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Productivity of Columbus Grass (*Sorghum almum*) Intercrop with Lablab(*Lablab purpureus*) in Shika, Nigeria

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Target audience: Smallholder farmers, Livestock owners, Forage agronomists and Extension agents

Abstract

An experiment was conducted to assess the productivity of Sorghum almum intercropped with Lablab (Lablab purpureus). The experiment was laid in a Randomized Complete Block Design (RCBD) which consisted of intercropping systems as sole S. almum, S. almum with lablab in intra rows (IR), S. almum with lablab legume in alternate rows (AR) and sole lablab. Plant height and plant density were significantly (P<0.05) affected by sowing arrangements. The number of tillers, leaves and leaf: stem ratios were not significantly (P>0.05) affected by sowing arrangement. The highest total biomass yield of 12.85 t/ha DM was obtained from S. almum and lablab mixtures in alternate rows (AR) while the lowest yield was 7.06 t/ha DM from sole S. almum.The land equivalent ratios (LER) obtained was 1.98 for intercrop in AR and 1.88 for intra row treatment which were all above one (1.00). These values means 98.0 % and 88.0 % intercrop advantage of AR and IR respectively over sole cropping. The leave area index (LAI) of S. almum (0.74) in (AR) was significantly (P<0.05) higher than the value of 0.65 forS. almum in (IR). The percentage proximate composition and fiber fractions were significantly (P<0.05) affected by intercropping systems. The highest value of 18.82 % crude protein and lowest value of 23.23 % crude fiberwas obtained in Sorghum almum and lablab in AR. Higher values of 54.55 %NDF and 23.96 %Hemicellulose are observed in sole grass compared to the two intercrop systems. Na, P, K, Mg and Mn were not significantly (P>0.05) affected by intercropping except for Ca, which gave a highest value of 3.21 g/kg Sorghum almum and lablab in AR compared to 1.71 g/kg for sole grass. This study revealed that Sorghum almum can be intercropped with lablab in alternate rows for higher yields and improved nutrient qualities than the sole crop. Therefore, intercropping Sorghum almum with lablab in alternate rows and gave the best forage productivity and good quality forage. Intercropping of Sorghum almum with Lablab purpureus in alternate rows is hereby recommended for livestock owners in Nigeria.

Key words: Productivity, intercropsystems, yield and quality.

Description of Problem

In most tropical countries, where 80-90 % of livestock depend on available grasses during the wet season, scarcity and the low quality of these feeds have made it mandatory to produce and conserve quality forages against dry season and periods of drought. Intercropping legumes into grass pastures have proven to be a viable means to mitigate the decline in quantity and quality of grass forages (1). The practice of intercropping is an alternative way identified for smallholder farmers to improve the yield and nutritive quality of the native grasses.It has been reported that intercropping of grasses with legumes increased yield, improved growth, enhanced palatability and nutritive quality feeds for animals (2). Tanko (3) noted that one of the advantages of intercropping forage legumes into farming system include the transfer of nitrogen to the component cereal crops thereby, increasing the crude protein content of the grasses. *S. almum*is a short-lived perennial forage species which is easily established from seed with rapid growth and fodder yield accumulation within the year of establishment (4). Lablab (*Lablab purpureus*) is a creeping legume which produces high nutritive quality of conserved feed in form of hay or silage (5) and if utilised in conjunction with natural pasture, sown pasture, browse plants and crop residue, will help to reduce weight losses common to livestock during the dry season. In Nigeria, there is limited information on the productivity of *Sorghumalmum* intercropped with *Lablabpurpureus*. Therefore, the present study was aimed at evaluating the productivity of *Sorghumalmum* intercropped with lablab on yield and quality of the grass.

Materials and methods

Description of the experimental site

The study was conducted during the 2015 rainy season at the Experimental Farm of the Feeds and Nutrition Research Programme, National Animal Production Research Institute (NAPRI), Shika, Zaria. Shika is located on Latitude 11^0 12'W. Longitude 07^0 33'E at an altitude of 660 m above sea level, along Zaria-Funtua Road in the Northern Guinea Savannah zone of Nigeria. The climate of the study area is characterised by a defined wet and dry season. Wet season starts from April to early May and ends in late September to early October while the dry season last from October to April. Long-term annual rain fall (2005-2015) averaged 1135 mm with a maximum temperature of 37^0C in May and minimum temperature of 11.5^0C recorded in December/January and relative humidity of approximately 70% (6). Weather observations at Shika and environs during the experimental period in 2015 is presented in Table 1.

Soil Sampling and analyses

Soil samples were collected from the experimental site with the aid of a soil auger at 4 corners and centres of the plots at 0-15 and 15-30cm depths. The samples collected at each depth were mixed and representative samples were taken for soil analysis before the commencement of the experiment. The soil samples were analysed for physical and chemical properties as described by Agricultural Experimentation Station (A.E.S, 7), to determine soil texture, particle size, total nitrogen, total carbon, phosphorus, soil pH and cations exchange capacity (CEC). The analysis was carried out at the Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Table 1: Weather observations at Shika and environs during the experimental period in 2015

Months	Max. air temp (^0C)	Min. air temp (^0C)	Rainfall (mm)	Relative humidity (%)	Sunshine (hours)
May	37.36	24.19	91.50(7)	41.21	6.91
June	32.63	22.13	95.80(10)	64.58	7.36
July	30.63	20.07	123.30(16)	73.63	5.30
August	29.67	19.50	452.30(21)	77.13	4.58
September	31.62	25.45	312.5(15)	71.19	6.31
October	33.23	18.23	85.4(7)	55.68	8.16
Total	NA	NA	1160.80(76)	NA	38.62
Mean	32.52	21.60	193.47(13)	63.90	6.44

N.A not applicable, Number of rain days are in parenthesis. Records on temperatures, relative humidity and sunshine (hours) were obtained from Institute of Agricultural Research, Samaru about 12 kilometres from Shika, Nigeria

Soil characteristics of the experimental site

The physical and chemical characteristics of the composite soil samples taken from 0 to 15 cm and 15 to 30 cm depths at the experimental site are presented in Table 2. The soil consisted of 73.95 - 74.0 % sand, 16.20 - 16.50 % clay and 9.50 - 9.85 % silt. The organic carbon is between 0.75 - 0.90 % for both depth measured. The pH values 5.2 and 5.1 for 0-15cm and 15-30cm respectively.The soils are slightly acidic in nature and hence affects soil microbial activities, which could lead to poor productivity of forage crops. Typically with tropical soils, the soil of the experimental site was low in both total Nitrogen (0.12 -0.2 %) and available Phosphorus (90.4 - 96.4 ppm)

Table 2: Physical and chemical properties of soils of the study area collected at different depths before planting.

Physical properties	0-15cm	15-30cm
Particle size (%)		
Clay	16.20	16.50
Silt	9.85	9.50
Sand	73.95	74.0
pH ($CaCl_2$)	5.2	5.1
Chemical properties		
Total Nitrogen (%)	0.12	0.20
Organic carbon (%)	0.90	0.75
Zn (ppm)	3.82	3.60
P (ppm)	96.4	90.4
Exchangeable cation (meg/100g of soil)		
Ca^{2+}	2.25	2.11
Mg^{2+}	0.82	0.73
K^+	0.22	0.20
Na^+	0.1	0.09

Experimental layout, treatments and design

A total land area of 2142 m^2 (126m x 17m) was used for the trial. The land was ploughed and harrowed twicewith tractor drawn implements and ridged with a pair of workbulls to provide a clean seed bed and to enhance early seed germination. The experimental plots were laid out in a Randomized Completely Block Design (RCBD). The experimental plot was divided into 3 sub plots measuring (30 m x 17 m) each, with 2 m pathways represents the sowing arrangement are *S. almum* intercropwith lablab intra rows (IR), *S. almum* intercrop with lablab in alternate rows (AR) with sole *Sorghumalmum* and sole lablab for comparism, then each sub plot was further divided into 3 sub-sub plots each measuring (30 m x 5 m) with 1m pathways as replicates totalling 9 sub-sub plots.

Experimental materials and forage agronomic study

Sorghum almum and *Lablab purpureus* (cv. white Rongai) seeds were obtained from the Feeds and Nutrition Research Programme of the National Animal Production Research Institute (NAPRI) Shika, Zaria. The Seeds of *Sorghum almum* were planted on the ridges at about 2 cm depth using a seed rate of 15 kg/ha. Sowing was done when rain was established on 25th Julyand the soil moisture sufficient for germination. First and second weeding were carried out manually with hoes at 3 and 6 weeks after sowing, respectively. The common weeds found at the experimental site were *Eleusineindica, Cassia tora, Amaranthusspinosus*and*Cynodondactylon*. The *S. almum* was thinned to 3 plants per stand after the first weeding and a uniform single dose fertilizer was applied at the rate of 100 kg NPK (20:10:10) per hectare, immediately after the first weeding to control any variation that could be due to soil fertility. The lablab seeds were treated with seed dressing chemical (Apron plus 50 DS) at recommended rate of 2g to 2kg of seeds (8). At 3 weeks after sowing the *S. almum*, lablab seeds were sown at 3 seeds per hole on hills within *S. almum* stand (intra rows) and in alternate single rows with *S. almum* respectively. These gave a total plant population of 144,000/ha per crop spaced at 25cm x 85cm.

Forage yield determination and land equivalent ratio (LER)

This was determined by harvesting the fresh forage within each sub-plot in a 1m^2 quadrat at a height of 15cm above the ground using a hand sickle for total fresh forage yield and a sub sample of (150g) was weighed and oven dried at 65^{0}C for 48 hours and reweighed to estimate dry matter yield. Dry matter production is calculated as reported by (9)

Dry matter yield (kg/ha) = (Total FW x (DWss/FWss)) x 10 = where:

Total FW = Total fresh yield from 1 m^2 in (g)

DWss = Dry weight of the sub-sample in (g)

FWss = Fresh weight of the sub-sample in (g)

The effect of competition between two species in the experiment was calculated by land equivalent ratio. LER verifies the effectiveness of intercropping for using the resource of the environment compared to sole cropping. The LER was calculated as reported by (10).

LER_{total} = IYG/SYG +IYL/SYL = LER_g + LER_l

Where:

SYG = is the sole yield of *Sorghum almum*

IYG= the intercropped yield of *Sorghum almum*

IYL= the intercropped yield of Lablab

SYL= sole yield of lablab

LER_g represent the partial *Sorghum almum* equivalence

LER_l represents the partial equivalence for lablab

The value indicates advantage through intercropping when the LER_{total} value is greater than one and a disadvantage when the value is less than one and no effect when the value equals one.

Data collection and chemical analysis

Parameters and phenological observations on growth components (plant height, number of tiller, number of leaves, plant density/m^2 and leaf: stem ratios) and yields were recorded at10 weeks after sowing. Five (5) plants were randomly sampled per plot and tagged for the measurements of growth components using the Standard Procedure of (9).

Samples of the forage materials harvested at 10 weeks after sowing were taken to laboratory for chemical analysis. The dried sample of forages was ground with a simple laboratory hammer mill fitted with a 2mm sieve. Proximate analysis was carried out to determine Nitrogen (N) for crude protein determination (N x 6.25), crude fibre (CF), Ether Extract (EE), Nitrogen Free Extract (NFE) and ash content according to AOAC (2005). Neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose, cellulose and acid detergent lignin (ADL) were determined by method of(11). Mineral contents (Sodium, Calcium, Potassium, Magnesium and Phosphorus, Iron and Manganese) were determined by the standard laboratory procedure of (12) using the atomic absorption spectrophotometer.

Statistical analysis

The general linear model procedure (Proc. GLM) of statistical analysis system (13) was used to analyse all variables. Data on growth components were analysed using repeated measures analysis of variance and forage yield was analysed using one way analyses of variance (ANOVA). Significant ($P<0.05$) differences between treatment means were compared by applying the probability of difference (PDIFF) option of Least Square Means of the SAS package.

Experimental model;

$$\mathbf{Y_{ijk} = \mu + I_i + B_j + Eijk}$$

Where:

Y_{ijk} = is the record of observations for dependent variables

μ= is the population mean

I_i= effect of intercropping (i = 1, 2 and3)

B_j= effect of Blocks (1, 2 and 3)

E_{ijk}= Random error assumed

Results and discussions

The effect of intercropping on percentage field germination of *Sorghum almum* and lablab was presented in Table 3. The highest 70 %

germination was recorded for sole grass which was significantly ($P<0.05$) different from (61.11 %) for *S. almum* intercropped with lablab intra rows but not significantly ($P>0.05$) different from (67.78 %) for *S. almum* intercropped with lablab in alternate rows while the highest value of 82.78 % germination was recorded for lablab in AR compared to 75.56 % for sole lablab. The percentage germination of *S. almum*obtained in this study were lower than 85 % germination reported by (14, 15).The higher percentage germination of lablab observed in this study 75.56-82.78 % than *Sorghumalmum* is attributed to the purity and viability of seeds sown. Also, variations observed in the percentage field germination of both *S. almum* and lablab could be attributed to higher soil moisture content during the planting period. This could be attributed to moisture content during sowing period. This agrees with (16) who reported that high moisture stress can result in poor seed germination and death of seedling which eventually affects stand count and low yield at the early stage of growth.

Table 3: Germination percentage *Sorghum almum*as affected by intercropping system.

Intercropping systems	% Germination of *Sorghum almum*	% Germination of lablab
Sole S. *almum*	70.0^{a}	-
Sole lablab	-	75.56^{b}
S. *almum* + Lablab (IR)	61.11^{b}	82.22^{a}
S. *almum* + Lablab (AR)	67.78^{ab}	82.78^{a}
SEM	1.70*	1.95*

S. almum =*Sorghumalmum*, SEM= standard error of mean, LS= level of significance, IR= intra rows, AR=alternate rows, *Means with different superscripts within columns differed significantly ($P<0.05$).

The effect of intercropping on growth components of *Sorghum almum*is presented in Table 4. The plant height of 167.26 cm for *S. almum* and lablab in intra rows (IR) was significantly ($P<0.05$) higher than sole *Sorghum almum* with plant height of 162.12 cm but not statistically ($P>0.05$) different from 163.43 cm for *S. almum* and lablab in alternate rows (AR). This could be due to nitrogen fixation of lablab by rhizobia relative to other intercropped system which was benefited by the *S. almum*. This was in agreement with the report of (17) who noted an increased in plant heights of corn/bush bean, corn/cowpea and corn/soya bean when intercropped than sole cropping. Also, (30) reported that plant height of maize and legumes when intercropped was significantly greater than sole maize. It has been reported that height of *S. almum* significantly increase with the addition of manure or fertilizer and plant height was an indicator of herbage yield (19). The values of 167.26cm and 163.43cm obtained in intercropped were statistically similar to 153 cm and 169 cm reported by (20) when 60 kg/ha nitrogen fertilizer was used at plant spacing of 0.5 m x 0.5 m. This result was however, inconsistent with earlier report (21) who noted a reduction in plant height of Sorghum due to intercrop with legumes. Also, (22) and (10) noted a decreased plant height of cereal-legume intercropped than the sole cereal. Intercrop of *S. almum* and lablab resulted into an increase in the height of *S. almum*through the benefit derived from nitrogen fixation by the legume crop. The number of tillers per plant, number of leaves per plant and leaf to stem ratios were not significantly (P>0.05) affected by Intercropping systems. The plant height has a direct relationship with the number of leaves and the leaves play an important role in manufacturing and supply of food materials synthesized during photosynthesis. Thus an increase or decrease in the number of leaves per plant has a direct effect on the green forage yield of forage crops (23).

Plant density was measured as the number of plants per unit area. The highest plant density of (49.00 plants/m^2) was observed in *S. almum*and lablab legume intercropped in alternate single rows which was significantly (P<0.05) higher than *S. almum*and lablab intercropped in intra rows (43 plants/m^2) and sole *S. almum* (42 plants/m^2). The highest plant density recorded from*S. almum*and lablab in alternate rows due to less competition for light, space and nutrient between the two forages compared to other intercropped systems. This agrees with the report of (24) who noted that plant density vary with the ability of crops to acquire growth resources from the environment.

Table 4: Growth components of *Sorghumalmum* as affected by intercropping systems.

Intercropping systems	Plant height (cm)	No. of tillers per plant	No. of leaves per plant	Plant density No./m^2	Leaf: stem ratio
Sole *S. almum*	162.12^{b}	15.0	7.0	43.00^{b}	1.64
S. almum + L (IR)	167.26^{a}	16.0	7.0	42.00^{b}	1.55
S. almum + L (AR)	163.43^{ab}	17.0	8.0	49.0^{a}	1.53
SEM	2.53	1.31	0.60	2.26	0.44
LOS	*	NS	NS	*	NS

L= lablab, SEM= Standard Error of Mean IR=intra row, A R= alternate row, ^{abc}Means with different superscripts within columns differed significantly (*P<0.05). NS- not significant.

Figures 1 and 2: shows the fresh and dry matter yields of *Sorghum almum* and lablab as affected by intercropping systems. Fresh and dry matter yields were significantly (P>0.05) affected by intercropping systems. The highest fresh forage yield of S. *almum*(18.36 t/ha) obtained in *Sorghumalmum* intercropped with lablab in alternate single rows was significantly (P>0.05) higher than (14.54 t/ha) for the sole S. *almum*but not significantly (P<0.05) different from S. *almum* intercropped with lablab intra rows. The fresh forage yield of sole lablab was significantly (P>0.05) higher (8.51 t/ha) than the intercropping systems. The highest total fresh biomass yield of (26.21 t/ha) was obtained in alternate row intercropped which differ significantly (P<0.05) than the yields of sole crops.The dry matter yield of *S. almum* was significantly (P<0.05) higher (8.68 t/ha) in alternate rows intercrop than 7.06 t/ha obtained in sole S. *almum.* The highest dry matter yield of lablab differs significantly (P<0.05) from the intercropped systems. However, the total biomass dry matter yield was significantly (P<0.05) higher(12.85 t/ha) in alternate row intercropped than the sole crops, although it was not significantly (P>0.05) different from intra row intercrop. The fresh and dry matter yields of crops determines it economic value. The growth and development of plants depends on the conditions prevailing on the ground surface as well as in the rhizosphere (23). The highest fresh and dry matter yields obtained in alternate rows intercrop could be attributed to the less competition for environmental resources and the ability of lablab to fixed more nitrogen which was used by the component grass. This was in line with the report of (20) and (23) who reported that higher rate of nitrogen in soil can lead to progressive increase in biomass yield of the crop. The yield of sole lablab was higher because, it has a greater opportunity to access sunlight energy (25). The earlier report of (26) stated that lablab can compete favourably with other species for light and other nutrient. The total combined biomass yield obtained in this study for *S. almum* and lablab intercrops is higher than its component sole *S. almum*. This could be due to additional biomass obtained from lablab forage. The increase in forage yield was due to the presence of associated lablab crop which provide additional yield to *S. almum*. This agrees with the report of (22) that, to make the best use of available resources like land, light and nutrient, intercropping systems should be adopted for additional biomass from component legumes. Mixture components intercropped use these environmental resources more efficiently than monocrops and will support a greater number of plants leading to greater biomass yields.

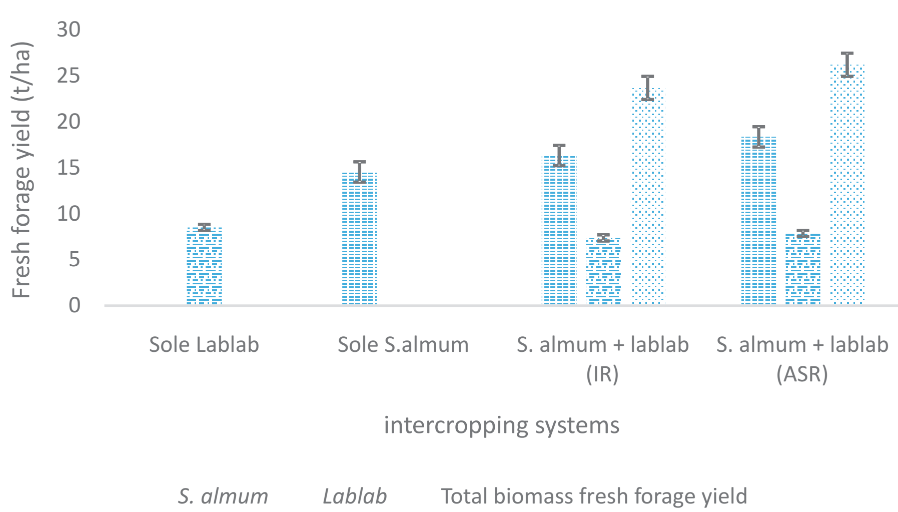

Figure 1: Fresh forage yield of *Sorghum almum* and lablab in sole, intercrop and total combined biomass yield

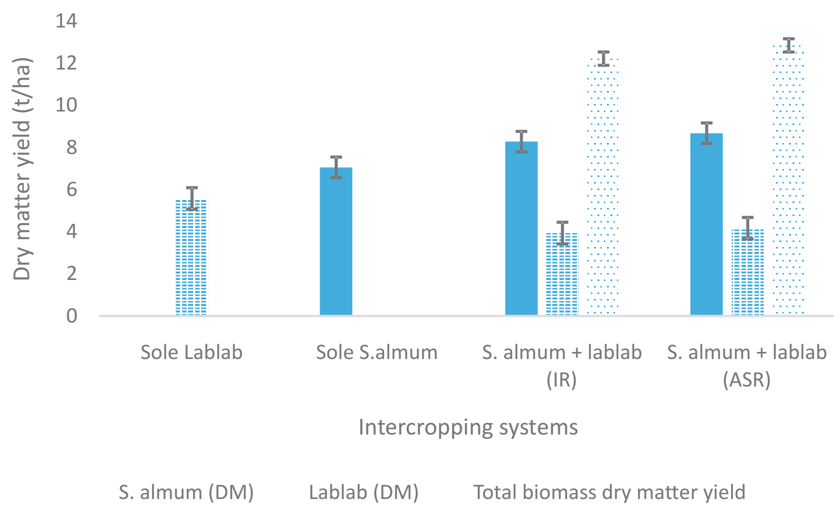

Figure 2: Dry matter yield of *Sorghum almum* and lablab in sole, intercropped and totalcombinedbiomass yields.

Table 5: Shows the land equivalent ratio (LER) and leaf area index (LAI) as effected by intercropping. The LER (1.98) for intercrop in alternate rows (AR) was at par with LER (1.88) for intercrop in intra rows (IR) but significantly ($P<0.05$) higher than the sole S. *almum*. The LER of both intercrops are greater than one (1.0). The Leaf Area Index (LAI) for *S. almum* was not significantly ($P>0.05$) affected by intercropping systems.

Land equivalent ratio (LER) is defined as the land area required for sole crop to obtain the same yield from intercropping under the same management levels (22). An LER of 1.0 shows that intercropping produce the same yield as sole cropping and above 1.0 means greater intercrop yield than sole crops. The land equivalent ratio of (1.98) for *Sorghum almum* and lablab intercrop in alternate rows and (1.88) for *Sorghum almum*-lablab in intra rows in this findings, showed that intercropping of *Sorghum almum* and lablab legume was more advantageous than the sole *S. almum*. Yields advantage from intercropping as compared to sole cropping are often attributed to mutual complementary effectsof component crops (22). The LER was greater for intercrop in alternate rows than intercrop in intra rows, indicating that for the same amount of forage yields of 98 % and 88 % more area would be required for sole cropping system compared to intercropping respectively. However, yield advantage occurs because component crops differ in their use of growth resources. It means that when they are grown in combination they are able to complement each other and make better use of overall resources than when they are grown separately (22, 27).

Table 5: Land equivalent ratio (LER) and leaf area index (LAI) of *Sorghumalmum* as affected by intercropping, plant spacings and their interactions.

Intercropping systems	Total land equivalent ratio (LER)	Leaf Area index of lablab	Leaf area index of *S. almum*
Sole *S. almum*	1.00[b]	0.78	2.29
S. almum + L (IR)	1.88[a]	0.65	2.17
S. almum + L (AR)	1.98[a]	0.74	2.27
SEM	0.23	0.25[NS]	0.48[NS]

L= lablab, SEM= standard error of mean, IR=intra row, AR= alternate rows, [abc]Means with different superscripts within columns differed significantly (*P<0.05). NS- not significant.

The LAI is the measure of size of assimilatory system of plant. It is considered to be mainly concerned with accumulation and partitioning of photosynthesis to the economic part of the plant, it also has economic role in the final biomass yield of the crop (23). The LAI for *S. almum* reported in this study (2.14-2.42) were similar to 1.6-3.0 for maize reported by (26) in a study under irrigation. The LAI were lower in intercropping as compared to sole cropping. The higher LAI in *S. almum* in this study can be ascribed to better leaf growth possibly due soil moisture, environmental resources (light, space, and soil nutrients), vertical plant structure and leaf architecture, which might have been an advantage over lablab that spread horizontally. Higher LAI (4.1) in dry season and (2.9) in wet season have been observed when sweet sorghum was intercropped with Mung bean and Soybean in Thailand (22). These values are higher than those reported for this study. On the other hand, (29) reported a lower LAI (1.82) for *S. almum* in Pakistan, compared to the values obtained in this study (28).

Table 6: Proximate composition of *Sorghumalmum*and *Sorghumalmum*/lablab mixtures as affected by intercropping systems.

	Proximate composition (% DM)					
Intercropping systems	DM	CP	CF	EE	Ash	NFE
Sole *S. Almum*	93.12	15.95[c]	26.67[a]	6.44[c]	7.40[a]	43.54[a]
S. almum + L (IR)	92.58	17.50[b]	24.95[b]	7.47[b]	7.22[b]	42.87[ab]
S. almum + L (AR)	92.54	18.82[a]	23.23[c]	7.83[a]	7.12[c]	42.41[b]
SEM	0.50[NS]	0.64*	0.53*	0.14*	0.45*	0.63*

L= lablab, SEM= standard error of mean, IR= intra rows, ASR= alternate single rows,[abc]Means with different superscripts within columns differed significantly (*P<0.05). NS- not significant.

Table 6 shows the proximate composition of *Sorghum almum*and *Sorghumalmum*/lablab mixtures as affected by intercrop systems. The crude protein, crude fiber, ether extract, ash and nitrogen free extract are significantly (P<0.05) affected by intercropping systems. The highest crude protein (18.82%CP) and ether extract (7.83%EE) were observed in *Sorghum almum* and lablab legume in (AR) while lowest value of CP (15.95 %) and EE (6.44 %) were obtained in sole *Sorghum almum*. The highest CF, Ash and NFE values of (26.67 %, 7.40 % and 43.54%) were recorded in sole *Sorghum almum*respectively, while lowest values of CF (23.23 %), Ash (7.12 %) and NFE

(42.41 %) were obtained in *Sorghum almum* and lablab legume in (AR).

The crude protein contents are one of the most important parameter that affects the nutritional quality of forage crops (23). The result of this study showed that crude protein content of sole *Sorghum almum* was lower than intercropped. Intercropping *Sorghum almum* with lablab increased the crude protein content of the forage mixtures. This may be due to additional crude protein obtained from lablab forage. The value of crude protein 15.95 %reported in this study was similar to 15.30% CP of sole *S. almum*reported by (15). The findings of (21) reported a lower value for sole *Sorghum almum* as 9.35-9.94 %CP and that of Sorghum + sesbania mixed forage has 14.89 %CP. Crude protein increases due to intercrop mixtures of legumes with grasses (3). The percentage CP values were within the requirements for growing goats (10-31 % CP) reported by (30).

Table 7: Fibre fractions of *Sorghumalmum*and*Sorghumalmum*/lablab mixtures as affected by intercropping systems

Intercropping systems	ADF	NDF	Hemicellulose	Cellulose	Lignin
Sole *S. almum*	30.59	54.55^{a}	23.96^{a}	22.18^{b}	8.42
S. almum + L (IR)	31.14	52.08^{b}	20.94^{b}	23.55^{a}	7.58
S. almum + L (AR)	31.95	50.61^{c}	18.66^{c}	24.20^{a}	7.76
SEM	0.77^{NS}	0.70*	0.69*	0.68*	0.60^{NS}

SEM= standard error of mean, L= lablab, IR= intra rows, AR= alternate rows, ^{ab}Means with different superscripts within columns differed significantly (*P<0.05). NS- not significant.

Table 7showed thefiber fractions of *Sorghumalmum*and sorghum almum/lablab mixtures as affected by intercropping systems. The percentage ADF and lignin were not significantly (P>0.05) affected by intercropping systems but NDF, hemicellulose and cellulose showed significant (P<0.05) difference. The highest values of 54.55%NDF, 23.96% hemicellulose and 8.42 % lignin were obtained in sole *S. almum*while the lowest values of 50.61% NDF, 18.66% hemicellulose were obtained in *S. almum* and lablab legume in (AR). Also, highest value of 24.20 %cellulose was observed in *S. almum* and lablab legume in (AR) which was significantly (P<0.05) higher than 22.18 % in sole S. *almum*.The values of 30.59% ADF and 54.55% NDF reported in this study for sole *S. almum* were lower than 40.0-44.0% ADF and 61.2-75.3% NDF in *Sorghum almum*reported by (15). These values were also lower than earlier reports of (31) and (20). The intercrop of S. *almum* and lablab (IR) and *S. almum* and lablab (ASR) showed a decrease in ADF, NDF, hemicellulose and lignin compared to the sole cropped. This may be attributed to the higher crude protein contents of the intercropped which consequently decrease their crude fiber fractions. Higher lignin content in sole grass could be due to the development of lignified structures in their cell walls, on the contrary (1)reported a higher lignin in legumes than grasses, as legumes synthesis lignin for strength.

Table 8: Mineral elements of *Sorghumalmum* as affected by intercropping systems

Intercropping systems	Na (%)	P (%)	K (%)	Ca (g/kg)	Mg (g/kg)	Mn (g/kg)	Fe (g/kg)
Sole *S. almum*	0.74	1.25	2.24	1.71^{b}	0.47	0.05	0.75
S. almum + L (IR)	0.77	1.00	2.43	2.77^{a}	0.51	0.05	0.99
S.almum+ L (ASR)	0.92	1.46	2.60	3.21^{a}	0.48	0.06	0.83
SEM	0.23^{NS}	0.47^{NS}	0.33^{NS}	0.59*	0.15^{NS}	0.06^{NS}	0.27^{NS}

L= lablab, SEM= standard error of mean, IR= inter rows, AR= alternate rows, abc*Means with different superscripts within columns differed significantly (P<0.05), NS= not significant.

The mineral composition of *Sorghum almum*and sorghum almum/lablab mixtures as affected by intercropping systems is presented in Table 8. The amount of Na, P, K, Mg, Mn and Fe were not significantly (P>0.05) affected by intercropping system except for % Ca. The highest value (3.21 gCa/kg DM) was obtained in *Sorghum almum* and lablab legume intercropped in alternate rows (AR) which was significantly (P>0.05) higher than the value of 1.71 g/kg DM in sole *Sorghum almum.* This could be attributed to the soil nutrient of the experimental site which shows a higher value of Calcium than all the other exchangeable cations reported in Table 2.The mineral components of *Sorghum almum* in sole and intercropped observed in this study were similar to the previous values reported by (15) for *Sorghum almum*. The value of Calcium greater than 0.7-0.9 g/kg DM reported earlier by (31and 32) was lower than the value of Ca (1.13-4.54 g/kg DM) reported in this study. The Ca content was sufficient to meet the daily (0.5-1.1 g/Ca/day) requirement of goats (30 and 26). The amount of Ca obtained in this study was also, within the value of 3g /kg DM recommended for ruminants needs in warm climates (33).

Conclusions and applications

It could be concluded from the results of this study that:

1. *Sorghum almum* should be intercropped with lablab for higher yields and nutrient quality than sole cropping. It enhance better productivity of *S. almum* in terms of yield components which produced the highest total biomass dry matter yield of 12.85 t/ha and had the best land equivalent ratio (LER) of 1.98 which was equivalent to 98 % advantage ofintercrop.
2. Intercropping of *S. almum* and lablab legume in alternate single gave the highest crude protein of 18.82 % and lowest crude fiber of 21.90 % than sole *Sorghumalmum*
3. Intercropping of *S. almum* and lablab legume in alternate rows gave the highest Ca content of 3.21 g/kg.
4. The mineral elements studied were adequate to meet the nutritional requirement of small ruminants in Nigeria.

Applications

It could be applied from the result this study that Smallholder farmers, Stock owners and Research Institutions and Universities to:

1. Adopt the intercropping of *Sorghum almum* and lablab legume in alternate rows (AR) for higher and quality yields

which could be transferred through extension services to farmers

2. Provide *Sorghum almum* and lablab legume mixtures as feed for ruminants in Nigeria.
3. Produce *Sorghum almum* and lablab hay mixtures in bales which could serve as source of income.

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