Forage yield and soil improvement potential of some annual and short-term perennial legumes at two sites in Ghana

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SUMMARY

Six annual and semi-perennial legumes were evaluated for forage production and their effect on soil properties at two sites, Pokoase (transition zone) and Nyankpala (Guinea savanna zone). The common legumes evaluated at the two sites were *Lablab purpureus, Desmodium distortum, Crotalaria ochroleuca,* and *Macroptilium lathyroides,* whilst *Clitoria ternatea* was additionally evaluated at Nyankpala and *Mucuna pruriens* was additionally evaluated at Pokoase. Herbage yields and herbage chemical composition were determined at the two sites. Soils under the different legumes at Pokoase were also analysed for nitrogen, extractable phosphorus, exchangeable potassium, and organic carbon contents. The large-leaved climbing and decumbent species *L. purpureus* and *M. pruriens* as well as the erect *M. lathyroides* showed very good attributes in forage production and soil improvement properties. Herbage yields in the three species at the Pokoase site exceeded 6 t/ha and produced high crude protein contents in the range 14.71 to 17.38 per cent. The soils under *L. purpureus* and *M. pruriens* showed high N contents (> 0.5 per cent) whilst *M. lathyroides* improved soil organic carbon best. *Macroptilium lathyroides* also showed the highest contents of available P and exchangeable K in soil under it compared to the other legumes.

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RÉSUMÉ

BARNES, P.: *Le rendement de fourrage et le potentiel d'amélioration du sol de quelques légumineuses annuelles et vivaces à court terme aux deux emplacements au Ghana.* Six légumineuses annuelles et semi-vivaces étaient évaluées pour la production de fourrage et leur effet sur les propriétés de sol à deux emplacements: Pokoase (zone de transition) et Nyankpala (zone de savane guinéenne). Les légumineuses communes évaluées à deux emplacements étaient-*Lablab purpureus, Desmodium distortum, Crotalaria ochroleuca* et *Macroptilium lathyroides* tandis que *Clitoria ternatea* était évaluée de plus à Nyankpala et *Mucuna pruriens* était évaluée de plus à Pokuase. Dans l'évaluation les rendements d'herbages et la composition chimique d' herbage étaient déterminés aux deux emplacements. Les sols sous les légumineuses différentes à Pokoase étaient également analysés pour l'azote, le phosphore extractible, le potassium échangeable et les contenus de carbone organique. L'étude montrait que les espéces grimpantes et décombantes à grande feuille *L. purpureus* et *M. pruriens* ainsi que la verticale *M. lathyroides* montrait de trés bons attributs en production de fourrage et en propriétés d' amélioration du sol. Les rendements dans les trois espéces à l'emplacement de Pokoase excédaient 60 t/ha et produisaient le contenu de protéine brute dans la variation de 14.71 et 17.38 pour cent. Les sols sous *L. purpureus* et *M. pruriens* montraient les contenus d' azote élevés (> 0.5 pour cent). Tandis que *M. lathyroides* améliorait le carbone organique du sol la meilleure. *Macroptilium lathyroides* montrait également les contenus les plus élevés de phosphore disponible et de potassium échangeable dans le sol sous elle par comparaison avec les autres légumineuses.

Introduction

Leguminous plants have been recognized by many agronomists as having the best potential to contribute significantly to the maintenance of

nitrogen levels, organic matter content, and physical properties of soils in continuously cropped or overgrazed land. According to COMBS (1995), legumes can be integrated into cropping systems as cover crops, live-mulch, fodder, or food crops through alley farming, planted fallow, or multiple cropping systems. COMBS (1995) also observed that legumes can contribute best to weed suppression if they have a vigorous early growth and cover the soil quickly. Climbing legumes like *Mucuna* probably suppress erect and tall-growing grasses more than bush-type legumes such as *D. distortum* and *C. ochroleuca.*

Extensive evaluation of forage legumes over the years in Ghana (Barnes, 1985; 1996; Adjei & Fianu, 1985) have shown that many annual and semi-perennial ones are fast growing and capable of covering the soil rapidly and totally. Because of their fast growth, high herbage production, and quick soil cover, some of these legumes need to be evaluated for their usefulness as forage and control of common weeds.

Cobbina (1992) studied herbage yield and soil fertility restoration potential of some forage legumes over a 2-year period, and found that *Stylosanthes guianensis* cultivars, *Pueraria phaseoloides,* and *Centrosema macrocarpum* produced high herbage dry matter yields (9-16 t/ha). The same legumes produced high herbage N contents and caused significant improvements in soil organic carbon, but not in extractable phosphorus or exchangeable potassium.

This study aimed at ascertaining the forage yields in the main growing season, the quality of forage, and soil improvement attributes of some annual and short-term perennial legumes.

Materials and methods

The study was conducted at two sites, Nyankpala (9°25'N, 1°00'W, 200 m alt.) in the Guinea savanna zone and Pokoase (5° 40'N, 0° 18'W, 152 m alt.) in the coastal savanna forest transition zone. The average annual rainfall at Nyankpala is about 1060 mm but in the year of the trial in 1995, the total rainfall was 996.2 mm, slightly below average. The average annual rainfall at Pokoase is 1080 mm but in the year of the trial in 1996, the total rainfall was 753.0 mm, well below average.

The soil at the Nyankpala trial site had the following physical and chemical properties at the 0-10 cm depth: sand, 61.7 per cent; silt, 28.8 per cent; clay, 9.5 per cent; *p*H (water), 6.1; O.M., 0.92 per cent; N, 0.44 per cent; and available P, 3.49 ppm. The soil at the Pokoase trial site had the following features at the 0-10 cm depth: sand, 80.34 per cent; silt, 12.64 per cent; clay, 7.02 per cent; *pH* (water), 5.86; N, 0.13 per cent; available P, 2.10 ppm; available K, 55 ppm; and O.M., 2.61 per cent.

The trials conducted at the two sites were laid down in a randomized block design with three replicates for each site. The legume entries for both stations were *C. ochroleuca, D. distortum, L. purpureus,* and *M. lathyroides*. Besides, Pokoase had *M. pruriens* whilst Nyankpala had *C. ternatea*. At Nyankpala, the plot size for each legume species was 17 m × 3 m with 1 m borders. These legumes were sown on 20 Jun 95 at a spacing of 50 cm × 50 cm. At harvest time on 7 Dec 95, two 1-m^2 quadrats were used per plot and herbage was harvested at ground level. Subsamples from the harvests were dried at 60 °C for 72 h for dry matter yield determination. At Pokoase, the plot size for each legume entry was 15 m × 5 m with 1 m borders between plots. The trial was sown on 24 Jun 96 at plant spacing of 1 m × 50 cm and harvested on 30 Nov 96. Harvested samples were subsampled for dry matter yield estimates as was done in the Nyankpala trial.

The two harvests at the two sites were chemically analyzed for crude protein, ash, and calcium contents according to AOAC (1984) guidelines.

The soils under the legumes at the Pokoase site were chemically analyzed only according to methods outlined by IITA (1979).

Results

Table 1 presents herbage yield and some chemical

TABLE 1

Herbage Yield (kg/ha), Crude Protein (percent), Ash (percent) and Calcium (percent) of the Herbage of the Legume Entries in the Study after 170 Days Growth Period in the Field at Nyankpala

Legume entry	*Herbage dry matter (kg/ha)*	*CP (%)*	*Ash (%)*	*Ca (%)*
Clitoria ternatea	159.0c	12.76b	9.24b	1.09c
Crotalaria ochroleuca	-	-	-	-
Desmodium distortum	159.7c	13.46b	11.00b	2.97ab
Lablab purpureus	661.3a	20.66a	11.26b	2.22b
Macroptilium lathyroides	406.3b	14.81b	13.78a	3.37a
Mean	346.6	15.42	11.32	2.41
LSD (0.05)	175.72	3.75	2.50	0.98
CV (%)	25.4	12.2	11.1	20.4

Means in a parameter column with different letters are significantly different ($P<0.05$).

composition parameters at Nyankpala. At the time of data collection, herbage on *C. ochroleuca* had been completely shed, but herbage yield on the remaining entries could be measured. *Lablab purpureus* and *M. lathyroides* registered the highest yield whilst *C. ternatea* and *D. distortum* produced lower but similar yields. *L. purpureus* produced significantly the highest crude protein content in herbage among the entries, with the remaining showing significantly similar levels. *Macroptilium lathyroides* had the highest ash and calcium contents.

Table 2 shows mean herbage yield, crude protein, ash, and calcium contents of herbage of the five legumes used in the Pokoase trial. There were no significant differences among the five legume entries in herbage yield. The chemical analysis showed that *C. ochroleuca* produced the highest crude protein content. The rest of the entries were similar in crude protein contents, ranging between 14.71 and 17.38 per cent. For ash and calcium contents, *L. purpureus* and *M. pruriens* showed high calcium contents.

Table 3 presents *p*H and some properties of the soils under the different legumes at Pokoase. The *p*H levels were similar, and were all just under *p*H 6 (moderately acidic). Nitrogen content of soils under the legumes showed *that L. purpureus* and *M. pruriens* contributed a lot of N in soils under them. Nitrogen content of soils under *M. lathyroides* was extremely low. Soils under the five legumes showed high contents of P and K compared to the control, indicating the contribution of the legumes in enhancing the contents of these macro minerals in soils. Soils under *M. lathyroides* and *D. distortum* had high levels of organic carbon compared to soils under the other legumes.

Discussion

Green manure crops or forage legumes are necessary in the Guinea savanna zone in contributing to soil organic matter build up. Soils in the Guinea zone are noted to have low organic carbon in the range from 0.3 to 0.8 per cent (COMBS, 1995). In the study at Nyankpala which lies in the Guinea savanna zone, *L. purpureus* had the highest forage dry matter production and crude protein content. *Macroptilium lathyroides*

TABLE 2

Mean Herbage Yield (t/ha), Crude Protein (percent), Ash (percent), and Calcium (percent) of Herbage in the Legumes under Test at Pokoase Site of the Trial from 24 Jun 96 to 30 Nov 96 (159 days)

Legume species	*Herbage[1] dry matter (kg/ha)*	*CP (%)*	*Ash (%)*	*Ca (%)*
Crotalaria ochroleuca	5289a	24.10	7.33	0.58
Desmodium distortum	4887a	16.05	7.38	1.14
Lablab purpureus	6207a	17.38	8.59	0.92
Macroptilium lathyroides	7067a	15.57	6.73	1.03
Mucuna pruriens	6845a	14.71	8.77	1.22
Mean	6059	17.56	7.76	0.98
LSD (0.05)	2634.5			

Values under CP, Ash and Ca are means (percent) of two determinations per species sample. ([1] Means with the same letters are not significantly different, $P<0.05$).

TABLE 3

Some Chemical Properties of Surface Soils under the Five Legumes at Pokoase after the Herbage Harvest

Legume species	*pH* (H_2O, 1:2.5)	*N* (%)	*Available P* (ppm)	*Available K* (ppm)	*Org.C* (%)	*Org. matter* (%)
Crotalaria ochroleuca	5.96	0.19	3.85	225.00	1.37	2.36
Desmodium distortum	5.95	0.35	3.50	225.00	1.82	3.13
Lablab purpureus	5.93	0.53	5.07	175.00	1.16	2.00
Macroptilium lathyroides	5.66	0.06	5.32	275.00	2.86	4.92
Mucuna pruriens	5.80	0.56	3.43	150.00	1.63	2.80
Original soil sample	5.86	0.13	2.10	55.00	1.52	2.61

(Values are means of two determinations per soil sample under the five test legumes).

was second to *L. purpureus* in forage dry matter production and was prominent in crude protein, ash, and calcium contents. These legumes could thus be recommended for use in green manure production ahead of the other legumes in the trial.

At Pokoase, based on the dry matter yield and chemical composition, all the five legumes evaluated could be recommended for use as forage, green manure, and crops for enhancing soil properties.

In a study of forage legume potential for use in the south-eastern USA by Brink & Fairbrother (1988), it was found that among 10 tropical and subtropical legumes which included *L. purpureus*, *M. lathyroides*, *Vigna unguiculata, Aeschymomene americana, Trifolium pratense, Medicago sativa,* and *Lespedeza* spp., it was *L. purpureus* and *M. lathyroides* which yielded the highest herbage in the first year of the study. The performance of *L. purpureus* and *M. lathyroides* in the study just referred to corroborates their performance in this study.

From the soil analysis data, it could be deduced that *L. purpureus, M. pruriens,* and *D. distortum* enhanced soil nitrogen contents about 3 to 5 times more than the control plots. COMBS (1995) reported that the contribution of *M. pruriens* and *D. distortum* to soil nitrogen were high and moderate, respectively.

According to Ogebe *et al.* (1995), soil contents of phosphorus and potassium below which the soil is considered deficient or low in both are 17 and 37 ppm, respectively. In the soil analysis data associated with the five legumes, it could be seen that phosphorus contents under all the five legumes were low and below the critical levels stipulated by Ogebe *et al.* (1995). However, potassium contents were higher than the critical level of 37 ppm suggested.

COMBS (1995) grades soil organic content (percent) of less than 0.3 as very low, 0.3-0.8 as low, and more than 0.8 as moderate. In this study, soil organic carbon content of both the control plots and those under the different legumes were higher than the 0.8 moderate level suggested by COMBS (1995). However, it was *M. lathyroides* which enhanced soil organic carbon content the most.

The study at the two sites has shown that each species evaluated for forage production and potential for improving soil properties has one merit or the other, but weighty trend of results show that *M. pruriens* and *L. purpureus* were the most promising species for forage production and amelioration of soil characteristics.

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