PRELIMINARY GRAZING TRIALS IN TRINIDAD

By

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C O N T E N T S

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FOREWORD

The following is a joint dissertation conducted by K.R.M. Anthony and J.D. Hunter-Smith. For this presentation the latter is responsible, but for loyal cooperation in the planning and execution of the field work, the author wishes to express appreciation and thanks to his colleague.

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INTRODUCTION

That livestock must play a bigger part in the agriculture of the British West Indies is now realized (Stockdale 1940-2). It is a realization based on the urgent need for improved human nutrition and soil conservation and entails a change from the single crop agriculture and shifting cultivation of the past.

The most conspicuous method for the improvement of tropical livestock has been the importing of sires of European breeds. There is a danger however, of breeding for production beyond the natural ability of the country to supply the necessary high grade feed (Hammond, 1932). Whilst in Jamaica, the writer observed that there was a definite inverse correlation between the 'kindness' of the general management and the emphasis of the pen-keepers on the percentage of Indicus blood (Zebu) in their cattle. At the Government Stock Farm where conditions were excellent, pedigree Jersey's were regarded as quite suitable. Elsewhere at least one quarter Indicus blood was insisted upon.

One aspect of the environment, amenable to improvement in the tropics, is the quality of the pastures and fodders. Generally speaking, throughout the tropics these are lower in quality than temperate leys (Paterson, 1944).

Forage and Fodder Position in Trinidad

(a) Pastures

A striking feature of the agriculture is the poor quality of the pastures. They are, in fact, nothing more than waste ground which has been left to re-establish natural vegetation. The better ones are hand cut and hand weeded once or twice per year, but in general, the management is negligible

and haphazard.

The most common grasses are Bahama grass (Cynodon dactylon); Sour grass (Paspalum conjugatum) and Savannah grass (Axonopus compressus). They are all stoloniferous but the typical mat or sward of a temperate ley is not produced. Together with the grasses there is a miscellaneous collection of other species many of which are shrubs or semi-shrubs.

The peasant relies extensively on grazing the natural vegetation of road-sides and hedge-rows. There are a few communal pastures with the resultant overstocking and other disadvantages of such a system. For such grazing the charge is from 50 cents[1] to 2 dollars[2] per month.

(b) Fodders

Fodder grasses are cultivated extensively to supplement the poor natural rough grazing. Uba cane, Guatemala grass and Elephant grass are widely used, and Para and Guinea grasses to a smaller extent. Very high yields are obtained in comparison with the rough grazing.

Many authorities, Stockdale (1940-2), Faulkner & Shephard (1943) and Paterson (1937) have expressed the opinion that the greatest potential for improvement in stock rations lies in the better development of these cultivated fodder crops. It is certain that the management and productivity of the natural rough grazings must greatly be improved before they approach the returns of nutrients obtained from the cultivated fodders.

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[1] San Carlos Estate, Las Lomas district.

[2] Mahaica village, Las Lomas. Included bull service.

Research

In Trinidad work has been devoted mainly to finding the best methods of propagation, cultivation, utilization and management of the fodder grasses (Paterson 1933, 1935, 1936, 1938). Introductions and trial of new grasses has been carried on and a continuous search made for a suitable forage or fodder legume. No extensive study has been made of the natural rough grazing. In this respect research has been on quite different lines to that which has taken place, with great success, in temperate countries. It is felt by the writer, that this aspect of research should not be overlooked. The high rainfall and long growing season supply the basic factors which, if properly harnessed, might make the tropical pastures exceed the productivity of the temperate ley.

Grazing Versus Soiling of Fodder Grasses

Tropical fodder grasses have been conveniently divided by Paterson (1944) into two groups according to their habit of growth:-

1. Trailing species e.g. (a) Para grass (Brachiaria mutica); (b) Molasses or Wynne grass (Melinis minutiflora); (c) Star grass (Cynodon plectostachyum). These send out a profusion of stolons forming a dense cover up to 3 feet thick.

2. Stool forming species e.g. (a) Elephant grass (Pennisetum purpureum); (b) Guatemala grass (Tripsicum laxum); (c) Guinea grass (Panicum maximum). This group is characterized by tall growth and tufted habit. Cultivation is in rows with a distance of usually 2 to 3 feet between the stools.

The first type conforms more to the orthodox concept of a pasture. Para and Molasses grasses are grazed in Jamaica and Star grass shows great promise for grazing in Southern Rhodesia (Arnold 1944).

The grazing of stool forming species is less common. Apart from Guinea grass pastures in Jamaica and Tobago, grazing management is still in the experimental stage or, as in Hawaii, recently adapted to general farm practice (Wilsie and Takahashi, 1934).

In Trinidad fodder grasses are invariably cut and stall fed. Theoretically at least, certain advantages might accrue if it were found possible to graze instead of soil, some of those which are known to thrive in the Island.

The main economic advantage would be the reduction of labour costs. It would be unnecessary to cart large tonnages of grass, consisting mainly of water, to the byre daily. If 80 lbs. are carted per head, per day, a total of 260 tons would be required for a herd of 20 cattle per year. The cost of cutting and carting, on the basis that one man with a mule and cart can cut and carry one ton per day, would be as follows:-

1 man day unit at 88 cents (Minimum wage 1945)
1 mule " " " 45 cents (Moire 1941).
$1.33 per ton.

For 260 tons $350.00

The cost of storing and carting the manure has also to be considered. With consistently increasing labour costs, these expenses, incurred under soiling but not under grazing, may become an overriding consideration.

For the peasant the cost of his own labour is of less importance. However most of these small cultivators do not possess carts and the distance that grass and manure can be hand carried is very small. Often his land is widely scattered; his cow remains near the dwelling and the arable land a mile or so away. This encourages:- (1) omission to cultivate high yielding fodders and (2) waste of manure because of inability to carry it from the byre to the right places. Failing a reallocation of holdings, a solution to this problem would be found if it were possible to graze a fodder grass. The animal's abdominal viscera would then act as the natural cart.

A proviso of the fore-going statements is that the cattle and the grasses do not suffer from such a system of grazing management. Before this can be decided, a great deal of fundamental research by agrostologists, animal nutritionists and physiologists will have to be carried out. The Trinidad and Tobago Agricultural Policy Committee (1943) makes the following suggestions for research on animal nutrition:-

"Determination of the basic scientific facts which must be the foundation for building up practical systems of livestock management (a) on an open range, (b) under stall fed conditions".

Object of Experiments

The following experiments were conducted to determine the effect of the biotic factor (a) on some of the fodders on the Imperial College farm, (b) on a natural rough grazing paddock. We were concerned essentially with the effects on the grasses although some observations were also made on the reactions of the stock.

PART I

A. Rotational Grazing of Elephant and Guatemala Grass

Description of Grasses

1. Elephant Grass (Pennisetum purpureum, Shum)

A full botanical description is available in Kew Bulletin (1926). For the present investigation it is necessary to stress its tufted and tall growing characteristics. If left to maturity on rich soil and under moist conditions it will attain a height of 12 - 14 feet.

There are several cultivated strains of Pennisetum purpureum. Namely Marker, Napier and Elephant grass which can be distinguished by relatively slight differences in vegetative characters. On the College farm the predominant type is the Uganda strain of Elephant grass. It was obtained from that Colony because of its resistance to Helminthosporium leaf spot, which caused considerable mortality in the original local strain in certain seasons (Paterson, 1939). At the present time both the "Original"* and the Uganda strain occur together in the College fields. They can be distinguished by the following vegetative characters:-

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* The strain cultivated before the var Uganda.

	Original	Var. Uganda
Culm.	Densely pubescent - Hairs white, 3-5 mm. Almost round; slightly flattened at base. Pinkish colouration at base.	Sparsely pubescent.- Hairs white 1-2 mm. More flattened, especially at base. Pinkish colouration at base.
Blades. (1) Upper side	Almost glabrous; in region of ligule sparse hairs, 4-7 mm. Uniform green colour.	Densely pubescent - Most marked on upper leaves. Variegated with light green spots especially on upper leaves.
(2) Lower side	Glabrous	Sparsely hairy
(3) Margins	Rough	Rough
Helminthosporium	Susceptible	Resistant

During the experiment there was a slight attack of Helminthosporium leaf spot. The difference in resistance between the Var. Uganda and the 'original' type was conspicuous. The Var. Uganda remained green and was approximately 2 feet taller than the 'original' type. The percentage of the resistant type was 50 - 70 of the total.

The experimental plots were planted in 1937 and up to commencement of the experiment the area was managed for soiling.

2. Guatemala Grass (Tripsicum laxum, Nash)

This grass is less widely cultivated than Elephant grass. Its use is still mainly in the West Indies and around its home in Central and Latin America. Like Elephant grass it is tall growing and tufted; but on the College farm, if cut at the same interval, it does not reach the same height as Elephant grass. With age the stools exhibit a tendency to spread.

Two inherent features which proved to be of importance in this grazing investigation were:-

1. The cord-like adventitious root system which spreads close to the surface of the soil. Observations by Moir (1941) showed that at no point did the roots penetrate more than 6 inches below the surface.

2. The midrib which thickens rapidly towards the base of the leaf. Measurements on plants 5 feet tall showed midribs 5 - 7 mm. thick near the ligule.

The experimental grass was established in 1935.

Review of Literature

1. Soiling

Paterson, (1935) cutting at 45, 90, 120 and 180 day intervals found that:- (1) Progressively higher yields were obtained for less frequent cutting, except in the case of Elephant grass where 120 days was found to give the highest return of green herbage. (2) There was a progressive fall in percentage of protein with less frequent cutting. For both grasses the maximum yield of protein was obtained from the 90 day cutting interval. Mal and Joachim (1937) working on Elephant grass in Ceylon found that 2 monthly cuttings yielded better than 6 weekly or monthly. However, they note that at the 2 monthly stage of growth a certain amount of the grass was rejected by stock.

From the point of view of animal and grass they recommended 6 weekly cutting provided fertilizers were applied. Cowan (1943) in Trinidad found that 'total digestible nutrients' per acre, per annum, increased rapidly under decreasing frequency of cutting. The digestibility figures showed that for Elephant grass the yields of digestible protein remained pretty constant for the 4 cutting frequencies i.e. 32, 46, 60 and 74 days. From this aspect alone he recommends the 74 day cutting cycle. However, considering palatability also he compromises and recommends the 6 - 7 weeks cutting interval. For Guatemala grass he found that the yield of digestible protein diminished with decreasing frequency of cutting. On that score he recommended 4 weekly cuttings unless other sources of protein were cheaply available.

It is apparent that the optimum cutting period depends on from what aspect it is considered - for the stock the younger the grass the better. However, there is a limit to the frequency that the grasses can be cut without deleterious effect. Paterson (1936) has shown that there is a marked increase in stool mortality both for decreased frequency and lower height of cutting. He also showed (1938) that high cutting (1 foot above the ground) resulted in a small but statistically significant rise in the protein and mineral content of the cut herbage. This is an important nutritional advantage, which would be fully realized, under the grazing system of management where the stock do not eat the grasses down to the same low level as it is normally cut for soiling.

Paterson (1938) has summarized the data obtained from experiments at the Imperial College of Tropical Agriculture in respect to yields and percentages of nutrients of the three most important fodder grasses, namely Guatemala, Para and Elephant grass. In yield of fresh herbage Elephant was better than Guatemala. However the percentage of D.M. in Guatemala was markedly higher. In total yield of dry-matter Elephant had a slight

advantage. The same was the case in respect to protein - Elephant yielded a slightly greater bulk but Guatemala showed the highest percentage. In short, Guatemala grass is the more concentrated feed: 57 lbs. are required for maintenance (6 lbs. S.E.) as compared with 77 lbs. of Elephant grass Paterson (1938).

Of the two grasses Elephant is the more susceptible to serious pests and deseases in Trinidad. Froghoppers (Tomaspis saccharina) (see appendix B) and leaf spot (Helminthosporium sp), on the non resistant stools, can be serious in certain seasons. Guatemala grass is relatively free of serious diseases although a rust (Puccinia polysora) is common on the leaves. The extent of the damage done, however, is inconsiderable.*

2. Grazing

No reference to the grazing of Guatemala grass has been found.

Records have been made of the grazing of the Napier and Marker strains of Pennisetum purpureum. In Florida (Blazer, Kirk and Stokes, 1942) Hereford and Brahman Steers made daily gains of 1.60 lbs. and 1.41 lbs. on heavily and lightly fertilized Napier pasture respectively. These figures are striking in comparison with 0.64 lbs. for Savannah grass (Axanopus compressus); 0.66 on Bahia grass (Paspalum notatum); 0.61 on Bahama grass (Cynodon dactylon) also cited in that paper. The method was to graze any one paddock in 5 to 6 days and allow 20 or more days for the grass to recover. The desirability of a

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*The fungus spores pass through the gut in large numbers, apparently undamaged. This observation was made during examination of the faeces for internal parasites.

uniform genatype, in the seed used for establishment, is stressed so as to avoid uneven grazing. There was a deterioration in the stand after the 3rd grazing season. It is claimed that this was largely because of differential grazing, due to variation in leafiness, pubescence, height and thickness of stem. It was shown that "Napier grass managed for grazing produced forage higher in dry matter and protein than Napier managed for soiling. This is readily explained because the lower, ungrazed portion (primarily stems) is inferior to the consumed grass in protein, ash, calcium and phosphate. The spacing between the stools was 2 by 8 feet and the cattle remained on the plots day and night.

In Hawaii both Napier and Merker grass are now used quite extensively for pasture purposes, Wilsie and Takahashi (1934). On one ranch it is stated there are "more than 600 acres in pure stands of Napier grass, the paddocks ranging in age from recent plantings to others more than 12 years old". The system is to put the cattle into the pasture when it has reached a height of 6 feet or more. No mention is made as to what height the grass is eaten down. When finished the cattle are put into other pastures until the first one is ready for grazing once more.

Site of Experiments

The College farm is situated at the foot of the Northern Range. The soil is a detrital silt of medium to low fertility.

Layout

A 3 X 3 Latin square was used with each plot 36 X 36 feet; or approximately 1/33 acre. Paths 3 feet wide were left between the plots and a discard of 3 feet round the outsides of the plots allowed in all observations and data. This was necessary,

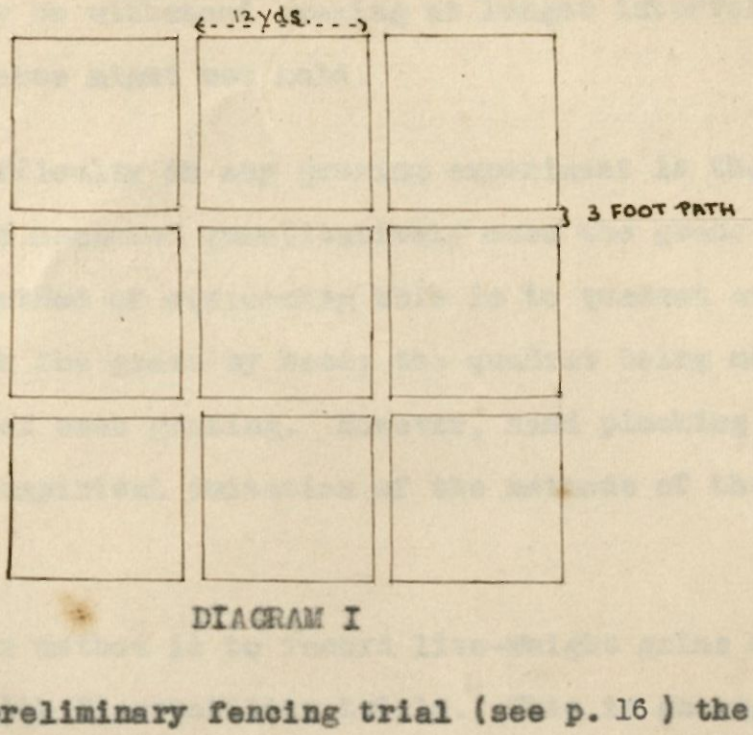

DIAGRAM I

because at the preliminary fencing trial (see p. 16) the cattle walked repeatedly round the plot by the fence resulting in excessive trampling of stools round the edges of the plot. It was also necessary in order to discount any effect which the small water tub and shelter might have in the grazed plots.

Treatments

The 3 treatments were:-

1. Grazing at 6 weekly intervals (G)
2. Alternate cutting-and-grazing at 6 weekly intervals (CG)
3. Cutting at 6 weekly intervals (C)

For simplicity the treatments will sometimes be referred to as G, CG and C.

Methods of Experimentation

A 6 weekly grazing rotation, in preference to the longer cutting cycle advocated by Paterson (1935), was decided upon for the following reasons:-

1. More grazings would be possible in the short time available and so a more critical test given.
2. The palatability at 6 weeks growth would be relatively good and the stock would therefore be encouraged to graze low and uniformly.
3. If the grasses could survive a 6 weekly grazing they would

be likely to withstand grazing at longer intervals; whereas the converse might not hold.

The difficulty in any grazing experiment is that yields, per se, cannot be measured quantitatively once the grass has been consumed. One method of overcoming this is to quadrat small areas and clip or pluck the grass by hand; the quadrat being moved to a new position after each grazing. However, hand plucking or clipping is only an empirical imitation of the methods of the grazing animal.

Another method is to record live-weight gains of the stock in conjunction with digestability trials. This is an expensive method requiring large numbers of animals in order to get reliable results.

The method adopted was as follows:-

1. The grass was cut down to a uniform height of 3 inches in the case of Guatemala grass and 8 inches in the case of Elephant grass.

2. Six weeks later it was cut again and yields recorded from all the plots.

3. The plots were subjected to their respective treatments i.e. cutting, alternate cutting-and-grazing and grazing. This was repeated four times at 6 weekly intervals. After the last grazing all the plots were cut down to the same height.

4. A final cutting of all the plots was taken and the yields recorded.

By this method it was hoped to assess the effect of the treatments on yield by a comparison of yields at the final cutting with those at the preliminary cutting; the changes in yield of the cut, or control, plots being a measure of seasonal variation.

Reallocation of Guatemala Plots

At the preliminary cutting the treatment totals on the

Guatemala grass were widely divergent. The difficulty was to decide whether a true comparison of grazing V. cutting would be obtained when the treatment plots differed widely in their initial productivity. It was decided to reallocate the plots so that the Cutting (C) and Grazing (G) treatment total were as nearly as possible equal. A reallocation of this sort is a great drawback to the analysis of results statistically. No such reallocation was necessary in the case of the Elephant grass plots.

The Grazing Animals

These were 3/4 bred Zebu - Holstein, 2 year old heifers. Their average weight at the beginning of the experiment was 3½ cwt. Four animals were used and were rotated round the various experiment plots in pairs.

Fencing

The problem was to find a suitable but inexpensive method of fencing. A preliminary trial was made of various methods on Guatemala grass.

1. Tethering

It was found that excessive trampling occured round the periphery of the grazable area. The rope wound round the picket and as the radius decreases a fresh area, nearer to the peg, was trampled. The rope itself also caused the tall grass to lodge.

2. Iron hurdles

These were heavy and cumbersome. At the time of trial the ground was hard and it was necessary to dig holes for the legs with a crowbar. Even so strengthening of the structure with wooden stakes was required. Furthermore one Holstein got into difficulties by putting its fore-legs between the rails.

The labour requirement for one small plot was 6 man hours.

3. Barbed wire

This method was efficient but the expense of sufficient strong permanent parts to cover all the experiment plots would have been high. The labour requirement for one plot was 11 man hours.

4. Electric fence

This type of fencing is being increasingly used in Britain. There was doubt expressed as to whether it would be suitable for Zebu or Zebu crosses such as occur in Trinidad. In this preliminary trial a ¾ bred Holstein and a pure bred Zebu were put together in the same 36 X 36 foot plot enclosed by one strand of plain, electrified wire at 3 feet 6 inches from the ground. The height was later reduced to 3 feet which proved efficient for both the Zebu and the Holstein. The labour requirement for the plot, including putting in the posts, was 3 man hours.

In view of its efficiency and economy in materials and labour, this method was adopted.

Throughout the experimental grazings the electric fence proved satisfactory. Some trouble was encountered during the first week when the animals escaped from the plot on three occasions. This was largely due to one nervous animal charging the wire when anyone approached the plot. During this training period it was necessary to have three strands of wire and posts at 12 feet intervals. The number of strands and posts was gradually reduced until after a fortnight one strand and four corner posts, plus one as a gate, were being used. Later the cattle became well accustomed to the fence and it was found quite safe to turn off the current at night.

The bamboo posts used for supporting the wire were cheap but after five months some replacements were necessary due to termite damage and rotting at the point of entry into the ground. Barbed wire was used mainly but plain wire is suitable and much more pleasant to handle. The life of the battery varied considerably but averaged about six weeks. However, during that time the current was not on constantly.

This type of fencing did not cause the centre of the plots to be grazed or trampled disproportionately. The stock became adept at grazing very close, and even directly beneath the fence, without touching it.

The correct height for the wire was found by trial and error. A useful guide in determining the height is to make it equal to 2/3rds of the distance from the ground to the top of the withers. One disadvantage of this, however, is that any blades of the fodder grasses touching the wire have to be clipped. If this is not done the current is earthed, especially in wet weather.

Shade

During an afternoon in October one of the animals showed symptoms of excessive exposure to the sun. The symptoms were rapid panting with mouth wide open and head down. After this shelters were provided. Their essential features were:- (1) to provide adequate shade for two animals and (2) to be transportable on a farm cart. One was put in each plot during the grazings.

Manuring

The only manuring the plots received was the droppings from the grazing animals. Thus the cut plots during the seven months of the experiment received no artificials or organic manure.

Weighing and Dry-Matter Determinations

Cutting was always done at the same time in the mornings and only on fine days. Hand cutting with the Trinidad cutlasses was the only method available. The personal factor thus tended to cause slight discrepancies in uniformity of cutting. There is great need of a machine to cut and collect experimental plots of fodder grasses. After cutting women gathered the grass. Small errors arose here again because when the blades were relatively short i.e. during the Petit Careme*, there was a tendency for some blades to be overlooked.

Sampling for dry-matter determination was done after representative handfuls of the green material had been put through a cutting machine. Triplicate samples were taken from each plot.

Oven facilities for drying were rather inadequate. It was impossible to retain the temperature at 100°C. If it were attempted there was grave risk of charring. Consequently the temperature was retained throughout at between 85° to 95°C. Thus the dry-matter figures are only relative as some residual moisture remained in all cases.

RESULTS

Height of Grazing

The height of the two grasses at the beginning of grazing varied, of course, with the season. In general the height of the Guatemala grass was between three and four feet and the Elephant between four and a half and six feet.

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* Little Easter - corresponding with a short dry season in Trinidad.

During the experiment it was not attempted to graze down to any particular height but to leave the cattle to graze as low as they would. This led to markedly different results on the two grasses.

Elephant grass was grazed relatively uniformly. The first two grazings were down to between 12 - 18 inches; the remaining two fell between 18 and 24 inches. These figures do not include flowering culms present during the last grazing, but which remained uneaten. They were removed by cutting.

The height to which Guatemala grass was grazed varied considerably. Some stools were reduced to six inches whilst others in the same plot were not grazed below two feet, six inches. From the end of the first grazing the appearance of the plots was strikingly uneven in comparison with Elephant grass.

Difficulty in Grazing Guatemala Grass

The grazing of Guatemala grass presented a problem which at first seemed illogical. The first grazing was heavy though rather uneven. The height of the grazed stools was between six to fifteen inches. One of the plots was badly trampled.

At the second grazing the cattle first nipped off the tops of the leaves with ease and obvious relish. Grazing was completed to about two feet without difficulty. Below that the cattle showed disinclination to consume what looked like ample and palatable herbage. They stood round the gate and in spite of hunger, merely nibled at the youngest shoots. When some of the broader blades were hand-plucked and offered they were eaten readily. The cattle were then taken in turn, to some tall adjacent Guatemala grass which was consumed greedily. On being brought back to their own plots they still only picked at the grass here and there. It was evident that nothing was at fault

with the grass because it was eaten when hand plucked. Also no difficulty was encountered when young shoots, or the tips of mature blades were grazed.

During the grazing of the next plot a close study was made of the grazing sequence. Initially the tops of the blades were nipped off. Later the cattle were occasionally seen tugging at the leaves in an effort to bite through them. Sometimes they were successful but if not, either of two things happened:-

1. There was a squeaking noise as the blade slipped between the teeth and the upper gum.
2. A tiller was uprooted. In this case the blade and culm were masticated with the molars whilst the root and a portion of the lower culm was cut off and allowed to fall to the ground.

These two effects are directly due to two characteristics of the grass: Firstly, the thick, tough midrib and secondly, the shallow rooting and insecure attachment of the tillers. The midrib thickens rapidly as it nears the ligule and so it becomes more difficult for the stock to sever the leaf the lower they try to bite it off. There is consequently a greater tendency for tillers to be uprooted the lower the grass is grazed. Towards the tip of the blade the midrib becomes thin and is readily bitten through.

When the blade slips between the gum and the teeth it must, if done repeatedly, cause considerable pain in the mouth. This would explain the disinclination that was shown toward low grazing.

At the last grazing it was decided to measure the extent of refusal. The Cut-and-Grazed plots were due to be cut but it was decided to graze these together with the Grazed (G) plots in order to get as representative a figure as possible. After grazing,

the plots were cut at one foot, which was the height to which the C. plots were cut. The yields of green herbage were as follows:-

Yields in lbs. per plot

Cut at one foot		Cut at one foot after grazing			
C 1	50.5	G 1	8.0	CG 1	22.0
C 2	29.5	G 2	6.0	CG 2	10.0
C 3	32.5	G 3	6.0	CG 3	20.5
Total	112.5		20.0		52.5

Mean... 36.3

Thus by cutting at one foot after grazing a yield of 32% of the cut plots was obtained. This shows quantitively that with grazing at six weekly intervals the stock refused a considerable amount of apparently palatable herbage.

No difficulty of this nature was encountered in grazing the Elephant grass.

Extent of Uprooting

On the Elephant grass no animal was seen to uproot any portion of a stool. With Guatemala grass the number of tillers uprooted was considerable. After each grazing, except the third, counts were made of tiller sections lying on the ground. The figures are shown for each plot in Table I.

This table shows that the extent of uprooting was most serious during the first two grazings. These were the longest grazings because; (1) the yield was highest at that time. (2) the cattle were kept on the plots unduly long in an endeavour to get them to eat herbage which appeared to be adequate for their maintenance.

TABLE I

Guatemala grass: Treatment		Number of Uprooted Tillers per Plot 1st	2nd	3rd	4th
Grazed.	Plot 1	101	123	Not	17
"	" 2	117	112	Recorded	40
"	" 3	93	169		63
Total		311	404	-	120
Cut & Grazed	1	76	Cut	Not	13
"	" 2	67	Cut	Recorded	46
"	" 3	95	Cut		50
Total		238	-	-	109

From Tables I and V (see p. 33) a positive correlation between uprooted tillers and hours of grazing is indicated. An additional cause of disproportionate uprooting during the first two grazings was the climatic conditions. During the first and second grazings the average rainfall on the day before and during the days of grazing was 0.27 inches. During the second and third grazings the average was 0.04 inches. Thus the ground was considerably harder during the last two grazings.

The figures in Table I are for uprooted tillers in 144 square feet plots. Converted to acres the average uprooted per grazing was 2588. This as a percentage of total tillers, computed from Tables II and III was equivalent to 4% of the total tillers per grazing. This represents only those tillers completely uprooted. Many others which suffered seriously but remained loosely attached were not counted.

Stool Mortality

It was intended to make counts of the stool population per plot on both grasses immediately before the preliminary and final cuttings. This was done for Guatemala grass and for the first

count on the Elephant grass. However, owing to a severe attack by froghoppers (Tomaspis saccharina) on the Elephant grass in the middle of the experiment, the final count would have been work of supererogation. Observation alone indicated that whilst the froghoppers were responsible for stool mortality the grazing itself caused no damage to the stools.

With Guatemala grass difficulty was encountered in accurately defining a stool. The field was established ten years previously and there had been a tendency for stools to spread. For the purposes of the counts any tiller less than 12 inches from any other was considered to belong to the same stool. All counts were made in 10 X 10 yard plots i.e. a border of one yard round the fence was not counted.

The percentage mortality, shown in Table II, was as follows:-

TABLE II

	Guatemala Grass: Number of Stools per Plot											
	Cut			Av.	Cut & Grazed			Av.	Grazed			Av.
Prelim. Cut.	133	116	126	125	173	108	115	132	150	131	105	129
Final Cut.	130	104	114	116	152	104	105	120	97	100	86	94
Decrease	3	12	12	9	21	4	10	12	53	31	19	35
% Decrease				7				9				27

Grazed plots i.e. one cutting (the preliminary cut) and four grazings at six weekly intervals - 27%.

Cut-and-Grazed plots i.e. two cuttings and three grazings at six weekly intervals - 9%.

Cut plots i.e. five cuttings at six weekly intervals - 7%.

The 7% decrease on the cut plots is of the same order as was obtained by Paterson (1936) cutting every 45 days at four to

six inches from the ground. He showed a mortality of 16.6% (figures computed from Table) over a period of 12 months. The decrease in the present experiment covered seven months during the wet season. The preliminary cut was made in June and the final cutting in January and for all except the fourth treatment the cutting was at approximately six inches.

A 25% decrease on the grazed plots showed strikingly in their appearance at the end of the fourth grazing. There were large areas of blanks as is shown in the photographs (p. 37)

A larger decrease than 9% on the Cut-and-Grazed plots would at first sight be expected in view of the high percentage decrease on the grazed plots. However, it has already been mentioned that a disproportionate amount of uprooting took place during the first two grazings. The second grazing in particular accounted for the highest number of uprooted tillers (Table I) and at this time it was the turn of the Cut-and-Grazed plots to be cut. Thus these plots escaped grazing when conditions were at their worst for the grass.

Effect on Tillering

Guatemala grass tiller counts were made immediately before, the preliminary cutting, the second and fourth treatment series and the final cutting. Only the first count was made on Elephant grass because of the attack by Froghoppers.

Tillers on 10% of the stools, randomly selected, were counted in each plot. The data is shown in Table III.

This table shows that a large decrease in tillering occured under each treatment. The highest 61.2% was on the grazed plots. Alternate cutting-and-grazing caused a decrease of 47.4%; and cutting, a decrease of 35.7%.

TABLE III

Guatemala Grass: Av. Number of Tillers per Stool

	Cut			Av.	Cut-&-Grz.			Av.	Grazed			Av.
Prelim.Cut.	23	19	20	20.7	21	28	25	24.7	20	24	31	25.0
2nd.Treatment	21	17	21	19.7	16	24	20	20.0	20	21	23	21.3
4th "	13	11	14	12.7	9	14	12	11.7	7	8	12	9.0
Final Cut.	13	12	15	13.3	16	12	11	13.0	9	11	9	9.7
Decrease	10	7	5	7.4	5	14	14	11.7	11	13	22	15.3
% Decrease				35.7				47.4				61.2

The high figure for cutting must be attributed to: (1) The frequent cutting every six weeks, (2) low cutting and (3) lack of manuring. It will be observed from the table that the biggest drop occured between the second and fourth treatments. This period covers the petit careme which occurs in Trinidad in October. In spite of the high decrease due to cutting, the decrease on the grazed plots was almost double and with cutting and grazing intermediary.

Trampling and Puddling

Heavy rain during the first grazing of both grasses would have resulted in severe puddling if the stock had not been removed. Also during the second grazing of Guatemala grass the cattle had to be taken out of the plots because the ground was too wet and serious puddling was occuring. It was especially serious round the water tubs and shelters.

Observations indicated that to graze when the ground is saturated is unwise. However, the soil dries quickly and even in the wettest weather it was always found possible to return the cattle within two days.

Weeding

All plots were given a hand weeding before the preliminary cutting. Thereafter it was observed that the cattle showed considerable preference for some of the weeds especially Desmodium sp (Leguminoseae). It was decided not to weed in the hope that useful supplimentary nutrients, in particular protein, might become available. By the third grazing both grasses were suffering from excessive weed competition. Pueraria sp (Leguminoseae) was trailing the Guatemala culms and as it did not appear to be relished by the stock it was probably an additional cause of uneven grazing. On the Elephant grass plots shrubby and semi-shrubby species became increasingly predominant. Among these were Railway Daisy (Bidens pilosa); Rabbit's Meat (Alternanthera ficoidea) and Christmas Bush (Eupatorium odoratum). All plots were therefore hand weeded after the third grazing. Immediately before the second cutting a last weeding was carried out in order to have comparable data for the prelimimary and final cuttings.

Hours of Grazing and Tentative Estimate of Stock Carrying Capacity

The experiment was not designed to estimate stock carrying capacity and in the case of Guatemala grass any assessments would be rendered meaningless by the 25% stool mortality which had occured by the fourth grazing. The Carrying Capacity of the Elephant grass is calculated, however, because in view of the absence of any other data in Trinidad, it may serve as a guide in the planning of future experiments. Table VI shows the hours of grazing by two cattle on the Elephant grass plots. These figures have been used to compute the stock carrying capacity per head per acre shown in Table IV.

TABLE IV

Elephant Grass: Stock Carrying Capacity per Head per Acre

Plot	Carrying Capacity
G 1	1.6
G 2	2.1
G 3	2.0
CG 1	1.3
CG 2	2.0
CG 3	1.9
Mean	1.8

In considering the mean figure 1.8 shown at the bottom of the table, it must be remembered that:- (a) the length of the third grazing was shortened because of the froghopper damage; (b) three pounds of concentrates were fed per acre per day during the third and fourth grazings; (c) the trial was conducted in the wet season.

The carrying capacity obtained compares with the following figures for Napier grass in subtropical countries. In Hawaii (Wilsie and Takahashi, 1934) one mature beef animal is supported per acre. In Florida (Blazer et al, 1942) a carrying capacity of 1.4 on heavily fertilized and 0.9 on lightly fertilized paddocks was obtained (figures computed from Tables).

Yields of Green Herbage

Table VII shows the yields of fresh herbage from the cut plots converted to hundred weights per acre.

The mean yields for the seven months of the experiment were lower than is usually obtained in Trinidad.

The Elephant grass plots averaged 9.5 tons and the Guatemala 6.8 tons. Paterson (1935) cutting Guatemala grass every 45 days obtained yields of approximately 20 tons per acre per annum. However, this was after applying liberal dressings of organic manure and artificials. In the present experiment the cut plots received no manuring and in that respect were at a disadvantage to the grazed plots. Yields of Elephant grass recorded by Paterson (1935) for a 45 day cutting frequency were 14.7 tons per acre. In this case they were low because of severe attack by Helminthosporium; in the present experiment, because of attack by froghoppers.

The Effect of Grazing on the yield of Dry-Matter

The yields of dry-matter are shown in Table VIII. To interpret the treatment effects a statistical analysis is indicated to compare yields at the final cutting after correcting for treatment differences at the preliminary cutting. However, because of the plot reallocation the statistical approach is not strictly valid. It is given later, but first, as by rearranging the plots, the cut and the grazed treatment totals were initially equal, a direct comparison of the final yields is possible.

The final yields for the cut and the grazed plots were as follows:-

	Elephant Grass		Guatemala Grass	
	Cut	Grazed	Cut	Grazed
Yield lbs.	43.5	49.2	38.2	32.8
% of cut plots	-	113%	-	84%

Thus four grazings at six weekly intervals, as compared with four cuttings, increased the yield of Elephant grass by 13% and decreased the yield of Guatemala by 14%.

The increase on the Elephant grass can be attributed to the manurial effect of the grazing animals; the decrease on the Guatemala grass would be expected in view of the serious stool mortality, which is shown clearly in the photographs (see p. 38).

Statistical Interpretation of Dry-Matter Results

This method suffers from two disadvantages:- (1) Readjustment of the Guatemala grass plots (2) The small 3 X 3 layout. The small layout is partially overcome by combining the Guatemala and Elephant grass figures in the same analysis as follows:-

Preliminary Cut

Elephant Grass

				Rows
	11.7	12.2	20.6	44.5
	18.5	17.6	16.6	52.7
	15.7	16.0	15.5	47.2
Cols.	45.9	45.8	52.7	144.4

Guatemala Grass

			Rows
9.5	4.8	5.7	20.0
6.8	9.4	7.4	23.6
13.3	13.4	10.9	37.6
29.6	27.6	24.0	81.2

Treatment Totals *	Treatment Totals
C = 44.8	C = 25.7
CG = 55.1	CG = 29.9
G = 44.1	G = 25.6

Final Cut

Rows

C	G	CG	
13.2	23.4	14.7	51.3
CG	C	G	
19.7	14.1	16.4	50.2
G	CG	C	
9.4	11.5	16.2	37.1
Cols 42.3	49.0	47.3	138.6

Rows +

C	G	CG
15.9	11.8	25.5
C	C	G
8.7	13.6	12.2
CG	G	CG
11.8	8.8	13.9

Cols. +

\+ Differences between the rows and columns cannot be taken out from the error sum of squares because of the non orthoganal layout.

Analysis of Covariance

Factor	D.F.	x (Final cut) S.S.	y(Prelin.cut) S.S.	xy
Total	17	359.78	363.28	- 1.73
Rows	4	41.61	69.28	+ 2.74
Columns	4	8.09	15.81	+ 2.40
Variety	1	14.94	221.90	+57.58
Treatments	4	65.10	28.30	+13.57
Error	4	230.04	27.98	-74.56

b_{xy} = 2.665 - Significant at t.05.

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* At this time no treatments had been carried out. The totals are for the three plots which later during the experimental period received the treatments indicated.

Adjusted Treatment Totals at Final Cutting

Elephant Grass	Cut	= 52.3
	Cut-and-Grazed	= 27.2
	Grazed	= 58.8
Guatemala Grass	Cut	= 41.9
	Cut-and-Grazed	= 43.7
	Grazed	= 36.8

Reduced Analysis of Adjusted Treatment Totals

(a) Elephant Grass

	D.F.	S.S.	V	F
Treatment	2	185.65	92.83	8.88
Error	3	31.36	10.45	$f_{.05} = 9.55$

The treatments just fail to be significant at the 5% point.

(b) Guatemala Grass

	D.F.	S.S.	V
Treatment	2	8.52	4.26
Error	3	31.36	10.45

Thus treatment differences are non significant.

The layout and scope of the experiment was therefore not sufficient to show any significant effects of treatments on the yields of dry-matter. It would be unwise to assume that because the statistical analysis gives a non significant result that both grasses are equally suited to grazing or cutting. The non significance must be attributed to high experiment error due to (1) Poor facilities for accurate Dry Matter determinations
(2) The Froghopper attack on the Elephant grass
(3) Large initial fertility variation on the Guatemala grass area.

TABLE V

Guatemala Grass: Hours of Grazing by two Cattle per Plot

	Treatment				
Plot	1st	2nd	3rd	4th	Total
Grazed 1	62.0	87.5	41.0	17.0	207.5
2	46.5	66.5	22.5	10.0	145.5
3	49.5	92.0	24.0	17.5	183.0
Total	158.0	246.0	87.5	44.5	536.0
Cut-and- 1	38.5	cut	41.0	24.0	103.5
Grazed 2	19.5	"	17.0	28.0	64.5
3	40.5	"	26.0	26.5	93.0
Total	98.5	-	84.0	78.5	261.0

TABLE VI

Elephant Grass: Hours of Grazing by two Cattle per Plot

	Treatments				
Plot	1st	2nd	3rd	4th	Total
G 1	22.5	32.5	18.0	20.0	93.0
G 2	42.5	39.5	16.5	24.5	123.0
G 3	41.0	39.5	15.0	24.5	120.0
Total	106.0	111.5	49.5	69.0	336.0
CG 1	22.5	cut	16.5	cut	39.0
CG 2	41.0	"	18.0	"	59.0
CG 3	42.5	"	15.0	"	57.5
Total	106.0	-	49.5	-	155.5

TABLE VII

Yields of Green Herbage from the Cut Plots in cwts per Acre

	Elephant Grass					Guatemala Grass				
Treatment	Date	C 1	C 2	C 3	Mean	Date	C 1	C 2	C 3	Mean
Prelim.Cut	14/6/44	43.63	49.03	31.10	41.29	5/6/44	15.34	11.02	14.69	13.68
1st	27/7/44	63.50	45.06	36.42	48.33	17/7/44	32.40	19.87	26.57	26.28
2nd	5/9/44	40.39	20.74	16.42	25.85	26/8/44	44.17	35.42	36.30	38.63
3rd	17/10/44	13.82	6.91	5.40	8.71	9/10/44	24.41	12.74	12.74	16.63
4th	5/12/44	48.38	25.49	21.82	31.89	27/11/44	21.81	12.74	14.04	16.20
Final Cut	14/1/45	42.98	30.24	27.00	33.41	8/1/44	31.75	17.06	26.78	25.20
Total cwts	7months	252.70	177.47	138.16	189.48	7months	169.88	108.85	131.12	136.62
" tons	"	12.63	8.37	6.91	9.47	"	8.49	5.44	6.56	6.83

TABLE VIII

Yields of Dry-Matter in Lbs. per Plot

ELEPHANT GRASS

Treatment	Date	C 1	C 2	C 3	Total	CG 1	CG 2	CG 3	Total	G 1	G 2	G 3	Total
Preliminary cut	14/6/44	15.5	17.6	11.7	44.8	16.0	18.5	20.6	55.1	15.7	16.6	12.2	12.2
1st Treatment	25/7/44	25.3	19.8	17.0	62.1	Grazed			-	Grazed			-
2nd Treatment	5/9/44	18.0	11.6	8.3	37.9	12.5	9.8	12.7	35.0	Grazed			-
3rd Treatment	17/10/44	6.5	4.2	3.4	14.1	Grazed			-	Grazed			-
4th Treatment	5/12/44	17.7	12.6	10.4	40.7	12.0	14.0	13.9	39.9	Grazed			-
Final Cut	14.1.45	16.2	14.1	13.2	43.5	11.5	19.7	14.7	45.9	9.4	16.4	23.4	49.2

GUATEMALA GRASS

Preliminary cut	5/6/44	9.5	6.8	9.4	25.7	5.7	10.9	13.3	29.9	4.8	7.4	13.4	25.6
1st Treatment	17/7/44	17.3	10.4	14.0	41.7	Grazed			-	Grazed			-
2nd Treatment	26.8.44	22.6	18.5	19.5	60.6	17.6	13.5	21.4	52.5	Grazed			-
3rd Treatment	9/10/44	12.9	6.8	7.2	26.9	Grazed			-	Grazed			-
4th Treatment	27/11/44	11.7	6.5	7.5	25.7	Grazed			-	Grazed			-
Final Cut	8/1/45	15.9	8.7	13.6	38.2	25.5	13.9	11.8	51.2	11.8	12.2	8.8	32.8

ILLUSTRATIONS

A. GUATEMALA GRASS

Fig. 1. First grazing. Stools in foreground grazed; plot duo for grazing in centre; grazing in progress in background.

Fig. 2. Beginning of second grazing.

The appearance eight weeks after the end of the experiment

Fig. 3. Treatment (a) Rotational grazing.

Fig. 4. Treatment (b) Alternate cutting and grazing.

Fig. 5. Treatment (c) Rotational cutting

B. ELEPHANT GRASS

Fig. 6. Before grazing.

Fig. 7. During grazing.

Fig. 8. After grazing.

APPENDIX I

Description of Froghopper attack on Elephant Grass

Froghoppers are one of the most serious pests of sugar cane in Trinidad and Tobago. There is much literature dealing with its effect on cane but records of the symptoms on fodder grasses are limited to the statement that common grasses serve as alternate hosts, Williams (1921).

Table VII (see p. 34) shows that an attack can cause serious losses in yield. At the third grazing the yield was reduced to 8.7 cwts. per acre. The weather conditions at that time were dry and some reduction in yield to be expected. But whereas the Elephant grass out-yielded the Guatemala grass at the first two and the last two cuttings, at the second and third when the froghopper attack was at its peak, the yields were considerably lower.

The attack first appeared at the end of August. The leaves were marked with elongated brown feeding streaks. These spread and joined causing death of many leaves and tillers. Without disturbing the leaves up to 30 adults were counted on the larger stools. On the ground surrounding the base of the stools there were numerous "cuckoo spits". It is from these that the nymphs hatch.

The pest can be controlled on sugar cane by spraying with pyrethrum dust, but none of this was available. On the advice of the Government Entomologist the attack was left to run its natural course. By the fourth grazing in early December the attack had finished and all the plots had made a remarkable recovery. The cutting and weeding which took place in October may have had some beneficial effect in control.

There were no symptoms of Froghopper attack on the Guatemala grass.

APPENDIX II

Correlation between Yield of Green Herbage, Dry-Matter and Rainfall

Enough data was obtained from the cut plots to confirm much more detailed and comprehensive results obtained by Paterson (1935,1938) regarding the influence of precipitation on fresh weight yields and percentage dry-matter content of fodder grasses. Here only the Guatemala results have been used because of the influence of the Froghopper attack in the case of Elephant grass.

The graphs appended indicate:-

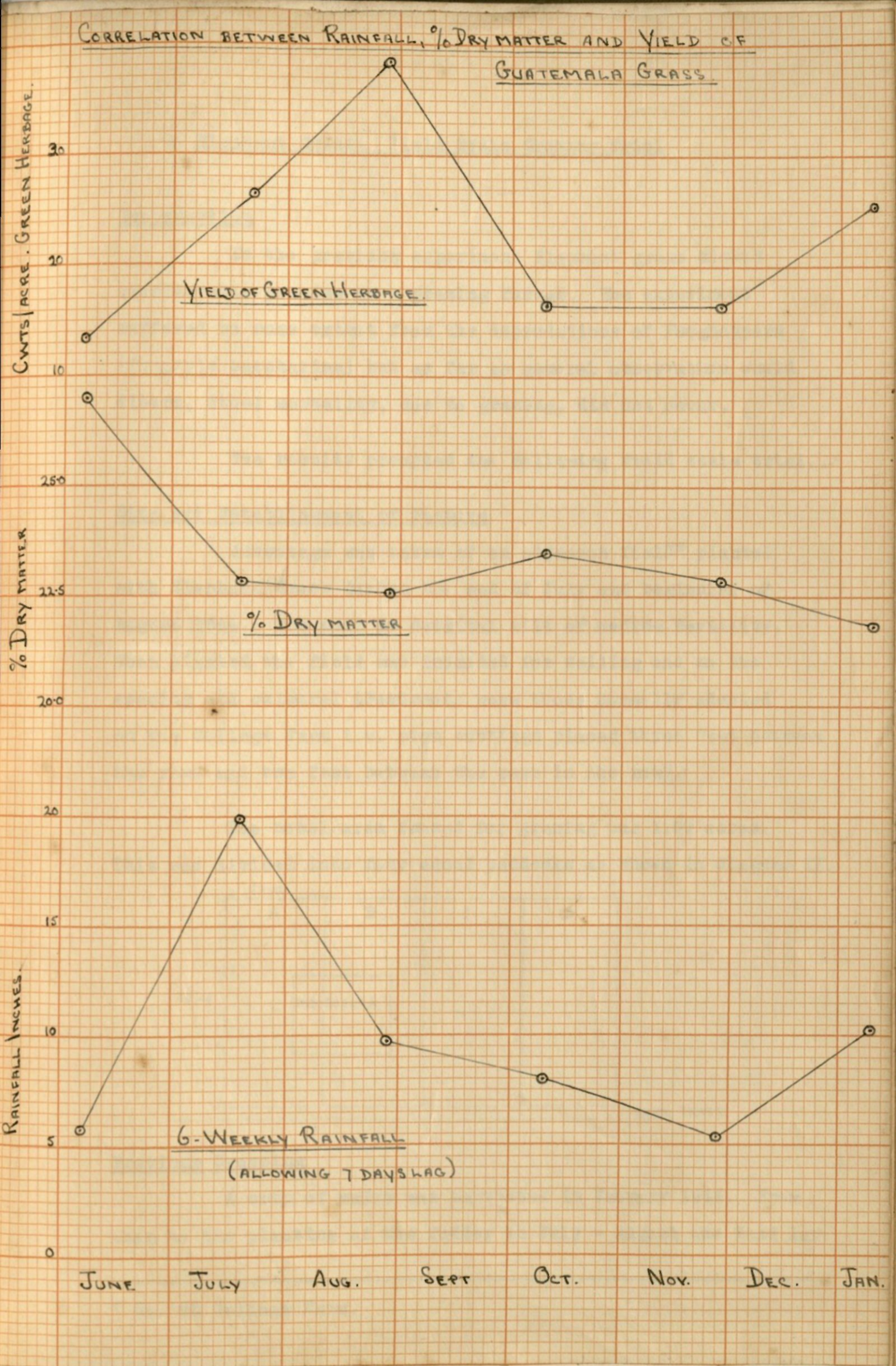
(1) A positive correlation between yield and rainfall. With the cutting interval of six weeks a corresponding time lag is shown between peak precipitation and peak yield.

(2) (a) A negative correlation between yield and dry-matter percentage.

(b) A negative correlation between percentage dry-matter and rainfall.

Facts of this nature have been amply proved in temperate agrostology by Woodman in England (1926, 1928, 1929 etc.). The same fundamental tenets are now being shown to hold equally in the tropics.

Correlation between Rainfall, % Dry matter and Yield of Guatemala Grass



B. Elephant Grass: Field Scale Grazing Trial

Introduction

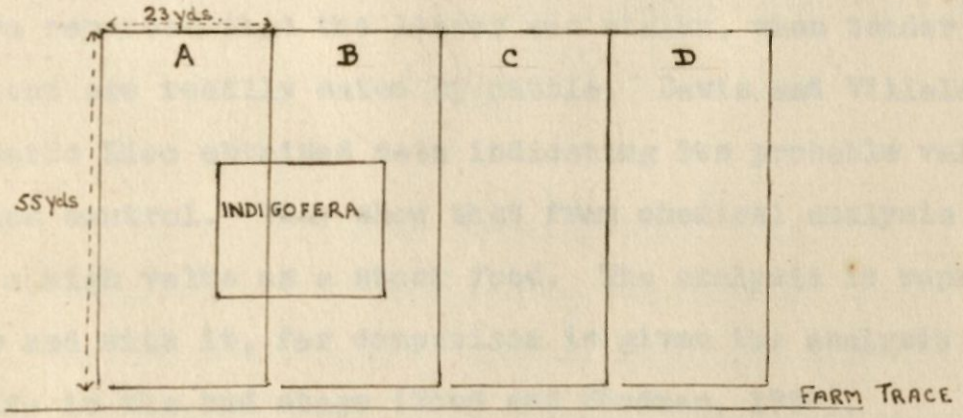
In the previous experiment Elephant grass showed considerable promise as a grazing forage. The experiment suffered to some extent from the depredations of Froghoppers (Tomaspis saccharina) but as far as general observation could disern, stool mortality, due to grazing, did not occur.

The results prompted the following field scale trial.

Site and Establishment of Pasture

Advantage was taken of an adjacent field* planted with Elephant Grass during the end of July and beginning of August 1944. The soil is detrital silt of medium fertility. When planted the field was intended for soiling and so the spacing and cultural treatments were those normally adopted on the College Farm i.e. stem cuttings placed three feet between the rows and two feet between the sets in the rows.

The total area fenced for grazing was 1.09 acres. This was divided into four equal paddocks as shown in diagram II.



Previous Cropping

A crop of maize was harvested in January 1944. From then to the planting of the fodder in July - August the land lay

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* No. 23 College Farm.

fallow. It became very weedy as does all fallow land in Trinida Before the first grazing the whole field was soiled once. It was cut from north to south starting on the 15th October and finishing on the 9th November. Throughout the trial, therefore the plots were grazed in sequence from A to D (Diagram II).

Indigofera as a Legume in Elephant Grass

The need for a legume in tropical forages is urgent. The value of an Elephant grass pasture would be much enhanced if a suitable, high protein legume, could be found to grow in association with it. Before the present grazing trial started the author observed that a plot of Guatemala grass on the College farm was serving as a cover crop for some Indigofera endecaphylla. It was surviving from an experimental plot which later had been planted to Guatemala grass. The regular weedings given to the fodder grass had not irradicated the Indigofera completely.

Indigofera endecaphylla is a trailing legume found throughout the tropics of the old world. Burkill (1935) from Malaya reported that the leaves and stalks, when tender and suculent are readily eaten by cattle. Davis and Villalobas (1940) in Puerto Rico obtained data indicating its probable value in erosion control. They show that from chemical analysis it whould have a high value as a stock feed. The analysis is reproduced below and with it, for comparison is given the analysis of Alfalfa in the bud stage (Wood and Woodman, 1939).

TABLE IX

Chemical Composition of Indigofera and Alfalfa

	Wet Basis		Dry Basis	
	Indigofera %	Alfalfa %	Indigofera %	Alfalfa %
Moisture	78.50	78.0		
Crude protein	4.21	4.5	19.56	20.5
Ether extract	0.93	0.5	4.33	2.3
Crude fibre	5.86	6.2	27.24	28.2
N-free extract	10.29	9.0	39.04	40.9
Ash	0.21	1.8	9.83	8.2
Calcium	0.297	-	1.38	
Phosphorus	0.0439	-	0.0204	
Total solids	21.50	22.0	-	-

The close similarity of the two legumes in chemical composition will be noted. The particularly important feature is the high protein content in which tropical forages tend to be low.

The same workers investigated propagation by seed and vegetative means. They found that cuttings gave initially the best results but after 18 days the stand produced by seed was not inferior.

From Hawaii Whyte (1944) reports that "it has grown exceptionally well .....under grazing conditions and persisted under very dry conditions". In British Guiana (Divisional Reports 1937) it is considered "the most satisfactory of all the legumes tried as a cover crop for orchards, coconuts etc as well as being very useful as a fodder grown between Guatemala grass; an extensive area is being grown".

It was decided to try and establish some of this legume amongst the stools in the present experiment.

Establishment of Indigofera

The planting material was mature creeping stems. The can be pulled by hand or a cutlass can be used to help sever the stems from the roots.

Planting and Spacing

Shallow drills two to three inches deep were made with hoes. Then the planting material was placed in the drills and the bases of the stems covered loosely with soil. The drills were made 18 inches apart i.e. two drills between each row of Elephant grass.

An area of 20 X 15 yards or 1/16 of an acre was established between plots A and B. To plant that area six women took five hours. This converted is equivalent to a gang of 12 women working one week to plant roughly one acre. Although planting is tedious this figure seems excessive. With practice and a larger area to plant the efficiency should greatly increase. The cost would be reduced if drills were made mechanically with a modified horse hoe.

Planting was done on the 28th July. At this time the Elephant grass had sprouted to about one foot which was insufficient to shade the Indigofera.

Establishment was a success on this plot. By the first grazing, which occured four months after planting, the Indigofera had spread uniformly between the stools, giving a luxuriant mat two feet tall. The only treatment given after establishment, was a thorough weeding on the 9th September. This was difficult because of the tangled mass of the legume. For much of the weeding the women had to use their hands.

Two further attempts were made to establish Indigofera

between fodder grass stools:- (1) In mature Guatemala grass (2) In mature Elephant grass. Neither of these plantings was successful. The procedure was the same as previously but the stools were cut back to six to nine inches before planting. The failure may have been due to the quicker growth of well established stools and consequent crowding out of the indigofera. A further cause, however, was that in contrast to the first plot, these plantings received a careless weeding. It is stressed that great care is needed in the initial weeding of newly established Indigofera.

Dolichos hosei

Adjacent to the three Indigofera plots a similar attempt was made to establish Dolichos hosei. This is one of the more successful of the leguminous cover crops grown in Trinidad. Stems, obtained by hand pulling, were used for planting material. The spacing was as for Indigofera but instead of making drills, the base of the stems were dibbled in with a cutlass. In all these plots the Dolichos failed to establish.

The Grazing Management of the Paddock

As there was no water or shade in the field the management had to be adapted accordingly. The dairy herd was turned into a plot about 8 a.m. after the mornings milking and taken out between 10 and 11.30 a.m. when the byre had been cleaned out. This arrangement fitted in well with the grazing habits of the animals. After two to three hours of steady grazing there was a pause for rumination. Also by 11 a.m. in Trinidad the sun gets very strong and the cattle naturally seek shade.

The plots were rotationally grazed. When the cows finished one plot they were turned into the Rough grazing paddock in the mornings until the next plot was ready for grazing. There was no specific interval between the grazing of plots. This would be unsatisfactory as the rate of growth depends largely upon seasonal factors. A plot was judged to be ready when yield was considered optimum in quantity and quality. The accuracy of such judgements depends, of course, on the skill and experience of the husbandman. The average interval between grazing was nine weeks. With the exception of the first grazings of plots A and B the trial was conducted in the Dry Season. The interval between the first and second grazing of plot A was only five weeks. This was during the wet season.

Height before Grazing

In general the height fell between five to six feet. However, there was considerable variation within the plots especially at the later grazings. Individual stools ranged from four to seven feet high and occasional flowering culms shot up to nine and ten feet.

Height to which grazed

The mean height of grazing throughout the trial was between two and three feet. There was, however, considerable variation ranging from three inches to three feet six inches. In December, January and February isolated flowering culms occured and remained ungrazed.

Necessity for Occasional Cutting

During the trial the height to which the fodder was grazed gradually increased from about two to three feet. The appearance after five and a half months, or three grazings, was of mature fibrous stems supporting a canopy of succulent leaves and shoots. With each grazing the stems became more cane-

like and increased in length slightly. After the fourth grazing all the plots were cut back to six inches so as to provide renewed palatable herbage from the base of the stool. In addition this provided a heavy mulch of organic matter, which, besides enriching the soil, was likely to reduce weed infestation.

Stool Mortality

Throughout the trial no mortality could be traced due to grazing. Some stools were squached by trampling but these were, by no means, irreperably damaged. Some blanks arose mainly in paddocks C and D but they were due to Helminthosporeum leaf spot on the "Original" type Elephant grass stools (see p. 9).

Tillering

After the first grazing there seemed to be a change in growth habit with a marked increase in tillering. Unfortunately no tiller counts were made before grazing but independent witnesses testified that an increase had occured. Each tiller shot out a sub-tiller from most of the nodes; up to nine of these node-shoots were counted on a single tiller five feet tall. The average number was three to four per tiller giving the stools a dense and luscious appearance. This profusion of tillers was gradually replaced in the third and fourth grazings by the cane-like stems supporting an umbelliferous canopy of foliage. The effect after the first grazing may have been a seasonal rather than a biotic influence. The season was an exceptional one for profuse flowering of fodder grasses e.g. Tripsicum laxum was observed to flower at the College farm for the first time in many years. Further work on the effects of different grazing managements on tillering is indicated.

Effect of Grazing on the Consumption of Stall Fed Fodder

The cattle after grazing returned to the byre. They remained there until the evenings milking, after which they were put out into the night poddock. The average daily consumption of stall fed fodder per head was 70 lbs. This was chopped Elephant and Guatemala mixture consumed when the cattle were not grazing the Elephant grass pasture. When the cattle were grazing the fodder paddock there was a reduction of about 50% in the amount of stall fed grass consumed. This figure is based on weighings of grass consumed in the byre during the grazing of three plots.

Notes on the Grazing of the Indigofera Plot

The appearance at the beginning of the first grazing was of an even almost pure stand between the stools. At the third grazing it was in general looking luxuriant; one foot deep and climbing two feet to two feet six inches up the stools. Weeds were, however, showing signs of encroachment in small areas. Before the fourth grazing the plot was becoming weedy. The stand was approaching a mixture of indigofera and sour grass (Paspalum conjugatum) with the indigofera predominant.

In grazing, the cattle showed no particular preference for Indigofera rather than Elephant grass. After grazing the indigofera looked patchy but it always made a remarkable recovery

Weeding

The weeding of indigofera is difficult. Unless some method of doing it easily and cheaply is found it is liable to be a limiting factor in its general use. The weeds at the completion of the present observation were mainly grasses whic were eaten readily by the cattle. Provided shrubby species do not encroach a stable ecological balance of indigofera and bottam grasses might be reached. If shrubby species do begin to predominate it might be possible to eradicate most of them

by horse hoeing without causing such serious damage to the Indigofera as to prevent recovery.

Apart from the Indigofera plot the paddock was weeded twice during the first six months. The first was a horse hoeing and the second by hand. The weeds were in order of prevalence - (1) Sour grass (Paspalum conjugatum, (2) Para grass (Brachiaria mutica, (3) Bamboo grass (Paspalum fasciculatum) and smaller amounts of Bahama grass (Cynodon dactylon), Fowl Foot (Eleusine indica) and Digitaria sanguinalis. All these species must possess a certain, although unknown, value and as a mixture the biological value of the nutrients should be enhanced through supplementary actions. To keep an Elephant grass pasture completely free of weeds would seem to be unnecessary labour and a less efficient utilization of land. Research is indicated to determine to what extent volunteer species would be beneficial.

The Effect of Indigofera on the Nitrogen Content of Elephant Grass

It has been shown in temperate countries that legume associations, in pastures, can increase the protein content of the grasses. Johnstone - Wallace (1937) found that whilst the protein content of Poa pratensis alone averaged 18%, in association with Trifolium repens it averaged 25%.

Immediately before the second and third grazings samples were taken from stools of Elephant grass - (1) inside the Indigofera plot and (2) just outside the Indigofera plot. Seventeen pairs of samples were analysed for nitrogen content. The method of sampling was to cut 12 inch lengths of leaf blades of as nearly as possible the same width. Only desease free blades were cut.

The results showed that no marked effect of the Indigofera on the nitrogen content of Elephant grass had occured. The data is summarimmarized in Table X.

TABLE X

Mean Nitrogen Content of Elephant Grass Leaf Blades

Expressed as % Dry Weight

Date of Sampling	- Indigofera	+ Indigofera
Feb. 3rd	1.312	1.420
Apr. 18th	1.345	1.266

The trial was perhaps premature as, at the time of the first sampling, the Indigofera had been established only six months.

Programme of Grazing

The grazing programme is shown in Table XI. It will be observed that the grazing of any plot was always completed in two to five days. In this way there was always an interval between the end of grazing in one plot and the beginning of grazing in the next. The table shown covers 166 days and during that time the plots were grazed on 40 days by five to ten animals. 290 unit cattle days grazing were provided by one acre in 166 days. This is equivalent to 1.8 head per acre. It must be remembered that these results refer mainly to the dry season and to a part time grazing management. However, for planning future paddocks, under this management, the figures indicate that one half to two-thirds of an acre should be allowed per animal in order to always have one plot ready for grazing. This might lead to the growth of grass exceeding the rate of consumption in the wet season. In that case the excess could be soiled or ensiled. Surfeits and deficits will necessarily arise according to yearly and seasonal climatic variations. The figure calculated i.e. one half to two-thirds of an acre per head is merely given as a guide to the order of planting area required.

TABLE XI

Programme of Grazing Elephant Grass, ¼ Acre Paddocks

Date		Plot	No. Stock	Put in a.m.	Taken out a.m.
1st. Graz.					
Nov. 30 1944			10	8.00	11.15
Dec.	1	A	10	8.15	10.50
"	2	A	10	7.55	10.25
"	7	B	10	7.20	10.55
"	8	B	10	7.40	10.30
"	9	B	10	7.30	10.30
"	18	C	10	8.00	11.30
"	19	C	10	7.50	10.30
"	20	C	10	7.50	10.45
"	28	D	10	8.00	10.30
"	29	D	10	7.50	10.20
"	30	D	9	8.15	10.45
2nd. Graz.					
1945 Jan.	4	A	10	8.15	10.50
"	5	A	10	8.15	11.00
"	6	A	10	8.15	11.15
Feb.	3	B	6	7.45	11.15
"	4	B	6	7.45	11.00
"	5	B	6	7.50	11.15
"	6	B	6	7.45	11.10
Mar.	1	C	6	8.10	11.30
"	2	C	6	7.45	11.10
"	3	C	6	8.00	10.00
"	8	D	6	8.00	11.10
"	9	D	6	7.55	11.00
3rd. Graz.					
Mar. 16					
		A	6	7.50	11.00
"	17	A	6	7.50	11.10
"	18	A	6	8.00	11.00
Apr.	19	B	6	8.00	11.00
"	20	B	6	7.55	11.05
"	21	B	6	8.05	11.00
"	22	B	6	8.00	11.00
May	4	C	5	7.40	11.00
"	5	C	5	7.40	11.00
"	6	C	5	7.30	10.45
"	7	C	5	7.40	11.00
"	8	C	5	7.30	10.45
"	12	D	5	7.40	11.00
"	13	D	5	7.35	11.00
"	14	D	5	7.40	11.10
"	15	D	5	7.30	11.00

ILLUSTRATIONS

ELEPHANT GRASS. Field scale grazing trials.

Fig. 9. The dairy cows beginning the grazing of a paddock.

Fig. 10. A typical tiller produced after three rotational grazings. Note the long cane-like stem which below 2 ft. 6 ins. is woody and unpalatable.

Indigofera endecaphylla as a ground legume in Elephant grass pasture

Fig. 11. After grazing. Indigofera between the Elephant grass stools.

Fig. 12.

Fig. 13.

Indigofera growing round a stool of Elephant grass. Both photographs taken at the end of the dry season after 3 grazings.

Fig. 12. Grasses (Paspalum conjugatum and Paspalum fasciculatum) in foreground growing in association with Indigofera.

Fig. 13. Indigofera climbing stool up to 2 ft.

C. Brachiaria decumbens

The grazing animals used in the small plot Elephant and Guatemala grass experiments were also utilized to graze a plot of Brachiaria decumbens. It was one of a number of 10 X 10 yard plots where exotic species are 'quarantined' before more extensive trial. This grass was selected for a grazing trial because:-

(1) It seemed well adapted to Trinidad conditions;

(2) It formed a dense sward over the whole plot.

The general appearance was more that of a pasture than a typical fodder grass.

Description

The floral parts are similar to Brachiaria brizantha (Stapf), a description of which can be found in Kew Bulletin on East African pasture plants (1926). Vegetatively it differs from B. brizantha in its pubescent leaves and semi-erect growth habit.

The plot grazed was established in 1938.

Literature on the grass is scanty and consists of observational records only. In Uganda (Thomas 1940) it occurs commonly as a bottom grass in Hyparrhenias. It is stated to form a good cover; provide good grazing and stand up well to the dry season. Establishment is said to be possible by cuttings only. In Queensland (Mc Taggart, 1935) it is reported as making abundant good quality foliage which can be grazed. It has been grown (Schofield, 1941) in association with Stylosanthes guyannensis var subviscosus. A photograph of the grass and the legume growing together is shown in the reference cited. In Trinidad, Campbell (1944) noted its aggressiveness and ability to smother weeds.

Grazing

The plot was grazed four times in eight months. Grazings were in September, November, January and May. The animals grazed from about three feet down to fifteen inches. It will be noted that the grazing interval was two months between the first three grazings and four months between the last two. The latter period was the dry season. During September there was a tendency towards seeding but seeded culms were grazed by the stock.

Before grazing the uniform cover and dense sward was a striking feature. Grazing caused some wastage due to trampling but in spite of that the plot supported two animals at each grazing for approximately the same time as similar sized plots of Elephant grass. Each grazing lasted about 40 hours. With more extended grazings on larger areas the effect of trampling might be more serious.

An encouraging feature was the absence of weeds. One stem of ~~Crotalaria~~ and a few plants of ~~Alysicarpus~~ were present at the first grazing. These were consumed, together with the rest of the herbage, and thereafter appeared no more.

Although the scale of the trial was small the ability of ~~Brachiaria decumbens~~ to withstand grazing and at the same time maintain a pure stand was clearly shown.

ILLUSTRATIONS

BRACHIARIA DECUMBENS

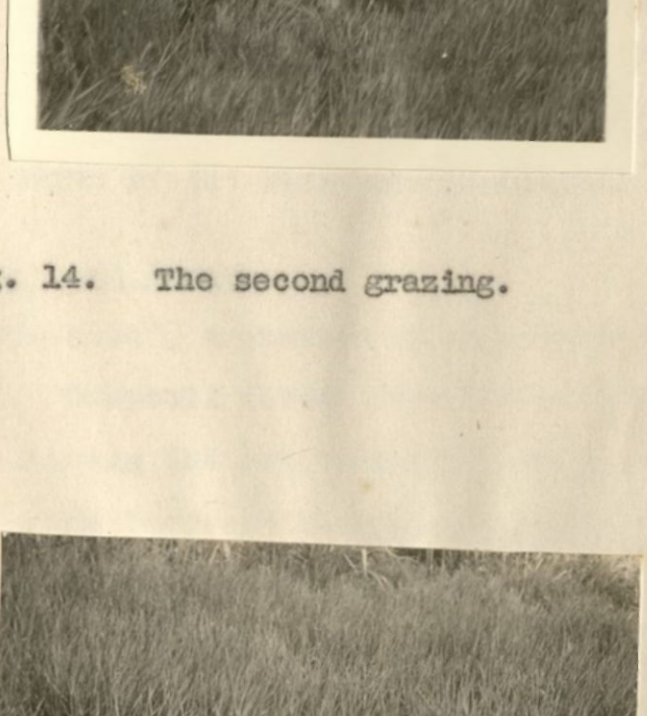


Fig. 14. The second grazing.

Fig. 15. After four grazings.

Note the uniform sward and dense ground cover.

D. Indigofera endecaphylla

The relevant literature on Indigofera has already been cited in connection with Elephant - Indigofera grazing trial (see p.43). Here a description is given of an experiment in which a pure stand of the legume was grazed.

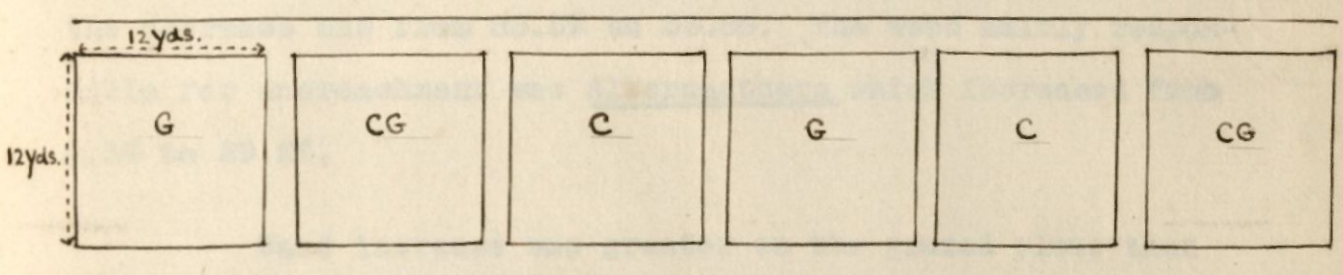
Object of Experiment

The object was to study Indigofera's response to grazing and alternate cutting and grazing as compared with cutting in terms of (1) Yield and (2) Purity of stand.

Establishment and Layout

The area*, a quarter of an acre, was planted in August 1941. Campbell (1944) reported an attack by an unidentified fungus during the wet season of 1943. After cutting and raking, to allow increased aeration beneath the thick mat of foliage, the disease disappeared. During 1943-4 Campbell states that a complete cover was formed and that all weeds except Water Grass (Commelina elegans), and Para Grass (Brachiaria mutica) were smothered.

The layout of the present experiment is shown in diagram III.



Treatments

The treatments were:-

1. Cutting every six weeks

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* I.C.T.A. Field No.28.

2. Cutting-and-grazing every alternate six weeks
3. Grazing every six weeks.

The six weekly interval between treatments was chosen arbitarily in view of the lack of any fundamental work on the optimum cutting or grazing frequency.

Methods

The method of Botanical Analysis is delt with in Part II of this dissertation. Analyses were carried out at three monthly intervals: (1) Before the preliminary cutting and weighing, (2) before the second treatments and (3) before the fourth treatments.

All other experimental methods were as already described in the small plot experiments on Guatemala and Elephant grass.

Results - 1) Botanical Analyses

In Table XII the percentage area covered by the various botanical species is shown. Each figure is the mean of 2 plots. Readings below 0.5% are recorded as traces (T).

It is clear from the first three rows of the table that the percentage area of Indigofera decreased speedily. Taking the mean of the readings on June 5th and December 21st the decrease was from 83.5% to 53.8%. The weed mainly responsible for encroachment was Alternanthera which increased from 6.3% to 29.2%.

Weed increase was greater on the grazed plots than on the cut plots; and on the alternately cut-and-grazed plots the increase was intermediary. At the final analysis there was 45% ground cover by Indigofera on the grazed plots; 65.5% on the cut plots, and 50.8% on the cut-and-grazed plots. The degree of infestation by Alternanthera was most under grazing, 33.3%; least under cutting, 24.0%; and 30.3% with cutting-and-grazing.

TABLE XII

Changes in Botanical Composition

Species	Treatment	% Area 1944 July 5th	Sept.30th	Dec.21st
Indigofera endecaphylla	Cut	84.3	76.3	65.5
(Trailing indigo)	Cut-&-Graz.	79.3	61.8	50.8
Leguminoseae	Grazed	86.8	75.8	45.0
Alternanthera ficoidea	C	6.0	18.0	24.0
(Rabbit's Meat)	CG	9.0	26.5	30.3
Amarantaceae	G	3.8	14.3	33.3
Commelina elegans	C	7.3	2.8	5.0
(Water grass)	CG	8.8	5.8	6.3
Commelinaceae	G	8.3	3.3	3.8
Cynodan dactylon	C	-	-	-
(Bahama grass)	CG	T	-	-
Gramineae	G	0.3	2.3	5.5
Eleusine indica	C	0.3	T	-
(Fowl foot grass)	CG	0.8	3.3	2.5
Gramineae	G	-	0.8	4.8
Brachiaria mutica	C	0.5	-	-
(Para grass)	CG	0.3	1.0	0.8
Gramineae	G	1.0	1.5	1.5
Paspalum conjugatum	C	T	1.8	4.3
(Sour grass)	CG	T	-	T
Gramineae	G	-	0.3	0.8
Synedrella nodiflora	C	-	T	0.3
Compositeae	CG	T	0.3	2.0
	G	-	1.3	5.3
Blechum pyramidatum	C	1.0	T	0.8
Acanthaceae	CG	-	-	T
	G	T	-	-
Pagasea dianthera	C	0.5	-	-
Scrophulariaceae	CG	0.3	-	3.5
	G	-	T	-
Bare Ground	C	0.5	-	-
	CG	0.8	1.8	1.8
	G	-	0.5	-

Further species recorded as traces were:-

Bidens pilosa	Compositae
Chloris gayana (Rhodes grass)	Gramineae
Cleome ciliata	Capparidaceae
Cyperus rotundus (Nut grass)	Cyperoceae
Eclypta alba (Congo Lala)	Compositae
Euphorbia hirta	Euphorbioceae
Ipomoea sp.	Convolvulaceae
Mimosa pudica (Sensitive Plant)	Mimoseae
Spigelia anthelmia	Loganiaceae
Spilanthes uliginosa	Compositae

The remainder of the species were of relatively minor importance in comparison with Alternanthera. Together they accounted for 10.2% of the total area in June and 17.0% in December. Commelina decreased slightly throughout but showed no marked differences in response to the various treatments.

Bahama grass and Fowl-foot grass increased under grazing, whereas Sour grass increased under cutting.

All the other species showed a slight increase from June to December at the expense of Indigofera. Their total area was too small to indicate any specific response to the various treatments.

2) Yields

Yield data were taken regularly but the high weed infestation rendered all except the first weighings meaningless as a measure of the cropping ability of Indigofera. At the preliminary cutting and the first treatment cutting the ground covered by Indigofera amounted to about 80% of the total area. In view of the lack of any existing work to show the yielding power of the legume the results obtained, converted to hundredweights per acre are shown in Table XIII.

TABLE XIII

Yields of Indigofera in Cwts. per Acre at the First Two Cuttings

Date	Plot	Cwts.per Acre. Green Herbage	% D.M.	Mean % D.M.	Cwts.per Acre. Dry Matter
7th Jul.1944	1	83.8	17.2		
			17.0	17.2	14.4
			17.3		
"	2	55.9	16.2		
			16.2	16.2	9.1
			16.2		
"	3	61.6	18.9		
			19.2	19.3	11.9
			19.9		
"	4	75.1	16.2		
			16.2	16.2	12.2
			16.1		
"	5	50.5	17.1		
			17.1	17.1	8.6
			17.2		
"	6	34.7	16.3		
			16.1	16.3	5.7
			16.5		
17th Aug.1944	1	53.8	21.0		
			20.4	20.6	11.1
			20.5		
"	2	58.8	24.1		
			23.1	23.5	13.8
			23.3		
Mean		59.3		18.3	10.9

The mean yield of two six-weekly cuttings was approximately three tons of fresh material and half-a-ton of dry matter. These are wet season yields. The rainfall in June 1944 was 23 inches which is exceptionally high even for the Trinidad wet season. In spite of these rather abnormal factors the data shows that Indigofera has a very promising yielding ability.

Notes on Grazing

The impression gained by watching the grazing animals was that Indigofera in a pure stand was not relished particularly by the cattle. Some souring and loss of condition occured. The cattle had no difficulty in biting off the leaves and stems and there was no uprooting or pulling out of long lengths of creepers.

The intensity of grazing was heavy. In Table XIV the number of hours on each plot has been converted to cattle days grazing per acre every six weeks.

TABLE XIV

Cattle Days Grazing per Six Weeks, per Acre

Date 1944	Treatment	Plot	Days Grazing per six weeks per acre
19th-25th Aug.	1st	CG 1	171
		CG 2	169
		G 1	171
		G 2	169
3rd-5th Oct.	2nd	G 1	104
		G 2	104
11th-15th Nov.	3rd	CG 1	102
		CG 2	101
		G 1	102
		G 2	101
22nd-23rd Dec.	4th	G 1	50
		G 2	50

These figures should not be used to assess Stock Carrying Capacity as it is doubtful whether a pure stand of Indigofera would be suitable to support cattle continuously. As farmers are aware in Britain great care is needed in grazing pure stands of clover leys because of 'bloat' and scouring. The position with Indigofera may well be analogous and throughout the experiment the cattle were removed in the afternoons to be given some roughage. The figures shown are given only to indicate that the intensity of grazing was high.

Discussion of Results and Suggestions for Future Investigations

The first experiment on Guatemala and Elephant grass indicated that Guatemala grass was unsuitable for grazing, under the management adopted, but that Elephant grass was more suitable.

In the case of Guatemala grass stool mortality was self-evident and the impracticability of attempting to graze below two feet clearly shown. The results, however were not reflected significantly in the final yields of dry-matter and for that reason the experiment cannot be said to have been conclusive. Further investigations are required with four to five treatment replications and continued for at least one year. It is suggested that grazing should begin at five to six feet and finish at two to three feet. Grazing at a younger stage, three to four weeks, might be possible from the viewpoint of the grazing animal but it is unlikely that the grass could withstand such a short interval between harvestings.

The grazing of Elephant grass is to be continued and extended on the College Farm. The present investigation has shown that the grass, previously regarded solely as a fodder in Trinidad, has great potentialities as a forage. It has been shown how a system of part time grazing can be simply and cheaply worked in to the general management of a dairy herd under Trinidad climatic conditions (see p. 46).

One difficulty that arises in Elephant grass pasturage is the unevenness of grazing. This, under a rotational system, becomes cumulative. A stool only partially eaten at one grazing is still less likely to be eaten at the next. The cause of selective grazing must be associated with uniformity of genatype and degree of soil heteroginity. By vegetative propagation the genatype would be entirely homogenous, provided all the planting

material is selected from the same strain. In the plantings on the Imperial College farm there exist both Elephant grass (the original type) and Elephant grass var. Uganda. It is strongly recommended that the latter alone should be used because of its resistance to Helminthosporium leaf spot. It can be easily distinguished by the varieated and pubescent leaves (see p.9).

The only practical method of minimising soil heterogeneity is to have small paddocks. This is a pre-requisite for scientific management of temperate leys and is likely to be of equal importance in the future grazing management of tropical forages. It entails capital outlay on fencing. In this respect the electric fence could be used as a means of economy without loss of efficiency. It was shown that Zebus and Zebu crosses were as amenable to enclosure by this means as are temperate breeds of cattle (see p.17).

With a uniform genotype and small paddocks it should not be necessary to cut Elephant grass to a uniform height after each grazing. It is considered necessary to cut the stools down to ground level about twice yearly i.e. after three to four grazings. This provides renewed palatable herbage from the base of the stool. If it is not done a fibrous cane-like stem, two to three feet high, and increasing in height with each grazing, is produced. (See Fig.10, p.52).

Brachiaria decumbens was note-worthy in its ability to smother weeds. After eight months of rotational grazing there was not a weed in the plot. A disadvantage of Brachiaria as a forage was the tendency towards wastage by trampling. It is considered that the best results would be obtained by rotational grazing, by a large number of stock in small paddocks so that

the length of each grazing would be short.

The striking similarity in chemical composition between Indigofera and Alfalfa has been pointed out. In the field scale grazing trial Indigofera showed its ability to grow as a ground cover beneath Elephant grass. It was grazed but the impression gained was that the cattle did not relish it much , especially when they were put onto a pure stand.

Trials should made to establish Indigofera by seed in view of the success obtained in Puerto Rico. The main drawback of the legume is likely to be the difficulty of maintaining it free from weeds. In the small plot experiment weediness was most under grazing, least under cutting and intermediary with alternate cutting and grazing. These results were limited to (1) the wet season, (2) a three year old stand and (3) severe treatments i.e. cutting as low to the ground as possible and heavy grazing. However there was the same tendency to weediness in the Elephant - Indigofera pasture after the legume had been established ten months and been grazed four times.

In the Field Scale Elephant - Indigofera trial the term 'weeds' is perhaps a misnomer. They were mainly volunteer grasses (see p. 49) which were eaten readily by the cattle. Provided they do not curtail the growth of the main fodder grass and shrubby species do not predominate, the nutritive value of a paddock would doubtless be enhanced by such 'weeds'. It would seem that to keep the rows between the stools in an Elephant grass pasture completely clean would be unnecessary labour, inefficient utilization of the land and in some cases, a source of soil erosion. Research is indicated to determine (1) to what extent volunteer species would be desirable and (2) whether tedious hand weeding can be eliminated by a rough horse hoeing which might be sufficient to destroy undesirable species. It

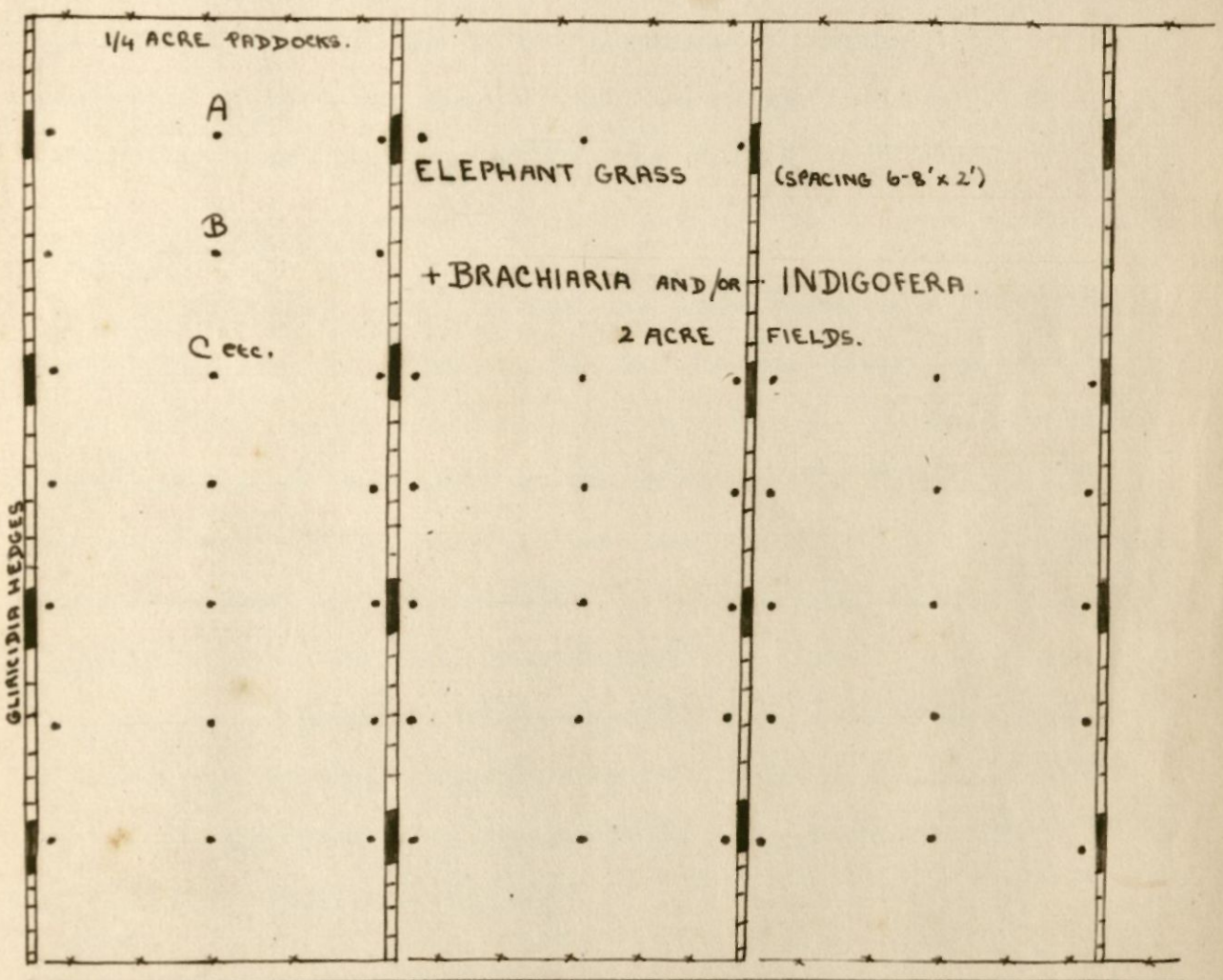
has been mentioned that the Indigofera in this trial was approaching, by the fourth grazing, a mixture of sour grass and indigofera. It remains to be seen whether any static balance will be reached. If the legume continues to suffer weed encroachment some form of weeding will have to be carried out. Hand weeding is extremely laborous because of the tangled mass of the creeping stems. It is possible that horse-hoeing might be sufficient. Although the legume would certainly be given a check it would probably make a quick recovery. Failing any practical method of controlling 'weeds' the legume could be re-established every two to three years i.e. on the ley principle.

The aim in pasture development in the tropics should not be to produce single species pastures but to find a suitable mixture of grasses and legumes that can be grazed together. It is in mixtures that the maximum nutritive value of 'feed' is realized. To attain a desired mixture is much more difficult in the tropics than in temperate climates. It seems that owing to the rapid growth of all vegetation the ecological balance of desirable forages tends to be replaced by shrubby species. One method of by-passing this difficulty would be to have adjacent single species pastures. For example, at the Imperial College plans are being made to establish adjacent fields of Indigofera - Elephant grass, Brachiaria decumbens and Guatemala grass. The Elephant grass will be grazed in the forenoon, the Guatemala grass stall fed in the afternoon and the Brachiaria grazed at night. The Brachiaria is chosen for night grazing because cattle lying down on closely planted Elephant grass would probably cause both discomfort to the cattle and damage to the stools. A further layout, worthy of trial, is to plant the Elephant grass six to eight feet apart between the rows and interplanted with Brachiaria or Indigofera, or both

separately, in different parts of the field. This should allow sufficient room between the stools for the cattle to lie down.

The scope for pasture research is vast throughout the whole of the tropics. In Trinidad, though the problem has hardly been touched, there undoubtedly are tremendous potentialities in grass and legume species known to thrive in the Island.

The type of pasture envisaged by the author, encorporating conclusions from the foregoing experiments, is shown in the diagram. It is realized however, that much experimental work is yet required before such a pasture can be advocated safely to the farming community. In fact the following ideas are merely a personal prognosis of the shape of things to come.



The important features of this layout are:-

1. The mixture of a tall forage with a ground grass or legume.
2. The use of an electric fence to make small paddocks.

The ground directly beneath the fence should be under one of the short growing species i.e. Brachiaria or Indigofera, so that the current is not earthed. A herd of 10 cattle would graze each paddock in two to three days.

3. Hedges of Gliricidia sepium)Leguminoseae). One of these is grazed regularly on the College Farm by draft Zebus and the Dairy cattle. It was a crude protein content of between 23 and 26% of the Dry-Matter as reported by Gale and Luscombe (1944.

PART II

ROUGH GRAZING

Mention has already been made of the poor quality and yield of the natural Rough Grazings in Trinidad. This is apparent from casual observation but no critical study has been made to show the precise botanical composition and the influence of seasonal and biotic factors on such pastures. The following experiment was conducted with the object of making a preliminary study of these matters.

The paddock examined was "established" as a pasture for the draught oxen on the Imperial College farm in 1939.[1] The usual practice of establishment was adopted, namely to allow the land to remain fallow and recolonise naturally. This was followed by periodic cutting and hand-hoeing to eradicate Sensitive Plant (Mimosa pudica) and shrubby species.

Ecological Factors

1. Climatic. In Trinidad the year is divided into well-marked wet and dry seasons, the dry season usually extending from January to late in May. During the year of the experiment 59.61 inches of rain fell in the eight months from June to December and 14.83 inches in the four months of the dry season. The dry season is characterised by warm drying winds and intense insolation when the sun is unobscured by cloud. In the wet season the humidity is high, reaching almost 100% nightly. The average monthly temperatures vary between maxima of 85° F. to 89° F. and minima of 66° F. to 72° F. In short, the climate is fully tropical and insular.

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[1] Field No. 24, I.C.T.A.

2. Edaphic. The only survey available was carried out by the Chemistry Department in 1937. (Bumpus, 1941) It showed the soil to be silty, alkaline (pH 7.5), medium to low in total organic matter, high in phosphate and adequate in potash.

3. Physiographic. The field is flat and sheltered by hedges of Gliricidia sepium on the eastern and western boundaries.

Experimental Design and Methods

About ½-acre of the paddock was fenced off and nine 12 x 12 yard plots, or approximately 1/33-acre each, marked out as a 3 x 3 Latin square.

The three treatments were:-

1. Cutting every six weeks (C).
2. Cutting and grazing every alternate six weeks (CG).
3. Grazing every six weeks (G).

A preliminary cutting was given over the whole area six weeks before the first treatment series. The problem of fencing on such small plots was solved by the use of an electric wire.

Fig. 1 7. The first grazing in progress.

Botanical Analyses

A modified percentage area technique was adopted after consulting literature by Davies (1931), Davies and Trumble (1934), and Bumpus (1941). These workers review the possible methods of pasture analysis, e.g. specific frequency, percentage frequency, point quadrat, percentage productivity, etc. The method adopted is based on eye-estimation conducted in the field, and does not involve elaborate weighing, counting and teasing out of species in the laboratory. It has the advantage that a large number of readings can be taken in a reasonable time, but the disadvantage of errors arising due to personal judgement.

The Method Adopted

Throughout these analyses a square grid 10 ins. x 10 ins., inside measurements, was used. The inside of the frame was marked off from 1 to 10 (four rulers were used joined in the form of a square). In the true percentage area method the grid is subdivided by cross wires into 100 individual squares. Then the area occupied by any one species is noted and the total percentage for the whole grid calculated. This presupposes a sward of fairly uniform height, in order for the grid to lie flat. In the present study the vegetation was not sufficiently even to permit cross meshes to be used. Consequently the grid was left open and the percentages of species estimated by eye, with the aid of the graduations marked on the inside of the frame. Although the accuracy obtained is undoubtedly less using an open grid as compared with a square mesh grid, the errors were minimised in the present case because each reading was studied by two observers who had to agree before passing on to the next reading. A further factor which greatly reduces the errors of personal judgement is that the percentages of all

species together in the grid have to add up to 100. However, in spite of these checks on the accuracy of the method, only large changes in the percentages of the main species have been considered in the discussion of results. If time had permitted a comparison of the accuracy of the estimation method of analysis and the more precise laboratory methods would have been made. Davies and Trumble (1934) in making such a comparison found that "estimation methods are not sufficiently precise to detect differences that are much below 20 per cent." These workers maintain that this is not a series disadvantage as differences of 500 per cent are common. Throughout the following discussion 20% has been taken as the approximate criterion of significance.

The procedure in taking readings

Ten throws were made in each plot, taking a zig-zag course in a pre-arranged direction so as to have the area covered as wide as possible. Davies (1931) showed that ten random samples were sufficient to give reliable data on small plots and that little increased accuracy resulted from a larger number of readings. In finally placing the grid the eyes were closed and the grid allowed to fall to the ground at random. Then a total of ten marks was carefully allocated to the various species occurring within the grid. Where a species only covered 0.5% of the area, i.e. could only be allocated ½ out of the ten total marks, it was recorded as a trace (T). After ten readings had been made the figures for each species were summated to give the percentage area occupied in the whole plot. Where dung occurred in the grid marks were allocated as a proportion of the area not covered by dung.

Programme of Analyses

The experiment continued from June 1944 to June 1945. This enabled five analyses to be carried out at 12-weekly intervals. The sequence of analyses in conjunction with the treatments received is shown in Table I.

TABLE I

Programme of Analyses with respect to Small Plot Treatments

Date 1944-5	Plots C	CC	G	Botanical[1] Analyses
18 May	Preliminary Cutting			
30 June	Cutting and Weighing			29 June
10 Aug.	Cut	Grazed	Grazed	
22 Sept.	Cut	Cut	Grazed	15 Sept.
1 Nov.	Cut	Grazed	Grazed	
21 Dec.	Cut	Cut	Grazed; then cut[2]	8 Dec.
5 Feb.	Cut	Cut	Cut	
20 Mar.[3]	Grazed	Grazed	Cut	15 Mar.
				1 June

[1] Dates represent day on which analysis completed.

[2] After grazing, rejected herbage cut.

[3] The treatments were reversed after the cutting of all plots in February.

Analyses were also made at approximately the same times, on a portion of the paddock outside the small plot area. This part of the paddock was grazed continuously at night by the dairy herd. It received weedings in December and March under the ordinary farm management routine. Two further analyses, one in the wet season and the other in the dry season, were made on a day paddock[1] which was situated about 100 yards from the night paddock.

Method of Presenting Results

The results of the analyses are given in the form of:-

1. A list of all species, Table II, together with their botanical family.

2. Table III showing the changes in percentage area of all species which occurred as more than 0.5% of the total vegetative cover. All figures in this table represent the means of three plot totals.

[1] Field No. 14, I.C.T.A.

3. Table IV showing the analyses of the night paddock. The area investigated was equivalent to three small plots, or one treatment series, in the Latin square. Each figure in the table represents the mean percentage of 30 throws of the grid.

4. Table V showing the results of one analysis in the wet and dry seasons on the day paddock. The total area of the paddock was approximately one acre. Each figure represents the mean percentage of 100 grid throws.

5. The botanical fluctuations of the six predominant species have been shown graphically (Graphs 1 to 4). Each point on the graph represents the mean percentage of three plots (30 readings) in the Latin square layout and the mean percentage of 30 readings for the continuous night paddock.

Reversal of Treatments

After the cutting of all the Latin square plots in February 1945, the plot treatments were reversed. By the fourth rotational grazing in December, the amount of palatable herbage on the G plots had become insignificant owing to the rapid increase in the proportion of shrubby species. One of the G plots was not grazed in December, i.e. when it was due for its fourth rotational grazing, because it would have been cruel to the animals to do so. Consequently it was decided to reverse the treatments to see whether changes in botanical composition that had occurred due to the treatments, would also be reversed. It was unfortunate that, due to insufficient time, it was only possible to do one botanical analysis after the treatment reversal. Where the switching round of treatments produced any marked effects, it has been referred to in the discussion of results.

RESULTS

TABLE XI

Species List. Field No. 24.

1. Grasses

Axonopus compressus (Savannah grass)

Cynodon dactylon (Bahama grass)

Digitaria sanguinalis

Eleusine indica (Fowl-foot grass)

Eragrostis ciliaris

Paspalum conjugatum (Sour grass)

Rottboellia exultata (Corn grass)

Sporobolus indicus (Tapia grass)

2. Miscellaneous species

Species	Family
Ageratum conyzoides (Herbe à femme)	Compositae
Alternanthera ficoidea (Rabbit's meat)	Amaranthaceae
Asclepias curassavica	Asclepiadaceae
Bidens pilosa (Railway daisy)	Compositae
Blechum pyramidatum	Acanthaceae
Borreria verticillatum (White broom)	Rubiaceae
Commelina elegans (Water grass)	Commelinaceae
Cyperus rotundus (Nut grass)	Cyperaceae
Desmodium adscendens	Papilionatae
Desmodium supinum	Papilionatae
Desmodium triflorum	Papilionatae
Eclipta alba	Compositae
Emilia coccinea	Compositae
Enicostema verticillatum	Gentianaceae
Eupatorium odoratum (Christmas bush)	Compositae
Euphorbia hirta	Euphorbiaceae
Gliricidia sepium (Nicaraguan Cacao shade)	Papilionatae
Ipomoea sp.	Convolvulaceae

Lantana camara (Wild sage)	Verbenaceae
Mimosa pudica (Sensitive plant)	Mimoseae
Pagasea dianthera	Scrophulariaceae
Phyllanthus sp.	Euphorbiaceae
Sida acuta	Malvaceae
Synedrella nodiflora	Compositae

Additional species occurring only in Field No. 14 (Day Paddock).

Species	Family
Centrosema pubescens	Papilionatae
Cleome ciliata	Capparidaceae
Fleurya aestuus	Urticaceae
Petiveria alliaceae	Phytolaccaceae
Pseudoelephantopus spicatus	Compositae
Spigelia anthelmia	Loganiaceae

TABLE IV

Herbage Analyses of Night Paddock; % Area. Field No. 24.

Species	June	Sept.	Dec.	Mar.
Cynodon dactylon	49.2	35.8	30.0	38.3
Blechum pyramidatum	20.5	17.7	17.8	4.2
Desmodium adscendens	16.5	9.3	1.8	0.2
Paspalum conjugatum	5.5	13.8	18.7	27.5
Phyllanthus sp.	0.3	6.0	2.8	---
Sida acuta	0.5	T	5.8	0.3
Mimosa pudica	1.7	T	2.3	1.0
Ageratum conyzoides	---	T	1.8	0.3
18 minor species	5.2	5.1	7.3	4.0
Dead vegetation	---	---	---	7.2
Bare ground	1.0	11.7	11.5	17.0

TABLE V

Herbage Analyses of Day Paddock; % Area. Field No. 14.

Species	Oct.	Mar.
Axonopus compressus	63.8	39.9
Cynodon dactylon	2.3	4.1
Desmodium adscendens	5.4	0.9
Synedrella nodiflora	2.8	---
Pseudoelephantopus spicatus	1.8	0.7
Blechum pyramidatum	---	1.8
17 minor species	7.4	2.5
Bare ground and dead vegetation	14.6	50.3

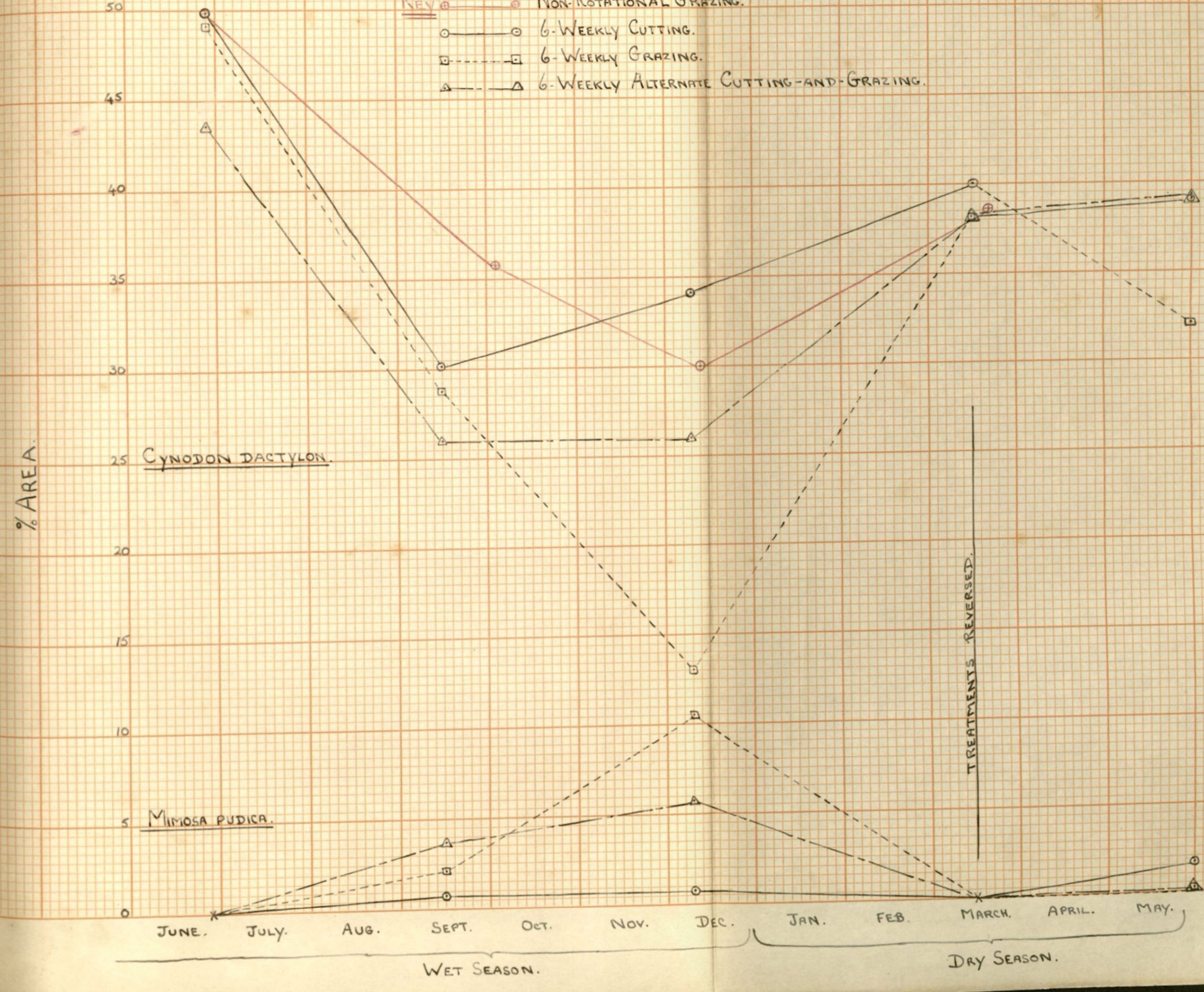
TABLE III

Herbage Analyses of Latin Square

Species	Grazed					Cut					Cut-and-Grazed				
	June	Sept.	Dec.	Mar.	June	June	Sept.	Dec.	Mar.	June	June	Sept.	Dec.	March	June
Cynodon dactylon	49.2	28.8	13.0	38.2	39.0	49.9	30.2	34.2	40.0	32.0	43.6	26.0	26.0	38.3	39.3
Paspalum conjugatum	14.3	17.7	29.5	39.0	30.5	17.0	25.8	36.5	29.5	42.3	18.8	20.7	35.0	40.8	39.0
Blechum pyramidatum	17.8	14.7	18.0	2.7	5.0	11.0	10.8	12.5	3.7	2.7	15.5	20.2	15.3	4.0	1.3
Desmodium adscendens	4.5	11.5	7.5	4.7	9.5	8.5	12.5	5.3	5.8	6.5	7.7	10.0	4.8	2.8	14.7
Desmodium supinum	1.5	1.7	4.0	1.2	6.3	3.0	2.8	2.2	4.3	10.3	1.5	1.7	1.5	1.2	2.8
Desmodium triflorum	-	-	0.2	0.3	1.3	-	1.3	-	-	2.3	-	-	-	0.3	1.3
Mimosa pudica	T	2.2	10.5	-	1.7	0.2	0.8	0.8	-	0.3	0.3	3.7	5.8	-	0.3
Ageratum conyzoides	2.7	9.0	5.5	-	0.7	2.8	6.2	1.5	-	T	5.7	9.5	3.8	T	-
Phyllanthus sp.	0.5	3.3	4.3	1.7	1.8	T	0.8	0.7	0.7	T	0.3	1.3	3.7	0.8	0.2
Euphorbia hirta	0.2	0.5	1.7	T	0.7	0.3	0.3	0.8	T	T	0.2	0.8	1.0	T	0.3
Emilia coccinea	0.8	0.7	1.2	0.2	0.2	0.8	0.8	T	T	T	0.8	0.5	T	T	-
Pagasea dianthera	1.0	0.2	0.5	T	0.2	1.2	T	T	T	T	0.3	2.3	0.7	0.2	0.2
Cyperus rotundus	0.2	0.8	0.5	0.3	0.2	0.2	0.2	0.3	0.7	0.2	0.5	T	0.2	-	-
Synedrella nodiflora	0.2	0.8	1.0	-	-	0.3	1.8	2.0	0.2	-	-	1.0	0.5	0.2	-
Eupatorium odoratum	1.0	T	-	-	0.2	1.0	-	0.2	-	0.3	0.7	0.8	T	T	-
Sida acuta	1.0	2.2	0.5	2.3	0.5	-	0.5	-	T	0.2	-	0.3	0.7	0.3	0.3
Rottboellia exultata	0.5	4.7	1.8	-	0.5	-	-	-	-	-	-	0.2	-	-	-
Axonopus compressus	0.2	-	-	-	-	-	-	-	1.7	-	-	T	-	-	-
Commelina eligans	0.3	-	0.2	-	-	0.8	1.7	0.2	-	-	T	0.8	-	-	-
Enicostema verticillatum	2.0	-	-	-	-	0.7	-	-	0.2	0.2	0.8	-	-	0.2	0.2
Bidens pilosa	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
Asclepias curassavica	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-
Ipomoea sp	-	-	-	-	-	-	0.7	0.5	-	-	-	-	-	-	-
Dead vegetation	-	-	-	1.7	0.2	-	-	-	4.0	0.5	-	-	-	6.8	-
Bare Ground	2.0	0.8	0.2	7.3	0.5	2.0	2.2	2.3	9.3	2.0	2.8	1.2	0.2	4.0	-

No. 1

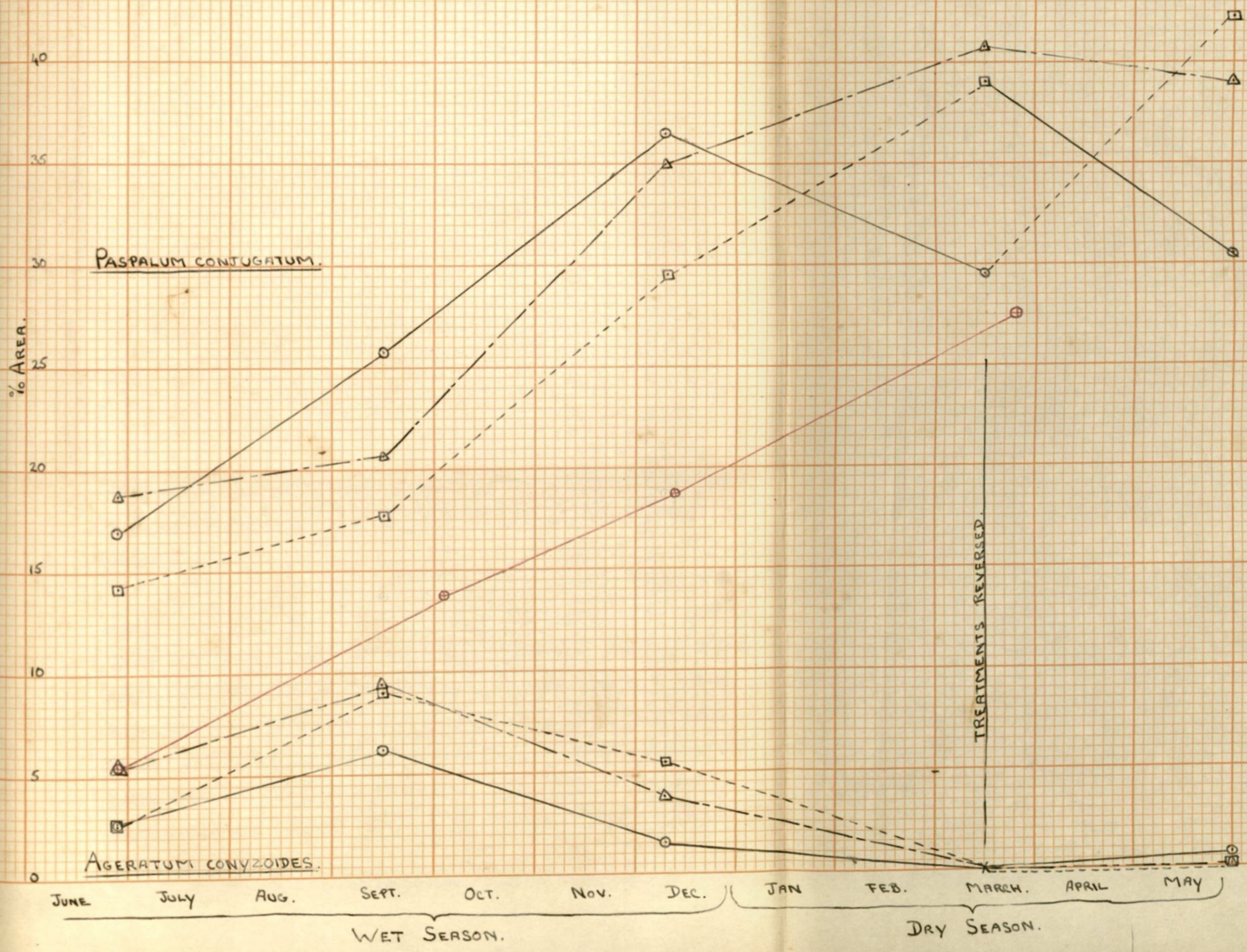
% of Bahama grass and Sensitive plant in the Sward



No 2.

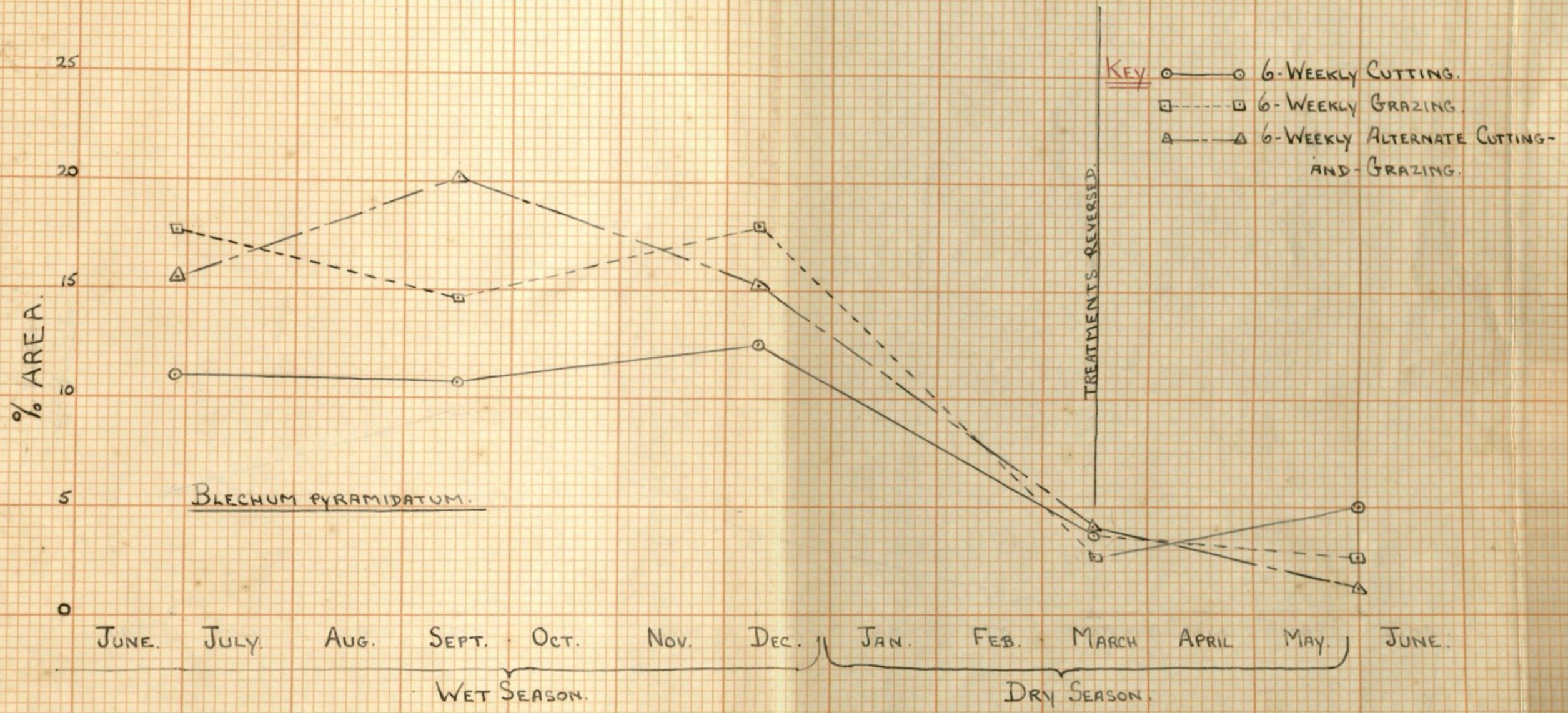
% OF SOUR GRASS AND AGERATUM CONYZOIDES IN THE SWARD.

KEY
- ⊕——⊕ NON ROTATIONAL GRAZING.
- ⊙——⊙ 6-WEEKLY CUTTING.
- ⊡- - - -⊡ 6-WEEKLY GRAZING.
- △—·—△ 6-WEEKLY ALTERNATE CUTTING-AND-GRAZING.

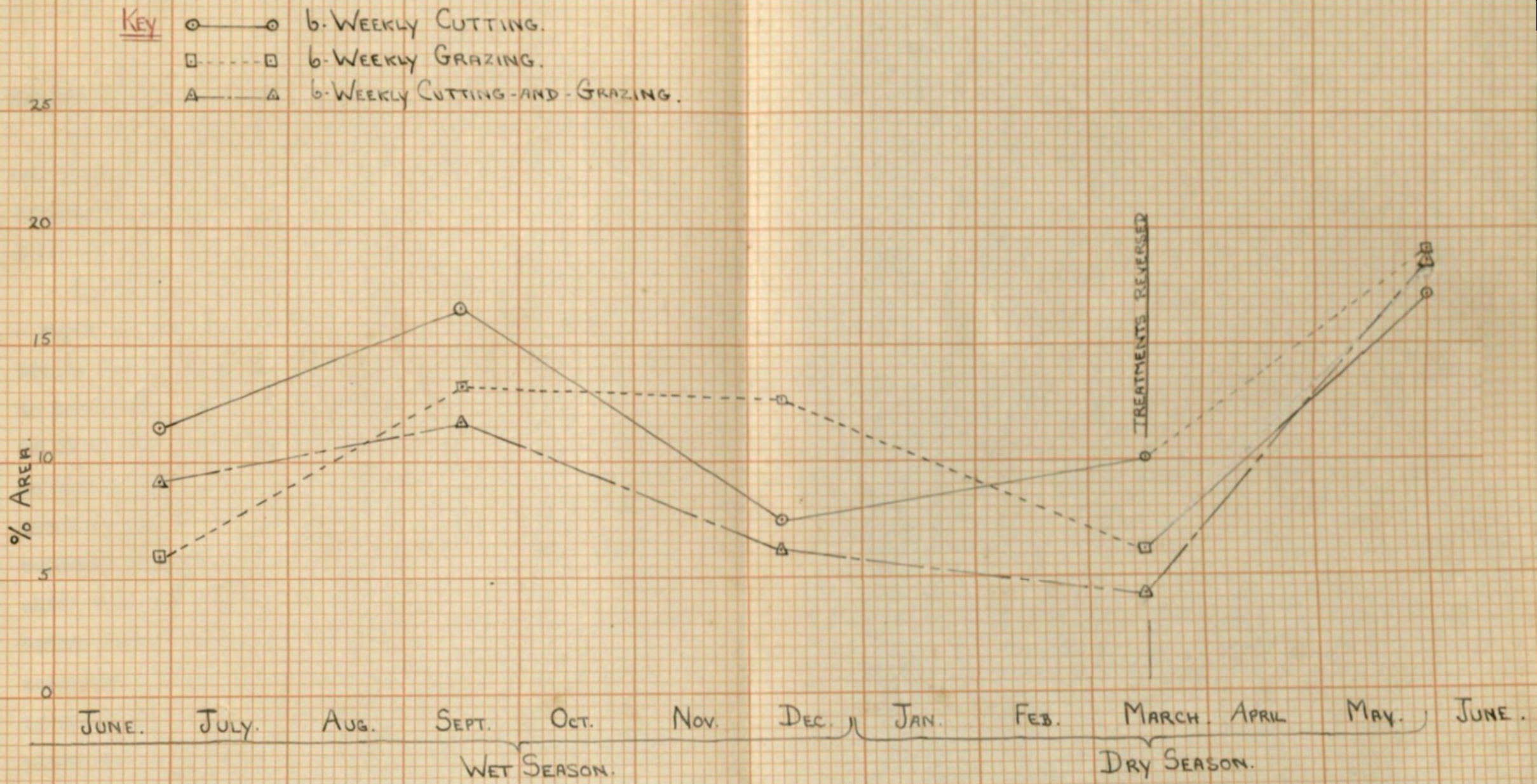


GRAPH NO 3.

% OF BLECHUM PYRAMIDATUM IN THE SWARD



No. 4. % OF DESMODIUM SPECIES IN THE SWARD



Discussion of Results

Cynodon dactylon (Bahama grass). See Graph No. 1.

At the first analysis, between the end of the dry season and the beginning of the wet season, Bahama grass was the dominant species. It occupied a percentage area of between 49.9 and 43.6 on both the small plots and the night paddock.

As the wet season progressed into September 1944 there was a rapid decrease in Bahama grass, to 26-30%. The effect of the biotic factor did not become apparent until the third analysis in December. At that time the percentage of the grass had fallen to 13 on the G plots as a result of three rotational grazings. On the CG plots, which had received two rotational grazings, interspersed by one cutting, the amount of Bahama grass remained constant at 26% between September and December. On the C plots, which were cut repeatedly, there was a rise in the amount of Bahama grass between September and December, to 34%. This coincided with a short spell of dry weather which occurs in Trinidad in October. With the onset of the main dry season all plots showed a very sharp rise in the percentage of Bahama grass. Not only was the seasonal influence marked but all the graphs converge in March showing the result of the cutting which took place on all plots in December 1944 and February 1945 (see Table I).

On the night paddock, which received a fairly close grazing, except during flush periods of heavy rainfall, the same seasonal trend was shown. There was a marked decrease in the wet season and an increase during the dry season. Throughout the period the percentage of Bahama grass remained higher on the continuously grazed area than on the rotationally grazed plots. This night paddock received two weedings in September 1944 and January 1945, which served to reduce weed competition by non-palatable species.

On reversing the treatments in March 1945, the same trend due to the biotic factor was beginning to show, namely on grazing the original cut plots there was a drop in the amount of Bahama grass as compared with a continuation of the cutting-and-grazing on the CG plots or the cutting of the original grazed plots.

Thus the data clearly showed two trends:-

1. Seasonal. Bahama grass decreased rapidly in the wet season and increased in the dry season.

2. Biotic. Rotational grazing greatly reduced the percentage of Bahama grass. From field observation this would seem to be due to selective grazing causing defoliation of the Bahama grass combined with a rejection of shrubby and semi-shrubby species which are able to gain an ascendency. Bahama grass appeared to resist damage by trampling owing to its tough, wiry stem.

The continuous grazing, aided by weeding, served to maintain the amount of Bahama grass at approximately the same level as rotational cutting.

Paspalum conjugatum (Sour grass). See Graph No. 2.

On the small plots Sour grass was the dominant species at the end of the wet season, whilst Bahama grass predominated at the end of the dry season. In December 1944 on the small plots, Sour grass occupied 30-35% of the total ground cover. Throughou the year the amount of Sour grass on the night paddock was less than on the small plots.[1]

The graph shows that changes in the percentage area of Sour grass were seasonal rather than due to the biotic factor. The analyses, for both the small plots and the night paddock, show a marked seasonal increase during the wet season. Between

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[1] The small plots were in the N.E. corner of the field.

June and December the small plots increased from about 15% to 35%. On the night paddock the increase was from 6% to 18%. After the end of the wet season a corresponding drop did not occur during the following dry season, which was relatively wet in comparison with the previous one. Pastures throughout the district did not suffer the same degree of burning as in 1944.

On the cut plots a decrease is shown from December to March. It did not occur in the other plots which were also cut in December. This isolated decrease was probably due to the exceptionally low cutting which those plots received. Irregularities in the height of cutting were inevitable as the only available device for the operation was the Trinidad brush-and-cutlass which is used by hand. The low cutting which the C plots received is reflected also in the high figure for bare ground, 9.3%, which showed in the March botanical analysis (see Table III). A further explanation for the drop is that those plots received no manure whereas the G and the CG plots received the droppings from the cattle. Thus with the smaller amount of organic matter in the soil the onset of the dry season would be expected to have a more pronounced effect in decreasing the percentage of Sour grass.

On reversing the treatments a marked divergence of the points on the graph is shown in May 1945. This is difficult to explain but one hypothesis supported by field observations is as follows:- On the G plots and the CG plots the percentage of Sour grass decreased as a result of the dry season, as would be expected after the marked increase in the wet season. The C plots which were grazed following the treatment reversal showed an increase in the percentage of Sour grass. This was possibly because the previous low cuttings had served to reduce greatly competition by shrubby species.

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To summarise: Sour grass showed a definite seasonal increase in the wet season but a corresponding decrease in the dry season did not occur equally on all plots. The influence of the biotic factor was not apparent to the same degree as Bahama grass.

Field observations showed the grass to be of medium to low palatability. When it was in flower it was not eaten by the animals. This observation is supported by Chase (1944), who reports that in Brazil and Venezuela Sour grass is rejected by stock. Saint (1928-9) found that its feeding value was very poor. It seems resistant to trampling by virtue of its prostrate habit, except when in flower, and also because of the conduplicate stem and folded leaves.

Mimosa pudica (Sensitive plant). See Graph No. 1.

Mimosa showed a definite response to the influence of the biotic factor. At the first botanical analysis in June 1944 the percentage on all the small plots was below 0.3%. By December the mean percentage on the G plots after three rotational grazings was 10.5. On one of these plots the figure was 25%. On the GG plots, which received two grazings interspersed by one cutting, Mimosa increased to a peak of 5.8% in December. In contrast to these figures, Mimosa on the cut plots at no time exceeded 0.8%. On the continuously grazed night paddock Mimosa was kept in check by a hand weeding in December.

Following the peak shown in the graph for December all the plots were cut. This, combined with the onset of the dry season, led to the non-appearance of Mimosa in the March readings. The treatment differences at the final analysis, after reversing the treatments, were small and it would be unwise to draw conclusions from the data.

Mimosa can only be considered as a noxious weed in pastures. It possesses sharp spines and a fibrous stem and was completely neglected by the animals during grazing. It was effectively kept

in check on the night paddock by tedious hand weeding, which, however, entails high labour costs. It was also reduced to insignificant quantities in the Latin square by periodic low cutting. Under rotational grazing it got out of hand in the space of one wet season.

Ageratum conyzoides (Herbe à femme). See Graph No. 1.

During the first three months of the wet season Ageratum increased on all plots. The increase was largest on the grazed plots. The graph does not show the true significance of this species because between the second and third analyses, in November, the flowering stage was reached and after seeding it died back before December. Field observation indicated that a total of approximately 30% on one of the grazed plots was reached. On the cut plots it did not attain maturity; on the CG plots the proportions were less than on the grazed plots. After December, the cutting of all plots, in conjunction with the onset of the dry season, prevented Ageratum from being recorded as anything but a trace in the March analysis.

The stock rejected Ageratum when it was in the seeding stage. When short they would have difficulty in avoiding it because of its close association with Bahama grass and Sour grass. It is unlikely that it would be relished because of its strong goat-like smell and hairy stem.

Blechum pyramidatum. See Graph No. 3.

Blechum was an important constituent of the pasture during the wet season. It accounted for 10-20% of the total vegetative cover from June to December. It would be unwise to make definite conclusions regarding the effect of the biotic factor owing to the irregularities of the graph. The only influence clearly shown by the analyses of both the Latin square and the night paddock (see Table III) was a marked drop coinciding with the

onset of the dry season.

Blechum is a short-growing plant and during the year never reached a height of more than 3 to 5 inches. It has a fibrous stem but because of its low height it was not possible to observe the extent to which it was eaten by the stock.

Desmodium species. See Graph No. 4.

Desmodium species formed the most important legume constituents of the pasture. The general average throughout the year was approximately 10% of the total vegetative cover. In order of prevalence the species were:- 1. D. adscendens; 2. D. supinum; 3. D. triflorum. In the graph the percentages of these three species have been added together because the individual fluctuations were similar (see Table III). The only pronounced effect shown in the graph is the sharp rise to the last analysis. This was carried out on the first of June, about one week after the wet season had begun. It is possible that the increase occurred mainly during that week of wet weather.

D. supinum has large leathery leaves and was refused by the stock. D. adscendens seemed more palatable and possesses leaves of softer texture. The amount of D. triflorum was small in comparison with the other two species (see Table III). All three species have a prostrate growth habit, except for the flowering culms. This factor, together with the fibrous stems, imparts a resistance to trampling.

Dead Vegetation. See Tables III and IV.

The figures for dead vegetation represent completely scorched foliage, devoid of any green coloration. This condition occurred only in the last two botanical analyses, i.e. during the dry season. The greatest percentage was in March, but it did not exceed 7.2. As already mentioned, the year 1945 had a relatively wet dry-season.

Bare ground. See Tables III and IV.

The amount of bare ground was of significant proportions only in the dry season. The highest figure recorded under the rotational treatments was 9.3% on the cut plots in March, following the exceptionally severe cutting that those plots received in December. On the night paddock the proportions were higher, namely 11.5% and 17.0% in December and March, following weedings in September and early December. Thus in order the keep the pasture clear of noxious weeds 10-17% of total ground cover was sacrificed.

Day Paddock. See Table V.

The predominant species in this paddock was Savannah grass (Axonopus compressus). In view of the close proximity of this field to the night paddock it is surprising that one should be predominantly Savannah grass and the other predominantly Sour grass or Bahama grass according to the season. It is remarkable because with few exceptions Rough Grazings in Trinidad are established by natural recolonisation of waste or arable land. There is no record of the establishment of this day paddock. The earliest reference to it, in the Farm Diary, was made in 1929, when it was already in existence as a pasture and was stated to consist predominantly of Savannah grass. In reply to enquiries amongst some of the older farm workers they said that it was in existence long before 1929 and that the presence of Savannah grass in contrast to the adjacent Sour grass field was due to very severe grazing. They maintained that unless Savannah grass is repeatedly "mashed" (trampled or cut) it dies out.

During the present study the field was heavily stocked in the day-time by dairy cattle, draught Zebus and mules. The analyses show that in the wet season approximately two-thirds of the total cover was Savannah grass and in the dry season about

one-third . Bahama grass remained at under 5% but there was a slight increase in the dry season. The most conspicuous feature of the analyses is the sharp increase in the proportion of bare ground and dead vegetation that occurred in the dry season, i.e. from 14% to 50%. The field became little more than an exercising ground due to the combined effect of season and very heavy stocking.

General Discussion

1. Degeneration due to rotational grazing

The changes in botanical composition of the six species comprising the bulk of the herbage have been discussed individually. It is not possible to deduce the influence of these changes on the nutritive value of the pasture until the feeding value of each species has been thoroughly worked out. However, in general terms, there can be no doubt that rotational grazing led to rapid degeneration in the quality of the pasture. This was very apparent by the fourth grazing of the G plots. The degeneration on one of these plots amounted to a reversion to bush, making further grazing impracticable. There were isolated shrubs up to 3 ft. in height, including Christmas bush (Eupatorium odoratum), Wild sage (Lantana camara) and Gliricidia sepium. With alternate cutting-and-grazing the reversion to bush was arrested but these plots presented an uneven and coarse appearance in contrast to the repeatedly cut plots. The fairly hard non-rotational grazing, combined with periodic weeding, served to maintain the condition of the pasture and prevent the tendency that is always present, for shrubby species to oust the grasses. The intensity of stocking, however, has to be carefully controlled. It should be as high as possible in the wet season but greatly reduced in the dry season. This, of course, is not an easy thing to arrange, but if it is not done there is grave danger of the pasture being relegated to a more exercising ground, as was the case in the day paddock examined.

When the experiment was planned it was intended to combine the results of the botanical analyses with yield data. Although the yields of dry matter were determined they are meaningless because of the large changes that occurred in botanical composition. Any work involving yield determinations of rough grazing must incorporate chemical analyses so as to be able to evaluate the yields of the nutrients separately.

2. Recommendations for future investigations

As the study of the natural pastures in Trinidad has received such scant attention the scope for future work is almost unlimited. The first step should be the determination of the nutritive value and palatability of the most important species comprising the sward. Without such information it is impossible to make sound deductions regarding the merits of any particular management. Some cultural treatments likely to yield profound results would be (1) a stiff harrowing once or twice in the wet season. This might lead to the eradication of most of the Mimosa, as well as probably having pronounced results on the texture of the sward. (2) Periodic machine mowing at 6-9 inches. This might serve to kill many of the shrubby species without affecting the botton grasses.

A further aspect of research is selection and breeding for the improvement of the indigenous species. Tropical pastures are often referred to as being devoid of any legume association. It was found in this study that Desmodium species accounted for approximately 10% of the sward. The quality of these legumes is undoubtedly low but considerable variation exists. There would appear to be much scope for the plant breeder without having to resort to introductions of exotic species.

Summary

Part I

The ability of the following fodders to stand up to grazing has been investigated:-

1. Guatemala grass. A heavy stool and tiller mortality occurred due to uprooting by the grazing animals.

2. Elephant grass showed considerable promise as a forage. It was grazed rotationally on a field scale by the dairy herd.

3. Brachiaria decumbens. The ability of this grass to withstand grazing and at the same time maintain a pure stand was clearly shown.

4. Indigofera endecaphylla. A pure stand, grazed in the wet season, rapidly became weedy. Its ability to grow as a ground cover beneath Elephant grass was shown, but it began to suffer from weed encroachment.

Part II

Changes in the botanical composition of Natural Rough Grazing, throughout one year, were studied under the following systems of management:-

1. 6-weekly Cutting, Grazing, and alternate Cutting-and-Grazing.

2. Fairly hard non-rotational grazing of a night paddock, combined with hand weeding.

3. Heavy non-rotational grazing of a day paddock.

The results have been discussed in terms of (1) the biotic factor, and (2) the seasonal influence.

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