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Compatibility of *Sorghum almum* (Columbus grass) with three forage legumes

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ABSTRACT

The study evaluated the compatibility of *Sorghum almum* (Columbus grass) forage with three forage legumes namely *Lablab purpureus* (lablab) *Stylosanthes hamata* (verano) and *Macroptilium bracteatum* (burgundy bean) in a randomized complete block design. The treatments consisted of monocultures of *S. almum*, lablab, verano, burgundy and their mixtures in the following grass-legume proportions 4:0, 3:1. 2:2, 1:3 4:0 replicated in four blocks in accordance with De Wit's (1960) replacement principle. The results revealed that dry matter yield values of grass monoculture were significantly greater ($P < 0.05$) than those of monocultures of legumes and mixtures except for monoculture of lablab found to be statistically at par with its corresponding grass monoculture. Grass-legume mixtures (2:2) tended to record higher total dry matter yield values compared to other mixtures (1:3 and 3:1) among mixtures. Relative yield (RY) total values of all mixtures were <1 except for grass-burgundy (2:2) (3.31). The legumes in mixtures were found to be more competitive than the grass given their higher relative crowding coefficient values (k). It was concluded that intercropping of grass-lablab and grass-stylo (verano) had no yield advantage compared to the corresponding grass monoculture. Furthermore, 2:2 sowing proportion appeared to be the best given the relatively higher dry matter yield values and RY among mixtures.

KEY WORDS: Compatibility, competition, grass, legumes, mixtures

INTRODUCTION

Animal production world over is based on pastures (Lascano, 2001). In the dry tropics such as the savannah zone of northern Nigeria, production of these animals is limited by seasonality in weather and climate leading to periods of forage surpluses (rainy season) and shortages (dry season).

In the dry season, the situation is compounded by the additional loss of quality of the predominantly grass vegetation leading to incidences such as reduced feed intake, slow growth rate decreased productive, and reproductive performances.

One of the ways to minimize the constraints above to animal production is through the intercropping of grasses and legumes. Intercropping is an old and widespread practice used in low-input cropping system in many areas of the world (Anil *et al.,* 1998). Intercropping has some advantages such as higher total yield and better land use efficiency (Dhima *et al.*, 2007) yield stability of the cropping system (Lithourgidis *et al.*, 2007) better utilization of light, water and nutrient, (Javanmard *et al.*, 2009) and a host of other advantages.

However, the realization of some of the benefits above conferred by intercropping will very much depend on compatibility between the components crops in the mixture. Several indices, such as relative yield (RY), relative crowding coefficient (RCC), and aggressivity index (AI), have been used to analyze competition in intercropping (Banik *et al.*, 2000; Ghosh, 2004; Midya *et al.*, 2005). RY shows the advantage of mixture compared to monocultures in terms of utilization of resources; RCC indicates the competitive ability of one crop relative to another while AI gives a measure of aggressive and aggressor in a competition between two crops. The experiment, therefore, aims at evaluating the compatibility of *Sorghum almum* (Columbus grass) with three legumes (*Lablab purpureus*, *Stylosanthes hamata* (verano), and *Macroptilum bracteatum* (burgundy bean).

MATERIALS AND METHODS

The study was conducted at the University Teaching and Research Livestock Farm, Bayero University Kano. Kano lies between latitude 9° 31′ and 12° 30′ North, latitude 9° 30′ and 8° 42′ East in the Sudan Savannah ecological zone of Nigeria. Mean annual temperature ranges from 21°C to 39°C while annual rainfall from 500 mm to 1000 mm (Knarda, 2001). Soil of the area is a sandy loam soil with the following proportions of N P and K (0.1%, 9.9 ppm, and 0.69 Cmol/kg), respectively).

Treatments and Experimental Design

The treatments consisted of monocultures of *S. almum*, *L. purpureus*, burgundy bean, *S. hamata* and their mixtures in the following proportions 0:4, 1:3, 2:1, 3:1, and 4:0, grass-legume and Legume-grass mixtures replicated in four blocks in a randomized complete block design. Each block contained 15 1 × 1 m^2 plots, distances between plots and blocks were 0.5 and 1 m, respectively. The treatments combinations were as indicated below:

1. *S. almum*-lablab (SL) (0:4)
2. *S. almum*-lablab (SL) (1:3)
3. *S. almum*-lablab (SL) (2:2)
4. *S. almum*-lablab (SL) (3:1)
5. *S. almum*-lablab (SL) (4:0)
6. *S. almum*-stylo (SS) (0:4)
7. *S. almum*-stylo (SS) (1:3)
8. *S. almum*-stylo (SS) (2:2)
9. *S. almum*-stylo (SS) (3:1)
10. *S. almum*-stylo (SS) (4:0)
11. *S. almum*-burgundy (SB)(0:4)
12. *S. almum*-burgundy (SB) (1:3)
13. *S. almum*-burgundy (SB) (2:2)
14. *S. almum*-burgundy (SB) (3:1)
15. *S. almum*-burgundy (SB) (4:0)

Land Preparation and Field Culture

The land was ploughed harrowed and demarcated into plots of 1 × 1 m² sizes; legume seeds were scarified using hot water at 80°C for 5 min to break hard seededness (Baba *et al*., 2011).

Seeding was done according to the ratio prescribed for each treatment. Seeds were sown in shallow holes dug at the four corners of each plot at a distance of 25 cm from the margin according to the sowing proportion. 10 seeds of each species were used and later trimmed to 3 seedlings per sowing hole.

Fertilizer Application and Weeding

Grass and legume monocultures plots received N P K and P K fertilizer, respectively, at the rate of 50 kg/ha each while mixtures had P and K fertilizers only. Fertilizer was applied in the form of Urea (N) single superphosphate (P) and muriate of potash (K). Weeding was done as at when desired.

Harvesting

Harvesting was carried out at 82 days post sowing at about 10% heading of *S. almum*. Forage materials were harvested to a stubble height of 5 cm to the ground fresh weights were taken, using a digital balance the materials were then oven dried at 65°C for 72 h for dry matter determination.

Leaf to stem ratio was measured by separating the harvested materials into leaf, and stem the material were then oven dried at 65°C for 72 h.

Other parameters measured included leaf area (using leaf area meter model YMJ-A) and a number of the tiller of *S. almum*.

Data Analysis

Data were analyzed by analysis of variance Using SAS (Version 9.2, 2009). Where significant difference existed Duncan's multiple range test was used to separate the treatment means.

Competition Indices Computed

RY, relative yield total (RYT), RCC or (k), and AI were calculated according to the following equations:

$RY = RY_{ab} = DMY_{ab}/DMY_{aa}$, $RY_{ba} = DMY_{ba}/DMY_{bb}$ (Ghosh *et al*., 2006)

$$RYT = DMY_{ab}/DMY_{aa} + DMY_{ba}/DMY_{bb}$$

RCC for 50:50 proportions:

$RCC_{ab} = DMY_{ab}/(DMY_{aa} - DMY_{ab})$, $RCC_{ba} = DMY_{ba}/(DMY_{bb} - DMY_{ba})$

For mixtures different from 50:50,

$$RCC_{ab} = DMY_{ab} \times Z_{ba}/(DMY_{aa} - DMY_{ab})\, Z_{ab}$$

$RCC_{ba} = DMY_{ba} \times Z_{ab}/(DMY_{bb} - DMY_{ba})\, Z_{ba}$ (Ghosh, 2004)

AI for 50:50 = $AI_{ab} = (DMY_{ab}/DMY_{aa}) - (DMY_{ba}/DMY_{bb})$, $AI_{ba} = (DMY_{ba}/DMY_{bb}) - (DMY_{ab}/DMY_{aa})$

For mixtures different from 50; 50:

$$AI_{ab} = DMY_{ab}/(DMY_{aa} \times Z_{ab}) - DMY_{ba}/(DMY_{bb} \times Z_{ba})$$

$AI_{ba} = DMY_{ba}/(DMY_{bb} \times Z_{ba}) - DMY_{ab}/(DMY_{aa} \times Z_{ab})$ (Agegnehu *et al.*, 2006)

In the equations, the following definitions apply, ab refers to performance of *S. almum* (a) mixed with either verano, burgundy, or lablab (b), ba is the performance of either of the legume (b) mixed with *S. almum* aa is the performance of *S. almum* in monoculture, and bb is the performance of either of the legume as a monoculture, Z is the sown proportion or ratio.

RESULTS

Dry Matters Yield of Grass-legumes and Mixture

The dry matter yield of grass-legume and total is shown in Table 1. Dry matter yields of grass in 2:2 grass-legumes mixtures were significantly greater ($P < 0.05$) than those of other mixtures (1:3 and 3:1), among the grass in mixture with legumes, the grass in grass-stylo mixture 2:2 tended to record higher dry matter yield (872 kg/ha) followed by the grass in grass-burgundy mixture (811 kg/ha) with the least recorded by grass in grass-lablab mixture (744 kg/ha). In the case of legumes in mixture lablab in grass-lablab mixture (3:1) (2179 kg/ha), lablab in grass-lablab mixture (2:2) (1931 kg/ha) and burgundy in grass-burgundy mixture (2:2) (1705 kg/ha) recorded significantly greater yield ($P < 0.05$) than the rest of the treatments except for lablab in grass-lablab mixture (1:3) (1256 kg/ha) found to be at par with burgundy in grass-burgundy mixture (2:2).

Total Dry Matter Yield

Grass monoculture recorded significantly greater yields ($P < 0.05$) than monocultures of legumes and mixtures except in the case of monoculture of lablab observed to be statistically at par with its corresponding grass monoculture, among the mixtures 2:2 grass-legume mixtures seemed to record higher total dry matter yields compared to other mixtures (1:3 and 3:1) irrespective of the species involved in the mixtures. Total dry matter yield was highest in SB (4:0) (4264 kg/ha). In the case of legume monocultures lablab recorded the highest yield (3513 kg/ha) followed by stylo (1235 kg/ha) with burgundy the least. Total dry matter yield was highest in 2:2 grass-lablab mixture (2675 kg/ha) among mixtures.

RY

The RY of legumes appeared to be higher than those of the grass (Table 2), among the grass and legumes RY was higher at 2:2 grass-legume mixtures compared to 1:3 and 3:1 except in 1:3 grass-stylo mixture. All mixtures had RYT of <1 except SB 2:2 (3.31).

RCC (k)

RCC in legumes seemed to be higher compared to grass except in SL (2:2) and SB (2:2) (Table 3). The higher K value recorded signifies higher competitive ability of the legume compared to the grass.

All 1:3 grass-legume and 3:1 grass-legume mixture had significantly higher K values than (2:2) grass-legume

Table 1: Dry matter yield of grass, legumes, and total

Treatment	Dmyg (kg/ha)	Dmyl (kg/ha)	Tdmy (kg/ha)
SL (0:4)	-	3513^{b}	3513^{b}
SL (1:3)	598^{b}	1256^{bc}	1854^{d}
SL (2:2)	744^{a}	1931^{a}	2675^{c}
SL (3:1)	245^{c}	2179^{a}	2424^{c}
SL (4:0)	3862^{ab}	-	3862^{ab}
SB (0:4)	-	558.3^{h}	558.3^{h}
SB (3:1)	618^{b}	297.3^{d}	915^{fgh}
SB (2:2)	811^{a}	1705^{ab}	2516^{c}
SB (3:1)	293^{c}	387^{d}	680^{gh}
SB (4:0)	4264^{a}	-	4264^{a}
SS (0:4)	-	1235^{efg}	1235^{efg}
SS (1:3)	595^{b}	800^{cd}	1395^{def}
SS (2:2)	872^{a}	701^{cd}	1573^{de}
SS (3:1)	290^{c}	895^{cd}	1185^{efg}
SS (4:0)	4218^{a}	-	2418^{a}

Means with different superscripts within same column are significantly different ($P<0.05$). Dmyg: Dry matter yield grass, Dmyl: Dry matter yield legume, Tdmy: Total dry matter yield, SL: *S. almum*-lablab, SB: *S. almum*-burgundy, SS: *S. almum*-stylo

Table 2: Relative yield of grass, legume, and total

Treatments	RYG	RYL	TRY
SL (1:3)	0.097^{bc}	0.356^{b}	0.453^{b}
SL (2:2)	0.195^{a}	0.542^{b}	0.737^{b}
SL (3:1)	0.064^{c}	0.382^{b}	0.446^{b}
SB (1:3)	0.11^{b}	0.552^{b}	0.662^{b}
SB (2:2)	0.189^{a}	3.119^{a}	3.309^{a}
SB (3:1)	0.069^{c}	0.314^{b}	0.383^{b}
SS (1:3)	0.114^{b}	0.665^{b}	0.778^{b}
SS (2:2)	0.207^{a}	0.578^{b}	0.785^{b}
SS (3:1)	0.069^{c}	0.299^{b}	0.368^{b}

Means with different superscript within the same column are significantly different ($P<0.05$). RYG: Relative yield grass, RYL: Relative yield legume, TRY: Total relative yield, SL: *S. almum*-Lablab, SB: *S. almum*-burgundy, SS: *S. almum*-stylo

Table 3: Relative crowding coefficient of grass and legumes

Treatment	RCCG	RCCL
SL (1:3)	0.32^{a}	2.81^{a}
SL (2:2)	-744^{b}	-1930^{d}
SL (3:1)	0.21^{a}	1.86^{a}
SB (1:3)	0.37^{a}	6.12^{a}
SB (2:2)	-811^{bc}	-1702^{c}
SB (3:1)	0.22^{a}	1.43^{a}
SS (1:3)	0.39^{a}	10.45^{a}
SS (2:2)	-871^{c}	-701^{b}
SS (3:1)	0.22^{a}	1.31^{a}

Means with different superscripts within the same column are significantly different ($P<0.05$). RCCG: Relative crowding coefficient grass, RCCL: Relative crowding coefficient legume, SL: *S. almum*-Lablab, SB: *S. almum*-burgundy, SS: *S. almum*-stylo combination, similarly, for grasses. The species appeared to be equally matched at 2:2 ratio combination given the seemingly lower K values.

AI

The AI of grass in all mixtures irrespective of sowing proportion showed negative sign while those of legumes were positive (Table 4). This is indicative of the fact that the legumes were more aggressive than the grass.

Morphological Parameters Measured

Morphological characteristics of grass and legumes are shown in Table 5.

Leaf Area

Leaf area of grass in the mixtures was significantly greater ($P < 0.05$) in SS (1:3 and 2:2) compared to other mixtures. In the case of legumes, SS (2:2 and 3:1) and SL (1:3 and 3:1) had superior ($P < 0.05$) leaf area than other mixtures.

Tillers Number

The number of tillers produced by grass in mixtures was not significantly different except in the case of grass in SL (2:2) that recorded significantly greater ($P < 0.05$) number of tillers than grass in SS mixture (3:1).

Table 4: AIG and AIL

Treatments	AIG	AIL
SL (1:3)	−0.971[d]	0.971[cd]
SL (2:2)	−0.355[c]	0.355[d]
SL (3:1)	−0.190[bc]	0.190[de]
SB (1:3)	−2.039[a]	0.039[f]
SB (2:2)	−2.926[e]	2.926[a]
SB (3:1)	−0.108[b]	0.108[e]
SS (1:3)	−1.881[de]	1.881[b]
SS (2:2)	−0.371[c]	0.371[d]
SS (3:1)	−0.667[d]	0.667[cd]

Means with different superscripts within the same column are significantly different ($P<0.05$). AIG: Aggressivity index grass, AIL: Aggressivity index legume, SL: *S. almum*-Lablab, SB: *S. almum*-burgundy, SS: *S. almum*-stylo

Table 5: Morphological characteristics of grass and legumes

Treatments	LAG	LAL	Tillers	L/SG	L/SL
SL (1:3)	112.3[b]	130[a]	23.75[ab]	0.864[b]	0.949[a]
SL (2:2)	87.4[c]	94.4[c]	27.25[a]	2.24[a]	0.793[ab]
SL (3:1)	99.4[c]	119[a]	25.25[ab]	1.411[b]	0.825[ab]
SB (1:3)	76.1[c]	28.7[c]	25[ab]	0.683[b]	0.622[b]
SB (2:2)	77[c]	25.1[c]	25.5[ab]	0.660[b]	0.798[ab]
SB (3:1)	31.7[d]	24.8[c]	23.25[ab]	0.654[b]	0.804[ab]
SS (1:3)	317[a]	21.8[c]	25[ab]	0.860[b]	0.724[b]
SS (2:2)	144[a]	143[a]	23[ab]	1.036[b]	0.746[ab]
SS (3:1)	87.3[c]	141[a]	19[b]	0.81[b]	0.828[ab]

Means with different superscripts within the same column are significantly different ($P<0.05$). LAG: Leaf area grass, LAL: Leaf area legume, L/SG: Leaf to stem ratio grass, L/SL: Leaf to stem ratio legume, SL: *S. almum*-Lablab, SB: *S. almum*-burgundy, SS: *S. almum*-stylo

Leaf to Stem Ratio

Leaf to steam in the grass was significantly greater ($P < 0.05$) in SL (2:2) compared to other mixtures. In the case of legumes, the leaf to stem ratio in SL (1:3) was significantly higher ($P < 0.05$) than those of SB (1:3) and SS (1:3).

DISCUSSION

Dry matter yield is a measure of pasture productivity. The higher dry matter yield recorded by grass monocultures compared to a monoculture of legumes and mixtures (Table 1) may probably be the due rapid rate of growth in grasses and their fibrous root system which enables them to extract nutrient and water from the ground. Baba *et al*. (2011) reported higher dry matter yield in grass compared to monocultures of legumes and mixtures. Similarly, Caballero *et al*. (1995) reported lower yield of mixtures than monocultures which they attributed to competition between the intercropped species The greater dry matter yield recorded by 2:2 grass-legume mixtures may be explained in the context that the dry matter yield of the grass component seemed to be favored more by this ratio, perhaps due to more nitrogen made available to the grass via nitrogen fixation.

RY

The higher RY of legumes compared to grass in mixtures (Table 2) lent credence to the higher dry matter yields recorded by legume in mixtures (Table 1) this indicates that the RY is a function of dry matter yield of the components species in the mixture. The RY of <1 in mixtures with the exception of guinea-burgundy mixtures (2:2) meant that there was no advantage in intercropping. Aasen *et al*. (2004) reported no yield advantage in pea-cereal forage mixtures compared to cereal forage sole crop.

RCC (k) and AI

The higher RCC of legumes compared to grass (Table 3) in almost all mixtures is indicative of the higher competitive ability of the legume compared to the grass in mixtures. Tessema and Baars (2006) reported higher mean RCC values of panicum and chloris in mixtures with medicago and desmodium and attributed it to higher dry matter produced by panicum and chloris thus more competitive. The positive AI recorded by legumes compared to grass (negative) in this study is indicative of the higher competitive ability of the legumes compared with the grass. Tessema and Baars (2006) showed that positive aggressivity index recorded by panicum and chloris in mixtures was indicative of superior competitive ability of the grasses compared to the legumes.

Tiller Number and Leaf to Stem ratio

The higher tiller number and leaf to stem ratio grass in SL 2:2 compared to other mixtures might have contributed to the highest dry matter yield recorded by SL (2:2). The greater number of tiller connotes greater yield while a higher amount of leaves meant higher photosynthetic capacity.

CONCLUSION

Based on the results of the research, it can be concluded that there was no advantage in intercropping between *S. almum* and the duo of *L. purpureus* and *S. hamata* (RYT <1) except in the case of SB (2:2) with RYT value of 3.309. In addition, the 2:2 sowing proportion appeared to be the best since dry matters yields were found to be higher ditto for RYT values.

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