LEGUME-LEGUME COMPLEMENTARITY FOR SUSTAINABLE PASTURE DEVELOPMENT IN THE TROPICS

M. Peters[1,2], S.A. Tarawali[3], R. Schultze-Kraft[2] and A. Musa[1]

[1] International Livestock Research Institute (ILRI), c/o L.W. Lambourn & Co., Carolyn House, 26 Dingwall Road, Croydon, CR 9 3EE, England

[2] University of Hohenheim (380), 70593 Stuttgart, Germany

[3] International Livestock Research Institute (ILRI)/International Institute of Tropical Agriculture (IITA) c/o L.W. Lambourn & Co., Carolyn House, 26 Dingwall Road, Croydon, CR 9 3EE, England

ABSTRACT

The use of legume-legume mixtures to alleviate limitations of individual species in legume based technologies was investigated in subhumid Nigeria. The results indicate the potential of legume mixtures, through processes of complementation and compensation, to reduce the risk of legume establishment and survival and thus ensure sustainable legume yields and percentages. The implications for on-farm adoption of forage legumes are discussed.

KEYWORDS

Legume mixtures, complementarity, sustainability, tropical forage legumes, pastures

INTRODUCTION

Lack of high quality dry season forage poses a severe constraint to ruminant production in subhumid west Africa. Generally, legumes are considered as an appropriate option to alleviate nutritional constraints in such climates (Humphreys, 1991); in view of this, in the 1980s, the International Livestock for Africa (ILCA; now International Livestock Research Institute, ILRI) developed a legume evaluation program to identify legume accessions adapted to the prevalent production systems in this environment (Tarawali *et al*., 1989). However, among the more than 1000 different legume accessions tested so far, none was found to be ideal for all situations, and variations in the performance of promising species (like *Aeschynomene histrix*, *Stylosanthes guianensis*) was found across and within sites (Peters *et al*., 1996). Such, often difficult to predict variations, could determine the success or failure of a particular legume accession. To alleviate this problem, a series of experiments using legume-legume mixtures were initiated. Mixtures of plant species or lines, thought to be more stable than sole stands, are often employed in crop and forage production (Wolfe and Southwood, 1980; Wolfe, 1985; Rattunde *et al*., 1988; Réategui *et al*., 1995) but systematic studies with tropical forage legumes are rare. This paper reports results from a small plot grazing trial comparing four mixtures of complementary legumes with single legume stands.

METHODS

The experiment, carried out near Kaduna in subhumid Nigeria (about 6 dry months), was a randomized complete block design with 4 replicates, plot size was 4*5 m. The treatments consisted of four mixtures of complementary legumes (in terms of ease of establishment, dry matter productivity and drought tolerance), each composed of three different species, in comparison to sole stands of the same legumes used in the mixtures. In all mixtures *Centrosema pascuorum* cv. Cavalcade, a fast establishing species and *Centrosema brasilianum* ILRI 155, slow establishing but of outstanding drought tolerance and high persistence were included. To these were added either *Stylosanthes guianensis* cv. Pucallpa (Mixture 1), *Stylosanthes hamata* cv. Verano (Mixture 2), *Chamaecrista rotundifolia* cv. Wynn (Mixture 3) or *Aeschynomene histrix* ILRI 12463 (Mixture 4), all known for potentially high dry matter productivity in the environment. At the onset of the wet season, 200 seeds/m^2 were sown for *S. guianensis*, *S. hamata*, *A. histrix* and *Ch. rotundifolia*, respectively and 52 seeds/m^2 for *C. brasilianum* and *C. pascuorum*, respectively; in the mixtures 1/3 of these seed rates was used for each species. Plots were fertilized with 150 kg/ha SSP prior to planting and weeded 3 and 6 weeks after planting. Establishment was monitored by estimating legume soil cover 8, 12, 16 and 20 weeks after planting. In the middle of the dry season plots were sampled for dry matter yield and crude protein (CP; micro Kjeldahl). In the middle of the dry season 1994 dry matter yield and botanical composition were assessed using the percentage rank and direct estimation of yield procedures of BOTANAL for small plots (Tothill *et al*., 1992; Waite, 1994). After sampling, plots were mob-grazed by three Bunaji steers for two to three weeks until forage was exhausted; plots cut back to a uniform height of 10-15 cm above ground level.

RESULTS

16 weeks after planting legume soil cover in the mixtures ranged between 76 and 84% and were significantly ($P<0.05$) higher than legume soil covers of sole stands of *S. guianensis*, *Ch. rotundifolia*, *S. hamata* and *A. histrix* (39 to 53 %).

Dry matter (DM) productivity was not significantly different between treatments at both harvests, but legume percentages varied ($P<0.05$). Total DM yields were similar in both years but legume percentages were lower in the 2nd year (Table 1). In the establishment year *Ch. rotundifolia*, *C. pascuorum* and *A. histrix* and in the following year *A. histrix*, *C. brasilianum* and *S. hamata* had the highest legume percentages in the single legume stands. The legume mixtures were always among the treatments with the highest legume percentages, though the contribution of the different legume species varied; in the establishment year *C. pascuorum* contributed 47-69% of dry matter, but disappeared in the second year and the, initially low yielding, *C. brasilianum* became the dominant legume species in Mixtures 3, 2 and 1 with 64, 75 and 100% of legume dry matter respectively. In mixture 4, having the highest legume yields and legume percentages, *A. histrix* and *C. brasilianum* each contributed 50% to legume dry matter.

CP concentrations of the legumes ranged between 5.1 and 9.8 % in the middle of the dry season with the individual species in the mixtures usually having higher CP concentrations than the same species in the single legume stands (Figure 1).

DISCUSSION

The results confirm the potential value of mixtures in maintaining high legume percentages in pastures over a period of time. Through processes of complementation and compensation it was possible to alleviate differences between species in terms of ease of establishment, survival and dry matter yield of individual species. Though previously reported to be highly productive in the environment (Peters *et al*., 1994; Tarawali, 1994), *S. guianensis* and *Ch. rotundifolia* performed poorly. In view of such variations in the performance of legume species within and among sites, the use of mixtures can give a much more robust pasture, with each legume finding its managerial-environmental niche (Scott, 1993; Réategui *et al*., 1995). The contribution of individual species is likely to be variable, but as the individual species respond to temporal, seasonal and spatial differences, good legume yields with high legume percentages are maintained. In this way, the potential for legume pasture adoption and sustainability with minimum risk is also increased; legume mixtures are therefore suitable for on-farm dissemination. The advantage of legume mixtures is further emphasized by apparent synergistic effects on CP concentrations of individual legumes, confirming results from another study (M. Peters, unpublished). From the present study, mixtures containing both *A. histrix* and *C. brasilianum*, together with *C. pascuorum* appear to be the best choice; however, in view of the emphasis on risk minimization, the use of more complex mixtures containing three to six complementary legume species (if seeds are available) could be appropriate.

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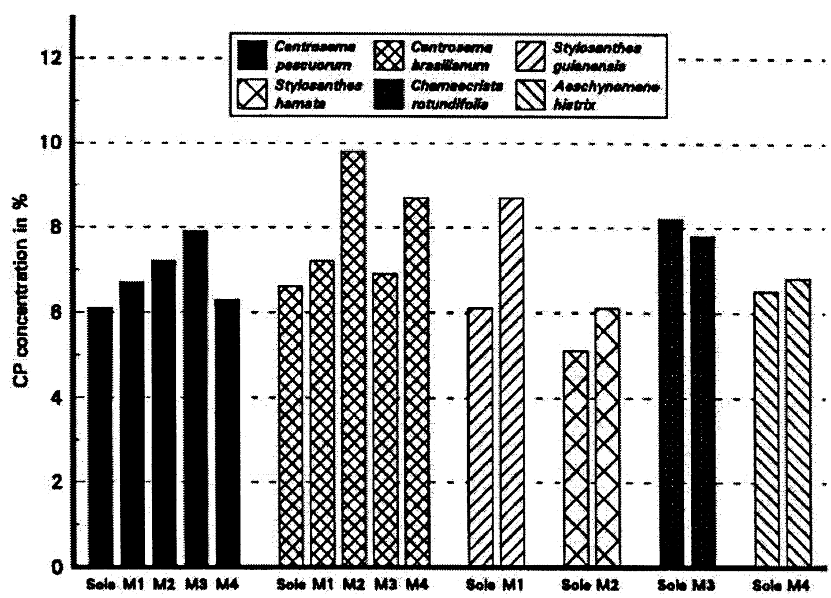
Table 1
Total dry matter yields and legume percentages of legume mixtures and single legume stands

Treatmet	1993 DM yield kg/ha	1993 sown legume %	1994 DM yield kg/ha	1994 sown legume %
Mixture 1	2948	82	2247	27
Mixture 2	2264	60	2746	30
Mixture 3	1500	82	2352	31
Mixture 4	2636	72	3518	63
C. pascuorum cv. Cavalcade	3274	68	2151	5
C. brasilianum ILRI 155	1426	37	2360	35
S. guianensis cv. Pucallpa	2859	34	3107	17
S. hamata cv. Verano	1235	58	2319	38
Ch. rotundifolia cv. Wynn	1683	71	1884	20
A. histrix ILRI 12463	2349	75	3379	53
LSD (P<0.05)	n.s.	33	n.s.	15

Figure 1
Crude protein (CP) concentrations of legume species in mixtures and sole legume stands in the middle of the dry season



M1 = Mixture 1; M2 = Mixture 2; M3 = Mixture 3; M4 = Mixture 4