THE EFFECT OF CUTTING INTERVAL ON THE YIELD AND NUTRITIVE VALUE OF SOME TROPICAL LEGUMES ON THE COASTAL GRASSLAND OF GHANA

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ABSTRACT

The yield, persistence and nutritive value of eight tropical legumes cut at intervals of 60, 90, or 120 days were studied for one year to assess their value for standing hay on the Coastal Grassland of Ghana.

Aeschynomene americana and Cajanus cajan produced the highest dry matter yield averaged over the three cutting intervals of about 5 t ha⁻¹ yr⁻¹ and Clitoria ternatea the lowest yield of 2.6 t ha⁻¹ yr⁻¹. Under the harvesting regimes imposed, only siratro and centro showed acceptable persistence while Aeschynomene demonstrated excellent regeneration ability from self-sown seed even at 90 days of cutting.

Average leaf crude protein (CP) was highest for Aeschynomene and Clitoria (c. 25%), and least for Stylosanthes humilis (15%). Macroptilium lathyroides, M. atropurpureum, Cajanus cajan, Stylosanthes humilis and Clitoria ternatea had a decreasing leaf CP content with increasing cutting interval from 60 to 120 days while Centrosema pubescens, Desmodium intortum and Aeschynomene americana recorded their highest leaf CP at 90 days.

Stem crude fibre (CF) levels were lowest for Clitoria (<20%), c. 23% for siratro and above 30% for the remaining legumes. Leaf CF levels, which averaged 25% over all legumes, were consistently lower than stem CF.

Significant variable response to cutting interval was exhibited by the legumes for ether extract, nitrogen free extract, P and Ca levels.

INTRODUCTION

Seasonal imbalance between pasture production/quality and animal requirements remains one of the most serious problems retarding the development of the livestock industry in West Africa. The dominant grass species in the natural pasture have low yields of only 3-4 t ha⁻¹ of dry matter annually and are poor in quality resulting in a low carrying capacity of at best one 300 kg beast to about 3 ha of native grassland.

The role of pasture legumes in improving the yield and quality of legume-grass associations is well authenticated. For example, increased animal performance and carrying capacity were obtained when legumes were successfully introduced into native pastures in Queensland (Shaw 1961, 1978; Tothill 1974). Although the factors which influence the yield and quality of herbage would include the nutrient status of the soil and local climate and management, the stage of growth of the herbage plant is by far the most important factor in terms of nutritive potential (Sullivan 1969). Data provided by Milford (1967) and Ademosun (1970) on some tropical legumes showed that yield, measured in terms of dry matter, increased with advancing stage of growth. On the contrary, the nutritive value of the forage showed a gradual decline as the plant matured (Ademosun 1970; Oyenuga 1957). Wilson and Lansbury (1958) observed the potential of Centro for ground cover and as a forage crop in cleared rain-forest of Ghana.

The problem of selecting pasture legumes to improve the year-round quality of available forage on the coastal grassland of Ghana is difficult because of the adverse climate and the prevailing extensive livestock management systems. Suitable pasture legumes must not only be able to withstand recurrent droughts and bushfires, total neglect and continuous grazing, but also be capable of competing with the native grasses and aggressive, unpalatable resident weeds.
The objective of this study was to assess the yield, nutritive value and persistence of eight tropical legumes under three harvesting regimes to ascertain their potential for standing hay.

MATERIALS AND METHODS

The study was conducted at the Agricultural Research Station, Legon, of the University of Ghana, located on the Western side of the Accra Plains (lat 5–6°N). The underlying soil consisted of Simpa-Agawtaw Series belonging to the vertisol classification. Rainfall occurs in two distinct seasons with a high peak about June and a smaller one about October separated by two dry seasons of unequal length (August–September and November–March). The average annual rainfall is about 880 mm.

The experiment consisted of a split plot design with the eight legume species as the main plots and the cutting intervals (60, 90 and 120 days) as the sub-plots with three replicates each. The forage legumes studied were Centrosema pubescens (centro), Desmodium intortum (desmodium), Aeschynomene americana (jointed-vetch), Macroptilium lathyroides (phasey bean), M. atropurpureum (siratro), Cajanus cajan (pigeon pea), Stylosanthes humilis (Townsville stylo) and Clitoria ternatea.

The year-old established legume plots, each measuring 4.5 × 3 m received fertilizer application at an annual rate of 22 kg ha⁻¹ P₂O₅ as single superphosphate and 44 kg ha⁻¹ K₂O as muriate of potash. After the major wet season, the established plots were cut back to about 7.5 cm for the stoloniferous species (centro, siratro, stylo and Clitoria) and 15 cm for the erect species (desmodium, aeschynomene, phasey bean and pigeon pea) on August 28, 1980 and each legume plot was subdivided into three sub-plots with distinct boundaries. The three harvesting treatments were then randomly assigned to the subdivisions. Harvesting of sub-plots was made on the 60th, 90th and 120th day from cutback and repeated at these intervals throughout the year.

A quadrat frame of 0.84 m² in each sub-plot was cut to a height of about 15 cm for erect legumes and 7.5 cm for trailing legumes. Fresh weight was recorded and a representative sub-sample was removed, weighed and bagged for dry matter content and yield determination. A second sub-sample was separated into leaves and stems for quality determination. The sub-samples were oven-dried at 60°C for 48 hours and re-weighed before being ground in a Wiley mill to pass a 1 mm sieve. All ground samples were re-dried and placed in CaCl₂ desiccators immediately before analysis. The proximate composition of the sample was determined using the Weende method.

Calcium was estimated by the oxalate permanganate method (AOAC 1970) and phosphorus colorimetrically as vanadate (Jackson 1958).

The percentage cover of plots by legumes under each treatment was estimated using a divided quadrat at the beginning of the experiment in August, 1980 and then a year later in July, 1981 to determine their persistence.

All data were subjected to statistical analysis and are presented graphically.

RESULTS

Annual dry matter yield

Annual dry matter yield of all eight legumes increased significantly with a longer cutting interval (Fig. 1a).

The average DM production over all legumes at 60, 90 and 120 days regrowths was 2.9, 3.6 and 4.8 t ha⁻¹ annually, respectively. Although the highest yield of 6.2 t ha⁻¹ was recorded for Aeschynomene at 120 days regrowth, the mean production of that crop over the three cutting intervals (4.7 t ha⁻¹) was similar to the mean yield of pigeon pea (4.9 t ha⁻¹). The lowest DM yield of 2.6 t ha⁻¹ was observed for Clitoria.

Persistence

The percentage ground cover of the established legume in the stands at the onset of the experiment ranged from 45% for pigeon pea to 73% for Aeschynomene (Fig. 1b).
The effect of cutting at intervals of 60 (H), 90 (M) and 120 (L) days throughout the year on the (a) annual dry matter yield and (b) persistence of eight tropical legumes. Significance level: NS, non significant; * P < 0.05.

Aeschynomene was the only legume to increase % ground cover during the course of the experiment. Siratro and centro also showed good persistence with their best recovery at cutting every 90 days. All the other species showed lack of persistence as a result of severe weed competition and the long dry season, especially at frequent cutting intervals. At the cutting height of 15 cm, the ground cover of pigeon pea was drastically reduced to under 2% even with a cutting interval of 120 days.

**Crude protein**

Crude protein (CP) levels in the leaf were much higher than in the stem (Fig. 2a). The legumes could be separated into two groups regarding their response in leaf CP content to cutting interval but behaved similarly regarding their stem CP response. Phasey bean, siratro, pigeon pea, stylo and Clitoria exhibited a decreasing leaf CP content with longer cutting interval, while centro, Desmodium and Aeschynomene recorded their highest leaf CP at 90 days of regrowth. The mean leaf CP was best for Aeschynomene and Clitoria with 25.2% and 24.0% respectively, followed by centro, siratro and pigeon pea with respective mean values of 21.5, 20.9 and 21.4%. The lowest leaf CP value of 14.6% was obtained for stylo.

Stem CP levels were generally less variable than leaf CP, with pigeon pea, a woody plant, having much the lowest average value of 6.8%. Except for Aeschynomene, all the legumes produced their highest stem protein at the 60 day regrowth and least at the 120 day regrowth.
FIGURE 2

The effect of cutting at intervals of 60 (H), 90 (M) and 120 (L) days throughout the year on the content of (a) crude protein, (b) phosphorus and (c) calcium in the leaf (shaded block) and stem (open block) of eight tropical legumes. Significance level: NS, non significant: * P < 0.05; ** P < 0.01.
Phosphorus

Phosphorus content in leaves was higher than in stem for all legumes (Fig. 2b) but the response of phosphorus level to cutting interval was variable for the different legumes. Leaf phosphorus level showed a progressive drop with longer cutting interval for Desmodium and Aeschynomene; a rise and fall pattern for centro and pigeon pea; a drop and rise for phasey bean, stylo and Clitoria but a progressive rise for siratro. The least and highest phosphorus contents in leaves were measured for phasey bean (0.23%) and Desmodium (0.39%), respectively. Stem phosphorus level was remarkably low in pigeon pea (0.09%).

FIGURE 3

The effect of cutting at intervals of 60 (H), 90 (M) and 120 (L) days throughout the year on the content of (a) crude fibre, (b) ether extract and (c) nitrogen free extract in the leaf (shaded block) and stem (open block) of eight tropical legumes. Significance level: NS, non significant; * P < 0.05; ** P < 0.01.
Calcium

With the exception of centro (at 60 and 90 days cutting), stylo (at 60 days) and Clitoria (at 90 days), the level of calcium in the stem was higher than in the leaves (Fig. 2c). Again the legumes were extremely variable in the change in calcium content with cutting interval. Clitoria maintained quite an outstanding calcium content throughout its growth in both leaf (2.3%) and stem (2.4%). For the remaining legumes, the leaf calcium content was more than 1.5% only for stylo and centro in the 60 day regrowth and phasey bean and siratro in the 90 day regrowth.

Crude fibre

A progressive significant increase in crude fibre (CF) content of both stems and leaves was observed for all legumes with longer cutting interval (Fig. 3a). Stem CF levels were higher than those for the leaves in all treatments except Clitoria which had equal leaf and stem CF levels for the 120 and 90 day regrowths and a higher leaf CF than in the stem for the 60 day regrowth. Siratro and Clitoria, both creeping plants, had much lower CF contents than the remaining legumes. For example leaf and stem CF contents averaged 15.4 and 20.8% in siratro and 15.3 and 22.9% in Clitoria, respectively, values which were much lower, than those for the other legumes.

Ether extract

The ether extractives (EE) from the leaves were consistently higher than from the stems (Fig. 3b). However, no consistent pattern emerged in the response of either the leaf or stem EE to cutting interval. Pigeon pea had the highest average leaf EE level of 4.3%, owing to a very high value of 5.8% in its leaves at 60 days regrowth while stylo contained the lowest overall leaf EE of 2.3%. Average values for the other legumes were, Clitoria 3.4%, centro 3.2%, Aeschynomene 3.2%, siratro 2.9% and Desmodium 2.7%. Stem EE content was lowest in Stylo (1.3%) then phasey bean (1.7%) and Aeschynomene (1.9%). Stem EE for the other legumes ranged between 2.1 and 2.4%.

Nitrogen free extract

The prominent aspects of the nitrogen free extract (NFE) data (Fig. 3c) were the variable responses exhibited by the different legumes to cutting interval; the remarkably high levels measured for Clitoria compared to the other legumes; the higher levels of NFE obtained for the stems than leaves in most cases except the 120 and 90 day regrowths of siratro; and the much lower levels recorded in the leaves of Aeschynomene compared to leaves of the other legumes.

Generally, cutting interval had little effect on stem NFE contents. Clitoria had the highest stem NFE of 66.3% followed by pigeon pea 52.0%, stylo 51.8%, centro 49.6%, phasey bean 49.3%, Desmodium 48.3%, siratro 47.6% and Aeschynomene 46.6%.

DISCUSSION

The increased DM yield from 2.9 to 4.8 t ha\(^{-1}\) with increased cutting interval from 60 to 120 days underscores the controlling effect of management on forage legume DM production. However, except for centro, phasey bean and Clitoria, persistence of the legumes was influenced more by other extraneous factors than cutting interval. The high ground cover shown by Aeschynomene during the second wet season was due to a high regeneration from seed and also to seedlings with a
significant competitive ability against weeds. The competitive ability of Desmodium, phasey bean and stylo against resident weeds under prevailing conditions was unsatisfactory. Cutting to a 15 cm stubble proved destructive to pigeon pea with the total DM yield reported for it being obtained only from the initial cut, followed by plant death.

The decrease in mean CP from 22.5 to 17.5% for leaves and 11.9 to 9.4% for stems with longer cutting interval, and the accompanying increase in mean CF from 20.0 to 26.8% for leaves and 27.1 to 31.9% for stems, were indicative of decreasing forage quality with age. The classic concept of a herbage plant growing to maturity envisages a relatively rapid intake of minerals at early growth stages with a relatively slow production of dry matter. Subsequently dry matter production outstrips mineral intake and due to a natural dilution process, mineral contents decline. Tenable though this model is, exceptions occur with different species and elements, and under varying conditions of soil moisture and nutrient availability (Butler and Bailey 1973) as observed for Ca and P in this experiment. Generally the levels of nutrients measured were in agreement with data compiled by Skerman (FAO 1977).

Efficient forage utilization for animal products demands wise compromises between quantity and quality (Ivins et al. 1958) but as cautioned by Blaser et al. (1973) and Mott (1973) this concept of making wise compromises between yield and quality only relates to the animal. It often does not take into consideration the optimal requirement for the plant species in the pasture and, for persistence of certain forage species, a lower harvesting pressure even into the under utilization range, may be desirable.

Regarding the choice of legumes, all entries had much higher CP content than is obtained with the native grasses (3–7%, CP). The level of phosphorus in the leaves of all legumes was consistently above the 0.2% level which would satisfy livestock dietary maintenance requirement (NRC 1970) during the dry season. However, the phosphorous level in the stems of pigeon pea, phasey bean and mature (120 day regrowth) Aeschynomene were far below the maintenance level. Calcium levels measured in both the stems and leaves (above 0.8%) were far above livestock dietary requirements (NRC 1970). Although Clitoria recorded significantly higher levels of CP and NFE, the yield obtained was very low at all cutting intervals. Aeschynomene recorded high DM yield, CP, and excellent reseeding ability, but a rather fast physiological development lead to a short life cycle, early loss of leaves and a stemmy development which is obviously a disadvantage for standing hay. Desmodium, phasey bean, stylo and pigeon pea recorded poor persistence under the prevailing conditions.

Centro and siratro appeared the best legumes in terms of yield, quality and persistence for standing hay under the test conditions. They should be harvested at between 60 and 90 days interval for the best results. The experiment has demonstrated the variable potential of tropical legumes for improving the quality of the dry season livestock diet on the coastal grassland of Ghana. The role of centro, siratro and more drought tolerant introductions in the genera *Stylosanthes* and *Desmanthus* needs further long term investigation.

**REFERENCES**


TESTING NEW CENTROSEMA GERMLASM FOR ACID SOILS

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ABSTRACT

Adaptation of Centrosema to an acid Ultisol (pH 4.1, 89% Al saturation), was assessed using a collection of 133 accessions representing 12 species, in a preliminary evaluation trial conducted at Santander de Quilichao, Colombia. On the basis of vigour ratings over a period of 21 months, the tested germplasm was classified into 7 cluster groups. All accessions of C. angustifolium, C. pascuorum, C. plumieri, C. sagittatum, C. schottii, C. virginianum, and some C. brasiliannum and C. pubescens accessions, were poorly adapted to the soil at the site. All accessions of C. macrocarpum, C. arenarium and an undescribed species (Centrosema sp.n.), and several C. brasiliannum and C. pubescens accessions, grew well. Rhizoctonia foliar blight mainly affected C. brasiliannum. Pseudomonas bacterial blight mainly affected Centrosema sp.n. and C. schiedeanum.

In a second experiment, 12 selected accessions of C. macrocarpum, Centrosema sp.n., C. brasiliannum, C. pubescens, and C. schiedeanum were compared under cutting over a 24-month period. C. macrocarpum outyielded the other species by 50–100%. Centrosema sp.n. and C. schiedeanum also grew well. Leaf:stem ratio was highest in the non-adapted commercial C. pubescens control and below average in C. macrocarpum and C. brasiliannum. The capacity to root on trailing stems was best in C. pubescens, C. schiedeanum, and one of the Centrosema sp.n. accessions, and practically non-existent in C. brasiliannum. Forage quality of the acid soil-tolerant accessions compared favorably with the commercial control.

INTRODUCTION

The genus Centrosema comprises about 35 recognized species of herbaceous tropical legumes (Clements and Williams 1980). Of these, essentially only C. pubescens has attained economic importance as a forage plant and as a cover crop in plantation agriculture. A high proportion of published Centrosema research deals with this species (e.g. reviews by Teitzel and Burt (1976), and Clements et al. 1983). However, due to lack of adaptation to acid soils with high Al saturation (Clements et al. 1983), C. pubescens has had no impact in those areas of tropical America which are characterized by acid, infertile Oxisols and Ultisols (pH 4–5; up to 90% Al saturation) and these areas extend over more than 400 million ha (Cochrane 1982). In recent years, scientists from the CIAT Tropical Pastures Program have developed a pasture plant germplasm base for acid soil areas. This effort has included an attempt to broaden the genetic base of the Centrosema collection. Systematic collecting missions were undertaken, with emphasis on the acid soil regions of tropical America (R. Schultze-Kraft 1985). As a result the CIAT Centrosema collection now comprises some 1450 accessions representing 28 species. Sixty-one percent of the collection consists of species other than C. pubescens.