

Leaf-Stem Ratio Studies in Six Grasses*

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LEAFINESS of forage is closely correlated with its economic value. Leaves exist as an inseparable component along with the stem in forage vegetation. This induces selectivity by the grazing animal and complicates pasture management.

Johnstone Wallace *et al* (7) in their observations on grazing cattle have shown that leaves are consumed in preference to stems. Heady and Torrel (6) using oesophageal fistulated sheep reported a high degree of selectivity by the sheep during grazing. It has been shown quite conclusively by a host of authors (1, 5, 8, 9, 11) that leaves are richer in nutrients than stems, and that coincidentally the animals preferred more leafy herbage.

Chemical analysis of the grasses in the field does not give a true picture of the nutritive value of the herbage actually consumed by the grazing animal (8). This is due to the selectivity of the grazing animal for the leafier components of the pasture. Hardison *et al* (5) have shown experimentally that the food actually ingested by the grazing animal contained 23.3 per cent. more crude protein, 37.3 per cent. more fat, 25.6 per cent. more ash and 16.8 per cent. less of crude fibre than the values obtained by chemical analysis of the grazed sward. Such selectivity on the part of the grazing animals results in a higher intake of available nutrients (12) and increased output of meat and milk (3). Clearly, the chemical analysis of the herbage offering in the field is not a reliable index of the nutritive value of the herbage actually consumed by the grazing animal.

The occurrence of a high degree of selective grazing is undesirable, since in the long run per acre yields and per animal efficiency are greatly reduced. Selectivity on the part of the grazing animal when grazing stemmy herbage slows down the grazing process. Fernando and Sivalingam (4) have shown that grazing time in the dry months (when quality is low) is appreciably greater than during flush periods (when quality is high). This increase in grazing time, due to the

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movement of the grazing animal in its search for richer herbage, results in a waste of energy. This wastage of energy is arrested if selectivity is minimised by the provision of a leafy herbage offering. Recently developed systems of pasture management, e.g., strip grazing, controlled rotational grazing and zero grazing, tend to minimise the incidence of selective grazing. These derivatives of the rotational system of grazing result in a more leafy herbage offering and, consequently, since the proportion of stem is more or less negligible animal selectivity is greatly minimised.

In view of the importance of the leaf stem ratio of herbage in relation to the productive efficiency of both the herbage offering and the grazing animal, a study of the leaf stem ratio of six common tropical grasses in relation to (a) different systems of management and (b) productivity, composition and nutritive value, was undertaken at Maha Illuppallama. The results of this investigation are given below.

THE SIX GRASSES

1. *Panicum maximum*—Jacqr—Guinea

A tussocky fodder grass producing frequent flower shoots. The flower stalk is woody and fibrous. With maturity of inflorescence the vegetation matures and changes colour from dark green to yellowish green. The mature grass is coarse and rough. This grass has a high tiller count, producing about 60 to 75 productive tillers (10).

2. *Pennisetum purpureum*—Schumach—Napier

A highly reputed, tall growing fodder grass. The leaves are long and pubescent. It takes a long time to flower, therefore does not mature quickly. When herbage with mature stem is fed to cattle, the stems are discarded, being less palatable.

3. *Brachiaria ruziziensis*

A semi erect type of pasture grass, more drought avoiding than resistant. Produces frequent flower shoots. The inflorescence is not woody and is therefore grazed by cattle. Even though the grass changes colour at maturity the mature herbage is palatable. A pasture with this grass is generally leafy and relished by cattle.

4. *Brachiaria brizantha*—(Hochst) Stapt—Kenya Strain

A well reputed pasture grass in the dry zone areas of Ceylon. Semi-erect habit. The stems are generally prostrate but turn up with increasing denseness of the sward. The grass flowers freely, putting

forth conspicuous flower heads borne on long stalks. Flowering is uniform. At the time of flowering the growth of this grass is arrested, and the grass becomes coarse.

5. *Brachiaria brizantha*—Tanganyikan Strain

Even though this grass has drought endurance qualities it is slow in growth and recovery, and hence its limited popularity. The leaves and stems are glabrous. Flowering is not as free as in the other strains of *Brachiaria*. The flower heads are small and palatable to grazing animals.

6. *Brachiaria mutica*—(Forsk) Stapf

Rather coarse, trailing type of pasture grass in the dry zone areas of Ceylon. It is drought resistant to some degree and also tolerant to water stagnation. Its forage qualities are rather limited due to the predominance of stems in the herbage. Leaves are fewer and set apart on the trailing stem. The sparse growth exhibited by this grass, due to the preponderance of stems, gives rise to weed infestation in the sward. Over matured stems are woody and fibrous. The grass is observed not to withstand heavy grazing or frequent cutting, hence it is used as a browse grass.

EXPERIMENTAL METHODS

A split-split plot design was employed. Grasses formed the main plots, cutting frequencies the sub plots, and different levels of nitrogen formed the sub-sub plots.

Grasses were planted at $1\frac{1}{2} \times 1\frac{1}{2}$ feet, and established in the previous growth season. The experiment was started after fully establishing the stand of the grasses. All the plots were level cut four inches high with an auto-scythe before starting the experiment.

The different frequencies of defoliation were 30, 60, and 90 days and the levels of nitrogen were 0, 60 and 180 lb. N per acre per year. Nitrogen was applied in two doses, one in October and the other in April, with the seasonal showers. A blanket application of 2 cwts. of Single Superphosphate and 1 cwt. of Muriate of Potash per acre was applied in two doses just before the nitrogen application.

The plots were sampled on the due date, and a known sample from each plot was hand separated into leaves and stems. The leaves were removed by holding the shoot in one hand and pulling the leaves with

the sheath backwards. The separation was done in the laboratory. For this study, leaves consisted of the lamina and the sheath, and the remaining shoot was the stem. Flower shoots and inflorescences were also regarded as stems. A composite unseparated known sample was also taken from each plot. All the samples were weighed individually and dried for eight hours in a Unitherm dryer at 100°C. The samples, after dry matter determination, were analysed for crude protein, crude fibre and total ash. Starch equivalent was calculated using standard equations suggested by Bredon, Harker and Marshall (2). In this study, the weight of the stems was taken as unity for expressing the ratio of leaf to stem.

RESULTS

A. The Grasses

The results of two years indicate clearly that the ratio of leaves to stems (stems taken as unity) is influenced by the growth habit of the grass. Guinea excelled all the other grasses tested in having the highest ratio of leaves to stem in both years of study (5.2 and 12.8 in the first and the second year respectively). Napier ranked second (4.5 and 9.3 in the first and second year respectively). The other grasses, in the order of decreasing leaf-stem ratio were *Brachiaria ruziziensis* (2.3 and 5.7), *Brachiaria brizantha*—Kenya Strain (1.6 and 3.3) and *Brachiaria brizantha*—Tanganyikan Strain (1.4 and 1.8). The last of the grasses was *Brachiaria mutica* with a ratio of only 0.6 in both years of study. The differences between Guinea, Napier and *Brachiaria ruziziensis* were not significant in both years. Both strains of *Brachiaria brizantha* gave a similar leaf stem ratio in the first year, but in the second the Kenya strain proved distinctly leafier than the Tanganyikan strain.

B. Frequency of Defoliation

Different cutting frequencies resulted in significant differences in the leaf-stem ratio. A thirty day frequency resulted in the highest leaf-stem ratio in both years (viz., 4.5 and 10.8 respectively). At 60-day intervals the ratio was 2 and 3.8 respectively, while at 90-day intervals the ratio was lowest, viz., 1.2 and 2.1 respectively. The

differences in leaf-stem ratio at different cutting frequencies were most marked in Guinea. In *Brachiaria ruziziensis* defoliation at 30 and 60-day intervals respectively resulted in a similar leaf-stem ratio. The Tanganyikan strain of *Brachiaria brizantha* showed no significant differences in the leaf-stem ratio at different frequencies of defoliation.

C. Levels of Nitrogen

Nitrogen treatments resulted in significant differences in the leaf-stem ratio. The leaf component decreased with increase in the level of Nitrogen. Concomitant with this decrease in leaf, the proportion of the stems increased. All the grasses behaved similarly.

D. Nutritive Value

The nutritive quality of herbage under a given set of conditions, is indicated by its chemical composition. Quality in this experiment was judged by the percentage of crude proteins, crude fibre and total ash in the dry matter, and by the calculated starch equivalent.

1. Crude Protein

The frequency of defoliation had a pronounced effect on the crude protein content of leaf and stem. The highest proportion of crude protein in both leaves and stems occurred where the interval between defoliations was shortest viz., 30 days. At this cutting frequency the protein content of the leaf component was not significantly superior to that of the stem fraction. Where the interval between defoliations was prolonged however, e.g., 90 days, both leaf and stem were much poorer in crude protein. This decrease is more pronounced in the case of the stem, which consequently exhibits a considerably lower crude protein content than the leafy fraction. The crude protein content of both leaf and stem was increased with increasing level of nitrogen application. All the six grasses behaved similarly in regard to these effects of cutting frequency and nitrogen levels on the crude protein content of stem and leaf.

2. Fibre

The stem component was always characterised by a higher fibre content than the leaf fraction. With increase in the interval between successive defoliations there was a marked increase in the proportion

of stem in the herbage, and consequently the crude fibre content of the herbage was considerably greater than with more frequent cutting. Different levels of Nitrogen did not appreciably influence the crude fibre content of the grasses studied.

3. Total Ash

Total ash content generally followed the trends exhibited by the crude protein. The highest values were more associated with a cutting frequency of 30 days. The drop in ash content as the interval between defoliations is increased from 30 to 60 days is more marked than the decrease observed as the interval between cuts is increased from 60 to 90 days. Napier and Guinea were slightly richer in ash than the other grasses. Nitrogen did not influence the ash content of the herbage.

4. Starch Equivalent

The calculated starch equivalent of the leaves was always higher than that of the stem. All the species of *Brachiaria* showed high values for starch equivalent, with *Brachiaria ruziziensis* recording the highest value. Starch equivalent decreased with increasing interval between defoliations. Different levels of nitrogen application had no effect on the starch equivalent of the herbage.

DISCUSSION

In both the fodder grasses, Napier and Guinea, the proportion of leaf was smaller under less frequent cutting. This is due, not to a decrease in the weight of leaves, but due to a considerable increase in the weight of stem. In Guinea the frequent production of inflorescences greatly increased the predominance of stem. Since the stem fraction is largely unpalatable, total weight of herbage under less frequent cutting is no longer a reliable index of palatable herbage yields under these conditions.

Among the pasture grasses *Brachiaria ruziziensis* showed the highest ratio of leaves to stem. The fall in the leaf stem-ratio with increasing interval between cuts was gradual in this grass. The Kenya strain of *Brachiaria brizantha* showed a slightly higher leaf-stem ratio than the

other strain, but this difference was not significant. The leaf-stem ratio was lowest in *Brachiaria mutica*. The sparse growth exhibited by this grass, due to the predominance of stems, results in considerable weed infestation. This grass has not proved satisfactory as a pasture species—being useful only as a browse grass under conditions where better grasses do not thrive.

Frequency of defoliation produced a profound effect on the leaf-stem ratio of all the grasses studied. In general, under a 30 day cutting frequency, the proportion of stem was negligible ; but with increasing intervals between successive defoliations, the leaf-stem ratio declined rapidly owing to a much greater increase in the quantity of stem. The effect of nitrogen fertilizer levels on the leaf-stem ratio is less marked. Frequency of defoliation is therefore the more decisive factor in pasture management. Longer intervals between defoliation result in a considerable increase in tonnage, but the herbage is considerably stemmy.

Crude protein is the main measure of the quality of tropical herbage. Frequency of defoliation had a markedly greater effect on the protein content of herbage than the level of nitrogen fertilisation. The level of crude protein in both leaf and stem decreased with a lengthening of the interval between successive cuts.

The crude fibre content of herbage brings down its quality, both by its mere presence and its dilutary effect. Herbage digestibility is decreased by the presence of excessive fibre, and animal selectivity is generally attributed to the predominance of crude fibre in the herbage offering. Crude fibre in herbage also increases the resistance to grazing or cutting and this results in further wastage of energy. Stems, with their higher crude fibre content are therefore considerably inferior to leaves. Less frequent cutting results in increase in the fibre content of both leaf and stem ; since the proportion of stem in the herbage is also greater under these conditions, the crude fibre content is considerably increased, resulting in a sharp decrease in its feeding value. It is of interest that nitrogen application has little effect on the crude fibre content of the herbage.

The energy value of the herbage consumed, expressed in terms of starch equivalent, was always higher in the leaves than the stems. The species of *Brachiaria* gave higher values for energy than the fodder grasses, Guinea or Napier. The starch equivalent value of both leaf and stem decreased with less frequent cutting, probably due to the increase in fibre content under such management.

In graph 2 the crude protein and starch equivalent values of the leaf and stem fractions are expressed as percentages of the respective values found in the corresponding composite samples. The leaf fraction is richer in crude protein and particularly starch equivalent than the corresponding stem fraction,—the disparity being more pronounced with less frequent cutting. Since animals, by selectivity in grazing, tend to gather the more leafy portion of the herbage, the herbage consumed by the animals is of greater nutritive value than the herbage offering (as represented by the composite sample). Composite sampling thus under-estimates the nutritive value of the feed actually consumed by the grazing animal. Assessments of nutritive value of the herbage consumed, based on the leaf fraction, on the other hand presume that selectivity on the part of the animal is at its maximum, and therefore represent an over-estimate. A certain percentage depending on the leaf-stem ratio in the herbage offering, must therefore be deducted from the nutritive value of the leafy component, in order to allow for the stem consumed by the grazing animal.

SUMMARY

The leaf stem ratio of six tropical grasses was found to be influenced more by the frequency of defoliation than by nitrogen fertiliser levels. An interval of 30 days between successive defoliations resulted in the highest quality herbage, characterised by a high proportion of leaf. Nitrogen decreased the leafy component of herbage. Since the leaf is considerably richer in nutrients than the stem, and the grazing animal selects the more leafy component of the herbage offering, estimation of the nutritive value of the herbage consumed, on the basis of the composite sample, results in serious under-estimation.

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LEAF-STEM RATIO STUDIES IN SIX GRASSES

TABLE 1.—Ratio of Leaves to Stems (stems taken as unity)—Averages

Nitrogen Levels	Defoliation Intervals												G.T.
	30 Days				60 Days				90 Days				
	N0	N1	N2	Total	N0	N1	N2	Total	N0	N1	N2	Total	
<i>Grasses—</i>													
<i>1st Year:</i>													
Napier	11.5	9.5	8.3	29.3	2.5	3.3	2.5	8.3	1.1	0.8	0.8	2.7	40.3
Guinea	15.9	8.4	7.5	31.8	5.1	2.7	3.0	10.8	1.6	1.5	0.9	4.0	46.6
Br. ruz.	2.9	2.4	2.5	7.8	2.3	1.8	2.1	6.2	3.8	1.6	1.1	6.4	20.4
Br. bz.K	1.7	1.6	1.6	4.9	2.0	1.9	1.9	5.8	1.5	1.2	0.9	3.6	14.3
Br. bz. T	1.3	1.3	1.4	4.0	1.2	1.6	1.4	4.2	1.7	1.4	1.3	4.4	12.6
Br. mutica	0.7	0.8	0.8	2.3	0.5	0.5	0.5	1.5	0.5	0.4	0.4	1.3	5.1
Total	34.0	24.0	22.1	80.1	13.6	11.8	11.4	36.8	10.2	6.9	5.3	22.4	139.3
Average	5.7	4.0	3.7	4.5	2.3	2.0	1.9	2.0	1.7	1.2	0.9	1.2	—
<i>2nd Year</i>													
Napier	22.5	22.2	16.8	61.5	3.8	6.6	4.0	14.4	3.4	2.2	1.9	7.5	83.4
Guinea	42.0	28.6	17.6	88.2	8.0	6.2	4.2	18.4	4.3	2.3	2.0	8.6	115.2
Br. ruz.	8.6	8.8	6.1	23.5	7.1	6.6	5.3	19.0	3.8	2.0	3.0	8.8	51.3
Br. bz. K	4.2	5.1	5.1	14.4	3.4	2.7	2.8	9.0	2.4	2.3	1.5	6.2	29.6
Br. bz. T.	1.6	1.7	1.8	5.1	1.6	2.2	2.0	5.8	2.0	1.8	1.5	5.3	16.2
Br. mutica	0.8	0.7	0.8	2.3	0.6	0.5	0.5	1.6	0.5	0.5	0.5	1.5	5.4
Total	79.7	67.1	48.2	195.0	24.5	24.8	18.8	68.1	16.4	11.1	10.4	37.9	301.1
Average	13.3	11.2	8.0	10.8	4.1	4.1	3.1	3.8	2.7	2.0	1.7	2.1	—

TABLE 2.—Ratio of the Chemical Constituents of Leaves to Stems (Stems taken as unity)—Averages

Chemical constituents :—Crude Proteins (C.P.), Crude Fibre (C.F.), Total Ash (T.A.) and calculated Starch Equivalents (S.E.)

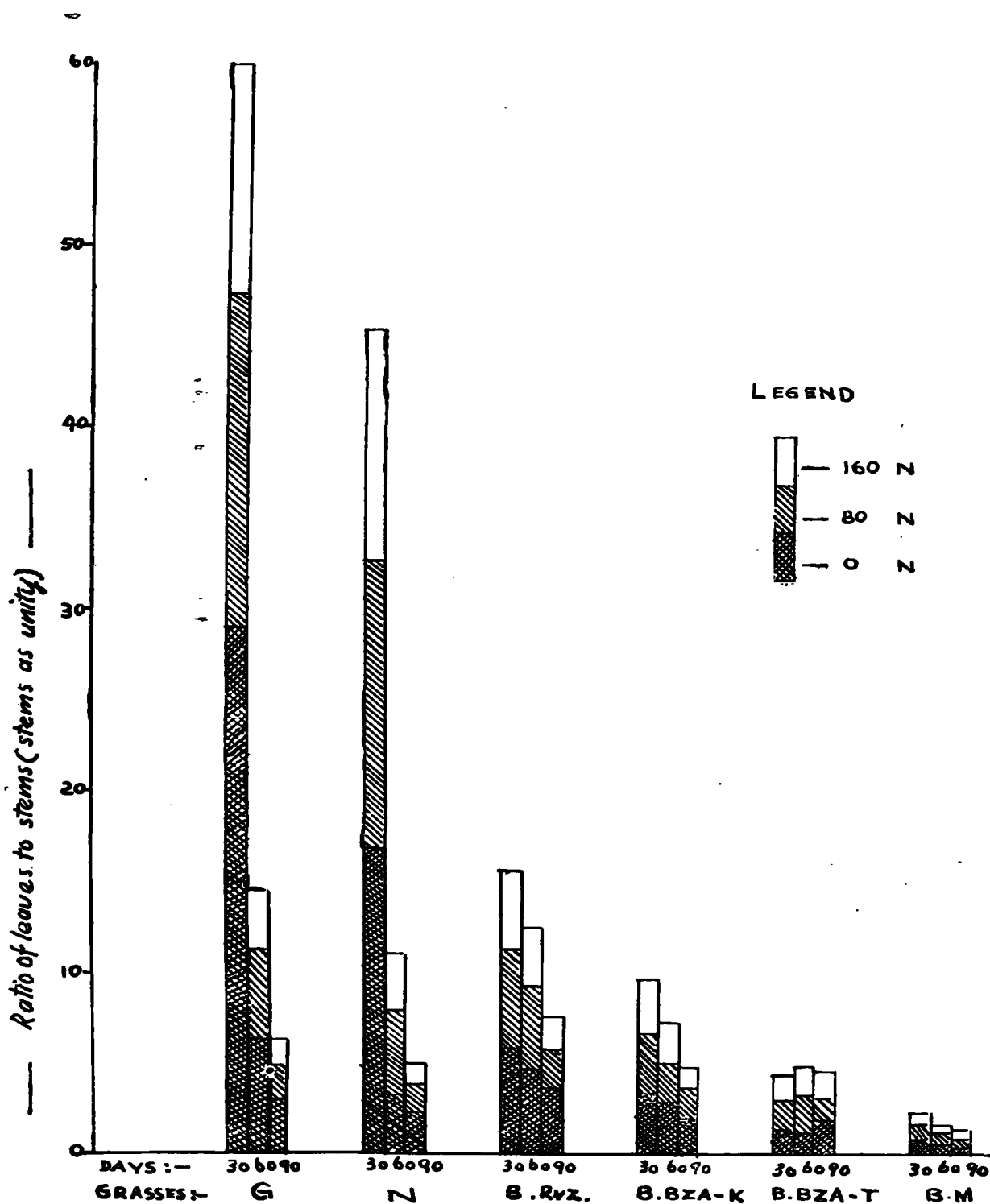
Defoliation intervals :—		30 Days			60 Days			90 Days		
Grasses	Ch. com.	N0	N1	N2	N0	N1	N2	N0	N1	N2
Napier	C.P. ..	2.0..	1.59..	1.45..	2.13..	2.24..	1.91..	1.68..	1.36..	1.97
	C.F. ..	0.91..	0.90..	0.91..	0.91..	0.92..	0.92..	0.89..	0.89..	0.84
	T.A. ..	1.20..	1.15..	1.14..	1.34..	1.31..	1.36..	1.17..	1.12..	1.14
	S.E. ..	1.16..	1.18..	1.14..	1.15..	1.14..	1.14..	1.28..	1.25..	1.54
Guinea	C.P. ..	1.83..	1.74..	1.36..	1.96..	1.93..	2.01..	2.43..	2.15..	1.92
	C.F. ..	0.92..	0.85..	0.88..	0.84..	0.83..	0.83..	0.86..	0.85..	0.84
	T.A. ..	1.45..	1.41..	1.33..	1.25..	1.46..	1.49..	1.29..	1.56..	1.36
	S.E. ..	1.13..	1.28..	1.23..	1.28..	1.30..	1.31..	1.39..	1.45..	1.46
Br. ruz.	C.P. ..	2.12..	2.12..	2.02..	2.14..	2.09..	1.70..	2.13..	1.35..	1.42
	C.F. ..	0.83..	0.81..	0.80..	0.85..	0.86..	0.87..	0.80..	0.76..	0.81
	T.A. ..	1.35..	1.54..	1.26..	1.29..	1.28..	1.26..	1.33..	1.31..	1.38
	S.E. ..	1.22..	1.25..	1.28..	1.22..	1.21..	1.19..	1.38..	1.48..	1.39
Br. bz.-K	C.P. ..	2.26..	2.38..	2.34..	2.19..	2.32..	2.29..	4.28..	2.93..	2.29
	C.F. ..	0.81..	0.80..	0.79..	0.87..	0.90..	0.91..	0.81..	0.86..	0.86
	T.A. ..	1.45..	1.48..	1.38..	1.34..	1.47..	1.39..	1.30..	1.26..	1.21
	S.E. ..	1.26..	1.30..	1.38..	1.19..	1.13..	1.13..	1.37..	1.28..	1.29
Br. bz.-T	C.P. ..	2.01..	1.92..	2.27..	2.17..	2.06..	2.43..	1.96..	0.92..	0.96
	C.F. ..	0.85..	0.86..	0.81..	0.88..	0.88..	0.86..	1.98..	0.90..	1.02
	T.A. ..	1.27..	1.34..	1.33..	1.36..	1.60..	1.28..	1.78..	0.94..	1.20
	S.E. ..	1.26..	1.20..	1.25..	1.20..	1.20..	1.22..	1.13..	1.17..	1.00
Br. mutica	C.P. ..	2.10..	2.22..	2.26..	3.26..	2.95..	2.55..	2.34..	2.64..	2.98
	C.F. ..	0.82..	0.80..	0.83..	0.87..	0.88..	0.85..	0.93..	0.92..	0.91
	T.A. ..	1.37..	1.41..	1.41..	1.58..	1.61..	1.49..	1.31..	1.45..	1.47
	S.E. ..	1.29..	1.36..	1.27..	1.18..	1.17..	1.21..	2.10..	1.11..	1.11

TABLE 3.—Analysis of Variance

Treatments		Calculated F values	
		1st Year	2nd Year
1.	Grasses ..	102.9**	181.5**
2.	Cuttings ..	95.1**	159.1**
3.	Nitrogen ..	15.7**	11.9**
4.	Grasses × Cuttings ..	16.7**	10.6**
5.	Grasses × Nitrogen ..	1.7	2.0
6.	Cuttings × Nitrogen ..	7.6**	6.12**
7.	Grasses × Cuttings × Nitrogen ..	1.0	1.9
	Coefficient of Variation ..	5.2	5.4

LEAF-STEM RATIO STUDIES IN SIX GRASSES

GRAPH 1.—The Ratio of leaves to stems (stems as unity) in different Grasses at different cutting frequencies and at different Nitrogen Levels (Average for two years)



GRAPH 2.—The variability of the values of crude Proteins and Starch Equivalents from that of the composite sample—
expressed in percentage of variability from the composite sample

