

Performance of mixtures of selected grasses and adapted herbaceous legumes in south-west Nigeria

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Abstract

The dry matter (DM) yields, crude protein (CP) concentration and N transfer of simple mixtures of guinea grass (*Panicum maximum*) cv. Ntchisi, elephant grass (*Pennisetum purpureum*) cv. S9 and star grass (*Cynodon nlemfuensis* var. *nlemfuensis*), and Verano stylo (*Stylosanthes hamata*) cv. Verano, centro (*Centrosema pubescens*) cv. UI13 and tropical kudzu (*Pueraria phaseoloides*) cv. UI113 were compared with those of the pure grasses, with or without urea at 200 kg N/ha/yr, and the pure legumes in a cutting trial during the rainy seasons of 1988–1990. The mixtures produced 22–154% higher total DM yields than their respective unfertilised pure grasses. The mixtures were also more effective in controlling weeds and the mixed forage had higher CP concentration than grasses alone, N-fertilised or unfertilised. Verano mixtures with star grass, guinea grass and elephant grass, which yielded on average 13.8 t DM/ha/yr, and tropical kudzu mixtures with guinea grass and elephant grass, which yielded on average 13.6 t DM/ha/yr, were as productive as N-fertilised guinea grass and star grass and pure Verano with 15.3, 13.2 and 13.4 t DM/ha/yr, respectively. The legumes transferred between 3 and 42 kg N/ha/yr to associated grasses in mixtures, but did not significantly improve the performance of the grasses. The superiority of the mixtures was, therefore, mainly due to the contributions of legumes to total forage.

Introduction

The humid zone of Nigeria, which has an 8-month rainy season and high potential for

forage production, has not been a major cattle production area, mainly because of the presence of tse-tse fly and the disease, trypanosomiasis, it transmits. In recent years, however, clearing of forest, the natural habitat of tse-tse fly, for farming and other land development activities has reduced the risk of trypanosomiasis (Bourn *et al.* 1986; Jabbar 1993). South-west Nigeria has, therefore, become more suitable for cattle production based on non-trypanotolerant breeds of cattle such as White Fulani zebu (ILCA 1990). This has encouraged settlement by nomadic Fulani herders, and cattle rearing has become more prevalent among the indigenous people of south-west Nigeria (ILCA 1990). There is also potential for the population of resident trypanotolerant small ruminants in south-west Nigeria to increase because of successful development of economic control measures for major diseases such as *pestes des petits ruminants* (PPR) (Opasina 1984).

With concurrent increase in human and ruminant livestock populations, together with intensification of arable crop cultivation, farm sizes have decreased and cultivation of land around the homestead or compound has increased. This has led to the need for greater control of free-roaming sheep and goats including total confinement and outright banning of these animals in certain villages, to forestall damage to crops (Mack *et al.* 1985). It also necessitates forage cultivation for an easily accessible feed supply for confined animals.

Poor access to feed is a major constraint to realising increased ruminant production in south-west Nigeria. Grass-legume mixtures have long been recognised as a means of providing adequate forage for ruminant livestock (Adegbola and Onayinka 1966). Grass-legume mixtures produce higher forage dry matter (DM) yields than pure grass or legume stands and there is a saving in inorganic N needed to obtain similar levels from pure grass stands (Evans 1970; Akinyemi

and Onayinka 1976). Higher liveweight gains of animals are also obtained from grass-legume mixtures than from pure grass stands (Akinyemi and Onayinka 1982) because of better forage quality. The importance of grass-legume mixtures in south-west Nigeria can be appreciated better when one realises that the livestock component is a low-input adjunct to the major arable crop component. Inorganic fertilisers are scarce and expensive and there is no tradition of forage crop cultivation in the area. Farmers are, therefore, more likely to cultivate pastures and keep animals if the pastures are productive without the necessity of inorganic fertilisation.

Through research, productive grass-legume mixtures have been identified (Oyenuga and Olubajo 1975; Akinyemi and Onayinka 1976, 1982). However, most early studies utilised unspecified genotypes of grasses or mixtures of such genotypes, which limits the value of the results. In addition, the studies did not include pure stands of grasses and legumes so that the contributions of the components of the mixtures to total DM yields and quality could not be ascertained.

Forage improvement efforts in the Department of Agronomy, University of Ibadan, Nigeria (Chheda and Akinola 1971; Chheda *et al.* 1974; Aken'Ova and Saleem 1982) have resulted in the development of specific genotypes of guinea grass, elephant grass and star grass with superior forage DM yields and quality in sole stands. There was no information on the productivity of these grasses, especially elephant grass and star grass, in mixtures with legumes. In the present study, DM yields and crude protein (CP) concentrations of these grasses in mixtures with adapted herbaceous legumes were compared with those of N-fertilised grasses and unfertilised pure stands of the grasses and legumes. The contributions of these legumes to yield and weed control were also determined while their use as sources of nitrogen for their companion grasses was compared with inorganic N fertiliser.

Materials and methods

Location

The study was conducted on the Teaching and Research Farm of the University of Ibadan, Ibadan (7°20' N, 3°50' E; 200 m above sea level), in a zone of transition between the humid forest

and wet subhumid savanna agro-ecological zones of Nigeria. Mean daily temperatures in Ibadan vary between 24°C (night-time) and 34°C and are fairly uniform throughout the year and representative of south-west Nigeria, excluding the coastal areas. Relative humidity values of 80–90% are recorded in the rainy season and 42–50% in the dry season. Average annual rainfall is about 1200 mm with up to 95% falling in the growing season (April–October). The soil of the experimental site was an Alfisol with loamy sand texture, and contained 0.02% N, 6.11 mg/kg available P (Bray 1), 0.20 cmol/kg exchangeable K, 0.20% organic C and pH (H₂O) of 6.2, at the beginning of the trial.

Establishment and field operations

In June–July 1987, stands of grasses, *viz.* star grass (*Cynodon nlemfuensis* var. *nlemfuensis*), elephant grass (*Pennisetum purpureum*) cv. S9 and guinea grass (*Panicum maximum*) cv. *Ntchisi*, and legumes, *viz.* Verano stylo (*Stylosanthes hamata*) cv. Verano, centro (*Centrosema pubescens*) cv. UI13 and tropical kudzu (*Pueraria phaseoloides*) cv. UI113, as well as grass-legume combinations were established. The experimental site was ploughed and harrowed and the grasses planted vegetatively in rows at 1 × 0.5 m spacing, except that star grass was planted at 0.5 × 0.5 m when in pure stands. Stem cuttings were used for elephant grass, crown splits for guinea grass and stolons for star grass. Legume seeds were drilled in between the grass rows at 4 kg/ha, 10 days after planting the grasses, according to local practice. Seeding rate for legumes in pure legume plots was also 4 kg/ha in rows 1 m apart. Each plot measured 3.0 × 4.5 m.

The plots were weeded manually as necessary only during the year of establishment. On March 29, 1988, all plots were cut with machetes to 15 cm above ground level, and cut forage was discarded. Regular 6-weekly harvests commenced thereafter. Five harvests were taken at 15 cm during the rainy seasons of 1988, 1989 and 1990. Plants were not cut during the dry season. At each harvest, total fresh yield from an area of 4.5 × 2 m per plot was recorded. Sub-samples were taken and separated into component species, including weeds, and each weighed fresh. The grass and legume sub-samples were oven-dried at 70°C to constant weight for the determination of DM content and thence yields. Yield advantages

of the different mixtures were compared using the Land Equivalent Ratio (LER) calculated by the equation:

$$\text{LER} = \text{LG} + \text{LL};$$

$$\text{LG} = \text{YG}/\text{SG} \text{ and } \text{LL} = \text{YL}/\text{SL} \text{ (Mead and Willey 1980),}$$

where LG and LL are the partial LER values of grass and legume, YG and YL are their yields in mixtures, and SG and SL are their respective yields in the pure stands.

Fertiliser application

A basal dressing of 300 kg/ha of 15:15:15 (N:P:K) fertiliser was broadcast at land preparation. A total of 200 kg N/ha/yr was applied as urea to designated pure grass plots in 5 equal split doses given about 10 days after each harvest, except the last one each year when conditions were too dry. Potassium (K) was applied to all plots as muriate of potash (133 kg K/ha/yr) in 1988 and 1989, and phosphorus as single superphosphate (16.4 kg P/ha) to each plot after the second harvest in 1989. Fertilisers were broadcast in the star grass, grass-legume and legume plots, but were side-dressed in guinea grass and elephant grass stands.

Chemical analyses

The grass and legume sub-samples were milled and analysed for nitrogen (N) concentration using the Kjeldahl method as described by AOAC (1990). Crude protein (%N x 6.25) concentrations of the mixtures (CP_{mix}) were estimated by the following equation:

$$\% \text{CP}_{\text{mix}} = [(\% \text{CP of grass} \times \text{DM yield of grass}) + (\% \text{CP of legume} \times \text{DM yield of legume})] / (\text{DM yield of grass} + \text{DM yield of legume}).$$

Nitrogen transfer from legume to associated grass in the mixtures was estimated using N-difference method. Thus, N yield of grass in unfertilised plots was subtracted from N yield of grass in grass-legume mixtures.

Treatments, experimental design and data analysis

As each grass was combined with each legume in mixtures, there were 9 grass-legume treatments. Another 6 treatments consisted of pure grass

stands of each of the 3 grasses with or without applied N. Finally, there were pure stands of each of the 3 legumes. Thus, there were 18 treatments in a randomised complete block design with 4 blocks. Data were analysed according to the Analysis of Variance (ANOVA) procedures of the Statistical Analytical Systems (SAS 1986). Means were separated by the Least Significant Difference (LSD) method at the 5% level of significance.

Results

Dry matter yields

Most of the components were persistent over 3 years of testing (Table 1). The exceptions involved centro, which was defoliated and weakened from June 1989 by a foliar blight caused by *Rhizoctonia solani*. Mixtures with centro and tropical kudzu had higher yields than their components grown alone. Verano alone generally yielded as much as or more than mixtures containing it, except in the first year.

Grass yield in mixtures was variable relative to unfertilised grass. Averaged over 3 years, only star grass in mixture with Verano yielded more than unfertilised pure grass. In contrast, fertilised pure star grass and guinea grass always yielded more than grass in mixture, whereas elephant grass response to fertiliser was so small that the yield of fertilised grass was no higher than grass in mixture.

Star grass and guinea grass mixtures with Verano or tropical kudzu generally had similar yields to pure fertilised grass. Centro mixtures were generally lower-yielding and elephant grass mixtures higher-yielding than comparable pure fertilised grass.

Verano and tropical kudzu produced significantly higher DM yields in pure stands than in the mixtures in each year. In the case of centro, this occurred only in 1988.

Nitrogen fertilisation of star grass and guinea grass produced significantly higher grass DM yields than association with legumes. In the case of elephant grass, average annual DM yields of N-fertilised grass and the grass in mixture with stylo or centro were similar. Star grass, with 154% higher average annual DM yield than its yield when unfertilised, exhibited better response to N fertilisation than the tall grasses, guinea grass (51%) and elephant grass (22%).

Table 1. Annual dry matter yields (t/ha) of grass (G), legume (L) and total (T) and the proportions (%) of weeds in the total herbage.

| Treatment | 1988 | | | 1989 | | | 1990 | | | Mean | | | Weed proportion |
|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|-----------------|
| | G | L | T | G | L | T | G | L | T | G | L | T | |
| Star grass with: | | | | | | | | | | | | | |
| Verano | 7.6 | 6.4 | 14.0 | 6.8 | 4.8 | 11.6 | 8.1 | 6.8 | 14.9 | 9.5 | 6.0 | 13.5 | 6 |
| Centro | 5.8 | 5.1 | 10.9 | 6.4 | 2.2 | 8.7 | 5.9 | 3.1 | 9.0 | 6.0 | 3.5 | 9.5 | 13 |
| Tropical kudzu | 6.4 | 5.1 | 11.6 | 5.9 | 3.9 | 9.8 | 5.4 | 5.6 | 11.0 | 5.9 | 4.9 | 10.8 | 2 |
| N fertiliser | 13.3 | — | 13.3 | 12.0 | — | 12.0 | 14.4 | — | 14.4 | 13.2 | — | 13.2 | 10 |
| No fertiliser | 6.3 | — | 6.3 | 3.7 | — | 3.7 | 5.5 | — | 5.5 | 5.2 | — | 5.2 | 35 |
| Elephant grass with: | | | | | | | | | | | | | |
| Verano | 11.5 | 5.1 | 16.6 | 9.7 | 3.7 | 13.4 | 8.0 | 4.7 | 12.7 | 9.7 | 4.5 | 14.2 | 5 |
| Centro | 9.9 | 4.0 | 13.9 | 9.6 | 2.7 | 12.3 | 8.6 | 2.4 | 11.0 | 9.4 | 3.0 | 12.4 | 5 |
| Tropical kudzu | 8.2 | 4.6 | 12.8 | 7.8 | 5.1 | 12.9 | 8.2 | 5.7 | 13.9 | 8.1 | 5.1 | 13.2 | 1 |
| N fertiliser | 13.0 | — | 13.0 | 9.2 | — | 9.2 | 7.8 | — | 7.8 | 10.0 | — | 10.0 | 18 |
| No fertiliser | 10.4 | — | 10.4 | 6.9 | — | 6.9 | 7.2 | — | 7.2 | 8.2 | — | 8.2 | 22 |
| Guinea grass with: | | | | | | | | | | | | | |
| Verano | 10.9 | 4.8 | 15.7 | 7.7 | 4.7 | 12.4 | 7.3 | 5.8 | 13.1 | 8.6 | 5.1 | 13.7 | 2 |
| Centro | 10.3 | 4.9 | 15.2 | 10.0 | 1.9 | 11.9 | 7.7 | 1.5 | 9.2 | 9.3 | 2.8 | 12.1 | 1 |
| Tropical kudzu | 9.3 | 4.1 | 13.4 | 10.0 | 5.0 | 15.0 | 7.5 | 6.2 | 13.7 | 8.9 | 5.1 | 14.0 | 1 |
| N fertiliser | 17.2 | — | 17.2 | 16.8 | — | 16.8 | 11.8 | — | 11.8 | 15.3 | — | 15.3 | 0 |
| No fertiliser | 11.7 | — | 11.7 | 9.4 | — | 9.4 | 9.2 | — | 9.2 | 10.1 | — | 10.1 | 10 |
| Pure legumes: | | | | | | | | | | | | | |
| Verano | — | 11.5 | — | — | 12.2 | — | — | 16.4 | — | — | 13.4 | — | 11 |
| Centro | — | 7.8 | — | — | 2.6 | — | — | 3.0 | — | — | 4.5 | — | 40 |
| Tropical kudzu | — | 8.8 | — | — | 7.6 | — | — | 9.7 | — | — | 8.7 | — | 2 |
| LSD (P<0.05) | 1.2 | 1.3 | 2.8 | 0.8 | 1.2 | 1.9 | 0.7 | 1.4 | 2.1 | 1.6 | 0.9 | 1.8 | |

In all cases, average annual DM yields of mixtures were significantly higher than those of unfertilised pure grasses. The average annual DM yields of star grass-Verano stylo, guinea grass-Verano stylo and guinea grass-tropical kudzu were not significantly different from the yields of the respective N-fertilised grasses. All elephant grass mixtures produced significantly higher average annual DM yields than the N-fertilised pure grass.

The legumes produced significantly higher average annual DM yields in pure stands than in mixtures (Table 1).

The proportionate contributions of Verano and tropical kudzu to total DM yields of the mixtures remained at the same level or increased over time (Table 2). However, proportions of centro in the mixtures declined with time, and more so in mixtures with the tall grasses than with star grass. From the second year, Verano and tropical kudzu maintained higher proportions in the respective mixtures than centro. All legumes maintained higher proportions with star grass than with the tall grasses.

Land Equivalent Ratio (LER)

The LERs of grass, legume and grass-legume mixtures are shown in Table 2. With the exception of the elephant grass in mixture with tropical kudzu, star grass and elephant grass had LER values of greater than 1, indicating their good competitive abilities, in mixtures. On the other hand, LER values for guinea grass in mixtures were less than 1. The highest LER of 1.44 was recorded for star grass in mixture with Verano. LER values of the legumes in mixtures were always less than 1 indicating the adverse competitive effects of the associated grasses. Verano and centro had higher LER values in mixture with star grass than with the tall grasses. All mixtures gave LER values of greater than 1 indicating varying yield advantages over the unfertilised pure grass plots, *viz.* 23–89% in star grass, 54–93% in elephant grass and 47–69% in guinea grass mixtures.

Proportion of weeds

All mixtures except star grass-centro had low weed levels (Table 1). Guinea grass and tropical

Table 2. Proportions of legume in total forage and land equivalent ratios (LER) of the mixtures.

| Treatment | % Legume | | | Mean | LER ¹ | | |
|----------------------|----------|------|------|------|------------------|--------|---------|
| | 1988 | 1989 | 1990 | | Grass | Legume | Mixture |
| Star grass with: | | | | | | | |
| Verano | 46 | 41 | 46 | 44 | 1.44 | 0.45 | 1.89 |
| Centro | 47 | 26 | 34 | 36 | 1.15 | 0.78 | 1.93 |
| Tropical kudzu | 44 | 40 | 50 | 45 | 1.13 | 0.56 | 1.69 |
| Elephant grass with: | | | | | | | |
| Verano | 31 | 28 | 37 | 32 | 1.18 | 0.34 | 1.52 |
| Centro | 29 | 22 | 22 | 24 | 1.15 | 0.67 | 1.82 |
| Tropical kudzu | 36 | 40 | 41 | 39 | 0.99 | 0.59 | 1.58 |
| Guinea grass with: | | | | | | | |
| Verano | 31 | 38 | 44 | 38 | 0.85 | 0.38 | 1.23 |
| Centro | 32 | 16 | 16 | 21 | 0.92 | 0.62 | 1.54 |
| Tropical kudzu | 31 | 33 | 45 | 36 | 0.88 | 0.59 | 1.47 |

¹Based on average annual dry matter yields.

kudzu had the lowest weed levels alone or in mixtures. Unfertilised grasses and pure Verano and centro had weed levels greater than 10% of the sward.

Crude protein concentration and yields and nitrogen transfer

The legumes had higher levels of CP than the grasses and had similar CP concentration in both mixtures and pure stands (Table 3). The contributions of the legumes to total CP yields of the mixtures were generally above 50%.

In general, CP yields of star grass and guinea grass in the mixtures were not significantly different from those of the unfertilised pure grasses, but were significantly lower than those of the N-fertilised pure stands (Table 3). However, the total CP yields of mixtures were significantly higher than those of unfertilised grasses and similar to those of the N-fertilised grasses. Elephant grass in mixtures with Verano and centro had higher CP yields than unfertilised grass, but similar CP yield to the N-fertilised grass. The CP yield of the N-fertilised grass was only 50–57% of those of the mixtures.

The estimated amounts of N transferred from legumes to the associated grasses are given in Table 3. There was inter-generic variation in the amount of N taken up by the grasses in the mixtures and from N fertiliser. Star grass obtained more N in mixture with Verano stylo than with the other legumes, while elephant grass benefitted the most from association with Verano and centro.

The amounts of N transferred to guinea grass from any of the legumes in the mixtures were negligible. More N was transferred to the grasses from N fertiliser than from the legumes, except for elephant grass, which obtained more N from Verano than from N fertiliser. The N-utilisation efficiencies of applied inorganic N, *i.e.* N transferred as a percentage of N applied, were 53 and 58% for guinea grass and star grass, respectively, and 15% for elephant grass.

Discussion

The present results have confirmed that these legumes can make significant contributions to DM yields and even more to CP concentrations and yields when grown in mixtures with grasses. Having legumes in mixtures also reduced the proportion of weeds.

The proportions of legumes in the mixtures were generally within the 30–50% considered desirable in grass-legume mixtures (Crowder and Chheda 1982), an indication of compatibility between mixture components. Changes in DM yields of the legumes were therefore an important determinant of total DM yields of the mixtures.

The high DM yields of the N-fertilised star grass and guinea grass confirm reports that these grasses, typical of tropical grasses, are highly responsive to N fertilisation (Chheda and Akinola 1971; Onayinka and Akinyemi 1977; Crowder and Chheda 1982). Although some elephant grass varieties respond to applied N (Akinola 1982; Mureithi *et al.* 1995), the variety used in this trial

Table 3. Crude protein concentrations and yields and estimated amounts of N transferred to associated grasses in the grass-legume mixtures and the N-fertilised plots.

| Treatment | CP concentration | | | CP yield | | | N transferred (kg/ha) |
|----------------------|------------------|--------|---------|----------|--------|---------|--------------------------|
| | Grass | Legume | Mixture | Grass | Legume | Mixture | |
| | (% DM) | | | (kg/ha) | | | |
| Star grass with: | | | | | | | |
| Verano | 7.4 | 12.3 | 9.5 | 0.55 | 0.73 | 1.28 | 29 |
| Centro | 7.3 | 17.8 | 11.0 | 0.47 | 0.62 | 1.09 | 16 |
| Tropical kudzu | 8.0 | 17.9 | 12.5 | 0.48 | 0.81 | 1.29 | 18 |
| N fertiliser | 8.5 | — | — | 1.10 | — | — | 117 |
| No fertiliser | 6.9 | — | — | 0.37 | — | — | |
| Elephant grass with: | | | | | | | |
| Verano | 7.9 | 12.1 | 9.2 | 0.80 | 0.52 | 1.32 | 42 |
| Centro | 7.8 | 18.4 | 10.3 | 0.74 | 0.54 | 1.28 | 32 |
| Tropical kudzu | 7.9 | 17.3 | 11.6 | 0.63 | 0.84 | 1.47 | 14 |
| N fertiliser | 7.3 | — | — | 0.73 | — | — | 30 |
| No fertiliser | 6.5 | — | — | 0.54 | — | — | |
| Guinea grass with: | | | | | | | |
| Verano | 6.6 | 12.0 | 8.5 | 0.55 | 0.58 | 1.13 | -13 |
| Centro | 6.2 | 17.0 | 9.1 | 0.65 | 0.44 | 1.09 | 3 |
| Tropical kudzu | 6.7 | 14.5 | 9.5 | 0.58 | 0.72 | 1.30 | -8 |
| N fertiliser | 8.4 | — | — | 1.29 | — | — | 106 |
| No fertiliser | 6.1 | — | — | 0.63 | — | — | |
| Pure legumes: | | | | | | | |
| Verano | — | 12.5 | — | — | 1.66 | — | — |
| Centro | — | 17.2 | — | — | 0.82 | — | — |
| Tropical kudzu | — | 15.9 | — | — | 1.37 | — | — |
| LSD (P<0.05) | | | | 0.13 | 0.15 | 0.20 | |

did not respond to the application of 200 kg/ha/yr of N as urea to the same extent as star grass and guinea grass. A similar result was reported by Aken'Ova and Chheda (1986), who noted that another elephant grass genotype originating in south-west Nigeria failed to produce DM yield responses when given 200 kg/ha N.

The absence of a consistent beneficial effect of legumes on DM yields of the associated grasses has been recorded in other studies (Akinyemi and Onayinka 1976; Reynolds 1982) in the tropics. It may be related to the low amounts of N transferred from legumes to grasses, and/or the competitive effects of the legumes in the mixtures as reported by Akinyemi and Onayinka (1976). The lower yields of guinea grass in mixtures than in pure stands and LER values of less than unity are due to competition with the associated legume. However, legumes are generally poorer competitors than grasses in mixtures (Haynes 1980) as confirmed by the present LER values of less than unity for the respective legumes in the mixtures. An examination of LER and N-transfer data revealed that the amount of N transferred by the legumes depended on the competitive ability

of the associated grasses. Therefore, guinea grass, which was comparatively less competitive than the other grasses, obtained the least N from the associated legumes.

The estimated 3–42 kg/ha/yr of N transferred from the various legumes to the associated grasses is comparable with the 5–23 kg/ha reported for guinea grass mixtures with several legumes by Reynolds (1982) in Samoa. Higher amounts of N were taken up by the N-fertilised grasses which exhibited superior DM yields than when grown in mixtures. Owing to the low levels of N made available by the legumes, the superiority of the CP concentrations and yields of the mixtures as compared with the pure grass stands was therefore largely due to the contributions of the legumes in the mixtures. Legumes contributed more to total CP yields of the mixtures than they did to the total DM yields.

The DM yields of tropical kudzu and Verano, in pure stands and in mixtures, in the present study were generally higher than yields reported for the same species in mixtures in tropical areas (Akinyemi and Onayinka 1976; Ng and Wong 1976; Akinola 1981; Reynolds 1982). The higher

yields of these legumes in pure stands than in the mixtures were due to the absence of competition from the grasses.

On the basis of the LER values of the grasses, guinea grass may be regarded as having lower competitive ability than star grass and elephant grass. The higher LER values of Verano and centro in mixtures with star grass than with the tall grasses, indicates the importance of competition for light in the mixtures. The results of this study highlight aspects of grass and legume compatibility. Thus, sod-forming star grass with shrubby/erect Verano and viny/climbing tropical kudzu with tall grasses, guinea grass and elephant grass, formed reasonably stable mixtures.

Grown alone, viny and creeping tropical kudzu suppressed weeds more successfully than shrubby Verano or diseased centro. There are no previous reports of disease infestation of centro in southern Nigeria, although the adverse effects of diseases caused mainly by *Cercospora* and *Rhizoctonia* have been reported in other creeping legumes in warm humid conditions (Ng and Wong 1976; Akinola 1981).

The outstanding DM performance of Verano in the present trial is better than those reported for other stylos in the same environment (Enwezor *et al.* 1989). This is partly related to the self-seeding nature of Verano and indicates the suitability of this cultivar for the area. Verano produces and sheds seed in the dry season with the seeds regenerating at the beginning of the rainy season (Mohammed Saleem 1986; Onifade and Agishi 1990).

Conclusion

A star grass-shrubby Verano stylo mixture was persistent and gave similar performance in terms of DM and CP yields to N-fertilised grass while the tall grasses, guinea grass and elephant grass, performed well with viny tropical kudzu. These mixtures possess good forage production potential and are recommended for sown pastures in south-west Nigeria. Our results demonstrated the importance of careful selection of the components of a grass-legume mixture, and confirm that plant growth habit may be a good basis for selection of compatible grass and legume species.

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References

- ADEGBOLA, A.A. and ONAYINKA, B.O. (1966) The production and management of grass/legume mixtures at Agege. *Nigerian Agricultural Journal*, **3**, 84–91.
- AKEN'OVA, M.E. and SALEEM, M.A.M. (1982) Screening of Guinea grass (*Panicum maximum* Jacq.) accessions for forage value in the lowland humid tropics. *Nigerian Journal of Agricultural Science*, **4**, 41–43.
- AKEN'OVA, M.E. and CHHEDA, H.R. (1986) Effects of nitrogen fertilizer on dry matter yields and feeding value of elephant grass (*Pennisetum purpureum*) and F1 *Pennisetum* hybrids. *Nigerian Agricultural Journal*, **21**, 40–50.
- AKINOLA, J.O. (1981) Growth of signal grass (*Brachiaria decumbens*) alone and with legumes in northern Nigeria. *Tropical Grasslands*, **15**, 130–134.
- AKINOLA, J.O. (1982) Effects of plant spacing and fertilizer on herbage production of elephant grass. *Nigerian Journal of Animal Production*, **9**, 21–27.
- AKINYEMI, A.A. and ONAYINKA, B.O. (1976) Grass/legume compatibility in the derived savanna regions of western Nigeria. *Nigerian Journal of Animal Production*, **3**, 120–125.
- AKINYEMI, A.A. and ONAYINKA, B.O. (1982) The productivity and carrying capacity of *Panicum maximum* planted with or without *Centrosema pubescens*. *Nigerian Journal of Agricultural Science*, **4**, 33–38.
- AOAC (Association of Official Analytical Chemists) (1990) *Official Methods of Analysis*. 15th Edn. (AOAC: Washington, DC).
- BOURN, D., MILLIGAN, K. and WINT, W. (1986) Tsetse, trypanosomiasis and cattle in a changing environment. In: Kaufmann, R., Charter, S. and Blench, R. (eds) *Livestock Systems Research in Nigerian Subhumid Zone. Proceedings of the Second ILCA/NAPRI symposium held in Kaduna, Nigeria, 29 October–2 November, 1984*. pp. 85–109. (ILCA: Addis Ababa, Ethiopia).
- CHHEDA, H.R. and AKINOLA, J.O. (1971) Effects of cutting frequency and level of applied nitrogen on productivity, chemical composition, growth components and regrowth potential of three *Cynodon* strains. 1. Yield, chemical composition and weed competition. *Nigerian Agricultural Journal*, **8**, 44–62.
- CHHEDA, H.R., AKEN'OVA, M.E. and CROWDER, L.V. (1974) Forage crops research at Ibadan. 2. *Pennisetum purpureum*. In: Loosli, J.K., Oyenuga, V.A. and Babatunde, G.M. (eds) *Animal Production in the Tropics*. pp. 95–101. (Heinmann Educational Books: Ibadan).
- CROWDER, L.V. and CHHEDA, H.R. (1982) *Tropical Grassland Husbandry*. (Longman: New York).
- ENWEZOR, W.O., UDO, E.J., USOROH, N.J., AYOTADE, K.A., ADEPETU, J.A., CHUDE, V.O. and UDOGHE, C.I. (1989) *Fertilizer Use and Management Practices for Crops in Nigeria, Series 2*. (Federal Ministry of Agriculture, Water Resources and Rural Development: Lagos).
- EVANS, T.R. (1970) Some factors affecting beef production from sub-tropical pastures in the coastal lowlands of south-east Queensland. *Proceedings of the XI International Grassland Congress, Surfers Paradise, 1970*. pp. 803–807.

- HAYNES, R.J. (1980) Competitive aspects of grass-legume associations. *Advances in Agronomy*, **33**, 227–261.
- ILCA (International Livestock Centre for Africa) (1990) *ILCA Annual Report 1989*. (ILCA: Addis Ababa, Ethiopia).
- JABBAR, M. (1993) Evolving crop-livestock farming systems in the humid zone of West Africa: potentials and research needs. *Outlook on Agriculture*, **22**, 13–21.
- MACK, S.D., SUMBERG, J.E. and OKALI, C. (1985) Small ruminant production under pressure: the example of goat in southwest Nigeria. In: *Proceedings of the Workshop on Small Ruminant Production Systems in the Humid Zone of West Africa, held at Ibadan, Nigeria, 23–26 January, 1984*. pp. 47–52. (ILCA: Addis Ababa, Ethiopia).
- MEAD, R. and WILLEY, R.W. (1980) The concept of 'Land Equivalent Ratio' and advantages in yields from intercropping. *Experimental Agriculture*, **16**, 217–228.
- MOHAMMED SALEEM, M.A. (1986) The establishment and management of fodder banks. In: Kaufmann, R., Charter, S. and Blench, R. (eds) *Livestock Systems Research in Nigerian Subhumid Zone. Proceedings of the Second ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29 October–2 November, 1984*. pp. 85–109. (ILCA: Addis Ababa, Ethiopia).
- MUREITHI, J.G., REYNOLDS, L., THORPE, W. and TAYLOR, R.S. (1995) Fodder production from Napier grass (*P. purpureum*) and hedgerows of *Leucaena leucocephala* in alley farming system. In: Kang, B.T., Osiname, O.A. and Larbi, A. (eds) *Alley Farming Research and Development. Proceedings of an International Conference held at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, 14–18 September, 1992*. pp. 162–172. (IITA: Ibadan, Nigeria).
- NG, T.T. and WONG, T.H. (1976) Comparative productivity of two tropical grasses as influenced by fertilizer nitrogen and pasture legumes. *Tropical Grasslands*, **10**, 179–185.
- ONAYINKA, B.O. and AKINYEMI, A.A. (1977) The effect of nitrogen fertilizer and interval of cutting on the dry matter yield and crude protein content of six Guinea grass varieties. I. Dry matter yield. *Nigerian Agricultural Journal*, **13**, 36–43.
- ONIFADE, O.S. and AGISHI, E.C. (1990) A review of forage production and utilization in Nigerian savanna. In: *Utilization of Research Results of Forage and Agricultural By-products Materials as Animal Feed Resources in Africa. Proceedings of the First Joint Workshop held in Lilongwe, Malawi, 5–9 December, 1988*. pp. 114–125. (PANESA/ARNAB, ILCA: Addis Ababa, Ethiopia).
- OPASINA, B.A. (1984) *Disease constraints on village goat production in southwest Nigeria*. Unpublished M. Ph. Thesis. University of Reading.
- OYENUGA, V.A. and OLUBAJO, F.O. (1975) Pasture productivity in Nigeria. I. Dry matter and chemical composition of herbage. *Journal of Agricultural Science (Cambridge)*, **85**, 1–10.
- REYNOLDS, S.G. (1982) Contributions to yield, nitrogen fixation and transfer by local and exotic legumes in tropical grass-legume mixtures in western Samoa. *Tropical Grasslands*, **16**, 76–80.
- SAS (Statistical Analytical Systems) (1986) *SAS System for Linear Models*, 1986 Edn. (SAS Institute: USA).

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