 47 grams for no nitrogen. He also found that for each additional amount of nitrogen applied there is a corresponding decrease in efficiency that is usually associated with all growth factors, i.e., "the law of diminishing returns is operative and is true regardless the season during which the crop was grown." The efficiency was measured in grams of dry weight per gram of nitrogen.

The West Virginia Agricultural Experiment Station (12) reports the results of the tests for 10 grasses in the treatment of pastures with lime and fertilizer showing marked increases in carrying capacity. When nitrogen, phosphorus, potash and lime were applied they had increases from 112 per cent to 124.7 per cent. Irwin (8) in Alaska found that broadcasting 200 to 400 pounds of ammonium sulphate per acre or spreading manure at 6 to 8 tons per acre on grass meadows in the Spring at the beginning of the growing season more than doubled the yields of hay or pasture.

In Kansas (1) shortages of adapted brome grass seed were due primarily to the failure of brome grass stands to produce well after their 2nd. to 4th. year. Applications of nitrogen fertilizer supplying 75 to 100 pounds of nitrogen per acre corrected the unthrifty condition of the old brome grass sods and resulted in increased yields of both seed and forage. It was also found that protein percentage was increased materially. In North Dakota (14) they had the same problem with brome grass. They submitted a series of brome grass plots to the following treatments. 1—ammonium sulphage, 2—superphosphate, 3—a mixture of superphosphate and ammonium sulphate, 4—fresh barn yard manure and 5—cultivation alone. The study continued for three seasons and the influence of various treatments was measured by the number of seed heads produced and the yield of forage

compared with a check plot. During the third year nitrogen fertilizer had apparently increased the forage yield, and more when ammonium sulphate was used than when either manure or superphosphate was added. Manure had a very desirable residual effect.

Bartholomew (3) cites some examples of the capacity of non-leguminous grass crops to respond to nitrogen. In the Virginia Agricultural Experiment Station Orchard grass yields were increased from 1099 pounds an acre where no nitrogen was added to 5099 pounds when a hundred-weight of nitrogen was applied. The protein yields in pounds per acre in the two treatments were 99 and 528 pounds per acre respectively. In South Dakota the average yield of several adapted grasses from experiments in four counties was 1964 pounds an acre when no fertilizer was applied, 3093 pounds per acre when only nitrogen was used and 3240 pounds per acre when nitrogen was added along with phosphorus.

Sullivan (13) in his article about effects of fertilizers on herbage stated the following:

1. Fertilization influences the chemical composition of herbage in two ways:

a. favors the growth of some plants rather than others.

b. affects the quality of herbage by changing the chemical composition of individual plants.

2. Any effect of nitrogen fertilizer in increasing protein is usually apparent a short time only. In Connecticut, when it was applied to blue grass and bent grass in the Spring, only the first successive monthly cuttings showed greater protein contents than those from unfertilized areas. If high protein throughout the season is desired, the nitrogen must be applied frequently.

3. The more commonly applied fertilizers: nitrates, ammonium sulphate, phosphate and potash, and also lime, do promote an increase in one or more of the desirable major nutritive elements and thus, they improve forage quality. Weinmann (16) found that the dry matter yield from the fertilized, moderately grazed plots was significantly higher than that produced by any other treatment, the lowest yields being obtained from the unfertilized plots (control). Heavy grazing reduced significantly the herbage production when fertilizer was applied, but not in the unfertilized plots. The treatments and yields were the following.

Treatment	*Yield*
1. Moderately grazed and fertilized	8021 lbs. dry matter per acre
2. Moderately grazed and unfertilized	4473 lbs. dry matter per acre
3. Heavily grazed and fertilized	5851 lbs. dry matter per acre
4. Heavily grazed and unfertilized	4611 lbs. dry matter per acre
5. Control grazed and unfertilized	3541 lbs. dry matter per acre

The nutrient yields were highest in the fertilized moderately grazed plots. The application of fertilizer caused a considerable increase in the nutrient uptake under both grazing intensities. Fertilizer treatment produced, under both heavy and moderate grazing, a herbage of higher protein, phosphorus and potash content. The fertilizers used were 40 pounds of nitrogen, 120 pounds phosphoric acid anhydride and 40 pounds potash per 2.12 acres as first application, then 200 pounds of ammonium sulphate per 2.12 acres per season for three seasons. In California, Dickey (6) found that in an area of range representative of the 60,000,000 acres of land now devoted to grazing the application of ammonium phosphate-sulphate at the rate of 200 pounds per acre increased the production of hay from 1259 pounds to 3755 pounds per acre. He considered more important still that the range readiness of the fertilized plots was seven weeks earlier than the unfertilized plots.

From Holland, Riemsdyk (10) informs that the average crop of pasture may be estimated at 2500 Kg. starch value per hectare[4] or 3750 Kg. per hectare when grazed off. By application of 200 Kg. of nitrogen per hectare this latter figure might be increased to 5100 Kg. per hectare, and by improvement of the fields a further increase to 5500 Kg. may be expected.

Comparative digestibility trials with sheep were carried out by Ferguson (7) on hays top dressed with nitrogenous fertilizer 8 to 13 days before cutting and on similar untreated hays. One lot consisted of a mixture of Rye grass and cockfoot treated with ammonium sulphate while the other hay was a mixture of meadow grasses and a little wild white clover top dressed with Nitro chalk. An increase of 2 per cent of crude protein and 1.2 per cent of true proteins was produced by the treatment. The digestibility was significantly higher in the top dressed hays.

Brown (5), comparing legumes with grasses fertilized with nitrogen, for hay and pasture, stated that during a 5-year period the yields of timothy were increased markedly by both 28 and 56 pounds of nitrogen per acre annually; but in the same season, alfalfa on nearby plots unfertilized since seeding produced more dry matter and twice much more protein. Ladino clover-orchard grass seedings also yielded more dry matter and much more protein than a stand of timothy fertilized with 28 pounds of nitrogen in each of the months of April and June. The seeding of Ladino clover with either Kentucky blue grass or Rhode Island bent grass, land mowed 8 times per season for 7 years resulted in a larger total and better distributed yields than the application of nitrogen at 28 pounds per acre in each of the months of April, June and August on the grasses alone. On grazed permanent pastures spring applied nitrogen stimulated a 30 per cent increase in total yield over mineral fertilization.

[4] Hectare—2.5 acres.

Lavvorn (9), studying the effect of nitrogen fertilizer on legumes stated that apparently the use of nitrogen in legumes either depresses production or is of no benefit. The grass-legume combinations have the tendency to respond to nitrogen during the early stages, but once a satisfactory legume was established, regardless of whether it was a perennial as white clover or a winter annual as low top clover, the yields attained were as great from the mineral fertilizer as from the complete fertilizer.

PROCEDURE

The forage grasses used in this grazing trial were Guinea grass *Panicum maximum* Jacq, the mixture of Tropical Kudzu and Para grass *Pueraria phaseoloides Javanica* Benth, *Panicum purpurascens* Reddi and Tropical Kudzu.

The procedure was the same as that used in a previous trial (11) with some slight modifications. The grazing trial lasted 273 days (from December 18, 1946 to September 16, 1947), divided in three periods, according to the number of heifers in the grass plots. The first period of 115 days, with one heifer in each one-acre plot; the second of 48 days, with one heifer in each one-acre plot of Para-Kudzu and Kudzu and two heifers in each one-acre plot of Guinea grass, and the third period of 110 days, with two heifers in each one-acre plot of Para-Kudzu and Guinea grass and one heifer in each one-acre plot of Kudzu.

Following recommendations of the Soils and Agronomy Departments on November 18, 1946, one month before the beginning of the trial, 1000 pounds of 10-10-5 fertilizer per acre were applied to the Guinea grass in addition to 167 pounds of muriate of potash. To the following sub-plots[5] of Kudzu 167 pounds of superphosphate were added.

1. Block A—Sub-plot 3
2. Block B—Sub-plot 1
3. Block C—Sub-plot 2

Superphosphate at the same rate was applied also to the following Para grass-Kudzu sub-plots.

1. Block A—Sub-plot 2
2. Block B—Sub-plot 1
3. Block C—Sub-plot 3

[5] As explained before (11) each acre plot was divided into three ⅓ acre sub-plots for the rotation. The blocks were A, B and C, so the sub-plots were numbered A-1, 2 and 3; B- 1, 2 and 3, etc.

On February 10, 1947 another application of 200 pounds of ammonium sulphate per acre was made to the Guinea grass and then on June 4 another application of the same kind and amount of nitrogenous fertilizer.

A group of Holstein, Native and Native-Holstein heifers were used. To avoid breed differences the heifers were distributed among the grasses in the following way; one Holstein, one Native and one Native-Holstein in each grass, legume and legume-grass combination.

RESULTS AND DISCUSSION

Weight gains by period are presented in Table 1.

Although the heifers in the mixture plots gained more in the first two periods there is not much difference between the groups.

Since the mixture plots did not receive any nitrogenous fertilizer and they yielded practically the same as the grass which had received fertilizer, the superiority of the mixture and the legume over the grass is obvious.

The average chemical analysis for all the samples taken during the grazing trial are presented in table 2.

The protein content of the mixture and of Kudzu was more or less the same as in the previous trial (11) but the average crude protein content of Guinea grass under this fertilized condition was 8.56 as compared to 5.76 before; an increase of 2.80 per cent.

To see the immediate effect of the application of nitrogenous fertilizer on the analysis of Guinea grass, three samples, one from each acre plot, were taken one month after the application on February 10, 1947. These analyses were compared with those of three samples of the Para-Kudzu mixture taken on the same date. The results are presented in table 3.

The average analysis of crude protein for these particular Guinea grass samples is much higher than the over all average, while that for the mixture plots is a little lower.

The above results might explain the importance of the legume-grass mixtures for feeding purposes. The beneficial effects on the soil and on the grass exerted by the legume are more uniform and more permanent bringing with it a more uniform nutrient intake by the animals being grazed on it.

Nitrogenous fertilizer has an immediate effect on the analysis but after some time the grass comes back to what we can call, its normal condition for the kind of soil, clearly seen in the average analyses presented in table 2 of this and the previous trial (11). This is of great importance when the grass is to be used for soilage or for silage.

The total amount of clippings and dry matter content in pounds is shown in Table 4.

Larger amounts of clippings for the first period were as expected because

TABLE 1

Weight gains in pounds per group, mean gain per animal and least significant difference

Grasses	No. of heifers	Initial weight of group	Weight of group at end of period	Gains of groups in pounds	Mean gain in wgt. in lbs. per animal
		First Period 12-18-46 to 4-11-47			
PK*	3	958.00	1495.33	538.00	179.33
K	3	911.00	1315.67	404.67	134.89
G	3	1041.67	1480.33	438.66	146.22
Least sign. diff. 5%					48.41
1%					80.29
		Second Period 4-12-47 to 5-29-47			
PK	3	1495.33	1690.67	195.34	65.11
K	3	1315.67	1525.67	210.00	70.00
G	6	2609.33	2903.33	294.00	49.00
Least sign. diff. 5%					26.89
1%					39.78
		Third Period 5-30-47 to 9-16-47			
PK	6	3166.33	3904.00	737.67	122.95
K	3	1525.67	1903.34	377.34	125.89
G	6	2903.33	3708.33	805.00	134.17
Least sign. diff. 5%					44.00
Between PK and K 1%					54.59
Least sign. diff. 5%					35.96
Between PK and G 1%					44.61

* PK = Para grass-Kudzu mixture
K = Kudzu alone
G = Guinea grass

TABLE 2

Average analysis of the three forage crops during the whole trial in per cent, dry basis

Grasses	No. of samples	Moisture %	Ash %	Crude Protein %	Fat %	Fiber %	N.F.E. %
Para-Kudzu	33	75.8	7.60	10.05	1.87	32.43	47.38
Kudzu	15	79.59	6.39	18.94	3.07	31.73	39.88
Guinea grass	33	76.21	8.63	8.56	2.04	33.42	46.76

the plots rested for some time and when the heifers were put on them there was a rank growth in all. Some heifers grazed up their sub-plots first, or like in Kudzu alone the amount of roughage was much less than in the other grass plots causing frequent changes which permitted larger amounts of clippings in the Guinea and Para grass-Kudzu sub-plots when all the heifers were moved.

The larger amount of clippings from the Guinea grass plots all through the entire duration of the grazing trial was probably due to the fertilization.

Except for the first period, no residue was clipped from the Kudzu plots, the reasons of which will be discussed farther ahead.

TABLE 3

Average analysis of Guinea grass, samples taken 1 month after application of nitrogenous fertilizer and of the mixture of Para grass-Kudzu, samples taken the same date

Grasses	Moisture %	Ash %	Crude Protein %	Fat %	Fiber %	N.F.E. %
Guinea	77.43	9.65	13.24	3.30	32.10	41.80
Para grass-Kudzu	72.16	7.95	9.38	2.13	34.01	46.53

TABLE 4

Clippings and dry matter content in pounds by periods

	First period		Second period		Third period	
Grass	lbs. Clippings	lbs. Dry matter	lbs. Clippings	lbs. Dry matter	lbs. Clippings	lbs. Dry matter
PK	10155.00	2457.51	475.00	114.95	544.00	131.65
K	385.00	78.66	00.00	00.00	00.00	00.00
G	29288.00	6967.62	1081.00	257.17	1102.00	262.17

Data and calculation of total nutrients and carrying capacity is presented in table 5.

The carrying capacity shown by Guinea grass in this trial more than double the results obtained in the previous experiment (11). The rise was exactly from 0.42 to 1.21 due, with all probability, to the nitrogen applications. The mixture of Para grass-Kudzu had more or less the same carrying capacity as before, about one head per acre. Kudzu planted alone, in spite of its high nutritive value, had a carrying capacity of only 0.47.

Although the nutritive value of Guinea grass as shown by the average chemical analysis and the gain in weight of the heifers was lower than that for Para grass-Kudzu mixture the amount of roughage produced made it possible for it to have a little higher carrying capacity.

TABLE 5

Calculation of total digestible nutrients and carrying capacity for the three periods of the experiment

Items	First period			Second period			Third period		
	PK	K	G	PK	K	G	PK	K	G
1. Days in period	115	115	115	48	48	48	110	110	110
2. Number of heifers	3	3	3	3	3	6	6	3	6
3. Total heifer days (1) × (2)	345	345	345	144	144	288	660	330	660
4. Total initial weight in lbs.	958.00	911.00	1041.67	1495.33	1315.67	2609.33	3166.33	1525.67	2903.33
5. Total final weight in lbs.	1495.33	1315.67	1480.33	1690.67	1525.67	2903.33	3904.00	1903.34	3708.33
6. Average maintenance, lbs. $\frac{(4)+(5)}{2}$	1226.67	1113.33	1261.00	1593.00	1420.67	2756.33	3535.17	1714.51	3305.83
7. Total weight days (6) × (1)	141067.05	128032.95	145015.00	76464.00	68192.16	132303.84	388868.70	188506.10	363641.30
8. TDN for maintenance $\frac{(7) \times 7.925}{1000}$	1117.96	1014.64	1149.28	605.98	540.12	1048.51	3081.79	18859.10	2881.85
9. Weight gain in pounds	538.00	405.00	439.00	195.34	210.00	294.00	737.67	1494.66	805.00
10. TDN requirement for gain in lbs. (9) × 3.53	1899.14	1429.65	1549.67	689.55	741.30	1037.82	2603.98	377.67	2641.65
11. TDN requirements, pounds (8) + (10)	3017.10	2444.29	2698.25	1295.55	1281.72	2086.33	5685.77	1333.18	5723.50
12. TDN from residue, pounds	1769.40	56.63	5016.68	82.76	—	185.16	94.79	2827.84	188.75
13. TDN yield of pasture, pounds (11) + (12)	4768.50	2500.92	7715.63	1378.29	1281.72	2271.49	5780.53	2827.84	5912.26
14. TDN yield per acre $\frac{(13)}{\text{acreage}}$	1595.50	883.64	2571.88	459.43	427.24	757.16	1926.84	942.61	1970.75
15. Standard cow-days per acre $\frac{(14)}{(16)}$	99.72	55.23	160.74	28.71	26.70	47.32	120.43	58.91	123.17
16. Carrying capacity standard cow-days $\frac{(15)}{(1)}$	0.87	0.48	1.40	0.60	0.56	0.99	1.09	0.54	1.12

Numbers in parenthesis indicates item number

The analysis of the calculated total digestible nutrient yields is presented in table 6.

Both Para grass-Kudzu mixture and Guinea grass were superior to Kudzu alone in total digestible nutrient yields all through the three periods. Total digestible nutrients produced by Guinea grass during the first and second

TABLE 6

Mean total digestible nutrient yields per acre and least significant differences for the grass for the three periods

Grasses	Total digestible nutrient mean yields in lbs. per acre
First period	
PK	1595.00
K	833.00
G	2572.00
Least sign. difference 5%	381.00
1%	632.82
Second period	
PK	459.33
K	427.66
G	757.00
Least sign. difference 5%	168.53
1%	279.75
Third period	
PK	2020.33
K	988.00
G	2058.33
Least sign. difference 5%	308.55
1%	511.73

periods were higher than the amount produced by the legume grass mixture; the difference being highly significant. During the third period although Guinea grass produced 38 pounds more total digestible nutrients the difference was not significant. This indicates with all probability that by this time the grass was not receiving the effects of the nitrogen fertilizers as during the previous periods. This is sustained also by the results obtained for carrying capacity for this period. It also agrees with Sullivan

(13), who stated that the effect of nitrogen fertilizer is usually apparent for a short time only.

Abundant rain fell during the entire experimental period. Table 7 shows the precipitation by months.

In general, the water supply was adequate.

The uniformity of growth response to grazing and the nutritive value of the mixture of Para grass-Kudzu has been shown by the results of this and previous trials. Except for a small amount of superphosphate to some of the sub-plots no other fertilizer was applied considering that the application of nitrogen depresses the growth of the legume. (See literature review.) There is no doubt that the mixture of Para grass and Kudzu is very desirable for grazing animals.

TABLE 7

*Precipitation from December 1946 to September 1947 in inches**

Month	*Inches of rainfall*
December 1946	6.85
January 1947	7.71
February 1947	5.76
March 1947	1.38
April 1947	2.82
May 1947	10.24
June 1947	4.24
July 1947	1.88
August 1947	11.20
September 1947	12.22
Total	64.30

* Records kept at the Experiment Station farm.

Although Guinea grass grows fairly well in the northern part of the Island, it is typical of the dry fertile lands of the South.

In the North the soil is relatively poor and acid and Guinea grass gets sod bound after two or three years. This same thing happens to brome grass in Kansas and North Dakota. (See literature review.) Applications of nitrogen have corrected this condition. This indicates that in order to maintain Guinea grass always in good condition in this region of the Island, applications of nitrogen at constant intervals is necessary. Such management is quite costly and unnecessary if we consider that the introduction of a legume will correct the situation.

Tropical Kudzu is a very nutritive legume as shown by the chemical analysis and by the gains in weight of the animals that grazed on it. In combination with grass it is also very good, as shown by the results of this

and a previous trial. However, this legume has certain characteristics that have been observed which are not desirable when planted alone. These observed characteristics are the following:

1. It must be seeded during the rainy season, as it requires abundant moisture.
2. It is very slow in getting established, requiring 6 to 8 months for a good stand.
3. When grazed, the amount of forage produced is low because of a very slow recovery. This was responsible for too frequent changes to the next sub-plot in order to avoid over-grazing. This was also responsible for the lack of residue to be clipped from it after the changes and, of course, this lowered the carrying capacity.
4. Kudzu alone does not withstand much trampling, and many times the places where the animals slept could be noticed after three or four weeks.
5. During the months from November to February, when the days are shorter and the temperature is milder, very little growth is obtained from Kudzu. During this time weeds take advantage. Another factor which contributes to this retardation is that this legume blooms beginning at late November through December and seed matures during February.

SUMMARY AND CONCLUSIONS

A second grazing trial was conducted using the same procedure of the first except that nitrogenous fertilizer was applied to Guinea grass. This time the three roughages compared were Para grass-Kudzu, Kudzu alone and Guinea grass.

The performance of Para grass-Kudzu mixture was as uniform as in the previous trial; the carrying capacity being around one head per acre. The results obtained with fertilized Guinea grass more than doubled the results in the previous trial where no fertilizer was used. Besides an increase in forage, there was also an increase in protein content. The carrying capacity increased from 0.42 to 1.12 heads per acre. Kudzu had a lower carrying capacity than the mixture with Para grass and Guinea grass.

The conclusions arrived at in relation to the mixture of Para grass-Kudzu in the previous trial were verified by the results of this experiment. The uniformity in performance and high quality forage more than recommends the use of this combination for grazing, especially in the humid section of the northern part of the Island.

Guinea grass is a well known forage crop, principally in the grazing area of the South. Under normal conditions, with no fertilization, it is low in protein content. Fertilization increased the protein and doubled the yield but farmers must take into consideration the cost of the fertilizer and that

fertilization has only an immediate effect on the grass needing new applications at certain intervals to maintain that condition. In contrast, legumes do have a more permanent effect on the soil and the grasses growing with them. This makes them recommendable. Adapted legume grass mixtures are no more expensive to establish and are cheaper than grasses alone from all points of view.

The planting of Kudzu alone is not to be recommended.

LITERATURE CITED

1. Anderson, K. L., Krenzing, R. E. and Hidi, J. C. The effect of nitrogen fertilization on brome grass in Kansas. Jour. Am. Soc. Agron. **38:** 1058–1067. 1946.
2. Annual Book of Statistics of Puerto Rico. Department of Agriculture and Commerce, Bureau of Commerce. 1947–48.
3. Bartholomew, W. W. Fertilizers for grass in rotations. U.S.D.A. Yearbook. 199–202. 1948.
4. Borden, R. J. Nitrogen efficiency. Hawaiian Planters Record. **48** (3): 197–202. 1944.
5. Brown, B. A. and Munsell, R. I. Grasses fertilized with nitrogen compared with legumes for hay and pasture. Jour. Am. Soc. Agron. **35:** 811–816. 1943.
6. Dickey, Paul B., Hoglund, O. K. and Madson, B. A. The use of fertilizers on the production and season of use of annual grass range in California. Jour. Am. Soc. Agron. **40** (2): 186–188. 1948.
7. Ferguson, W. S. The effect of late nitrogenous top dressing on the digestibility of hay. Jour. Agr. Sci. **38** (1): 33–36. 1948.
8. Irvin, D. L. Forty-seven years of experimental work with grasses and legumes in Alaska, Alaska Agr. Expt. Sta. Bul. **12:** 1–48. 1945.
9. Lavvorn, R. L. The effect of fertilization, species competition and cutting treatments on the benaviour of Dallis grass, Paspalum dilatatum, Pair and Carpet grass, Anoxopus offinis, Chase. Jour. Am. Soc. Agron. **36:** 590–600. 1944.
10. Riemsdyk, J. F. van, en hart, M. L't. How much does pasture yield in Holland Abs. Biological Abstracts **22:** 673. No. 7276. March 1948.
11. Rivera Brenes, L. and Marchán, F. J. The utilization of grasses, legumes and other forage crops for cattle feeding in Puerto Rico. I. Comparison of Guinea grass, Para grass and Para grass and Tropical Kudzu as pasture crops. The Journal of Agriculture of the University of Puerto Rico. **31:** 2. April, 1947.
12. Scholler, F. W., Pohlman, G. G., Henderson, H. O. and Ackerman, R. A. Pasture fertilization experiments at Reymann Memorial Farm. West Virginia Agr. Expt. Sta. Bul. **324:** 1–24. 1945.
13. Sullivan, J. T. and Wilkins, H. L. What makes a nutritious forage? U.S.D.A. Yearbook 285–289. 1948.
14. Swallers, C. M. and Stoa, T. E. Influence of fertilizer and other treatments on old brome sod North Dakota Agr. Expt. Sta. Bimo. Bul. **9** (3): 67–69. 1947.
15. Weinman, H. Yields and chemical composition of pasture herbage as influenced by fertilizing and frequent clipping South African Jour. Sci. **40:** 127–134. 1943.
16. —— Effects of grazing intensity and fertilizer treatment on Transvaal Highveld. Empire Jour. Expt. Agr. **16:** 111–18. 1948.