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Effect of intercropping *Sorghum almum* with *Centrosema pascuorum* on Growth Components, Forage Yield and Chemical Composition Under Flooded Irrigation in Gashua, Nigeria

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Abstract

This study was carried out to assess the effect of intercropping Sorghum almum with Centrosema pascuorum on growth components, forage yield and chemical composition under flooded irrigation at Livestock Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Federal University, Gashua. The experiment was carried out using a Randomized Complete Block Design, consisting of six treatments: T1= as sole sorghum, T2=sole Legume, sorghum with Centro in inter-row ratios as; 1:1 (T3), 1:2 (T4), 2:1 (T5) and 3:1 (T6). Significant (P< 0.05) difference was observed in all the growth parameters measured. The highest plant height (145.17cm) and leaf area index (4.9) were obtained in T1, and the highest tiller number (16.94) was observed in T5 (2:1). Fresh and dry matter yields were significantly (P<0.05) affected by intercropping pattern. The highest fresh forage yield of S. almum (8.64 t/ha) obtained in Sorghum almum intercropped with C. pascourum in 1:2 inter-row ratio (T_4) was significantly (P>0.05) higher than (7.17 t/ha) and (7.25 t/ha) for T_3 and T_6 respectively. The dry matter yield of S. almum was significantly (P<0.05) higher in intercropped plots than in sole S. almum treatment (T_1). The highest dry matter yield of 6.48 t/ha was obtained in T_4, with the least recorded in T_1 (5.02 t/ha). The best total land equivalent ratio (TLER) was observed in the intercropped treatments. The value of one (1) recorded was against both sole S. almum (T_1) and sole C. pascourum (T_2) plots were significantly (P<0.05) lower than 2.67, 3.12, 2.50 and 2.41 for T_3, T_4, T_5 and T_6, respectively. The chemical compositions were significantly (P< 0.05) affected by intercropping pattern. The highest (92.60%) and lowest (89.58%) percentages of dry matter were obtained in T1 (sole S. almun) and T4 (1:2 S. almum-C. pascourum), respectively. The organic matter, crude protein and ether exract of S. almum were significantly (P<0.05) higher in the intercropped plots than in sole S. almum treatment (T_1). However, the ash (15.36 %), crude fibre (33.49 %), NFE (37.36 %) and NDF (54.93 %) were higher in the control (T_1). Among the two species, the legume had higher crude protein (22.75 %), ether extract (7.66 %) and hemicellulose (23.81 %) contents than the grass, S. almum. This study revealed that S. almum forage harvested in the intercropped plots had better forage quality than ones harvested in the sole plots with 1:2 inter-row ratio having best crude protein, crude fibre, ether extract and nitrogen free extract. Therefore intercropping S. almum with C. pascuorum in inter-row arrangement is recommended for livestock farmers in Nigeria to enhance meat and milk productions.

Keywords: Chemical composition, Flooded Irrigation, Growth parameters and Intercropping

Description of Problem

A major part of Nigerians' economic and social activities is occupied by livestock production. Pasture production is an important resource for livestock enterprises. Its establishment and improvement have been recommended for better performance of ruminant animals in the production of milk, meat, hide and skin, and other livestock such as rabbit, pig, etc. for their products (meat, fur, pork, and lard) (1). In most tropical countries of the world, about 80-90 % of the 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 (2, 3). Intercropping legumes into grass pastures has proven to be a viable means to mitigate the decline quantity and quality of grass forages (4, 5). The practice of intercropping is an alternative way identified for smallholder farmers to improve the yield and nutritional quality of the native grasses. It has been reported that intercropping grasses with legumes increased yield, improved growth, enhanced palatability, and nutritive quality feeds for animals (6).

The increasing shortage in forage for ruminant feeding, coupled with the inefficiency of crop residues to meet the nutrient requirements of ruminants during the off-season, and the need to ensure that feed is always available to the animals has become a serious challenge in ruminant nutrition and farmers are at receiving end (7). In recent years, the use of forage legumes in livestock production systems for ruminants in the tropics as an alternative to oil seed cakes has increased. Forage legumes and fodder trees provide high-quality proteins as well as digestible cell wall carbohydrates (7). Natural pasture grasses are wild and are characterized by low yield and poor nutrients (8) as they grow on infertile and erosion-degraded soils. Tropical forage grasses (*Sorghum almum*) have the ability for high yield and their nutrient content can be enhanced when intercropped with nitrogen-fixing crops like *Centrosema pascuorum*. *Centrosema pascuorum* (*C. pascourum*) is a vigorous, trailing, twining, and climbing perennial herb with trifoliate leaves and is fairly drought tolerant. *Centrosema pascuorum* is a legume species of high potential as a fodder crop because of its high biomass production compared to other forage legumes.

Like other nitrogen (N) fixing legumes, *C. pascuorum* is a soil improver and in association with grass in mixtures is beneficial to grass yields making nitrogen (N) fertilizer not necessary (9). Continuous use of inorganic fertilizers could eventually damage the soil by increasing soil acidity (10). Apart from legumes meeting their nitrogen requirement through symbiosis with nitrogen-fixing bacteria (*Rhizobium leguminosarum*), they are known to fix between 20-200kg/ha of nitrogen to the soil (11). The plant is recommendable for agricultural systems due to its ability for biological nitrogen fixation, resistance to drought, and high fodder nutritional value (1). Intercropping a high-yielding and ecologically adapted grass/legume mixtures such as *S. almum* with *C. pascuorum* under irrigation will help to increase the income of livestock farmers through an increase in biomass yields and high-quality fodder for silage or hay, to supplement the low-quality crop residues offered during the dry season (12). The general objective of this study was to determine the effect of intercropping *S. almum* with *C. pascuorum* on growth parameters, forage yield, proximate compositions, and fiber fractions under flooded irrigation in Gashua, Yobe State.

Materials and Method

Description of the Experimental Site

The experiment was carried out during the 2021 dry season between February to May, at the Teaching and Research Farm of the Department of Animal Science, Federal University Gashua, Yobe State. The vegetation characteristic of the area is Sahel Savannah. It consists of an open Thorny savanna with short trees and grasses. Gashua is located between Longitude 10° 02' and 11° 11'E and Latitude 12° 48' and 12°88'N. It is situated in the Sudan Savanna ecological zone of Nigeria. High temperatures and seasonal rainfall characterize the climate. The mean minimum temperature ranges between 10-12°C in December to January, while the mean maximum temperature is about 34-40°C in March-May. The mean rainfall is between 300-500 mm per annum and is unimodal and lasts mostly from June to September while the dry season is from October to May (13).

Soil Samples of the Experimental Site

Soil samples were collected from the experimental site with the aid of a soil auger at 4 corners and the center of the plots to depths of 0 – 30 cm. Samples collected were mixed thoroughly and a representative sample was taken for soil analysis before the commencement of the experiment. The soil sample was then analyzed for physical and chemical properties (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: Soil physical and chemical properties of the experimental site

Physical properties	
Soil depth	0-30cm
Particle size (%)	
Clay	17.00
Silt	31.00
Sand	52.00
Textural Class	Sandy loam
Chemical Properties	
pH (0.01McaCl)	7.50
Total nitrogen (%)	0.24
Organic carbon (%)	0.58
Phosphorus (ppm)	23.28
Exchangeable Bases (cmol/kg)	
Ca^{++}	8.23
Mg^{++}	0.94
K^{+}	0.64
Na^{+}	0.92

Experimental Layout, Design, and Treatments

The field was ploughed by a tractor and leveled manually with hand hoes before sowing to provide an appropriate and well-established bed for seed germination. The experiment was laid out in a Randomized Complete Block Design (RCBD), which consisted of six (6) treatments as T_1 = Sole *S. almum*, T_2 = Sole *C. pascuorum*, T_3 = 1:1 alternate rows, T_4 = 1:2 alternate rows, T_5 = 2:1 alternate rows and T_6 = 3:1 alternate rows and replicated three times. Seeds of the two species were drilled in rows with 50cm apart at the rate of 20kg/ha. The fertilizer (NPK 15-15-15) was applied during land preparation at 60 kg/ha. All plots were hand-weeded twice at 3 and 6 weeks after sowing. Also, flooded irrigation was carried out at three days intervals from the onset to the end of the experiment.

Determination of Growth Parameters

Data on growth parameters for *S. almum* and *C. pascourum* (plant height, number of leaves, and leaf area index (LAI) were taken at 9 WAS from five (5) randomly selected plants from the two middle rows of each plot. Plant height was measured

Table 1: Effect of Intercropping and Plant Species on Growth Parameters

	Parameters				
Treatments	Plant Height (cm)	Number of Leaves	Tillers Number	Plant Density	LAI
T_1	99.42^{b}	14.77^{c}	11.44^{b}	42.42^{b}	4.90^{a}
T_2	109.37^{b}	28.11^{a}	18.22^{ab}	34.74^{b}	0.42^{b}
T_3	110.35^{b}	18.71^{bc}	11.99^{ab}	65.33^{a}	5.46^{a}
T_4	149.17^{a}	19.53^{bc}	14.25^{ab}	69.44^{a}	3.90^{a}
T_5	99.94^{b}	19.36^{bc}	16.94^{a}	66.25^{a}	3.31^{a}
T_6	111.46^{b}	19.86^{b}	12.11^{ab}	72.08^{a}	3.68^{a}
SEM	7.53*	1.32*	1.41*	10.25*	1.16*
Species (S)					
S1	144.18^{a}	19.81	14.30	73.38^{a}	6.12^{a}
S2	77.10^{b}	19.77	12.45	42.25^{b}	1.47^{b}
SEM	13.08*	2.29^{NS}	2.14^{NS}	17.70*	2.02*

^{abc} means with different superscripts within rows differed significantly (P<0.05), * = significant at 5% level of significant, NS = not significant, SEM = standard error of mean, T_1 = sole sorghum almum, T_2 = sole Centrosema pascourum, T_3 = 1:1 *Sorghum almum – Centrosema pascuorum*, T_4 = 1:2 = *sorghum almum – Centrosema pascuorum*, T_5 = 2:1 *Sorghum almum – Centrosema pascuorum*, T_6 = 2:2 *sorghum almum – Centrosema pascuorum* ratios, LER = land equivalent ratio, $_s$ = sorghum almum, $_c$ = Centrosema pascuorum

Table 2: Effect of Intercropping and Plant Species on Forage Yields and Land Equivalent Ratio

	Parameters				
Treatments	Fresh forage Yield	Dry matter yield	LERs	LERc	TLER
T1	8.00^{ab}	5.68	1.00^{b}	1.00^{b}	1.00^{b}
T2	3.99^{d}	2.76	1.00^{b}	1.00^{b}	1.00^{b}
T3	7.38a^{b}	5.39^{b}	1.53^{ab}	1.32^{ab}	2.67^{a}
T4	8.64^{a}	6.48^{a}	1.54^{a}	1.56^{a}	3.12^{a}
T5	7.17^{c}	5.02^{b}	1.24^{ab}	1.26^{ab}	2.50^{a}
T6	7.25^{bc}	5.08^{b}	1.25^{ab}	1.24^{ab}	2.49^{a}
SEM	0.39*	0.28*	0.15*	0.14*	0.23*
Species					
S1	10.04^{a}	7.23^{a}	1.29	1.29	2.36
S2	4.55^{b}	3.25^{b}	1.30	1.27	2.57
SEM	0.68*	0.49*	0.26^{NS}	0.24^{NS}	0.40^{NS}

^{abc} means with different superscripts within rows differed significantly (P< 0.05), * = significant at 5% level of significant, NS = not significant, SEM = standard error of mean, T1 = sole sorghum almum, T2 = sole Centrosema pascourum, T3 = 1:1 Sorghum almum – Centrosema pascuorum, T4 = 1:2 = sorghum almum – Centrosema pascuorum, T5 = 2:1 Sorghum almum – Centrosema pascuorum, T6 = 2:2 sorghum almum – Centrosema pascuorum ratios, LER = land equivalent ratio, s = sorghum almum, c = Centrosema pascuorum from the ground level to the tip of the flag leaf. The leaf area index was calculated as the ratio of leaf area to the area of ground cover at 9 WAS, respectively as described by Tarawali *et al.* (14). Leaf area was calculated by multiplying the length of the leaf by its width and a factor of 0.75 as described by Adesoji *et al*. (15).

Determination of Forage Yield in t/ha:

Forage yield was determined by harvesting the fresh forage within each sub-plot within 0.5 m^2 quadrat at a height of 15cm above the ground level at 6 and 9 weeks after sowing using a hand sickle. The harvested fresh forage materials were weighed and a known weight of sub-samples (200-250 grams) was oven-dried at 65°C for 48 hours and reweighed to estimate dry matter yield (DWss) at the animal science laboratory, Faculty of Agriculture, Federal University Gashua. Dry matter yield (t/ha) was calculated using the formula below as reported by Akpensuen *et al.* (16) as stated below:

Forage dry matter yield (kg DM ha-1) = Fresh weight (kg) x Oven-dried weight (DM %) × 20,000. There are 20,000 quadrats (0.5m^2) per hectare.

Chemical Analysis

Samples of forage materials harvested were taken to the laboratory for chemical analysis. The dried samples of forage were ground using a simple mill and passed through a 1-2mm sieve. Proximate analysis was carried out to determine Nitrogen (N) for crude protein determination (N×6.25), crude fiber (CF), Ether Extract (EE), nitrogen-free extract (NFE), and ash content according to the procedure described by AOAC (17). Neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose, and acid detergent lignin (ADL) were determined by the method of Van Soest et al. (18).

Statistical Analysis

The results obtained were subjected to Analysis of Variance (ANOVA) using the General Linear Model procedure (proc. GLM) of SAS (19). Significant ($P<0.05$) differences among treatment means were compared using the Duncan Multiple Range Test (20) of the SAS package.

Results and Discussion

Growth components and forage yieldof *S. almum* intercropped with *C. pascourum* under flooded irrigation

The effect of intercropping *S. almum* with *C. pascuorum* on the growth components is presented in Table 3. The plant height of 145.19 cm for *S. almum* observed in T4 (1:2 *S. almum-C. pascourum*) was significantly ($P<0.05$) higher than sole *Sorghum almum* with a plant height of 109.33 cm. The number of tillers per plant, plant density, and leaf area index were also significantly ($P<0.05$) affected by the intercropping pattern with control having the lowest values. The lowest values recorded in the sole *S. almum* plots for the number of tillers per plant, plant density, and leaf area index were 14.77, 36.74 /m^2, and 1.42, respectively. The least value of 14.77 for the number of leaves per plant was also recorded with the control T1 (sole *S. almum*) but statistically similar ($P>0.05$) to 18.71, 19.58, and 19.36 number of leaves for T3 (1:1), T4 (1:2) and T5 (2:1), respectively. The least values recorded in the sole *S. almum* plots for the

Table 3: Effect of Intercropping and Plant Species on Proximate Composition and Fibre Fractions of *S. almum*

	Parameters (%)											
Treatments	DM	OM	ASH	CF	CP	EE	NFE	ADF	NDF	ADL	CEL	HCE
T1	92.60^{a}	77.24^{b}	15.36^{a}	33.49^{a}	12.22^{d}	3.36^{d}	37.36^{a}	35.64^{b}	54.93^{a}	19.31^{b}	16.15^{c}	18.78^{b}
T2	90.51^{c}	80.02^{a}	10.49^{d}	25.64^{c}	23.67^{a}	6.40^{b}	30.59^{b}	30.23^{d}	52.42^{b}	20.97^{a}	9.43^{d}	20.51^{a}
T3	91.85^{b}	79.50^{a}	12.34^{b}	33.11^{a}	19.05^{b}	5.38^{c}	31.10^{b}	35.81^{c}	47.83^{d}	14.02^{d}	19.78^{b}	13.75^{d}
T4	89.58^{d}	78.29^{ab}	11.29^{c}	29.91^{bc}	19.27^{b}	6.24^{b}	33.27^{ab}	35.47^{c}	48.00^{d}	15.53^{c}	20.93^{b}	15.95^{c}
T5	89.92^{cd}	77.43^{b}	12.49^{b}	29.35^{C}	20.68^{b}	7.37^{a}	30.09^{b}	43.42^{a}	50.71^{c}	7.28^{E}	36.14^{a}	20.24^{a}
T6	90.29^{c}	77.73^{b}	12.56^{b}	30.32^{bc}	15.13^{c}	7.70^{a}	34.27^{ab}	36.00^{b}	54.82^{a}	18.79^{b}	17.20^{c}	18.58^{b}
SEM	0.35*	0.63*	0.56*	1.19*	0.84*	0.17*	1.04*	0.30*	0.27*	052*	0.57*	0.26*
SPECIES												
1	91.13	78.55	12.57	32.89^{a}	13.73^{b}	5.01^{b}	35.80^{a}	36.43	53.90^{a}	17.50^{a}	19.23^{a}	16.92^{b}
2	90.15	78.08	12.07	28.22^{b}	22.75^{a}	7.66^{a}	29.29^{b}	36.61	49.39^{b}	12.77^{b}	16.04^{b}	23.81^{a}
SEM	0.60^{NS}	0.59^{NS}	0.57^{NS}	2.07*	1.45*	0.29*	2.43*	0.53^{NS}	0.46*	0.35*	0.46*	0.99*

^{abc} means with different superscripts within rows differed significantly (P<0.05), * = significant at 5% level of significance, N S = not significant, SEM= standard error of the mean, T_1 = sole sorghum almum, T_2 = sole Centrosema pascourum, T_3 = 1:1 *Sorghum almum – Centrosema pascuorum*, T_4 = 1:2 = *sorghum almum – Centrosema pascuorum*, T_5 = 2:1 *Sorghum almum – Centrosema pascuorum*, T_6 . 2:2 *sorghum almum – Centrosema pascuorum* ratios

number of tillers per plant, plant density, and leaf area index could be due to the absence of nitrogen fixation of *C. pascuorums* by rhizobia relative to intercropped plots which was benefited by the *S. almum*. This was in agreement with the report of (21, 10) who noted an increase in plant heights of maize/*Tephrosia bracteolata, Brachiaria ruziziensis*/*C. pascuorum* when intercropped than sole cropping. This also corresponds to the report of Ishiaku *et al*. (2) who noted that plant density varies with the ability of crops to acquire growth resources from the environment. Thobatsi (22) also found that maize intercropped with cowpea (*Vigna unguiculata*) had a higher leaf area index compared to sole maize crop.

The forage yield of *S. almum* intercropped with *C. pascourum* is presented in Table 2. The yield data obtained in this study are all within the range (5.4 - 19.4 DM t/ha). The findings revealed that *S. almum – C. pascourum* intercropped in a 2:1 row proportion resulted in the highest fresh (8.64 t/ha) and dry biomass (6.48 t/ha) than other spatial arrangements. The best total land equivalent ratio (TLER) was observed in the intercropped treatments. The value of one (1) recorded was against both sole *S. almum* (T_1) and sole *C. pascourums* (T_2) plots were significantly (P<0.05) lower than 2.67, 3.12, 2.50 and 2.41 for T_3, T_4, T_5 and T_6, respectively. This agrees with the report of Iqbal *et al*. (23); Abdullahi *et al*., (21) who also reported that when mash (*Vigna mungo* L.) and tephrosia (*Tephrosia bracteolata*) were intercropped with maize, intercropping resulted in a significantly higher LER. Similarly, when maize and cowpea were sown in mixtures of 100:100, 75:25, 50:50, and 25:75, LER for the intercropping systems was higher than 1 indicating an intercropping advantage compared to monoculture crops (**24**). It was also reported when maize (*Zea mays* L.) was planted in alternate rows with cowpea (*Vigna unguiculata* L.), comparatively had better agronomic growth of component crops led to the highest fresh and dry biomass owing to a greater number of plants per unit land area (25).

Proximate composition and fibre fractions of *S. almum* intercropped with *C. pascourum*

The proximate composition was significantly (P<0.05) affected by intercrops. The highest (92.60%) and lowest (89.58%) percentages of dry matter were obtained in T1 (sole *S. almum*) and T4 (1:2 *S. almum – C. pascourum*), respectively. The crude protein content is one of the most important parameters that affect the nutritional quality of forage crops (Ishiaku *et al.*, 2016). The CP content recorded in this study for both *S. almum* in sole and intercropped plots as well as for *C. pascuorums* was above the 7 to 8 % CP suggested as the threshold for sufficient utilization of feed by Lamidi and Osarobundo (26). Therefore, *S. almum* and *C. pascuorum* would provide the adequate nitrogen requirement for the rumen microorganisms to maximally digest the main components of dietary fiber leading to the production of volatile fatty acids which in turn facilitate microbial protein synthesis (27). Ash content is generally taken to be a measure of the mineral content of the original food (28). The higher level of ash content in the forages is an indication that the forage is rich in minerals which are essential in the formation and function of blood and bones (26).The forage of *S. almum* in the intercropped plots showed a decrease in ADF, NDF, 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 in the forage (2). The reasons for lower NDF and ADF in these treatments was attributed to the higher amount of nitrogen either by direct excretion from the legume nodule root system or by decomposition of the nodule and root debris. More, the decreased in crude fibre (CF) content of *S. almum* forage with increased in level of CP observed in this study is in line with the finding of Abdullahi *et al*. (8) who observed a decreased in CF percentage as the crude protein increases. The higher crude protein content in the intercropped plot obtained in this study corroborated with the report by Javanmard *et al.* (28) who also observed higher crude protein value in maize fodder in all the intercropping patterns than in the monocultures. Also, among different intercropping patterns the highest crude protein and least NDF and ADF content obtained in T_3 and T_4 which indicated that the two species, are more compatible at 1:1 and 1:2 inter-row ratios and the legume *C. pascuorum* was able to fixed more atmospheric nitrogen than in the other treatments. This result therefore suggests that intercropping *S. almum* and *C. pascuorum* under irrigation could assist smallholder farmers to minimize costs of purchasing expensive concentrate feeds during the dry season. Hassan *et al.* (12) found a similar result and concluded that grasses intercropped with legumes improve the protein content of the grass to meet the maintenance and production requirements of smallholders.

Conclusion

It was concluded that all intercropped plots gave higher leaf area index, plant density, crude protein, ash, and nitrogen-free extract than the sole treatment. However, intercropping *S. almum* and *C. pascuorum* at a 1:2 mixture (T_4) recorded 33%, 24%,, 27%, 12%, 68% and 37% higher plant height, number leaves, plant density, dry matter yield, total land equivalent ratio (TLER) and crude protein, respectively than the sole *S. sorghum*. The *C. pascuorum* species produces better crude protein and crude fiber under flooded irrigation in Gashua than previous reports by other researchers in the part country

Recommendations

It could be recommended from the result of this study that farmers should Cultivate *Sorghum almum* with legumes under flooded irrigation for better forage quality and yield during the dry season in Gashua, Yobe State as a mean of averting extreme feed shortage during the season.

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