MINERAL CONTENT AND YIELD OF GRASSES IN THE WET TROPICS AS INFLUENCED BY SEASONAL PRODUCTIVITY, FREQUENCY OF CUTTING AND SPECIES.

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TABLE OF CONTENTS.

SUMMARY.

1. The lime and phosphoric acid content of 19 grasses was determined under monthly, two-monthly and three-monthly cutting systems over periods of between one and two years.

2. Under monthly cutting there is during the first 12 months a negative correlation between lime content and rainfall and a positive correlation between phosphoric acid content and rainfall.

3. The four lime-rich grasses under monthly cutting include two varieties and one strain of Panicum maximum, and two varieties of Panicum maximum are among the four grasses with the highest mean phosphoric acid content for the first 12 months.

4. The same pattern of lime content is shown under two-monthly and three-monthly cutting as under monthly cutting. Phosphoric acid content is dependent on the stage of maturity.

5. The ratio of phosphoric acid and lime equivalents is satisfactory for some grasses but for others is much narrower or wider than the standard of 1·5 : 1 adopted for purposes of comparison.

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INTRODUCTION.

This paper is the third of a series dealing with investigations into the yield and chemical composition of pasture grasses conducted at the Bureau of Tropical Agriculture in coastal northern Queensland. The first paper (Schofield, 1944) dealt with the yield aspect of the work, and data on the protein content of the grasses were presented in the second paper (Schofield, 1945b). The lime and phosphoric acid content of various grasses, as influenced by productivity period, frequency of cutting and species, is discussed in the present paper.

Details of the experimental procedure were given in the two previous papers mentioned. Lime and phosphoric acid content was determined on samples of grasses cut at various times over a period of two years.

EXPERIMENTAL DATA.

Monthly Cuts—First 12 Months.

Table 1 shows the percentages of lime (CaO) and phosphoric acid (P_2O_5) in 19 grasses at five times during the first 12 months under a system of monthly cutting; the phosphorus-calcium "equivalents" (Crowther, 1939) are also given. Figures 1 and 2 illustrate in graphical form the seasonal variation in the lime and phosphoric acid content of *Panicum maximum* vars. *coloratum, trichoglume* and *typica, Paspalum dilatatum* and *Pennisetum clandestinum.*

Lime Content.

An examination of Figure 1 and the lime percentages in Table 1 shows the marked influence on lime content of two factors:—seasonal productivity and species. Some species—e.g. *Panicum maximum* Nos. 1200, 1202 and 3783 and *Chloris gayana* Nos. 6585 and 6586—show little change in lime content, but in

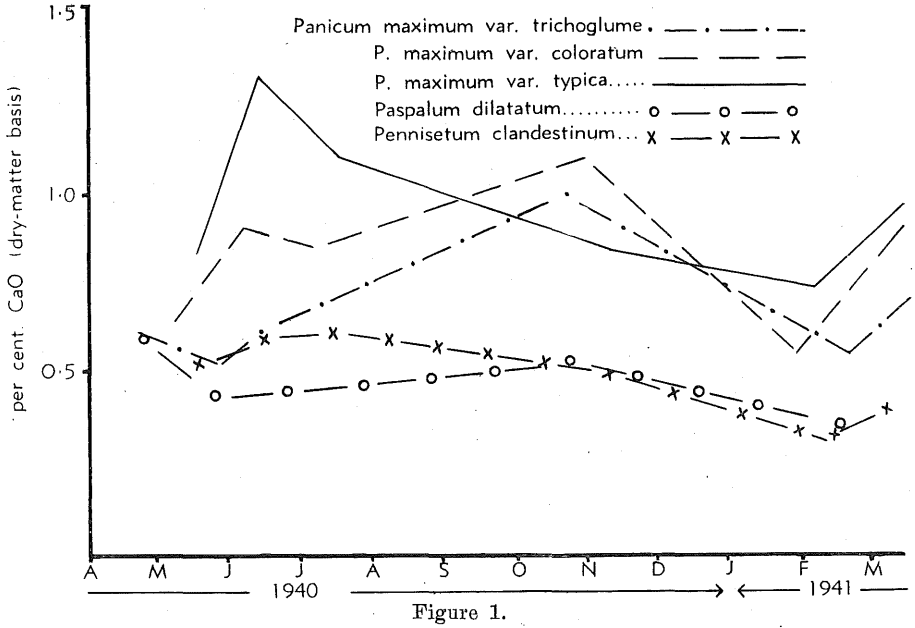

Figure 1.

Showing the seasonal variation in the lime content of five grasses during the first 12 months under a system of monthly cutting.

Table

LIME AND PHOSPHORIC ACID PERCENTAGES (DRY-MATTER BASIS) AND P_2O_5: CaO RATIOS FOR SYSTEM OF

Series 1. Date and Number of Cut.	26–4–40 (1st).			28–5–40 (2nd).		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Urochloa bolbodes	0·926	0·806	1·03	0·796	1·001	1·49
Panicum maximum var. *trichoglume*	0·614	0·911	1·76	0·555	1·025	2·18
P. maximum No. 1202	0·618	0·563	1·08	0·515	0·630	1·45
P. maximum No. 3783	0·531	0·611	1·36	0·548	0·657	1·42
Digitaria milanjiana	0·681	0·738	1·28	0·718	0·751	1·24
Paspalum dilatatum	0·616	0·624	1·20	0·449	0·509	1·34
Cenchrus ciliaris	0·638	0·978	1·81	0·670	1·245	2·20
Series 2. Date and Number of Cut.	**6–5–40 (1st)**			**6–6–40 (2nd).**		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Hyparrhenia aucta	0·530	0·493	1·10	0·594	0·443	0·88
Cynodon plectostachyum	0·513	0·796	1·84	0·608	0·893	1·74
Panicum maximum var. *coloratum*	0·664	0·842	1·50	0·918	0·852	1·10
P. maximum No. 1200	0·536	0·812	1·79	0·488	0·914	2·22
Brachiaria purpurascens	0·492	0·707	1·70	0·580	0·711	1·45
B. decumbens	0·538	0·571	1·26	0·606	0·589	1·15
Chloris gayana No. 6586	0·522	0·910	2·06	0·557	0·817	1·74
Series 3. Date and Number of Cut.	**16–5–40 (1st).**			**14–6–40 (2nd).**		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Pennisetum clandestinum	0·547	0·850	1·84	0·612	0·766	1·48
Panicum maximum var. *typica*	0·854	0·547	0·76	1·338	0·854	0·76
P. maximum No. 3820	0·954	0·555	0·69	1·079	0·716	0·79
Chloris gayana No. 6585	0·488	0·499	1·21	0·509	0·424	0·99
Melinis minutiflora	0·388	0·944	2·88	0·508	0·903	2·10
Mean for all Grasses	0·613	0·724	1·48	0·666	0.774	1·46

general the lime content is high during the period following establishment, rises to a maximum during the "low" period of productivity corresponding with dry winter conditions, and falls rapidly to reach its minimum value in the "zenith" period, which coincides with summer rainfall conditions.

The mean lime percentages for individual grasses at five cuttings during the first 12 months exhibit a range of values from 0·488 to 0·991. Godden (*in* Elliot *et al*, 1926) found the average lime content of an English cultivated pasture to be 1·004 per cent. (samples collected in the growing season May-October). In Kenya (Economic Advisory Council, 1931), samples of herbage collected throughout 12 months from various areas had a mean lime percentage of 0·902 (range 0·515-1·602) for good pastures and 0·412 (range 0·277-0·684) for very poor pastures.

1.

19 GRASSES AT DIFFERENT DATES DURING THE FIRST 12 MONTHS UNDER A MONTHLY CUTTING.

25–6–40 (3rd).			22–10–40 (7th).			19–2–41 (11th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·838	1·148	1·62	1·274	0·616	0·57	0·699	0·854	1·45	0·907	0·885	1·23
0·677	1·131	1·98	1·057	0·936	1·05	0·584	0·988	2·00	0·697	0·998	1·79
0·531	0·685	1·53	0·587	0·499	1·01	0·540	0·676	1·48	0·558	0·611	1·31
0·621	0·957	1·82	0·646	0·628	1·15	0·514	0·743	1·71	0·572	0·719	1·49
0·683	0·830	1·44	0·923	0·698	0·89	0·529	0·907	2·03	0·707	0·785	1·38
0·459	0·614	1·58	0·553	0·450	0·96	0·385	0·548	1·68	0·492	0·549	1·35
0·649	1·257	2·29	0·918	0·718	0·93	0·630	0·768	1·44	0·701	0·993	1·73
5–7–40 (3rd).			1–11–40 (7th).			30–1–41 (10th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·613	0·501	0·97	0·581	0·254	0·52	0·309	0·391	1·50	0·525	0·416	0·99
0·714	0·929	1·54	0·672	0·541	0·95	0·525	0·989	2·23	0·606	0·830	1·66
0·869	0·979	1·33	1·116	0·709	0·75	0·584	0·836	1·69	0·830	0·844	1·27
0·565	1·064	2·23	0·614	0·536	1·03	0·563	0·943	1·98	0·553	0·854	1·85
0·592	0·884	1·77	0·987	0·771	0·92	0·364	0·912	2·96	0·603	0·797	1·76
0·625	0·680	1·29	0·604	0·444	0·87	0·332	0·639	2·28	0·541	0·585	1·37
0·589	0·885	1·78	0·542	0·523	1·14	0·557	0·872	1·85	0·553	0·801	1·71
15–7–40 (3rd).			11–11–40 (7th).			10–2–41 (10th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·641	0·727	1·34	0·512	0·449	1·04	0·353	0·929	3·11	0·533	0·744	1·76
1·110	0·785	0·84	0·876	0·440	0·59	0·775	0·787	1·20	0·991	0·683	0·83
0·973	0·970	1·18	0·869	0·476	0·65	0·870	0·795	1·08	0·949	0·702	0·88
0·590	0·698	1·40	0·607	0·461	0·90	0·509	0·626	1·45	0·541	0·542	1·19
0·545	0·866	1·88	0·461	0·495	1·27	0·536	0·898	1·98	0·488	0·821	2·02
0·678	0·873	1·57	0·758	0·560	0·90	0·535	0·795	1·85	..	..	..

For the purposes of discussion of the data obtained at South Johnstone, the grasses are classified into three categories according to their mean lime values, viz., (1) lime-rich grasses, with a mean greater than 0·800 per cent. CaO; (2) grasses of medium lime content, with a mean of between 0·800 and 0·600 per cent.; and (3) lime-poor grasses, with a mean of less than 0·600 per cent. The grouping of the grasses, based on analyses made on five occasions during the first year, is as follows:—

Lime-rich: Panicum maximum No. 3820 and vars. *coloratum* and *typica*, and *Urochloa bolbodes*.

Medium Lime Content: Panicum maximum var. *trichoglume, Cenchrus ciliaris, Digitaria milanjiana, Cynodon plectostachyum* and *Brachiaria purpurascens*.

Lime-poor: Panicum maximum Nos. 1200, 1202 and 3783, *Chloris gayana* Nos. 6585 and 6586, *Brachiaria decumbens, Pennisetum clandestinum, Hyparrhenia aucta, Paspalum dilatatum* and *Melinis minutiflora.*

Phosphoric Acid Content.

The percentages for phosphoric acid content given in Table 1 show the strong influence of season and species. Thus, in the period following establishment phosphoric acid values are high, but under dry winter conditions characteristic of the "low" period of productivity they fall to a minimum, rising again with the onset of wet summer conditions corresponding with the "zenith" period. The trend of phosphoric acid content under a system of monthly cutting appears then to be correlated with soil moisture, dry conditions causing a rapid fall and wet conditions an increase in the phosphoric acid content. This apparent relation is no doubt directly attributable to the fact that ample soil moisture promotes leaf development in the grasses, leading to an increase in the percentage of phosphoric acid in the plant. Table 2 shows the mean lime and phosphoric acid percentages for 19 grasses at three of the 12 monthly cuttings, together with the rainfall received in the month preceding the date of the cut in Series 1.

Table 2.

SHOWING MEAN PERCENTAGES OF LIME AND PHOSPHORIC ACID IN 19 GRASSES AND RAINFALL DURING THE MONTH PRIOR TO CUTTING.

Date of Cutting.	Mean Percentage (Dry-matter Basis).		Rainfall in Inches in Mouth Prior to Cutting Series 1.*
	CaO	P_2O_5	
25–6–40 to 15–7–40	0·678	0·873	10·90
22–10–40 to 11–11–40	0·758	0·560	0·93
30–1–41 to 19–2–41	0·535	0·795	28·05

* See Schofield (1944) for details of series.

These figures indicate that there is a marked and inverse relationship between both lime content and phosphoric acid content and rainfall: the former displays a negative and the latter a positive correlation in this respect. These results are in agreement with the findings of many workers, including Orr (1929) and Du Toit and associates (1935), who noted that the phosphoric acid content of herbage cut at monthly intervals tended to be low in dry seasons and the lime content high.

The grasses which show the least change in phosphoric acid content throughout the first 12 months are *Paspalum dilatatum* and *Panicum maximum* No. 1202; those with the greatest differences are *Cenchrus ciliaris, Urochloa bolbodes* and *Panicum maximum* No. 1200.

The mean phosphoric acid percentages for five cuts during the first 12 months range from 0·560 to 0·873. Orr (1929) gave the phosphoric acid value for a good pasture as from 0·7 to 0·8 per cent. Kenya figures (Economic Advisory

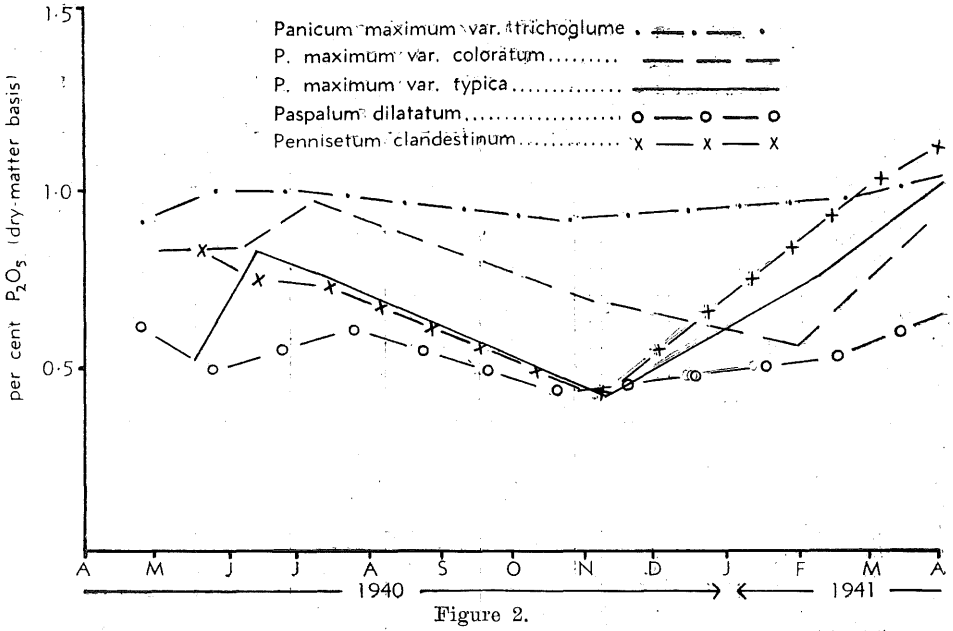

Figure 2.

Showing the seasonal variation in the phosphoric acid content of five grasses during the first 12 months under a system of monthly cutting.

Council, 1931) for samples of herbage collected throughout 12 months from good and very poor areas averaged 0·829 per cent. (range 0·346-1·213) for good pastures and 0·216 per cent. (range 0·111-0·267) for poor pastures. The following basis of classification of the grasses in this experiment according to their phosphoric acid content has been adopted:—(1) phosphoric-acid rich grasses, with a mean greater than 0·700 per cent. P_2O_5; (2) grasses of medium phosphoric acid content; and (3) phosphorus-poor grasses, with a mean of less than 0·500 per cent. Classification on the mean value for five cuts gives the following grouping:—

Phosphorus-rich: Panicum maximum Nos. 1200, 3783 and 3820 and vars. *coloratum* and *trichoglume, Urochloa bolbodes, Melinis minutiflora, Brachiaria purpurascens, Pennisetum clandestinum, Cenchrus ciliaris, Cynodon plectostachyum, Chloris gayana* No. 6586 and *Digitaria milanjiana.*

Medium phosphorus content: Panicum maximum No. 1202 and var. *typica, Brachiaria decumbens, Paspalum dilatatum* and *Chloris gayana* No. 6585.

Phosphorus-poor: Hyparrhenia aucta.

Yield of Lime.

The dry-matter yields of the various grasses (Schofield, 1944) have been used to calculate the yields of lime at each of the five cuttings shown in Table 3. Four of the five highest lime yields were obtained from lime-rich grasses—*Panicum maximum* var. *typica* (58 lb.), *P. maximum* No. 3820 (57 lb.), *Urochloa*

Table 3.

YIELD OF LIME IN POUNDS PER ACRE OF VARIOUS GRASSES AT DIFFERENT DATES DURING THE FIRST 12 MONTHS UNDER A SYSTEM OF MONTHLY CUTTING.

Series 1. Date and Number of Cut.	26–4–40 (1st).	28–5–40 (2nd).	25–6–40 (3rd).	22–10–40 (7th).	19–2–41 (11th).	Total.
Urochloa bolbodes	9	10	8	6	9	42
Panicum maximum var. *trichoglume* ..	8	7	6	3	6	30
P. maximum No. 1202	6	7	5	3	11	32
P. maximum No. 3783	6	10	4	3	5	28
Digitaria milanjiana	4	5	3	2	5	19
Paspalum dilatatum	4	4	4	2	4	18
Cenchrus ciliaris	5	6	4	3	7	25
Series 2. Date and Number of Cut.	**6–5–40 (1st).**	**5–6–40 (2nd).**	**5–7–40 (3rd).**	**1–11–40 (7th).**	**30–1–41 (11th).**	**Total.**
Hyparrhenia aucta	3	4	4	8	9	28
Cynodon plectostachyum	6	7	5	4	5	27
Panicum maximum var. *coloratum* ..	9	7	6	2	8	32
P. maximum No. 1200	4	4	4	2	4	18
Brachiaria purpurascens	8	10	6	2	4	30
B. decumbens	14	11	9	6	6	46
Chloris gayana No. 6586	4	6	4	2	4	20
Series 3. Date and Number of Cut.	**16–5–40 (1st).**	**14–6–40 (2nd).**	**15–7–40 (3rd).**	**11–11–40 (7th).**	**10–2–41 (11th).**	**Total.**
Pennisetum clandestinum	2	3	7	1	3	16
Panicum maximum var. *typica* ..	19	9	11	4	15	58
P. maximum No. 3820	14	12	6	6	19	57
Chloris gayana No. 6585	8	5	7	2	5	27
Melinis minutiflora	2	4	5	4	6	21
Mean for all Grasses	7	7	6	3	7	30

bolbodes (42 lb.) and *Panicum maximum* var. *coloratum* (32 lb.). The fifth grass—*Brachiaria decumbens* (45 lb.)—yielded highly because of its very high dry-matter production. Eleven grasses out of 19 have a yield exceeding 30 lb. of lime per acre, and six grasses a yield of less than 22 lb. per acre. A noticeable feature of the results is the very marked drop in mean lime yield for the cuts taken during October-November; the mean for this period amounts to 50 per cent. of the mean yield during June-July, and is less than this figure for each of the other three cuts. This reduction in yield occurs during the dry winter period in spite of the negative correlation which exists between rainfall and lime content, and is a direct result of the determinative nature of the "low" period of herbage productivity on yield.

Yield of Phosphoric Acid.

Table 4 shows the yield of phosphoric acid at five different cuttings during the first 12 months under a system of monthly cutting. Of the eight grasses

Table 4.

YIELD OF PHOSPHORIC ACID IN POUNDS PER ACRE OF VARIOUS GRASSES AT DIFFERENT DATES DURING THE FIRST 12 MONTHS UNDER A SYSTEM OF MONTHLY CUTTING.

Series 1. Date and Number of Cut.	26–4–40 (1st).	28–5–40 (2nd).	25–6–40 (3rd).	22–10–40 (7th).	19–2–41 (11th).	Total.
Urochloa bolbodes	8	12	11	3	11	45
Panicum maximum var. *trichoglume*	12	13	9	2	10	46
P. maximum No. 1202	6	8	6	3	14	37
P. maximum No. 3783	7	12	7	3	8	37
Digitaria milanjiana	4	5	3	2	9	23
Paspalum dilatatum	4	5	6	2	5	22
Cenchrus ciliaris	8	12	8	2	8	38
Series 2. Date and Number of Cut.	**6–5–40 (1st).**	**5–6–40 (2nd).**	**5–7–40 (3rd).**	**1–11–40 (7th).**	**30–1–41 (11th).**	**Total.**
Hyparrhenia aucta	2	3	3	3	12	23
Cynodon plectostachyum	9	10	7	3	10	39
Panicum maximum var. *coloratum*	11	6	7	2	11	37
P. maximum No. 1200	7	8	8	2	7	32
Brachiaria purpurascens	11	12	8	2	9	42
B. decumbens	15	11	10	4	11	51
Chloris gayana No. 6586	7	9	6	2	7	31
Series 3. Date and Number of Cut.	**16–5–40 (1st).**	**14–6–40 (2nd).**	**15–7–40 (3rd).**	**11–11–40 (7th).**	**10–2–41 (11th).**	**Total.**
Pennisetum clandestinum	4	3	8	1	7	23
Panicum maximum var. *typica*	12	6	8	2	15	43
P. maximum No. 3820	8	8	6	3	17	42
Chloris gayana No. 6585	8	4	8	1	6	27
Melinis minutiflora	4	7	8	5	10	34
Mean for all Grasses	8	8	7	2	10	35

which give a yield of more than 30 lb. per acre, five are varieties or strains of *Panicum maximum*. *Paspalum dilatatum* produced the lowest yield with 21 lb. per acre. An outstanding feature of the results is the very low mean yield of phosphoric acid at the October-November cut, which shows a reduction of over 71 per cent. compared with the June-July cut, 75 per cent. compared with the two cuts taken during April-June and 80 per cent. compared with the January-February cut. The large drop in yield of phosphoric acid which occurs under dry winter conditions is accentuated by the influence of the "low" period of productivity on herbage yield.

Ratio of Phosphoric Acid to Lime.

The optimum ratio of phosphoric acid to lime in a ration is not a constant figure, but fluctuates according to class of animal, plane of production, amount of sunshine, and so on. In this paper the suggestion by Crowther (1939) that

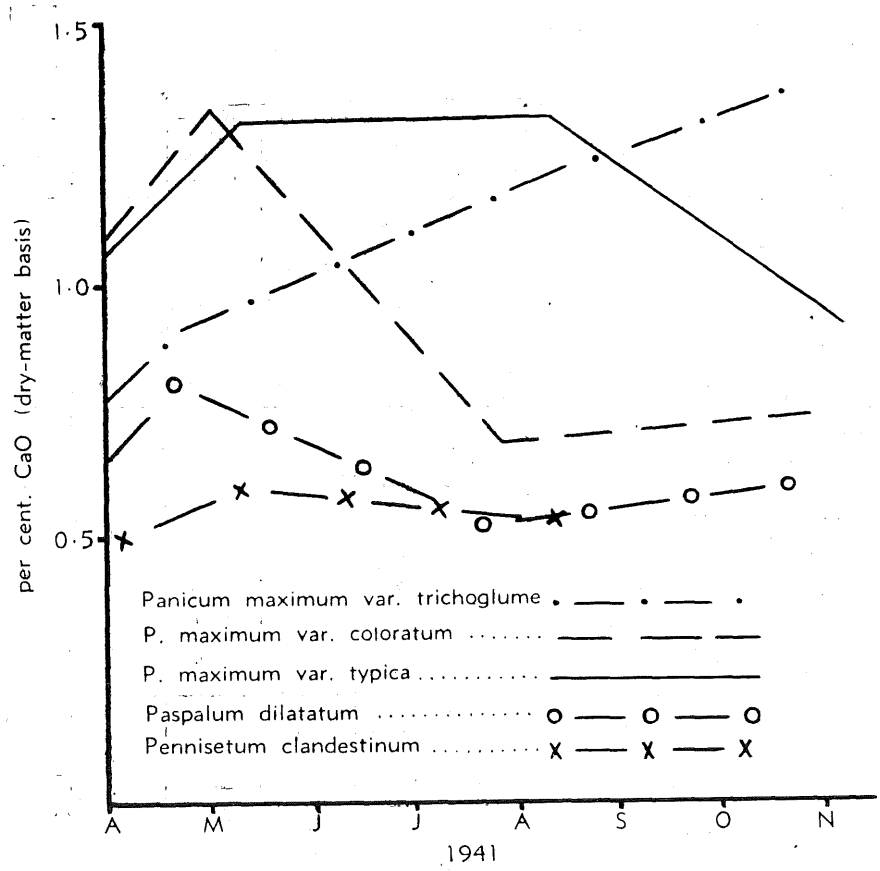

Figure 3.

Showing the seasonal variation in the lime content of five grasses during the second 12 months under a system of monthly cutting.

the average mineral content of milk should be taken as a standard has been adopted. Following Crowther also, the percentage figures for the two minerals have been corrected in proportion to the respective chemical equivalents, so that a P_2O_5 : CaO ratio of 1·5 : 1 is used as the basis of comparison of the "equivalents" calculated for the data in this experiment.

The ratios given in Table 1 confirm the effect of season, and particularly of the rainfall component, on the lime and phosphoric acid content of all grasses. There are considerable differences in the ratio of phosphoric acid to lime in the various species, but attention will be confined to the seasonal effects which have a major influence on this ratio. During the period April-July the proportion of phosphoric acid to lime tends to rise, and at the 3rd cut the ratio approximates to 1·5 : 1 in a number of grasses—exceptions are *Panicum maximum* No. 3820 and var. *typica,* in which the ratio is very narrow. However, the influence of dry winter conditions during the "low" period of productivity causes a

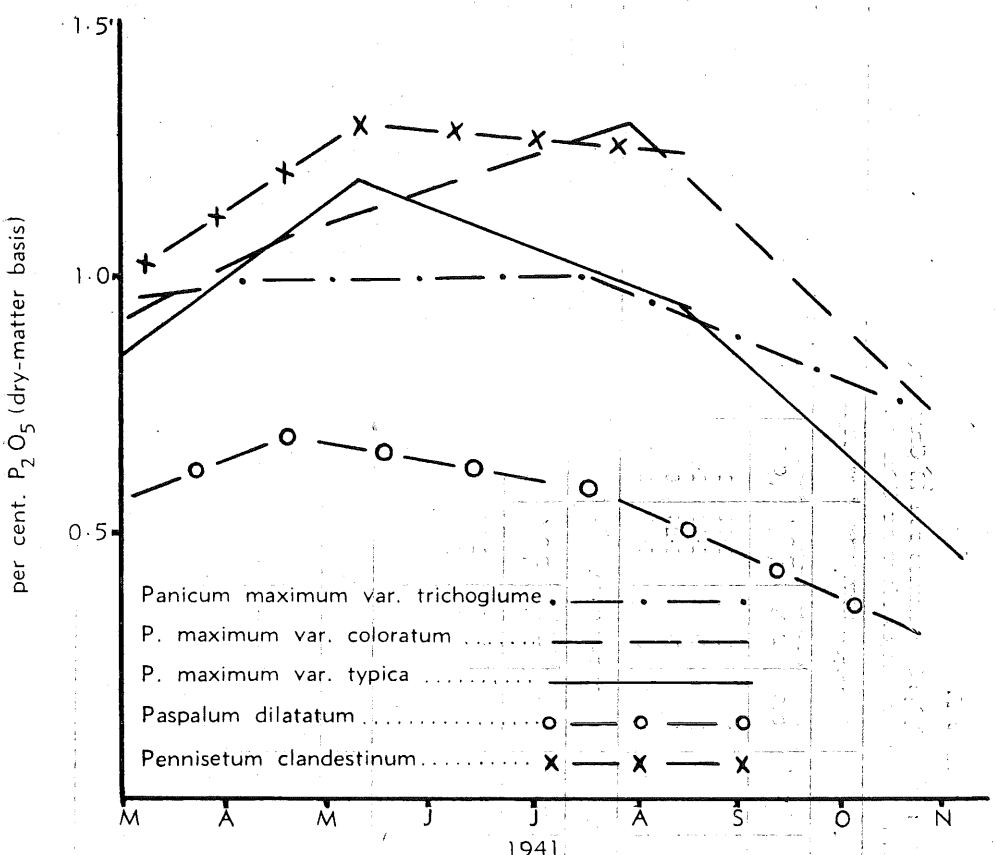

Figure 4.

Showing the seasonal variation in the phosphoric acid content of five grasses during the second 12 months under a system of monthly cutting.

pronounced fall of phosphoric acid in relation to lime with every grass and reflects the low percentage of phosphorus in the herbage at this time of the year. With the onset of wet summer conditions there follows a decided rise in phosphorus content and the ratio of phosphoric acid to lime with many of the grasses approximates to the standard; exceptions are *Pennisetum clandestinum* and *Brachiaria purpurascens*, which show a decided excess of phosphoric acid relative to lime.

Monthly Cuts—Second 12 Months.

Table 5 shows the lime and phosphoric acid content of 12 grasses during the second 12 months under a system of monthly cutting, together with the corresponding ratios of phosphoric acid to lime. As stated previously (Schofield, 1944), during the second period of 12 months a mixture of superphosphate and blood was applied immediately after each cut had been made. Figures 3 and 4 show in graphical form the variation in lime and phosphoric acid content of five grasses during this period.

Table 5.

LIME AND PHOSPHORIC ACID PERCENTAGES (DRY-MATTER BASIS) AND P_2O_5 : CaO RATIOS FOR 12 GRASSES AT DIFFERENT DATES DURING THE SECOND 12 MONTHS UNDER A SYSTEM OF MONTHLY CUTTING.

Series 1. Date and Number of Cut.	21–4–41 (13th).			18–7–41 (16th).			17–10–41 (19th).			Mean for Three Cuts.		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Urochloa bolbodes	0·700	1·082	1·83	1·634	1·577	1·14	1·670	0·490	0·35	1·335	1·050	1·11
Panicum maximum var. *trichoglume*	0·921	1·089	1·40	1·187	1·126	1·12	1·383	0·792	0·68	1·164	1·002	1·07
Digitaria milanjiana	0·797	1·129	1·68	1·113	1·177	1·25	0·670	0·616	1·09	0·860	0·974	1·34
Paspalum dilatatum	0·808	0·707	1·04	0·546	0·612	1·33	0·614	0·351	0·68	0·656	0·557	1·02
Series 2. Date and Number of Cut.	**30–4–41 (13th).**			**29–7–41 (16th).**			**27–10–41 (19th).**			**Mean for Three Cuts.**		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Hyparrhenia aucta	0·575	0·450	0·93	0·630	1·040	1·95	0·330	0·306	1·10	0·512	0·599	1·33
Panicum maximum var. *coloratum*	1·354	1·160	1·01	0·700	1·313	2·22	0·770	0·780	1·20	0·941	1·084	1·48
Brachiaria decumbens	0·811	0·812	1·18	0·780	0·960	1·46	0·820	0·470	0·68	0·804	0·747	1·11
Chloris gayana No. 6586	0·840	1·128	1·59	1·548	0·968	0·74	0·670	0·610	1·08	1·019	0·902	1·14
Series 3. Date and Number of Cut.	**9–5–41 (13th).**			**8–8–41 (16th).**			**6–11–41 (19th).**			**Mean for Three Cuts.**		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Pennisetum clandestinum	0·610	1·315	2·55	0·551	1·267	2·72	..	..	..	0·581*	1·291*	2·64*
Panicum maximum var. *typica*	1·320	1·214	1·09	1·345	0·897	0·79	0·920	0·479	0·62	1·195	0·863	0·83
Chloris gayana No. 6585	0·860	1·033	1·42	0·824	1·060	1·52	..	..	..	0·842*	1·047*	1·47*
Melinis minutiflora	0·635	1·260	2·35	0·584	0·952	1·93	0·562	0·550	1·16	0·594	0·921	1·81
Mean for all Grasses	0·853	1·032	1·51	0·953	1·079	1·51	0·841	0·544	0·86	..	..	..

* Mean of two cuts only.

Lime Content.

The figures given in Table 5 for the April-May cut show that a marked increase in the lime content of the majority of the grasses has occurred—the mean values for 19 grasses in January-February was 0·535 per cent. while the mean for 12 grasses in April-May reached 0·853 per cent. The period January-February falls in the "zenith" period of productivity, and April-May represents the early portion of the "rapid decrease" period, which coincides with a very marked fall in herbage productivity. For example, the mean daily dry-matter yield of *Panicum maximum* var. *trichoglume* dropped from 154 lb. in the "zenith" period to 41 lb. in the "rapid decrease" period (Schofield, 1944).

The figures in Table 5 show that the increase in lime content at the April-May cut compared with the January-February cut is marked with the leafy variety of *Panicum maximum* (var. *coloratum*) and with *P. maximum* var. *typica,* whereas *Urochloa bolbodes* and *Melinis minutiflora* show very small differences. The July-August cut, corresponding to the early portion of the "low" period of productivity, shows an increase in lime content with six grasses and a decrease with a similar number; the mean for this cut is 0·953 per cent., compared with 0·853 per cent. at the 13th cut.

The October-November cut represents the end of the "low" and the beginning of the "rapid increase" period and corresponds with the time when fertilizer is becoming effective. Four grasses show an increase and five a decrease in lime content compared with the July-August cut, and the mean has fallen by 0·112 per cent.

The mean lime content of individual grasses at three cuts during the second 12 months shows a range of values from 0·511 to 1·335 per cent., but as no figures are available for the "zenith" period—when the lime content is at a minimum—no classification into lime-rich and lime-poor can be made. However, it is noteworthy that the highest value is given by a leafy grass—*Urochloa bolbodes*—and the lowest by a stemmy grass—*Hyparrhenia aucta.* The three analyses made during the second 12 months indicate that there are marked trends in the lime content of the various grasses. These may be summarized as follows:—

(1) There is a marked rise in the lime content of all grasses in the "rapid decrease" as compared with the "zenith" period of productivity.

(2) The rise continues in the "low" period with a number of grasses.

(3) The lime content commences to decrease with a number of grasses at the beginning of the "rapid increase" period of productivity.

(4) There are marked differences in lime content between various species in the three productivity periods examined.

Table 6.

YIELD OF LIME IN POUNDS PER ACRE OF 12 GRASSES AT DIFFERENT DATES DURING THE SECOND 12 MONTHS UNDER A SYSTEM OF MONTHLY CUTTING.

Series 1. Date and Number of Cut.	21–4–41 (13th).	18–7–41 (16th).	17–10–41 (19th).	Total.
Urochloa bolbodes	2	1	2	5
Panicum maximum var. *trichoglume*	3	1	1	5
Digitaria milanjiana	3	1	1	5
Paspalum dilatatum	3	0	0	3
Series 2. Date and Number of Cut.	**30–4–41 (13th).**	**29–7–41 (16th).**	**27–10–41 (19th).**	**Total.**
Hyparrhenia aucta	1	1	1	3
Panicum maximum var. *coloratum*	3	0	1	4
Brachiaria decumbens	2	1	1	4
Chloris gayana No 6586	1	1	1	3
Series 3. Date and Number of Cut.	**9–5–41 (13th).**	**8–8–41 (16th).**	**6–11–41 (19th).**	**Total.**
Pennisetum clandestinum	1	0	..	..
Panicum maximum var. *typica*	4	1	2	7
Chloris gayana No. 6585	3	1	..	..
Melinis minutiflora	2	1	1	4
Mean for all Grasses	2	1	1	4

Table 7.

YIELD OF PHOSPHORIC ACID IN POUNDS PER ACRE OF 12 GRASSES DURING THE SECOND 12 MONTHS UNDER A SYSTEM OF MONTHLY CUTTING.

Series 1. Date and Number of Cut.	21–4–41 (13th).	18–7–41 (16th).	17–10–41 (19th).	Total.
Urochloa bolbodes	2	1	0	3
Panicum maximum var. *trichoglume*	3	1	1	5
Digitaria milanjiana	5	1	1	7
Paspalum dilatatum	2	0	0	2
Series 2. Date and Number of Cut.	**30–4–41 (13th).**	**29–7–41 (16th).**	**27–10–41 (19th).**	**Total.**
Hyparrhenia aucta	1	1	1	3
Panicum maximum var. *coloratum*	3	1	1	5
Brachiaria decumbens	2	1	1	4
Chloris gayana No. 6586	2	0	1	3
Series 3. Date and Number of Cut.	**9–5–41 (13th).**	**8–8–41 (16th).**	**6–11–41 (19th).**	**Total.**
Pennisetum clandestinum	3	1	..	..
Panicum maximum var. *typica*	4	1	1	6
Chloris gayana No. 6585	3	1	..	..
Melinis minutiflora	4	1	1	6
Mean for all Grasses	3	1	1	5

Phosphoric Acid Content.

The figures for phosphoric acid content given in Tables 1 and 5 show that a substantial increase has occurred from the January-February cut—with a mean of 0·795 per cent.—to the April-May cut, with a mean of 1·032 per cent.

At the July-August cut, which represents the early portion of the "low" period, the mean phosphoric acid value is 1·079 per cent. and shows little change from the value at the April-May cut. The October-November cut corresponds to the end of the "low" and the beginning of the "rapid increase" period of productivity and coincides with a very dry portion of the year. The only rain received in September was 77 points on the 1st, and in October only 2 points were recorded; from June the rainfall was very light and soil moisture was therefore particularly low at the October-November cut. The reduction in the mean phosphoric acid to 0·544 per cent. represents a fall of 0·535 per cent. from the mean at the July-August cut. This confirms the indirect relationship between soil moisture and herbage phosphoric acid content already mentioned.

Yield of Lime and Phosphoric Acid.

The yield figures given in Tables 6 and 7 show the marked decrease which has occurred in the yield of lime and phosphoric acid for all grasses during the second 12 months under a system of monthly cutting. The decrease is due to the considerable reduction in herbage yield at each of the three sampling cuts.

Ratio of Phosphoric Acid to Lime.

With the exception of *Urochloa bolbodes* and *Melinis minutiflora,* all grasses at the April-May cut show a reduction in the ratio of phosphoric acid to lime compared with the January-February cut. Two grasses—*Melinis minutiflora* and *Pennisetum clandestinum*—have a considerable excess of phosphoric acid relative to lime, but in a number of grasses the ratio is very narrow.

At the July-August cut six grasses show an increase in lime content compared with the April-May cut—*Urochloa bolbodes* shows the largest increase of 0·934 per cent.—and seven grasses register an increase of phosphoric acid. The ratio of phosphoric acid to lime shows an increase with seven grasses.

The mean lime value at the October-November cut shows a slight decrease, whereas the mean phosphoric acid figure falls by 0·535 per cent. The ratio for all grasses at this cut narrows as a result of the dry winter conditions experienced during the "low" period of productivity (July-October).

The mean figures for the phosphoric acid/lime ratio over the three cuts in the second 12 months under a system of monthly cutting show that the ratio for *Panicum maximum* var. *coloratum* is very close to the standard of 1·5 : 1; it is extremely wide in the case of *Melinis minutiflora* and narrower than the standard with the remaining grasses.

Table

LIME AND PHOSPHORIC ACID PERCENTAGES (DRY-MATTER BASIS) AND P_2O_5 : CaO RATIOS FOR

Series 1. Date and Number of Cut.	28–5–40 (1st).			23–9–40 (3rd).		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Urochloa bolbodes	0·800	0·634	0·94	1·263	1·065	1·00
Panicum maximum var. *trichoglume*	0·540	0·766	1·68	0·784	1·029	1·55
P. maximum No. 1202	0·554	0·536	1·14	0·737	0·607	0·97
P. maximum No. 3783	0·513	0·480	1·11	0·849	0·680	0·95
Digitaria milanjiana	0·652	0·659	1·20	1·140	1·055	1·09
Paspalum dilatatum	0·445	0·416	1·11	0·629	0·357	0·67
Cenchrus ciliaris	0·627	0·790	1·49	0·872	1·231	1·67
Series 2. Date and Number of Cut.	**5–6–40 (1st).**			**1–10–40 (3rd).**		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Hyparrhenia aucta	0·453	0·440	1·15	0·602	0·351	0·69
Cynodon plectostachyum	0·518	0·610	1·39	0·719	0·563	0·93
Panicum maximum var. *coloratum*	0·705	0·546	0·92	1·615	0·895	0·66
P. maximum No. 1200	0·398	0·575	1·71	0·481	0·624	1·53
Brachiaria purpurascens	0·496	0·480	1·14	0·915	0·678	0·88
B. decumbens	0·513	0·472	1·09	0·732	0·371	0·60
Chloris gayana No. 6586	0·455	0·622	1·62	0·673	0·631	1·11
Series 3. Date and Number of Cut.	**14–6–40 (1st).**			**11–10–40 (3rd).**		
	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$	CaO	P_2O_5	$\frac{P_2O_5}{CaO}$
Pennisetum clandestinum	0·606	0·651	1·27	0·678	1·270	2·22
Panicum maximum var. *typica*	1·224	0·537	0·52	1·250	0·552	0·52
P. maximum No. 3820	1·140	0·524	0·54	1·154	0·494	0·51
Chloris gayana No. 6585	0·570	0·588	1·22	0·489	0·458	1·11
Melinis minutiflora	0·523	0·812	1·84	0·488	0·609	1·48
Mean for all Grasses	0·617	0·586	1·21	0·846	0·712	1·06

Two-monthly Cuts.

Table 8 shows the lime and phosphoric acid content of 12 grasses sampled at five times from May-June, 1940, to September-October, 1941, under a system of two-monthly cutting, and of seven grasses sampled at three cuts during a shorter period, together with the corresponding ratios of phosphorus and calcium "equivalents." Figures 5 and 6 show in graphical form the seasonal variation in the lime and phosphoric acid content of *Panicum maximum* vars. *coloratum, trichoglume* and *typica, Paspalum dilatatum and Pennisetum clandestinum.*

Lime Content.

As in the case of monthly cutting, there is a marked seasonal influence on the lime content of certain grasses; its magnitude depends upon the species.

8.

19 Grasses at Different Dates under a System of Two-Monthly Cutting.

21–3–41 (6th).			20–5–41 (7th).			18–9–41 (9th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·503	0·633	1:49	0·792	1·008	1·51	1·872	1·468	0·93	1·046	0·962	1·17
0·444	0·909	2·42	1·062	0·988	1·10	1·255	1·343	1·27	0·817	1·007	1·60
0·483	0·603	1·48	..	..	..	..	..	..	..	..	..
0·624	0·670	1·27	..	..	..	..	..	..	..	..	..
0·658	0·730	1·31	1·372	1·040	0·90	1·250	1·000	0·95	1·014	0·897	1·09
0·292	0·333	1·35	0·720	0·336	0·55	0·851	0·371	0·52	0·587	0·363	0·84
0·463	0·662	1·69	..	..	..	..	..	..	..	..	..
30–1–41 (5th).			30–5–41 (7th).			26–9–41 (9th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·279	0·326	1·38	0·559	0·394	0·83	0·623	0·571	1·08	0·503	0·416	1·03
0·561	0·820	1·73	..	..	..	..	..	..	..	..	..
0·580	0·578	1·18	1·197	1·038	1·03	1·560	1·380	1·05	1·131	0·887	0·97
0·497	0·699	1·66	..	..	..	..	..	..	..	..	..
0·422	0·696	1·95	..	..	..	..	..	..	..	..	..
0·407	0·407	1·18	0·541	0·630	1·38	0·770	0·720	1·11	0·593	0·520	1·07
0·463	0·470	1·20	0·470	0·804	2·02	0·917	0·955	1·23	0·596	0·696	1·44
10–2–41 (5th).			9–6–41 (7th).			7–10–41 (9th).			Mean for Five Cuts.		
CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
0·339	0·638	2·23	0·470	0·804	2·02	0·594	0·919	1·83	0·537	0·856	1·91
0·693	0·580	0·99	1·801	0·698	0·46	1·340	0·616	0·54	1·262	0·597	0·61
0·855	0·557	0·77	..	..	..	..	..	..	..	..	..
0·392	0·399	1·20	0·710	0·771	1·28	1·129	0·904	0·95	0·658	0·624	1·15
0·428	0·614	1·70	0·662	1·093	1·95	0·548	0·754	1·63	0·530	0·776	1·72
0·494	0·596	1·48	0·863	0·800	1·25	1·059	0·917	1·09	..	..	..

Taking the grasses as a whole, the lime content is high during the period following establishment, with a mean value of 0·617 per cent.; an appreciable rise occurs in the "low" period (mean 0·846 per cent.), and in the "zenith" period (January-March) the mean falls markedly to 0·494 per cent.; a rise to 0·863 per cent. occurs in the "rapid decrease" period (May-June cut), and in the "low" period of the second 12 months (September-October cut) the mean reaches a peak value of 1·059 per cent. These figures appear to support the view that a negative correlation exists between soil moisture and herbage lime content. However, in the two- and three-monthly cutting systems the relationship between rainfall and mineral content which is apparent under monthly cutting will not be discussed, but attention will be directed to the effect of season

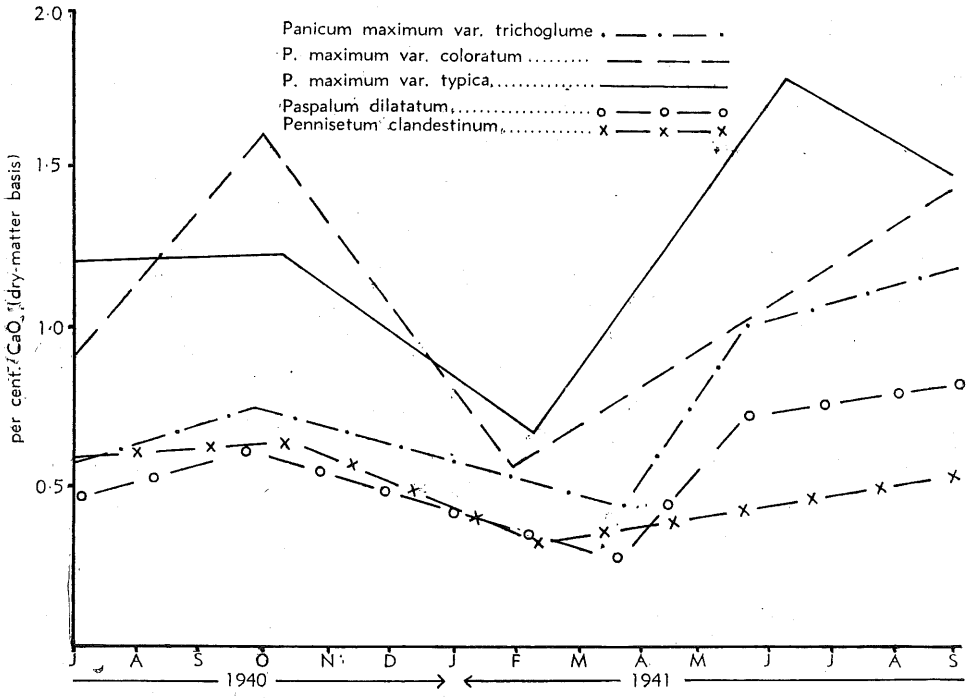

Figure 5.

Showing the seasonal variation in the lime content of five grasses during the first 12 months under a system of two-monthly cutting.

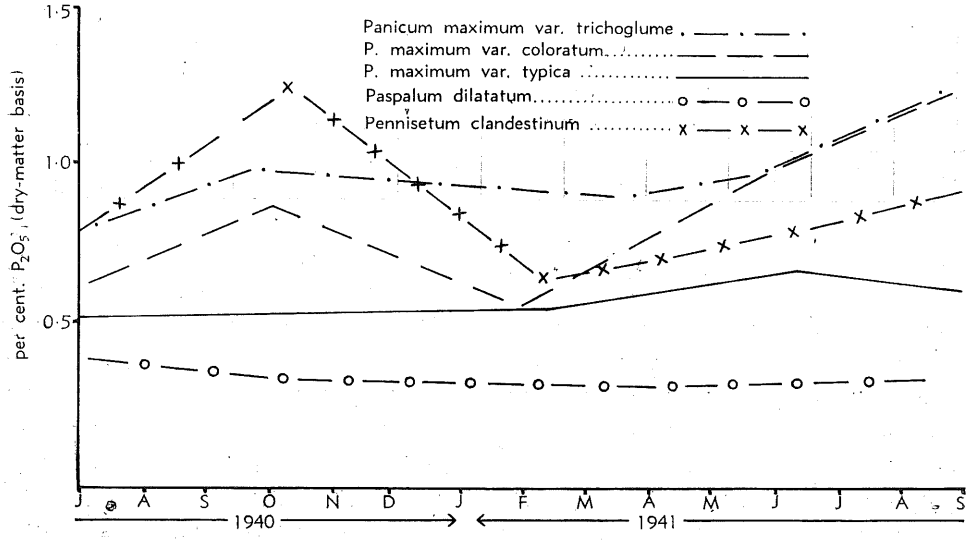

Figure 6.

Showing the seasonal variation in the phosphoric acid content of five grasses during the first 12 months under a system of two-monthly cutting.

and length of cutting rotation on the fundamental ratio of leaf to stem, which actually determines for each species the lime and phosphoric acid content of the herbage.

There are considerable differences between the various species in lime content and in their reaction to seasonal influences. The grasses which show the highest mean lime content for the five cuts given are *Panicum maximum* vars. *typica* and *coloratum*, *Urochloa bolbodes* and *Digitaria milanjiana*. The grasses with the lowest mean lime contents are *Melinis minutiflora* and *Hyparrhenia aucta*. It must be pointed out, however, that these mean values are for five cuts only and that two of the cuts come in the "low" period of productivity and only one in the "zenith" period; the figures therefore may be regarded as being higher than the true mean.

Turning to differences between the various species, the marked increase of 0·910 per cent. which occurs with a leafy variety of Guinea grass (*Panicum maximum* var. *coloratum*) from the May-June to the September-October cut is noteworthy, as also are the slight reductions shown by *Chloris gayana* No. 6585 and *Melinis minutiflora*. At the January-March cut ("zenith" period) the low values for *Paspalum dilatatum* (0·202 per cent.) and *Pennisetum clandestinum* (0·339 per cent.) compared with *Panicum maximum* vars. *typica* and *coloratum* (0·693 and 0·580 per cent.) are indicative of the inherent lime-rich character of the two Guinea grass species and the lime-poor character of the other two grasses. The considerable increase of 1·108 per cent. in *Panicum maximum* var. *typica* from the 6th to the 7th cut and the increase of 1·080 per cent. in *Urochloa bolbodes* at the 9th cut deserve mention.

Phosphoric Acid Content.

The figures in Table 8 demonstrate very clearly the effect of increasing the length of the cutting rotation on the phosphoric acid content of the herbage. Fagan and Milton (1931) have shown that with advancing maturity the percentage of phosphoric acid decreases and on the whole the lime increases. The figures in Table 9 show that the phosphoric acid content of the herbage rises from a mean of 0·586 per cent. in the period following establishment to 0·712 per cent. in the "low" period of productivity—this increase is explained by the fact that the grasses tend to become rather stemmy and leaf development restricted.

Yield of Lime and Phosphoric Acid.

The yield figures for lime and phosphoric acid shown in Tables 9 and 10 demonstrate the predominant influence of the dry-matter yield in each productivity period on the yield of minerals.

Table 9.

YIELD OF LIME IN POUNDS PER ACRE OF 19 GRASSES AT DIFFERENT DATES UNDER A SYSTEM OF TWO-MONTHLY CUTTING.

Series 1. Date and Number of Cut.	28–5–40 (1st).	23–9–40 (3rd).	21–3–41 (6th).	20–5–41 (7th).	18–9–41 (9th).	Total.
Urochloa bolbodes	28	14	13	3	4	62
Panicum maximum var. *trichoglume* ..	13	10	7	4	2	36
P. maximum No. 1202	18	10	20	..	..	..
P. maximum No. 3783	24	9	16	..	..	..
Digitaria milanjiana	9	7	16	11	1	44
Paspalum dilatatum	8	7	7	6	1	29
Cenchrus ciliaris	18	5	12	..	..	..
Series 2. Date and Number of Cut.	**5–6–40 (1st).**	**1–10–40 (3rd).**	**30–1–41 (5th).**	**30–5–41 (7th).**	**26–9–41 (9th).**	**Total.**
Hyparrhenia aucta	8	18	16	1	2	45
Cynodon plectostachyum	14	14	11	..	..	..
Panicum maximum var. *coloratum* ..	20	15	26	7	2	70
P. maximum No. 1200	6	6	8	..	..	..
Brachiaria purpurascens	24	12	11	..	..	..
B. decumbens	43	27	24	4	1	99
Chloris gayana No. 6586	11	6	9	1	2	29
Series 3. Date and Number of Cut.	**14–6–40 (1st).**	**11–10–40 (3rd).**	**10–2–41 (5th).**	**9–6–41 (7th).**	**7–10–41 (9th).**	**Total.**
Pennisetum clandestinum	7	5	4	4	0	20
Panicum maximum var. *typica* ..	40	10	25	6	3	84
P. maximum No. 3820	46	13	40	..	..	..
Chloris gayana No. 6585	19	6	14	6	1	46
Melinis minutiflora	11	9	14	4	3	41
Mean for all Grasses	19	11	15	5*	2*	..

* Mean for 12 grasses.

Ratio of Phosphoric Acid to Lime.

The ratios given in Table 8 for the period following establishment (mean 1·21 : 1) compared with the figures in the "low" period (mean 1·06 : 1) show that the ratio widens with three grasses—*Urochloa bolbodes, Cenchrus ciliaris* and *Pennisetum clandestinum*—and narrows with the remainder of the grasses except *Panicum maximum* var. *typica*.

In the "zenith" period (January-March) all the grasses show a marked widening of the ratio, several approximating to 1·50 : 1. In the "rapid decrease" period (May-June) the mean ratio for 12 grasses is 1·25 : 1. In the "low" period (September-October) of the second 12 months the mean ratio for 12 grasses is 1·01 : 1.

Table 10.

YIELD OF PHOSPHORIC ACID IN POUNDS PER ACRE OF 19 GRASSES AT DIFFERENT DATES UNDER A SYSTEM OF TWO-MONTHLY CUTTING.

Series 1. Date and Number of Cut.	28–5–40 (1st).	23–9–40 (3rd).	21–3–41 (6th).	20–5–41 (7th).	18–9–41 (9th).	Total.
Urochloa bolbodes	22	12	16	4	3	57
Panicum maximum var. *trichoglume* ..	19	13	15	4	2	53
P. maximum No. 1202	18	8	25	..	..	..
P. maximum No. 3783	23	7	18	..	..	..
Digitaria milanjiana	9	6	18	9	1	43
Paspalum dilatatum	7	4	8	3	0	22
Cenchrus ciliaris	23	7	17	..	..	..
Series 2. Date and Number of Cut.	**5–6–40 (1st).**	**1–10–40 (3rd).**	**30–1–41 (5th).**	**30–5–41 (7th).**	**26–9–41 (9th).**	**Total.**
Hyparrhenia aucta	7	10	19	1	1	38
Cynodon plectostachyum	17	11	17	..	..	..
Panicum maximum var. *coloratum* ..	15	8	26	6	2	57
P. maximum No. 1200	9	8	12	..	..	..
Brachiaria purpurascens	24	9	18	..	..	..
B. decumbens	39	13	24	5	1	82
Chloris gayana No. 6586	15	6	9	2	2	34
Series 3. Date and Number of Cut.	**14–6–40 (1st).**	**11–10–40 (3rd).**	**30–1–41 (5th).**	**9–6–41 (7th).**	**7–10–41 (9th).**	**Total.**
Pennisetum clandestinum	7	10	8	6	1	32
Panicum maximum var. *typica* ..	18	4	21	2	1	46
P. maximum No. 3820	21	6	26	..	..	..
Chloris gayana No. 6585	20	6	15	6	1	48
Melinis minutiflora	17	11	20	6	3	57
Mean for all Grasses	17	8	17	4*	1*	..

* Mean for 12 grasses only.

Three-monthly Cuts.

Table 11 shows the lime and phosphoric acid content of 19 grasses for 12 months under a system of three-monthly cutting, together with the corresponding ratios of phosphorus and calcium "equivalents." Figures 7 and 8 demonstrate the seasonal variation in the lime and phosphoric acid content of *Panicum maximum* vars. *coloratum, trichoglume* and *typica, Paspalum dilatatum,* and *Pennisetum clandestinum.* As these figures represent the complete lime and phosphoric acid data for 12 months they have been examined by the analysis of variance method to determine whether differences between the various species are significant: the effect of seasonal influence on mineral content has also been examined. The results are summarized in Tables 12 and 14.

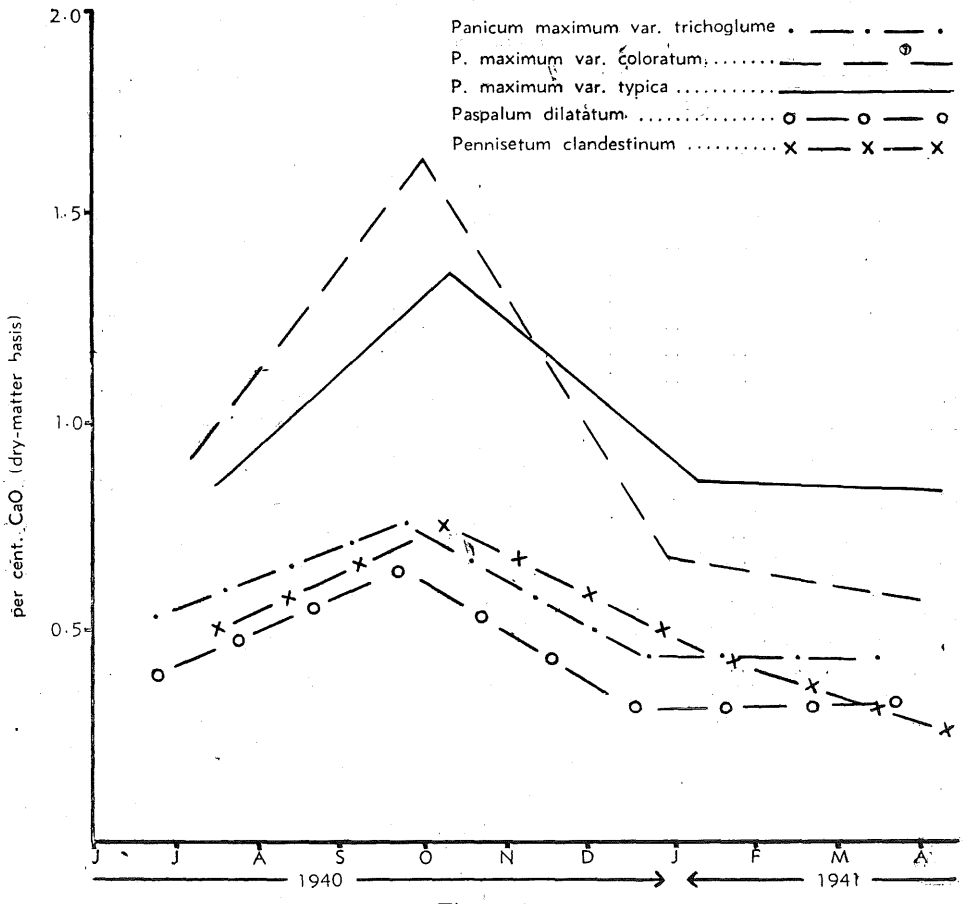

Figure 7.

Showing the seasonal variation in the lime content of five grasses during the first 12 months under a system of three-monthly cutting.

Lime Content.

The figures given in Table 11 show the same seasonal influence as under two-monthly cutting—namely, a marked increase from the period following establishment to the "low" period, and a considerable decrease in the "rapid increase" period which continues into the "zenith" period of productivity.

The analysis of variance shows that the F value for varieties is 13·207 and for seasons 55·399, both of which are very highly significant. The main features of the analysis are as follows:—

(1) The very marked differences in mean lime content shown by the various species—the range is from 1·042 per cent. to 0·369 per cent.

(2) The marked superiority in mean lime content of *Panicum maximum* No. 3820 and vars. *typica* and *coloratum*, which are significantly higher than all other grasses at the 1 per cent. level.

Table 11.

LIME AND PHOSPHORIC ACID PERCENTAGES (DRY-MATTER BASIS) AND P_2O_5 : CaO RATIOS FOR 19 GRASSES DURING THE FIRST 12 MONTHS UNDER A THREE-MONTHLY SYSTEM OF CUTTING.

Series. 1 Date of Cut.	25–6–40 (1).			23–9–40 (2).			20–12–40 (3).			21–3–41 (4).			Mean.		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Urochloa bolbodes	0·594	0·486	0·97	1·164	0·992	1·01	0·713	0·488	0·81	0·504	0·476	1·12	0·744	0·610	0·98
Panicum maximum var. *trichoglume*	0·526	0·687	1·55	0·773	0·857	1·31	0·457	0·664	1·72	0·440	0·687	1·85	0·549	0·724	1·61
P. maximum No. 1202	0·604	0·466	0·91	0·686	0·572	0·99	0·456	0·424	1·10	0·438	0·338	0·91	0·546	0·450	0·98
P. maximum No. 3783	0·533	0·515	1·14	0·768	0·545	0·84	0·611	0·497	0·96	0·386	0·407	1·25	0·574	0·491	1·05
Digitaria milanjiana	0·527	0·598	1·34	1·018	0·858	1·00	0·502	0·526	1·24	0·392	0·316	0·95	0·610	0·574	1·13
Paspalum dilatatum	0·403	0·372	1·09	0·667	0·309	0·55	0·314	0·454	1·71	0·335	0·233	0·82	0·430	0·342	1·04
Cenchrus ciliaris	0·688	0·831	1·43	0·985	1·181	1·42	0·601	0·717	1·41	0·536	0·435	0·96	0·702	0·791	1·31
Series 2. Date of Cut.	5–7–40 (1).			1–10–40 (2).			31–12–40 (3).			31–3–41 (4).			Mean.		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Hyparrhenia aucta	0·396	0·266	0·79	0·573	0·275	0·57	0·296	0·151	0·60	0·211	0·181	1·01	0·369	0·218	0·74
Cynodon plectostachyum	0·474	0·468	1·17	0·797	0·575	0·85	0·587	0·581	1·17	0·401	0·457	1·35	0·565	0·520	1·13
Panicum maximum var. *coloratum*	0·907	0·475	0·62	1·630	0·877	0·64	0·691	0·436	0·75	0·543	0·593	1·29	0·943	0·595	0·82
P. maximum No. 1200	0·748	0·481	0·76	0·581	0·624	1·27	..	..	..	0·375	0·532	1·68	0·568*	0·546*	1·24*
Brachiaria purpurascens	0·472	0·444	1·11	0·930	0·609	0·77	0·595	0·497	0·99	0·288	0·656	2·69	0·571	0·551	1·39
B. decumbens	0·376	0·339	1·07	0·691	0·361	0·62	0·420	0·298	0·84	0·337	0·356	1·25	0·456	0·338	0·95
Chloris gayana No. 6586	0·424	0·406	1·13	0·751	0·537	0·85	0·462	0·302	0·77	0·427	0·399	1·11	0·516	0·411	0·96
Series 3. Date of Cut.	15–7–40 (1).			11–10–40 (2).			10–1–41 (3).			10–4–41 (4).			Mean.		
	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO	CaO	P_2O_5	P_2O_5/CaO
Pennisetum clandestinum	0·509	0·579	1·35	0·774	1·320	2·02	0·484	0·532	1·30	0·289	0·543	2·22	0·514	0·743	1·72
Panicum maximum var. *typica*	0·875	0·423	0·57	1·380	0·434	0·37	0·884	0·357	0·48	0·843	0·483	0·68	0·996	0·424	0·52
P. maximum No. 3820	1·058	0·432	0·48	1·390	0·430	0·37	0·945	0·452	0·57	0·774	0·486	0·74	1·042	0·450	0·54
Chloris gayana No. 6585	0·435	0·362	0·98	0·491	0·387	0·93	0·464	0·429	1·09	0·307	0·340	1·31	0·424	0·379	1·08
Melinis minutiflora	0·437	0·457	1·24	0·501	0·566	1·34	0·367	0·466	1·50	0·385	0·562	1·73	0·422	0·513	1·45
Mean for all Grasses	0·578	0·478	1·04	0·871	0·648	0·93	0·547	0·459	1·06	0·432	0·446	1·31	..	..	..

1. Period following establishment.
2. Latter portion of "low" productivity period.
3. End of "rapid increase" and commencement of "zenith" period.
4. Latter portion of "zenith" period of productivity.
* Mean for 3 cuts only.

Table 12.

THREE-MONTHLY CUT—FIRST 12 MONTHS.
Summary of Results—CaO *Content.*

Grass.	Mean CaO Percentage.	Percentage of Mean.	Significance Table.	
			1 Per Cent. Level.	5 Per Cent. Level.
1. *Panicum maximum* No. 3820 ..	1·042	170·9	> Nos. 4–18	> Nos. 4–18
2. *P. maximum* var. *typica*	0·995	163·3	ditto	ditto
3. *P. maximum* var. *coloratum* ..	0·943	154·6	> Nos. 5–18	ditto
4. *Urochloa bolbodes*	0·744	122·0	> Nos. 12–18	> Nos. 7–18
5. *Cenchrus ciliaris*	0·702	115·2	> Nos. 14–18	> Nos. 12–18 (11)
6. *Digitaria milanjiana*	0·610	100·0	> No. 18	> Nos. 15–18
7. *Panicum maximum* No. 3783 ..	0·574	94·2	No significant difference	> No. 18
8. *Brachiaria purpurascens*	0·571	93·7		ditto
9. *Cynodon plectostachyum*	0·565	92·6	..	ditto
10. *Panicum maximum* var. *trichoglume*	0·549	90·1	..	ditto
11. *P. maximum* No. 1202	0·546	89·6	..	ditto
12. *Chloris gayana* No. 6586	0·516	84·6	..	No significant difference
13. *Pennisetum clandestinum*	0·514	84·3	..	..
14. *Brachiaria decumbens*	0·456	74·8	..	..
15. *Paspalum dilatatum*	0·430	70·5	..	..
16. *Chloris gayana* No. 6585	0·424	69·6	..	..
17. *Melinis minutiflora*	0·422	69·3	..	..
18. *Hyparrhenia aucta*	0·369	60·5	..	..
G. Mean	0·610	100·0	..	..
S.E. Mean of 4	0·0553	9·07	..	..
Sig. difference P = 0·05	..	25·74	..	..
Sig. difference P = 0·01	..	34·33	..	..
Season.				
1. Latter portion of "low" period of productivity	0·887	145·5	> Nos. 2–4	..
2. Period following establishment ..	0·569	93·3	> No. 4	..
3. End of "rapid increase" and commencement of "zenith" period ..	0·547	89·8	> No. 4	..
4. Latter portion of "zenith" period of productivity	0·435	71·4	..	..
G. Mean	0·610	100·0	..	..
S.E. Mean of 18	0·02607	4·28	..	..
Sig. difference P = 0·05	..	12·14	..	..
Sig. difference P = 0·01	..	16·18	..	..

(3) The low mean lime content of grasses Nos. 7-18, all of which fall into the lime-poor class with values of less than 0·6 per cent.

(4) The very low lime content of *Hyparrhenia aucta* (0·369 per cent.).

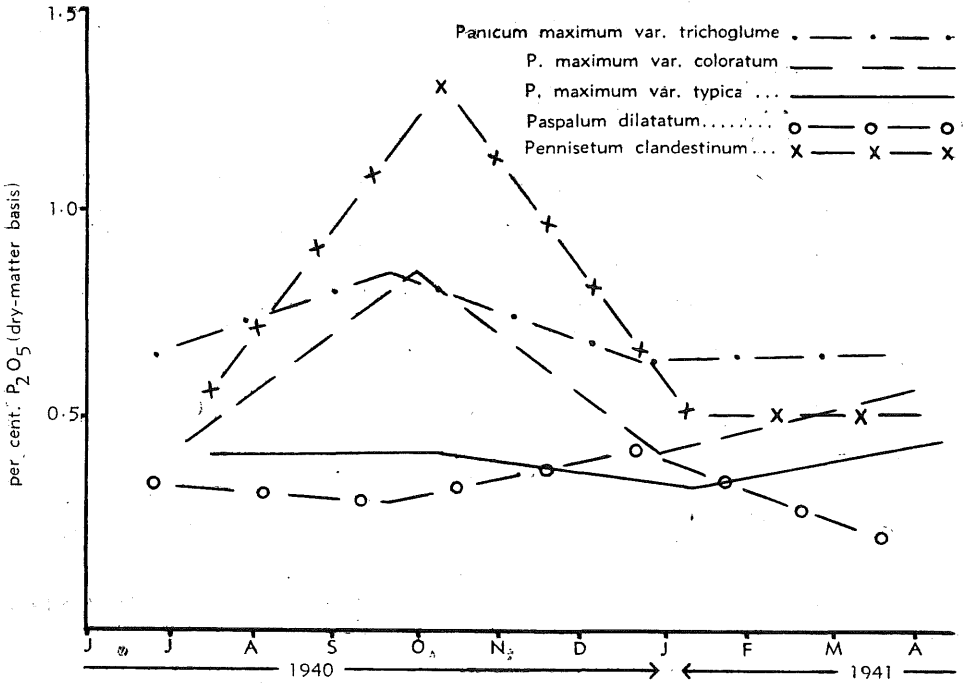

Figure 8.

Showing the seasonal variation in the phosphoric acid content of five grasses during the first 12 months under a system of three-monthly cutting.

(5) The significantly higher content of lime (1 per cent. level) in the "low" period of productivity than in any other period.

(6) The significantly lower yield of lime (1 per cent. level) in the "zenith" period of productivity than in any other period.

Figure 9 demonstrates the general pattern of mean lime content of 19 grasses under a system of three-monthly cutting.

The figures in Table 13 show the respective lime contents of 19 grasses in June-July under monthly and three-monthly cutting, and in September-October under two-monthly and three-monthly cutting systems.

At the time of the three-monthly cutting in June-July all grasses had passed beyond the hay stage, a number had completed a heavy seeding and in certain instances—*Urochloa bolbodes, Paspalum dilatatum, Cynodon plectostachyum, Brachiaria purpurascens* and *Brachiaria decumbens*—"the lower flag was brown or black due to the wet conditions and smothering habit of the top flag." The mean lime content of 19 grasses in June-July under three-monthly cutting was 0·578 per cent. compared with 0·678 per cent. under the monthly cutting rotation, though five grasses showed an increase under the longer cutting system. The general reduction in lime content under the more lenient cutting system is explained by the increase in stem relative to leaf in the period following establishment.

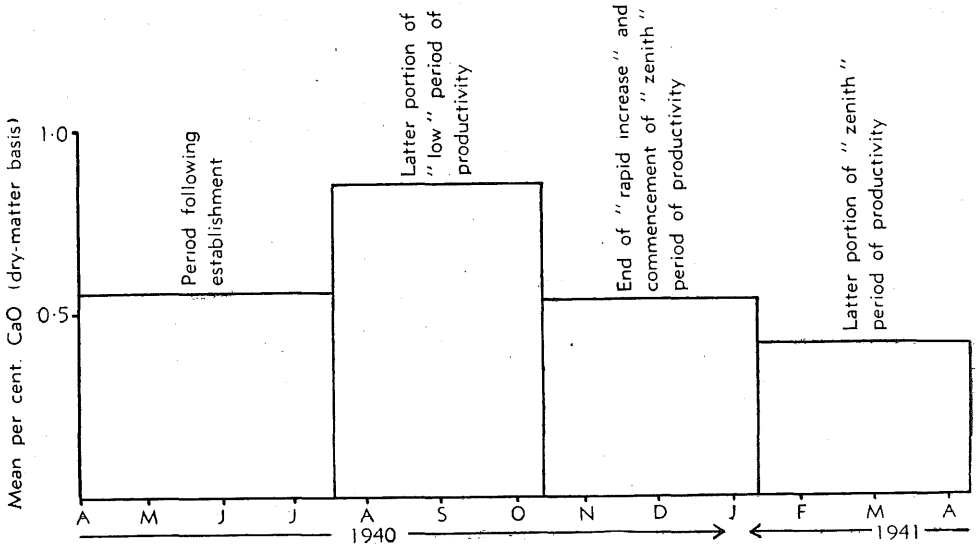

Figure 9.

Showing the seasonal variation in the mean lime content of 19 grasses during the first 12 months under a system of three-monthly cutting.

The second three-monthly cutting (September-October) corresponds with the latter portion of the "low" period of productivity (July to October) in which the hay stage is reached much more slowly. A reduction in the proportion of stem to leaf due to diminution of inflorescence emergence occurs, which results in the mean lime content being slightly higher under three-monthly than under two-monthly cutting.

Phosphoric Acid Content.

The figures in Table 13 indicate that the phosphoric acid content is dependent on the stage of maturity (which determines the ratio of leaf to stem) and decreases as the grasses advance in age. The effect of season is of course profound in this connexion, grasses maturing much more rapidly in the after-establishment, "rapid increase" and "zenith" periods than in the "low" period. Thus in the "low" period, when metabolic activity is at a minimum, values for phosphoric acid are at a maximum (mean 0·648 per cent.), whereas in the "zenith" period minimum values are recorded (mean 0·446 per cent.). The mean phosphoric acid values for 19 grasses have been examined by the analysis of variance method: the F value for varieties is 5·184 and for seasons 9·425, both of which are highly significant. A summary of the results is given in Table 14. The main features of these analyses of variance are as follows:—

(1) The considerable differences in mean phosphoric acid content of the various species, which range from 0·791 per cent. (*Cenchrus ciliaris*) to 0·218 per cent. (*Hyparrhenia aucta*); it is noteworthy that the range of values is much smaller and on a lower plane than with lime (1·042 to 0·369 per cent.).

Table 13.

SHOWING THE VARIATION IN THE PERCENTAGES OF LIME AND PHOSPHORIC ACID (DRY-MATTER BASIS) OF 19 GRASSES UNDER DIFFERENT SYSTEMS OF CUTTING.

System and Date of Cutting.	Monthly. 25/6/40–15/7/40.	Three-monthly. 25/6/40–15/7/40.	Monthly. 25/6/40–15/7/40.	Three-monthly. 25/6/40–15/7/40.	Two-monthly. 23/9/40–11/10/40.	Three-monthly. 23/9/40–11/10/40.	Two-monthly. 23/9/40–11/10/40.	Three-monthly. 23/9/40–11/10/40.
Series 1.	CaO		P_2O_5		CaO		P_2O_5	
Urochloa bolbodes	0·838	0·594	1·148	0·486	1·263	1·164	1·065	0·992
Panicum maximum var. *trichoglume*	0·677	0·526	1·131	0·687	0·784	0·773	1·029	0·857
P. maximum No. 1202	0·531	0·604	0·685	0·466	0·737	0·686	0·607	0·572
P. maximum No. 3783	0·621	0·533	0·957	0·515	0·849	0·768	0·680	0·545
Digitaria milanjiana	0·683	0·527	0·830	0·598	1·140	1·018	1·055	0·858
Paspalum dilatatum	0·459	0·403	0·614	0·372	0·629	0·667	0·357	0·309
Cenchrus ciliaris	0·649	0·688	1·257	0·831	0·872	0·985	1·231	1·181
Series 2.								
Hyparrhenia aucta	0·613	0·396	0·501	0·266	0·602	0·573	0·351	0·275
Cynodon plectostachyum	0·714	0·474	0·929	0·468	0·719	0·797	0·563	0·575
Panicum maximum var. *coloratum*	0·869	0·907	0·979	0·475	1·615	1·630	0·895	0·877
P. maximum No. 1200	0·565	0·748	1·064	0·481	0·481	0·581	0·624	0·624
Brachiaria purpurascens	0·592	0·472	0·884	0·444	0·915	0·930	0·678	0·609
B. decumbens	0·625	0·376	0·680	0·339	0·732	0·691	0·371	0·361
Chloris gayana No. 6586	0·589	0·424	0·885	0·406	0·673	0·751	0·631	0·537
Series 3.								
Pennisetum clandestinum	0·641	0·509	0·727	0·579	0·678	0·774	1·270	1·320
Panicum maximum var. *typica*	1·110	0·875	0·785	0·423	1·250	1·380	0·552	0·434
P. maximum No. 3820	0·973	1·058	0·970	0·432	1·154	1·390	0·494	0·430
Chloris gayana No. 6585	0·590	0·435	0·698	0·362	0·489	0·491	0·458	0·387
Melinis minutiflora	0·545	0·437	0·866	0·457	0·488	0·501	0·609	0·566
Mean for all Grasses	0·678	0·578	0·873	0·478	0·846	0·871	0·712	0·648

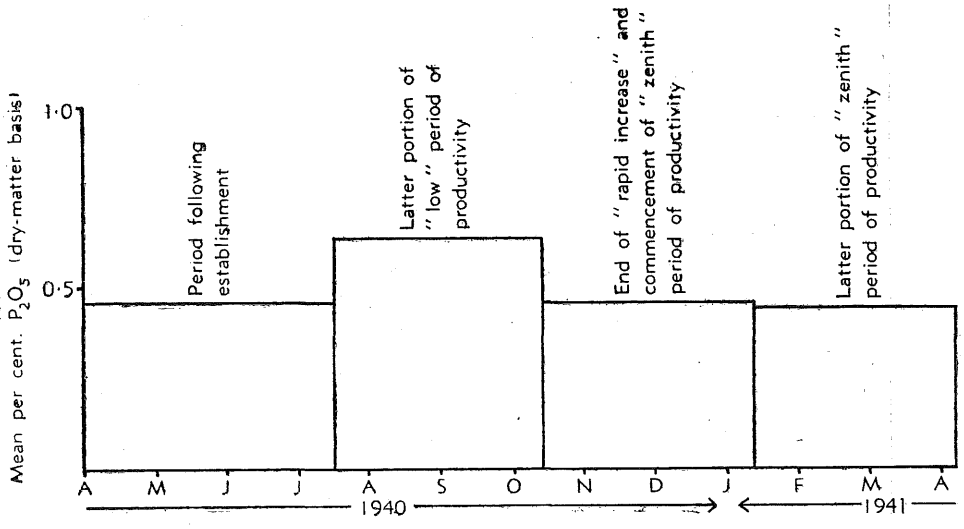

Figure 10.

Showing the seasonal variation in the mean phosphoric acid content of 19 grasses during the first 12 months under a system of three-monthly cutting.

(2) The superiority (1 per cent. level) of the following grasses to all other grasses in mean phosphoric acid content: *Cenchrus ciliaris, Pennisetum clandestinum, Panicum maximum* var. *trichoglume, Urochloa bolbodes, Panicum maximum* var. *coloratum, Digitaria milanjiana* and *Brachiaria purpurascens.*

(3) The low mean phosphoric acid content of grasses Nos. 10-18, all of which fall into the phosphorus-poor class with values of less than 0·5 per cent.

(4) The very low phosphoric acid content of *Hyparrhenia aucta* (0·218 per cent.).

(5) The significantly higher content (1 per cent. level) of phosphoric acid in the "low" period of productivity than at other periods.

(6) The insignificance of the differences in phosphoric acid values in the various periods of productivity: this contrasts with the lime values, which are significantly lower at the 1 per cent. level.

Figure 10 shows the general pattern of mean phosphoric acid content of 19 grasses under a system of three-monthly cutting. This is similar to the lime pattern.

The figures in Table 14 show the phosphoric acid contents of 19 grasses in June-July under monthly and three-monthly cutting and in September-October under two- and three-monthly cutting systems. The mean phosphoric acid content under monthly cutting in the period following establishment, when growth is rapid, is 0·873 per cent., whereas under the three-monthly system it is 0·478 per cent. All grasses show a marked reduction in phosphoric acid content

Table 14.

THREE-MONTHLY CUT—FIRST 12 MONTHS.
Summary of Results—P_2O_5 *Content.*

Grass.	Mean P_2O_5 Percentage.	Percentage of Mean.	Significance Table.	
			1 Per Cent. Level.	5 Per Cent. Level.
1. *Cenchrus ciliaris*	0·791	156·0	> Nos. 8–18	> Nos. 5–18
2. *Pennisetum clandestinum*	0·743	146·6	> Nos. 10–18	> Nos. 7–18
3. *Panicum maximum* var. *trichoglume*	0·724	142·7	> Nos. 11–18	> Nos. 8–18
4. *Urochloa bolbodes*	0·610	120·4	> Nos. 16–18	> Nos. 14–18
5. *Panicum maximum* var. *coloratum*	0·595	117·4	ditto	> Nos. 15–18
6. *Digitaria milanjiana*	0·574	113·3	> No. 18	ditto
7. *Brachiaria purpurascens*	0·551	108·8	ditto	> Nos. 16–18
8. *Cynodon plectostachyum*	0·520	102·6	ditto	> No. 18
9. *Melinis minutiflora*	0·513	101·1	ditto	ditto
10. *Panicum maximum* No. 3783 ..	0·491	96·8	ditto	ditto
11. *P. maximum* No. 3820	0·450	88·7	No significant difference	ditto
12. *P. maximum* No. 1202	0·450	88·7	..	ditto
13. *P. maximum* var. *typica*	0·424	83·7	..	ditto
14. *Chloris gayana* No. 6586	0·411	81·1	..	ditto
15. *C. gayana* No. 6585..	0·379	74·8	..	No significant difference
16. *Paspalum dilatatum*	0·342	67·4	..	..
17. *Brachiaria decumbens*	0·338	66·8	..	..
18. *Hyparrhenia aucta*	0·218	43·0	..	..
G. Mean	0·507	100·0	..	..
S.E. Mean of 4	0·0663	13·07	..	..
Sig. difference P = 0·05	..	37·08	..	..
Sig. difference P = 0·01	..	49·44	..	..
Season.				
1. Latter portion of " low " period of productivity	0·649	128·0	> Nos. 2–4	..
2. Period following establishment ..	0·478	94·3	No significant difference	No significant difference
3. End of " rapid increase " and commencement of " zenith " period of productivity	0·459	90·6	..	..
4. Latter portion of " zenith " period of productivity	0·442	87·1	..	..
G. Mean	0·507	100·0	..	..
S.E. Mean of 18	0·0312	6·16	..	..
Sig. difference P = 0·05	..	17·48	..	..
Sig. difference P = 0·01	..	23·31	..	..

as a result of the stemmy nature of the herbage under the longer cutting rotation and the fact that the phosphoric acid content of the dry matter falls with advancing maturity in both the leaf and the stem portions of the plant. The

Table 15.

YIELD OF LIME IN POUNDS PER ACRE OF 19 GRASSES DURING THE FIRST 12 MONTHS UNDER A SYSTEM OF THREE-MONTHLY CUTTING.

Series 1. Date of Cut.	25–6–40.	23–9–40.	20–12–40.	21–3–41.	Total.
Urochloa bolbodes	26	19	29	28	102
Panicum maximum var. *trichoglume*	19	14	10	18	61
P. maximum No. 1202	30	16	19	63	128
P. maximum No. 3783	30	17	21	33	101
Digitaria milanjiana	14	11	9	32	66
Paspalum dilatatum	13	11	5	12	41
Cenchrus ciliaris	21	8	8	23	60
Series 2. Date of Cut.	**5–7–40.**	**1–10–40.**	**31–12–40.**	**31–3–41.**	**Total.**
Hyparrhenia aucta	17	31	27	13	88
Cynodon plectostachyum	19	23	16	25	83
Panicum maximum var. *coloratum*	18	19	18	18	73
P. maximum No. 1200	25	6	..	8	..
Brachiaria purpurascens	30	22	11	8	71
B. decumbens	53	20	23	32	128
Chloris gayana No. 6586	20	15	13	20	68
Series 3. Date of Cut.	**15–7–40.**	**11–10–40.**	**10–1–41.**	**10–4–41.**	**Total.**
Pennisetum clandestinum	15	14	4	10	43
Panicum maximum var. *typica*	71	20	39	49	179
P. maximum No. 3820	65	25	39	55	184
Chloris gayana No. 6585	20	9	11	18	58
Melinis minutiflora	31	10	14	19	74
Mean for all Grasses	28	16	18*	25	89

* Mean for 18 grasses.

mean value for all grasses under a two-monthly cut in the "low" period of productivity (September-October) is 0·712 per cent. and under the three-monthly system 0·648 per cent. These figures show the same trend of decreasing phosphoric acid content with maturity as exhibited by the cuts taken in June-July, but the reduction at the three-monthly cut is considerably less than in the period following establishment owing to the lower rate of metabolic activity in the "low" period of productivity.

Yield of Lime.

The yield of lime at each cut during the 12 months is given for each of the 19 grasses in Table 15. The mean values demonstrate clearly the effect of the various periods of productivity on yield. This data has been subjected to the

Table 16.

THREE-MONTHLY CUT—FIRST 12 MONTHS.

Summary of Results—Yield of Lime.

Grass.	Total Yield CaO (Lb. Per Acre).	Percentage of Mean of 18 Grasses.	Significance Table.	
			1 Per Cent. Level.	5 Per Cent. Level.
1. *Panicum maximum* No. 3820 ..	184	206·7	> 5–18	> 3–18
2. *P. maximum* var. *typica*	179	201·1	> 5–18	> 5–18
3. *P. maximum* No. 1202	128	143·8	> 16–18	> 9–18
4. *Brachiaria decumbens*	128	143·8	> 16–18	> 9–18
5. *Panicum maximum* No. 3783 ..	101	113·5	No significant difference	> 17, 18
6. *Urochloa bolbodes*	97	109·0	..	> 17,18
7. *Hyparrhenia aucta*	88	98·9	..	No significant difference
8. *Cynodon plectostachyum*	83	93·3	..	..
9. *Melinis minutiflora*	74	83·1	..	..
10. *Panicum maximum* var. *coloratum*	73	82·0	..	..
11. *Brachiaria purpurascens*	71	79·8	..	..
12. *Chloris gayana* No. 6586	68	76·4	..	..
13. *Digitaria milanjiana*	66	74·2	..	..
14. *Panicum maximum* var. *trichoglume*	61	68·5	..	..
15. *Cenchrus ciliaris*	60	67·4	..	..
16. *Chloris gayana* No. 6585	58	65·2	..	..
17. *Pennisetum clandestinum*	43	48·3	..	..
18. *Paspalum dilatatum*	40	44·9	..	..
Total for Year—Mean for 18 Grasses ..	89	100·0	..	..
S.E. Total of 4	18·371	20·64	..	..
Sig. difference P = 0·05	52·14	58·59	..	..
Sig. difference P = 0·01	69·52	78·11	..	..
Season.	Mean Yield CaO (Lb. Per Acre).	Percentage of G.M.		
1. Period following establishment ..	28·44	127·8	> Nos. 3–4	..
2. Latter portion of " zenith " period of productivity	26·44	118·9	ditto	..
3. End of " rapid increase " and commencement of " zenith " period ..	17·56	78·9	No significant difference	..
4. Latter portion of " low " period of productivity	16·56	74·4	..	..
G. Mean	22·25	100·0	..	..
S.E. Mean of 18	2·1651	9·73	..	..
Sig. difference P = 0·05	6·145	27·62	..	..
Sig. difference P = 0·01	8·193	36·82	..	..

Table 17.

YIELD OF PHOSPHORIC ACID IN POUNDS PER ACRE OF 19 GRASSES DURING THE FIRST 12 MONTHS UNDER A SYSTEM OF THREE-MONTHLY CUTTING.

Series 1. Date of Cut.	25-6-40.	23-9-40.	20-12-40.	21-3-41.	Total.
Urochloa bolbodes	21	16	20	26	83
Panicum maximum var. *trichoglume*	25	16	15	28	84
P. maximum No. 1202	23	13	18	49	103
P. maximum No. 3783	29	12	17	35	93
Digitaria milanjiana	16	9	9	26	60
Paspalum dilatatum	12	5	8	8	33
Cenchrus ciliaris	26	9	10	19	64
Series 2. Date of Cut.	**5-7-40.**	**1-10-40.**	**31-12-40.**	**31-3-41.**	**Total.**
Hyparrhenia aucta	12	15	14	11	52
Cynodon plectostachyum	18	16	15	29	78
Panicum maximum var. *coloratum*	10	10	11	20	51
P. maximum No. 1200	16	7	..	11	..
Brachiaria purpurascens	28	14	10	19	71
B. decumbens	48	11	16	34	109
Chloris gayana No. 6586	19	11	9	19	58
Series 3. Date of Cut.	**15-7-40.**	**11-10-40.**	**10-1-41.**	**10-4-41.**	**Total.**
Pennisetum clandestinum	17	24	5	19	65
Panicum maximum var. *typica*	34	6	16	28	84
P. maximum No. 3820	27	8	18	34	87
Chloris gayana No. 6585	17	7	10	20	54
Melinis minutiflora	32	11	18	28	89
Mean for all Grasses	23	12	13*	24	73*

* Mean for 18 grasses.

analysis of variance: the F value for varieties is 5·105 and for seasons 7·852, both of which are highly significant. The results are shown in Table 16. The main features of these analyses may be summarized as follows:—

(1) The marked differences in total yield of lime for the first 12 months shown by the various species: *Panicum maximum* Nos. 1202 and 3820 and var. *typica* and *Brachiaria decumbens* (128 lb. each) are significantly higher at the 1 per cent. level than the remaining grasses.

(2) The relatively low lime yield of *Melinis minutiflora, Panicum maximum* vars. *coloratum* and *trichoglume, Brachiaria purpurascens, Chloris gayana, Pennisetum clandestinum* and *Paspalum dilatatum.*

(3) The significantly higher yield (1 per cent. level) of lime in the period following establishment and in the "zenith" period of productivity than in the other two productivity periods.

Table 18.

THREE-MONTHLY CUT—FIRST 12 MONTHS.

Summary of Results—Yield of Phosphoric Acid.

Grass.	Total Yield P_2O_5 (Lb. Per Acre).	Percentage of Mean of 18 Grasses.	Significance Table.	
			1 Per Cent. Level.	5 Per Cent. Level.
1. *Brachiaria decumbens*	109	149·2	> 13–18	> 10–18
2. *Panicum maximum* No. 1202 ..	103	141·0	> 15–18	> 11–18
3. *P. maximum* No. 3783	93	127·3	> 18	> 15–18
4. *Melinis minutiflora*	89	121·8	ditto	> 16–18
5. *Panicum maximum* No. 3820 ..	87	119·1	ditto	> 17, 18
6. *P. maximum* var. *trichoglume* ..	84	115·0	ditto	> 18
7. *P. maximum* var. *typica*	84	115·0	ditto	ditto
8. *Urochloa bolbodes*	79	108·1	No significant difference	ditto
9. *Cynodon plectostachyum*	78	106·8	..	ditto
10. *Brachiaria purpurascens*	71	97·2	..	ditto
11. *Pennisetum clandestinum*	65	89·0	..	No significant difference
12. *Cenchrus ciliaris*	65	89·0	..	..
13. *Digitaria milanjiana*	60	82·1	..	..
14. *Chloris gayana* No. 6586	58	79·4	..	..
15. *C. gayana* No. 6585..	54	73·9	..	..
16. *Panicum maximum* var. *coloratum*	52	71·2	..	..
17. *Hyparrhenia aucta*	51	69·8	..	..
18. *Paspalum dilatatum*	33	45·2	..	..
Total for Year—Mean for 18 Grasses ..	73·06	100·0	..	..
S.E. Total for 4	12·64	17·30	..	..
Sig. difference P = 0·05	35·87	49·09	..	..
Sig. difference P = 0·01	47·82	65·46	..	..
Season.	Mean Yield P_2O_5 (Lb. Per Acre).	Percentage of G.M.		
1. Latter portion of " zenith " period of productivity	25·11	137·5	> 3, 4	..
2. Period following establishment ..	22·94	125·6	> 3, 4	..
3. End of " rapid increase " and commencement of " zenith " period ..	13·33	73·0	No significant difference	..
4. Latter portion of " low " period of productivity	11·67	63·9	..	..
G. Mean	18·26	100·0	..	..
S.E. Mean of 18	1·49	8·15	..	..
Sig. difference P = 0·05	4·227	23·14	..	..
Sig. difference P = 0·01	5·636	30·86	..	..

Yield of Phosphoric Acid.

The yield of phosphoric acid at each cut for 19 grasses during the 12 months is given in Table 17; as with the lime values the mean figures for each cut show the marked influence of the various productivity periods. The totals

have been subjected to the analysis of variance: the F value for varieties is 2·491 and for seasons 20·534, both of which are highly significant. The results are given in Table 18. The main features of these analyses may be summarized as follows:—

(1) The marked difference in the total yield of phosphoric acid according to species: the range of yield (33-109 lb. per acre per annum) is not so large as with lime (40-183 lb. per acre per annum).

(2) The significantly higher yields of grasses Nos. 1-2 at the 1 per cent. level and of grasses Nos. 1-9 at the 5 per cent. level.

(3) The very low yield of 33 lb. of phosphoric acid per acre given by *Paspalum dilatatum.*

(4) The low yield of phosphoric acid by *Brachiaria purpurascens, Pennisetum clandestinum, Chloris gayana,* and *Panicum maximum* var. *coloratum.*

(5) The significantly higher yield (1 per cent. level) of phosphoric acid in the period following establishment and in the "zenith" period of productivity than in the other two productivity periods.

Ratio of Phosphoric Acid to Lime.

The ratios of phosphoric acid to lime at the cuts taken in June-July (period following establishment) show that with one exception—*Pennisetum clandestinum*—the grasses have decreased markedly in the relative amount of phosphoric acid to lime compared with the cut made on the same date under a system of monthly cutting. Under monthly cutting many of the grasses possess a mineral balance approximating to the standard, but under three-monthly cutting only four grasses—*Panicum maximum* var. *trichoglume* (1·54 : 1), *Pennisetum clandestinum* (1·35 : 1), *Digitaria milanjiana* (1·34 : 1) and *Melinis minutiflora* (1·24 : 1)—show a reasonably satisfactory ratio of phosphoric acid to lime. Of the remaining grasses, *Panicum maximum* var. *typica* (0·57 : 1) and *P. maximum* No. 3820 (0·48 : 1) have particularly narrow ratios.

At the September-October cut, corresponding to the "low" period of productivity, all grasses except *Brachiaria decumbens* have a lower phosphoric acid content than at the same date under a two-monthly system of cutting. Similarly, all except *Panicum maximum* Nos. 1200 and 1202 and var. *coloratum, Pennisetum clandestinum* and *Melinis minutiflora* show a decrease in the amount of phosphoric acid relative to lime at the second cut compared with the first cut under a system of three-monthly cutting. At this period only four grasses—*Cenchrus ciliaris, Melinis minutiflora,* and *Panicum maximum* var. *trichoglume* and No. 1200—have a P_2O_5 : CaO ratio of 1·5 : 1.

At the December-January cut, corresponding to the end of the "rapid increase" period, the proportion of phosphoric acid relative to lime has decreased with six grasses and increased with the other 12. Six grasses—*Panicum*

maximum var. *trichoglume, Paspalum dilatatum, Melinis minutiflora, Cenchrus ciliaris, Pennisetum clandestinum* and *Digitaria milanjiana*—have a P_2O_5: CaO ratio near the standard.

At the March-April cut, corresponding to the "zenith" period of productivity, the proportion of phosphoric acid relative to lime has decreased in five grasses and increased in 13. Seven grasses have a ratio of phosphoric acid to lime lying between 1·73 : 1 and 1·25 : 1

DISCUSSION.

The outstanding conclusion to be drawn from the investigation is that there are marked differences between the various species examined in both the content and the yield of lime and phosphoric acid. Under the same soil and climatic conditions, the mean lime content of 19 grasses for 12 months under a system of three-monthly cutting varied from a maximum of 1·042 per cent. (*Panicum maximum* No. 3820) to a minimum of 0·369 per cent. (*Hyparrhenia aucta*), and the yield from 184 lb. (*Panicum maximum* No. 3820) to 40 lb. lime per acre (*Paspalum dilatatum*). The corresponding mean phosphoric acid content ranged from 0·791 per cent. (*Cenchrus ciliaris*) to 0·218 per cent. (*Hyparrhenia aucta*), and the yield from 109 lb. (*Brachiaria decumbens*) to 33 lb. phosphoric acid per acre (*Paspalum dilatatum*).

These results show that, where supplementary mineral foods are not to be supplied, care must be exercised in selecting pasture or fodder grasses for use in the tropics. Certain grasses, particularly some types of Guinea grass, are lime-rich and approach in value the figure of 1·004 per cent. given by Godden (*in* Elliot *et al*, 1926) for an English cultivated pasture. Two lime-rich grasses—*Panicum maximum* vars. *typica* and *coloratum*—deserve special mention. Without fertilizer application and under three-monthly cutting, their mean lime contents for 12 months were 0·995 and 0·943 per cent., and their yield of lime 179 lb. and 73 lb. per acre respectively. These two grasses are hardy, vigorous and aggressive and the variety *coloratum* is particularly palatable: both deserve to be given widespread recognition as valuable lime-rich fodder grasses capable of thriving on acid soils. The small quantity of 73 lb. of lime per acre per annum given above for *Panicum maximum* var. *coloratum* is for the three-monthly cutting rotation, under which only 15·8 tons of green-matter per acre were produced: under a two-monthly rotation the yield of green-matter was 24·1 tons per acre (Schofield, 1944).

Among the grasses poor in lime under the conditions of the experiment are *Pennisetum clandestinum, Melinis minutiflora, Paspalum dilatatum* and *Chloris gayana* Nos. 6585 and 6586. It has been reported from the West Indies

that *Melinis minutiflora* is very poor in minerals and the suggestion made that the extension in the use of this grass should be confined to areas which will not grow *Panicum maximum* satisfactorily.

The phosphoric acid content also shows wide variation according to the species. Even under a system of three-monthly cutting (where values tend to be low due to the influence of maturity on phosphoric acid content) several grasses, including *Cenchrus ciliaris, Pennisetum clandestinum* and *Panicum maximum* var. *trichoglume,* exceed a mean value of 0·7 per cent. for the 12 months. At the other extreme are *Chloris gayana* Nos. 6585 and 6586, *Paspalum dilatatum* and *Brachiaria decumbens,* all with means of less than 0·4 per cent. Actually *Brachiaria decumbens* produced the highest yield of 109 lb. of phosphoric acid per acre per annum, but this was due to its extremely high yield of herbage.

Summed up, the results of the pasture investigations reported in the series of papers of which this is the third indicate that grasses are available which are suitable for pasture purposes on the alluvial schist soils of coastal tropical Queensland. While some are in themselves satisfactory with respect to yield of dry-matter and to content of protein, phosphoric acid and lime, others will require to be grown in association with a legume. Investigations have shown (Schofield, 1941, 1945a) that suitable legumes are available.

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