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Effect of Sorghum-Legume Intercrop on Quality and Rumen Degradability of Sorghum Stover in Adamawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author TFM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ZAG and BY managed the analyses of the study. Author BY managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to evaluate the effect of sorghum-legume intercrop on quality and rumen degradability of sole sorghum stover, sorghum stover with lablab or with groundnut intercrop at different stages of growth. The experimental design was randomized complete block design with three treatments and three replicates. Growth was significant (P<0.05) between treatments and higher at weeks 10 to 12. Crude protein was higher among sorghum with lablab or groundnut intercrop and least with sole sorghum stover and decreases with stage of growth, while ADF and NDF increases with stage of growth. A fistulated bunaji bull with 90 mm internal diameter was used for the degradability. Degradability was higher with sorghum stover with legume intercrops and least with sole sorghum stover and increases with time of incubation, but decreases with age of sorgum stover. The result indicated that sorghum-legume intercrop could lead to improved quality of stover, degradability and general performance of the animals.

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Keywords: Bunaji bull; degradability; intercrop; legume; sorghum stover.

1. INTRODUCTION

In Nigeria, the ability of ruminant animals to efficiently utilize non conventional feedstuffs is now attracting the attention of researchers. The Northern part which is the major ruminants animals producing area has available and cheap feedstuffs mostly cereals crop residues, native pastures and agro industrial by- products which support the pastoral households at least 46-58%. Unfortunately, these feedstuffs are low in nutritive value and hence results in reduced feed intake, digestibility and utilization [1]. Normally, the animals that rely solely on such poor quality feedstuffs for their nutrition always faced heavy weight losses during the dry season and drop in reproductive functions [2]. In order to increase ruminant animal productivity as most of the cattle owners are pastoralists, a strategy has been adopted by the farmers which include settling in midst of arable farming communities. There are also many farmers who engage in mix farming systems in Northern Nigeria and extending into other zones of the country. Despite the erratic rainfall experienced in Northern part of Nigeria, the zones are favourable for cereal crops and livestock enterprises. However, arable farming is spreading at the expense of traditional grazing land, but it does not seem to discourage the movement of livestock from their permanent residence within the zone. The situation has imposed strain on the dwindling grazing resources. Under the present farming systems, the land deteriorates rapidly and under sowing of cereals with forage legumes appears to offer a simple method of enhancing the quality of stover for animals after grain harvest [2-4]. This has helped in minimizing the inconveniences to or change in traditional cultural practices. However, in order to predict which feedstuff can support productive functions in the animals and the nutritive values of these stovers must be ascertained. The nylon bag technique offers a convenient way of assessing locally available feedstuffs which are accessible to farmers in Nigeria.

Therefore, this experience was designed to assess the effect of intercropping sorghum with lablab or groundnut on chemical composition and in sacco dry matter disappearance of sorghum stover with stage of growth in fistulated cattle.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was conducted at the Small Unit of Teaching and Research Farm of the Department of Animal Science and Range Management, Modibbo Adama University of Technology, Yola, Adamawa State. Yola is located in the North Eastern part of Nigeria. It is situated within the Savannah region and lies between latitude 7° and 11° North and longitude 11° and 14° East and altitude of about 185.9 m above sea level. Yola has a tropical climate marked by rainy and dry seasons. Maximum temperature can reach 40℃ particularly in April, while minimum temperature can be as low as 18℃ with annual rainfall ranging from 700 to 1600 mm [5].

Table 1. Mean annual rainfall and temperature of the study area during 2015 season

Month	Rainfall (mm)	Temperature (°c)	
		Max	Min
January	0.00	25.0	21.0
February	0.00	29.5	23.4
March	0.00	37.2	25.0
April	9.25	34.7	28.3
May	25.40	37.0	26.5
June	80.15	31.6	25.0
July	130.04	28.0	23.0
August	150.85	30.0	24.0
September	130.28	31.0	25.5
October	21.15	34.0	26.1
November	0.00	35.2	22.0
December	0.00	30.0	20.5

Source: Meteorological Station, Modibbo Adama University of Technology, Yola, Nigeria

2.2 Experimental Design

A Land area of 98 x 98 m was cleared, ploughed and harrowed to soften the soil for ease planting and germination. The main plot was divided into three sub- plots and replicated three times measuring 30 x 30 m with inter and intra row spacing of two metres each in a randomized complete block design (RCBD). The treatments are as follows:

SS = Sole Sorghum
SL = Sorghum + lablab
SG = Sorghum + groundnut

The sorghum seeds (variety Sk 5912) was obtained from the Department of Crop Production, Modibbo Adama University of Technology, Yola. The lablab Seeds (Cultivar Highworth) was obtained from NAPRI, ABU Zaria. The groundnut seeds (Yar Michika) was purchased from Yola market.

The plots were all sown to sorghum at seed rate of 10 kg/ha at 75 x 50 cm spacing. Three sub-plots of sorghum were randomly intercropped with lablab at 60 x 60 cm at Seed rate of 20 kg/ha and another three sub- plots were intercropped with groundnut at 60 x 30 cm at seed rate of 80 kg/ha, while the remaining three sub-plots were left sole sorghum as control. The planting was done on 10th June, 2015, while weeding was done at two, six, and nine weeks respectively.

2.3 Chemical Analysis

The samples for chemical analysis were taken from each of the harvested samples for the various stages of growth of sorghum and oven dried at 60℃ for 48 hours to constant weight. Crude protein (CP) was determined by Kjeldahl method, ash by burning in a furnace at 550℃ for 3 hours and crude fat by soxhlet extraction according to [6] method. Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined according to [7].

2.4 Determination of the Rumen DM Degradability of Feedstuffs

2.4.1 Experimental animal and management

A rumen cannulated Bunaji bull (White Fulani) with 90 mm (internal diameter) was used at the Department of Animal Science and Range Management, Modibbo Adama University of Technology, Yola. The animal was provided with a diet that was able to meet the rumen microbial requirements for essential nutrients. The bull was confined in a pen and fed with 7 -10 kg of feed comprising of groundnut haulms, rice husk, corn stalks, while salt lick and water were given ad-lib daily during the period of the study. The feeds were offered twice daily at 8:00 am and 4:00 pm.

2.5 Data Collection

The feed samples collected were dried at 60° for 48 hours and ground using a laboratory hammer mill to pass through 3 mm screen. The nylon bags with mesh size of about 45 mm and 140x90 mm size were weighed and numbered for easy identification using a marker. The marked nylon bags were arranged serially for the series of the samples at time of the incubation. Approximately 2 grams of the samples were weighed in replicates and put into the bags. The feed samples used were roughage materials, therefore, the period of incubation chosen were 6, 12, 24, 48, 72 and 96 hours respectively. The animal was then fed and removed from feed 1-2 hours before the time of sample removal. The whole component of the plastic tubes and the nylon bags after withdrawal were taken to the laboratory and washed for 5 minute under running tap water till clear water was obtained. The removal was according to specified incubation period as indicated on the plastic tube tags. The bags with the content were dried in an oven at 60℃ for 48 hours to constant weight to determine the amount of dry matter degradation rate. The washing loss (A) is the soluble portion of the feed, and was determined by weighing 2 grams of the feed samples into warm water at 40℃ for one hour. They were removed, washed under running tap water for 5 minutes till clear water was obtained. The bags were oven dried at 60° for 48 hours to constant weight.

2.6 Statistical Analysis

The results of the dry matter degradation rates obtained were fitted to the exponential equation of the form $P = a + b\ (1-e^{-ct})$ [8]. In the final analysis, the various rumen characteristics of sole sorghum, sorghum with lablab and sorghum with groundnut from the nylon bags, were defined as

P = amount degraded at time (t)
a =rapidly soluble fraction
b = amount which in time will degrade
c = fractional rate constant at which the fraction "b" will be degraded

3. RESULTS AND DISCUSSION

3.1 Growth Pattern of Sorghum

The result of growth measurements of sorghum is presented in Fig. 1. The growth in height ranged from 3.3 to 308.7 cm, 3.3 to 395.7 cm and 3.3 to 441.7 cm for T1, T2 and T3 respectively. Higher growth was recorded in treatment 3, followed by treatment 2 and least in treatment 1. The higher growth was recorded in treatments two and three (T2 and T3) which could be attributed to the legume intercrops. Though the growth was slow at early age, but picked up from week 4 and was consistent and increased with age for all the treatments. The trend suggests that nitrogen increase in the soil influenced the growth of the plants. [9] reported similar finding with millet in Maiduguri that nitrogen increase in soil influences plant growth. [10,11] reported that low productivity of crops could be as a result of low fertility status of the savannah soils. [12-15] gave similar reports that mixture of cereals and legumes are very advantageous as the legume depends mainly on its own nitrogen fixation and also fixes nitrogen from the free nitrogen in the soil atmosphere provided growing conditions are adequate and reduces competition for nitrogen among the associated crops. [16,17] observed that increased in plant height could be attributed to vegetative growth of the plant as a result of added nitrogen.

3.2 Chemical Composition of Sorghum Forage at Different Stages of Growth

The chemical composition of sorghum is summarized in Table 1. The dry matter content of sorghum ranged from 30 to 83. 10%, 31.65 to 86. 30% and 32.10 to 89. 0.5% for sole sorghum, sorghum intercropped with lablab and sorghum intercropped with groundnut in 2015. The dry matter increased with stage of growth and was highest with sorghum intercropped with groundnut followed by sorghum intercropped with lablab and lowest with sole sorghum. The sorghum- legumes intercropping significantly increase the dry matter yields of the sorghum. Also, the high dry matter obtained is in agreement with the ealier report by [18] who stated that delay in harvest beyond 86 days after planting of crops progressively decreased leaf yield by about 50.48%, 55.77% and 68.71% at 100, 114 and 128 days respectively, but increases the dry matter content, while [19] reported higher values of 87.4 to 90.9%, 90.4 to 95.2% for stem and leaves of sorghum without intercropping. A similar higher value of 94.12% was reported by [20] with sorghum stover and both of them attributed the difference to sorghum variety and rainfall or soil type. The crude protein content of sorghum ranged from 6.00 to 9.15%, 8.06 to 10% and 8.90 to 11.25% in sole sorghum, sorghum intercropped with lablab or groundnut. The crude protein decreases with maturity and this could be due to the demand for nitrogen during seed production. The higher crude protein content obtained with sorghum intercropped with lablab and groundnut could be due to the N-fixation activity by legume intercrops which were higher than in sole sorghum. This is in agreement with the earlier report by [13] who stated that legumes in intercrops contribute nitrogen to the associated cereal crops through nitrogen fixation. The crude protein content of the sorghum stover obtained is lower than with sorghum values. [20] reported higher values of crude protein than obtained in this study with sorghum legume intercrops and this could be due to variety, soil type or stage of harvest. The ash content ranged from 4.15 to 8.10% 4.75 to 9.30% and 5.10 to 10.05% in sole sorghum,

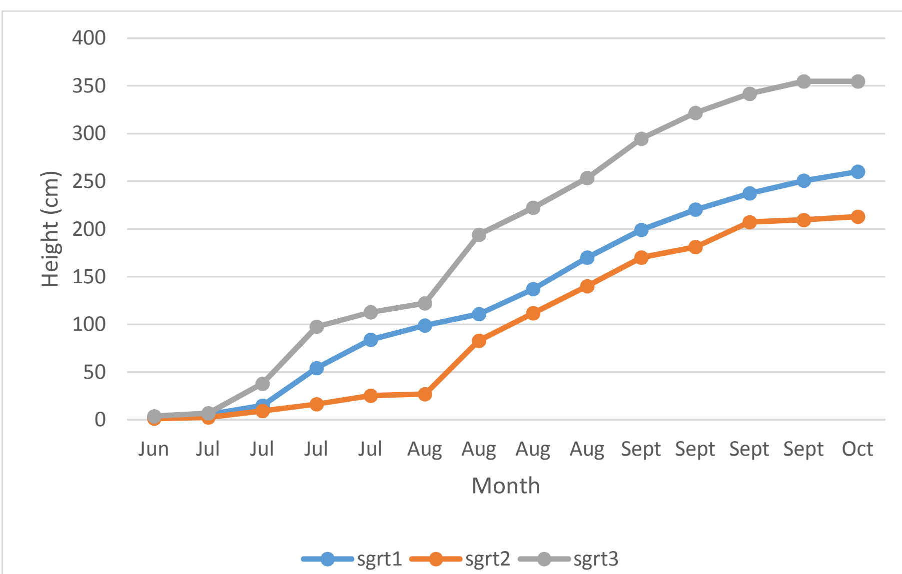

Fig. 1. Growth of sorghum (cm)

sorghum intercropped with lablab and groundnut respectively, the ash content increased with stage of growth and was higher in sorghum with groundnut followed by sorghum with lablab and lowest in sole sorghum. The values obtained are within the range of 8.4% reported by [21] and 7.33% reported by [20]. The calcium content of sorghum ranged from 0.28 to 1.30%, 0.48 to 1.55% and 0.04 to 1.32% in sole sorghum, sorghum intercropped with lablab and sorghum with groundnut for the respective treatments. The calcium content decreases with stage of growth and was higher in sorghum with groundnut followed by sorghum with lablab and lowest in sole sorghum. The values obtained are similar to the earlier report by [22] who reported a minimum value of 0.34% for sole sorghum. The phosphorus content ranged from 0.08 0.14%, 0.09 to 0.18%, 0.10 to 0.20% in sole sorghum, sorghum intercropped with lablab and sorghum with groundnut. The phosphorus also decreases with stage of growth. The obtained values are within the range of 0.06 to 11.00% reported by [22] and attributed the decreases to demand for phosphorus for seed production. The acid detergent fibre (ADF) content ranged from 18.00 to 37.12%, 17.34 to 35.40% and 17.32 to 34.28% and NDF ranged from 25.50 to 58.50%, 23.18 to 53.12% and 17.80 to 48.60% for sole sorghum intercropped, sorghum with lablab and sorghum with groundnut respectively. The neutral detergent fibre content generally was higher than acid detergent fibre in sorghum in all the treatments. The obtained values are both lower than the 73.5% values reported by [23,22] also reported 45.51% ADF which is higher than in this study and the difference could be due to sorghum variety, soil, rainfall, or stage of harvest.

3.3 Rumen Degradability Rates

The rumen degradation characteristics of sorghum forage with stage of growth are presented graphically in Figs. 2-6, while the actual values are presented in appendix 1. The mean dry matter degradation at 6, 12, 24, 48, 72 and 96 hours ranged from 53 to 129% (SS), 61 to 138% (SL) and 64 to 140%(SG) respectively. The degradation characteristics values were fitted to the exponential equation $P = a + b\ (1-e^{-ct})$ [8]. The degradability increased with increase in time of incubation to peak values as shown in figures 2, 3 and 4 for weeks 6, 8 and 10, and decreases with stage of growth from weeks 12 - 14 in Figs. 5 and 6 respectively. The sorghum intercropped with legumes (SL and SG) degraded better than sole sorghum (SS). The decrease in degradability with stage of growth could be associated with the high content of structural components (cell wall) and also declined in the ratio of leaves to stem and increase in the level of senescent plant which agrees with the reports by [24,25] and in another separate study by [26] reported that higher degradability can only occur when the NDF, cellulose and lignin content are low. The higher degradability in SL and SG could be due to increase in the nutritive value of the sorghum stover as a result of the legume intercrops. [27-29] in separate studies reported that treatment or improving the qualities of sorghum stover normally result into higher degradability. Generally degradability of tropical feeds is lower than that of temperate and subsequently reflected on the performance of the animals as reported by [30] and also suggests that improving the cropping systems of cereals and legumes helps in improving both the quality and quantity of the crop residues. The declined in degradability with stage of growth agrees with the earlier report by [24,31] who observed that digestibility of tropical forages decline with increase in stage of growth. [32] reported higher values of degradability with grasses (panicum repens and Brachia mutica) ranging from 32.1 to 70% at maximum of 96 hours than sorghum stover due to higher ADF and NDF content and the nylon bags used could also be a factor which is difficult to standardized. A similar work was reported by [20] with sorghum Stover mixed with low to higher protein sources and obtained a range value of 23 to 30% for medium and 27 to 42% for higher protein respectively. They also reported that greater degradability of basal diet may be achieved by increasing the protein content of diets fed to the animals and reported a range of value of 12 to 16% protein levels. The solubility (washing loss) “A” ranged from 0.63 to 0.96% (SS), 0.71 to 0.96% (SL) and 0.83 to 1.12% (SG). The solubility reduces with stage of growth for all the feeds and this could be due to increased in ADF and NDF content of the Stover or increased in structural components (cell wall) and also declined in the ratio of leaves to stem and increase in the level of senescent plant [24,25]. The solubility values or washing loss are higher with the Stover intercropped with legumes and this could probably be that the legumes have contributed nitrogen to the associated sorghum and subsequent enhancement of their solubility. The results obtained are lower than the range values of 6.0 to 29.20% [33,20,34] and the wide variety in the “A’’ values could be due to the type, particle size, fibre content of the feed or porosity of the nylon bags.

Table 2. Chemical composition of sorghum stover as influenced by different legume species with stage of growth (% DM)

WK	Stover	DM	CP	Ash	Ca	P	ADF	NDF
6	SS	30.30	9.15	4,5	1.30	0.14	18.00	25..50
	SL	31.65	10.00	4.7	1.55	0.18	17.34	23.18
	SG	33.08	11.34	5.60	1.32	0.20	17.32	17.80
8	SS	37.18	9.80	4.97	1.30	0.12	22.06	28.10
	SL	41.10	10.12	5.78	1.38	0.14	19.30	25.65
	SG	43.23	10.75	5.99	1.33	0.18	21.82	22.30
10	SS	54.60	7.88	7.30	0.88	0.15	32.18	37.70
	SL	59.30	9.11	6.45	1.00	0.13	26.15	34.40
	SG	60.31	9.45	7.13	1.10	0.16	28.31	30.48
12	SS	7.65	7.61	6.63	0.55	0.12	35.20	37.70
	SL	80.10	8.80	7.27	0.78	0.11	30.17	34.40
	SG	82.42	8.65	7.85	0.62	0.13	30.50	30.48
14	SS	84.23	6.11	7.95	0.28	0.08	37.12	58.50
	SL	87.35	8.41	8.10	0.48	0.09	35.40	53.12
	SG	86.82	8.25	8.61	0.40	0.10	34.28	48.60

KEY: SS = Sole Sorghum Stover; SL = Sorghum Stover with Lablab Intercrop
SG = Sorghum Stover with Groundnut intercrop; A=Rapidly Soluble Fraction

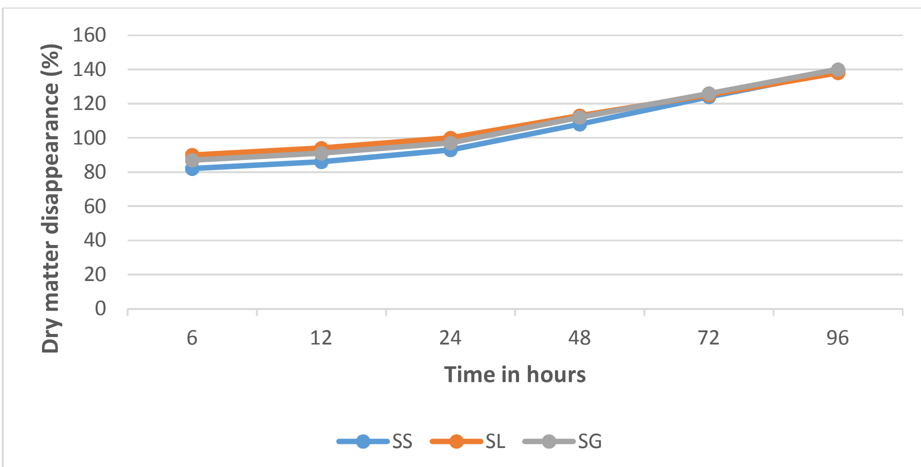

Fig. 2. Dry matter disappearance of sorghum stover (WK 6)

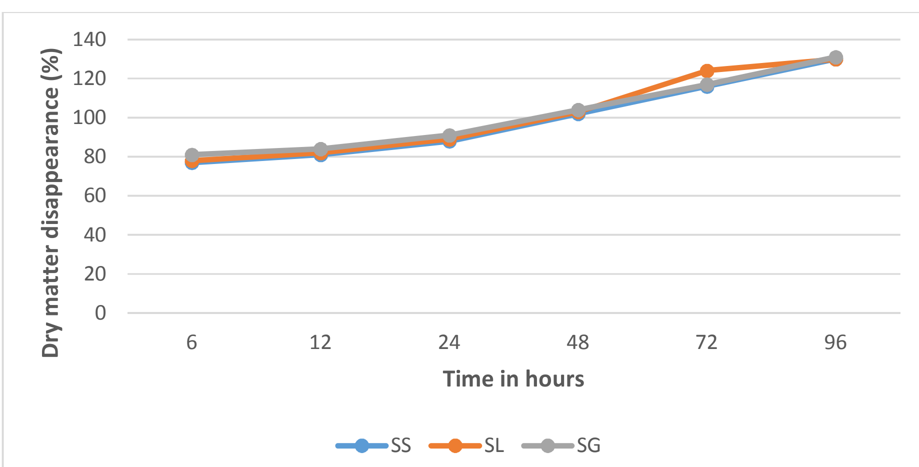

Fig. 3. Dry matter disappearance of sorghum stover (WK 8)

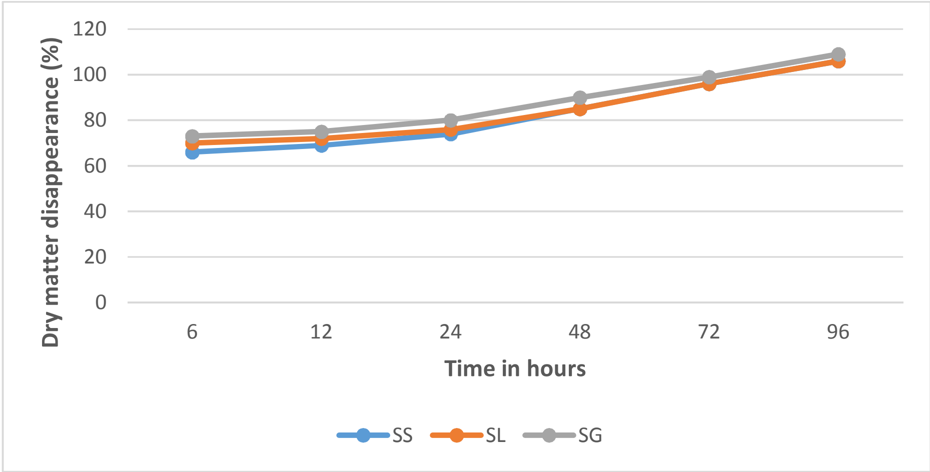

Fig. 4. Dry matter disappearance of sorghum stover (WK 10)

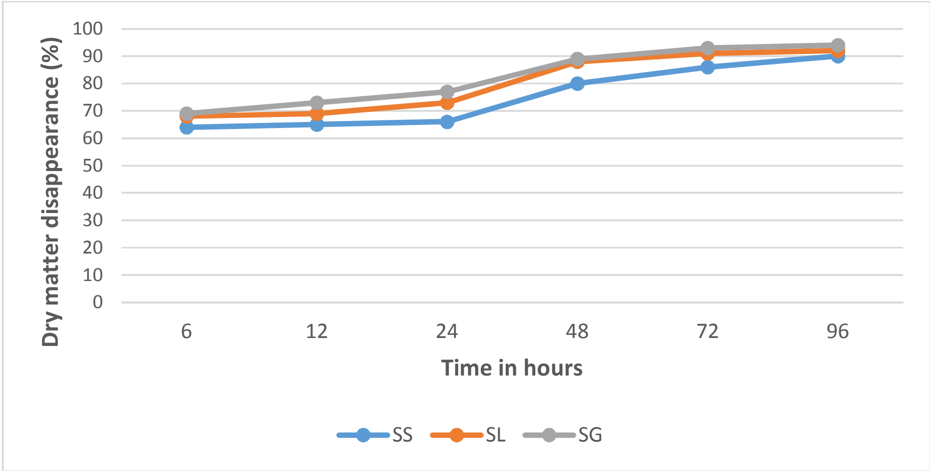

Fig. 5. Dry matter disappearnce of sorghum stover (WK 12)

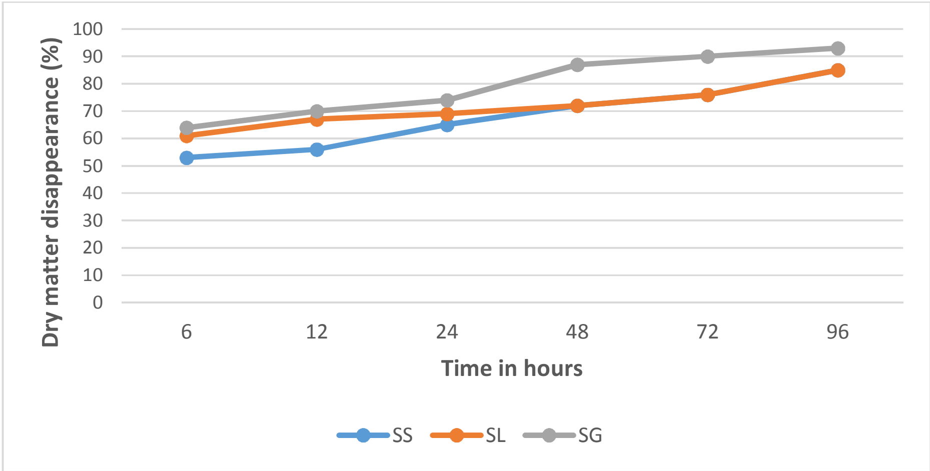

Fig. 6. Dry matter disappearance of sorghum stover (WK 14)

Figs. 2 – 6. Graphical presentation of rumen degradability characteristics of sorghum stover

The fractional rate constant ''C'' ranged from -0.003 to 0.009% (SS), 0.028 to 0.017% (SL) and 0.02 to 0.03% (SG). The fractional rate constant increased with stage of growth with maximum values for all treatments at week 14. There was significant difference ($p<0.05$) in degradability for all the feed samples with stage of growth and time of incubation. Higher fractional rate constant C in treatments SL and SG could be due to the legume intercrops which most have increased the level of nitrogen content of the associated crops. This is similar to the earlier report by [20] who obtained range values of 0.010 to 0.009% for sorghum Stover and groundnut haulms.

4. CONCLUSION

The study therefore showed that sorghum–legume intercrop is beneficial in improving the quality of sorghum stover as they degraded better than the sole sorghum stover. The degradability therefore decreases generally with increases in stage of growth for all treatments. This strategy, once adopted by farmers will help in reducing the losses confronted with during period of feed scarcity especially in this part of the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

Effect of legume intercrop and stage of growth on rumen degradability of sorghum stover

WK	TRT	A	TIME (hours)						C
			6	**12**	**24**	**48**	**72**	**96**	
6	SS	0.96	82	86	93	108	124	129	-0.003
	SL	0.96	90	94	100	113	125	138	0.028
	SG	1.12	87	91	97	112	126	140	0.002
8	SS	0.89	77	81	88	102	116	120	-0.002
	SL	0.93	78	82	89	103	124	130	0.012
	SG	1.06	81	84	91	104	117	131	0.004
10	SS	0.78	66	69	74	85	96	100	-0.004
	SL	0.83	70	72	76	85	96	106	0.004
	SG	0.99	73	75	80	90	99	109	0.005
12	SS	0.74	64	65	66	80	86	90	0.011
	SL	0.78	68	69	73	88	91	92	0.008
	SG	0.91	69	73	77	89	93	94	0.019
14	SS	0.63	53	56	65	72	76	80	0.009
	SL	0.71	61	67	69	72	76	85	0.017
	SG	0.83	64	70	74	87	90	93	0.013

KEY: SS = Sole Sorghum Stover
SL = Sorghum Stover with Lablab Intercrop
SG = Sorghum Stover with Groundnut intercrop
A= Rapidly soluble fraction

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