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Effect of Canopy Shade on the Agronomic and in-vitro Performance of Chloris gayana (Kunth).

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Abstract

Chloris gayana was established under shade and in the open and the effect of shade on the agronomic and in-vitro performance of the grass were examined. Harvesting of the grass was carried out at twelve weeks and the weight of the biomass yield was observed to be higher under the sunlight with 895.0g and least in the shade with 48.70g. The harvested grass was analyzed for Chemical and Mineral Compositions. Soil sample was also analyzed for its organic matter (O.M), Organic Composition (O.C), Calcium, Phosphorus, Potassium, Nitrogen and PH. Results show that CP, CF, EE, and ASH ranges from 7.89 – 11.12, 20.25- 23.81, 2.33- 10.66 and 10.76-11.37 under full sunlight and shade respectively. It is concluded that grasses can be planted under trees because they are capable of fixing Nitrogen to the soil thereby improving the forage quality and also provide shady haven for livestock during high ambient temperature when grasses are to be grazed by animals. The in vitro gas production characteristics were not significantly ($P>0.05$) different under sunlight and shade the highest value was obtained from T1 (3.00) and lowest for T4 (1.00). ME and OMD show significant difference between T1, T2, T3 and T4 while SCFA for T1 and T2 were significantly different. However, T3 and T4 were not significantly ($P>0.05$) different from each other. The in-vitro gas production chart has the highest volume of gas produced in T1 at 24hr period of incubation.

Keywords: Canopy shade, Ruminant, In-vitro gas production, Chloris gayana.

1. Introduction

A list of common grasses that can be used as forages in the tropics include *Andropogon specie, Bacharia brizantta, Chloris gayana, Cynodon dactylon, Panicum maximum, Digitaria decumbens* , among others.

Chloris gayana (Rhodes grass) is a perennial creeping grass with its habitat in grasslands with open or with scattered trees or shrubs along river banks lakes and seasonally water logged plains. (Mannetje and Kersten 1992). It is not tolerant to shade, flowering occurs throughout the

growing season depending on the cultivar, with seeds becoming ripe at twenty three (23) to twenty five (25) days after flowering. And it can be used primarily in pastures for grazing, hay and silage.

Growing crops under canopy of trees is known as ever green Agriculture, whereby trees are intercropped in annual food crop and livestock system (Dennis, 2010). It sustain green cover on the land throughout the year and also involves the integration of appropriate fertilizer trees into agriculture, this approach bolsters nutrients supply through Nitrogen fixation and nutrient recycling and tend to increase direct production of fodder and income from products produced from the trees. Such trees also greatly enhance carbon storage above ground and below ground compared to conventional agriculture (Dennis, 2010).

Muh. S. Kallah *et al*. (1996) reported that in Nigeria the major challenge to livestock production is ensuring adequate feed supply throughout the year in terms of quality and quantity in the traditional setting, this demand by the animals is presumptuously met through basal supply of natural pasture grass. Babayemi and Bamikole (2006) made a report that a basic knowledge of pasture plant soil - climate interrelationships facilitates the application of agronomic management practices to assure optima production of nutritious herbage and at the same time maintain soil fertility and desirable plant populations. Beetz (2002) reported that a diversity of pasture plants growing on healthy soil use sunlight and nutrients in the soil to effectively produce animal feed. Tropical grasses have ability for high yield and the nutrients are simultaneously enhanced when treated with organic or inorganic fertilizers or established with nitrogen fixing shrubs or tree legumes. (Babayemi and Bamikole, 2004)**.**

Trees are usually planted in pasture paddock to provide shade for animals during intensive heat, the leaves of this trees can also be cut for the animals to feed upon during periods of forage scarcity and some trees or browse plants like *Gliricidia sepium,Leucaenia leucocephela* help in the fixing of Nitrogen into the soil to aid grass production. Trees are also useful as paddock life fences in paddock construction. However Trees reduces the amount of sunlight reaching soils and plants through shading, the extent of this reduction varies according to tree size and leaf density (Breman and Kesler, 1995). However Blackshaw and Blackshaw, (1994) reported that Shade has generally been useful in increasing milk yields of dairy cattle and live-weight of feedlot cattle in hot climates, which is why agro foresters has promoted the benefits of having trees.

Burns *et al.* (1992) reported that pasture attributes, including quality and nutritive value of herbage often are useful for explaining differences in animal performance. Intake is the major determinant of animal performance (Poppi *el al*., (1997). Different methods are usually adopted in the determination of the nutritional value of feed fed to animals. However several authors (Babayemi *et al.,* 2004; Fievez *et al., 2005; Babayemi and Bamikole 2006)* had observed that invitro gas production is one of the most effective.

The in-vitro gas production method is a laboratory estimation of degraded feed, which are important in livestock nutrition. It is a method that is reproducible .In vitro gas production method have the advantage of not only being less expensive and less time consuming but the method allows experimental conditions more precisely than the in vivo method (Makkar, 2002).It is convenient and fast and allows a large number of samples to be handled at a time.

It is based on the quantification of substrate degraded and of gas produced in rumen fermentation system based on syringes (Menke *et al*., 1988).

2. Materials and Method

2.1 Site description

The experiment was located at the Teaching and Research Farm of Ladoke Akintola University of Technology Ogbomoso Oyo State. The site is on ($8^0 26^0$N, 4^0 29^OE). A derived savannah zone with annual rainfall of 1137mm usually between February and September.

2.2 L*and preparation*

The land was cleared with the aid of cutlass and hoe. After the land preparation, three beds in the sunlight and under the shade were made with each bed measuring 2m by 1m. The height of the tree was about 3m with a shade

circumference of 4m.

2.2 S*oil collection*

Soil samples were collected with the aid of a soil auger from each treatment prior to establishment, these samples were air dried and kept for further analysis of its organic matter and organic composition.

2.3 F*ertilization*

After the land was prepared NPK fertilizer was supplied at the rate of 0.67g for each bed measuring 2m by 1m to supply 50kg fertilizer / ha. Calculated thus;

$$\frac{\text{Plots } (m^2)}{10{,}000} \times \frac{\text{Rate Kg/h}}{\text{Concentration}} \times \frac{100}{1}$$

$$\frac{2}{10{,}000} \times \frac{50}{15} \times \frac{100}{1}$$

2.4 P*lanting*

Each of the bed measured 2m by 1m; the *Chloris gayana* cut to about 15cm in length was planted vegetatively to a depth of 4cm at a spacing of 30cm by 30cm.

2.5 M*anagement practices*

Weeding was done as often as required to prevent weeds from competing with the *Chloris gayana* for nutrients. The weed on removal was left on the bed to decay so as to return nutrients back to the soil .Rhodes grass that refuse to grow were replaced accordingly. The experiment lasted for ninety days (90days)

2.6 D*ata collection*

Twelve (12) weeks after establishment data were collected on the biomass yield, fresh weight of the sample, Dry weight of the sample.Tthe harvested materials were separated into leaf and stem fractions and then weighed individually.

2.7 B*iomass yield*

The biomass yield data of the harvested Rhodes grass under the sunlight and shade environment was determined in a 1m by 1m quadrant of each bed. In each quadrant, the grass was cut back to a height measuring 15cm above ground level

2.8 L*iquor collection*

Three West African Dwarf male sheep were fed 70% concentrate and 30% grass of *Panicum maximum* for three days prior to the collection of rumen liquor.

The liquor was collected into a pre-warmed thermos flask and flushed with carbon dioxide. About 30ml of rumen fluid that was buffered with 9.8 $NaCo_3$ +2.77Na_2HPO_4 + 0.57KCl + 0.47NaCl + 0.12 $MgSO_4$ + 0.16$CaCl_2$ +1.0Urea was taken into calibrated syringes that contain 200milligram of feed.

2.9 I*ncubation of the buffered rumen fluid*

Two hundred milligram (200mg) of ground samples were weighed into a 100ml calibrated syringes with pistons lubricated with Vaseline. A buffered solution 9.8 $NaCo_3$ +2.77Na_2HPO_4 + 0.57KCl + 0.47NaCl + 0.12 $MgSO_4$ + 0.16$CaCl_2$ +1.0 Urea was prepared, stirred under continuous flushing with carbon dioxide and was dispensed into another 50ml calibrated plastic syringe it was tapped and pushed upward by the piston to completely eliminate air in the inoculums. The syringes were pre-warmed (39^oC) for one hour before addition of 30 ± 1.0 ml of rumen fluid mixture into each syringe. It was swirled gently after reading. Calibrated syringes containing 30ml of the buffered rumen fluid were placed in an incubator at 39^o C.

2.10 *In-vitro gas production*

Gas production rates were recorded at 3, 6, 9.12,15,18,21 and 24 hours of incubation. The volume of gas produced was plotted against the incubation time, and the gas production characteristics were estimated using the equation: $Y= a + b (1 – e^{-ct})$ described by Orskov and Macdonald (1979), where Y= volume of gas produced at time't'

a= intercept (gas production from the soluble fraction)

b= gas production from the insoluble fraction

c= gas production rate constant for the insoluble fraction

t= incubation time.

Organic matter digestibility (OMD %) and metabolizable energy (ME, $MJkg^{-1}DM$), were calculated using the following equations according to (Menke and Steingass, 1988) Short chain fatty acid (SCFA) by (Getachew *et al*., 1999).

OMD=14.88+0.889*Gv+0.45*CP+0.65*A

ME=2.20+0.136*Gv+0.057*CP+0.oo29CF

SCFA=0.0239Gv-0.0601

Where Gv is 24hour net gas production (ml/200 mg DM), CP, CF and A are Crude Protein, Crude Fiber (% DM) and Ash respectively.

2.11S*oil analysis*

At twelve (12) weeks after establishment soil samples were randomly collected with the aid of a soil auger, air dried and analyzed for its mineral composition, organic carbon and organic matter composition.

2.12 P*roximate analysis*

Subsample of the grass was selected from the total grass in a quadrant measuring 1m by 1m on each of the bed. The fresh samples were sorted into leaf and stem fractions and weighed, Oven- dried, and reweighed to determine the dry matter.

Dry matter = Fresh weight - Oven dried weight.

The dried samples were grinded using a hammer mill into smaller sizes that can pass through a 2mm sieve for laboratory analysis of Crude protein, Crude fiber, Ether extract, and Ash, The proximate analysis was done according to AOAC (2000). Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Neutral Detergent Fiber (NDF) was assessed according to Van Soest *et al.* (1991) method.

2.13 S*tatistical analysis*

Data obtained were subjected to analysis of variance using the General Linear Model (GLM) of SAS (2000) and significant means were separated using the Duncan Multiple Range test of the same package.

3. Results

The biomass yield, fresh and oven-dried weight of *Chloris gayana* under sunlight and shade is as shown in Table 1, the results observed were significantly different (P>0.05) from one another. The highest yield was observed with the forages in the sunlight (859.0g) and lowest (48.70g) with the forages under the shade. The weight of fresh leaf and stem recorded their highest value with forages in sunlight (306.07g and 552.9g3) and lowest under the shade (20.83 and 27.87) respectively. Weight of dry leaf and stem was also observed to be high in forages under the sunlight than in the shade.

Table 2 shows the proximate composition of *Chloris gayana* in sunlight and shade after twelve weeks of establishment. The Crude Protein was highest in leaf under the shade with (11.12%) and least in stem under shade with (7.89%), the Crude Fiber in the stem was higher under shade (23.81%) and least in leaf under shade with

(20.25%), It was observed that Ether Extract in stem was higher with the value (10.60%) under full sunlight and low in leaf under shade with (2.33%). Higher value (11.37%) was observed for Ash in leaf and least value (10.76) in stem under shade. The Fiber fractions composition of *Chloris gayana* under sunlight and shade of both leaf and stem is as shown in Table 3. The percentage compositions of ADF, ADL and NDF in the stem were observed to be higher under shade (57.96, 14.23 and 71.06) and under sunlight (53.68, 13.86 and 66.77) respectively than that of leaf.

Table 4 shows the composition of soil before and after planting of Rhodes grass in full sunlight and under shade, it was observed that the Organic Composition, Organic Matter, Carbon, Potassium, Phosphorus and Nitrogen concentration of the soil before establishment in shade shows highest value with (1.87%, 3.22%, 1.51mol/kg, 4.97mg/kg, 1.29% and 0.97%) respectively. While the P^h of the soil shows the highest value (7.12) in sunlight after establishment.

The in-vitro gas production characteristics of *Chloris gayana* incubated for 24hrs is as shown in table 5. The soluble 'a' fraction of the samples shows no significant difference ($P>0.05$) between T2 and T3 but was lowest and significantly different in T4 (0.00). There were no significant differences ($P>0.05$) in the 'a+b' values (Potentially degradable fractions) of T2 and T4, these values were however significantly ($P<0.05$) higher for T1 and T3 (5.00 and 3.67) respectively. Potential gas production 'b' (ml/200mgDM) recorded for T3 and T4 were not significantly ($P>0.05$) different but there was significant difference ($P<0.05$) between T1 and T2. The incubation time't' were not significantly different ($P>0.05$) in T2, T3 and T4 also T1, T2 and T4 were similar.

$Y= a + b (1 – e^{-ct})$. The volume of gas produced at time't', the values obtained for T2 and T3 were not significantly different ($P>0.05$), higher value was observed for T1 (3.00) while lower value in T4 (1.00). The effect of in vitro fermentation on ME, OMD, and SCFA for *Chloris gayana* of leaf and stem under shade and sunlight for 24 hrs are presented in table 6. ME and OMD, shows significant difference between T1, T2, T3 and T4 while SCFA for T1 and T2 were significantly different while T3, and T4 were not significantly ($P>0.05$) different from one another. In figure 1, the highest gas volume was observed in T1 (Sunlight leaf) and lowest in T4 (Shaded stem).

4. DISCUSSION

The low yield of grass under shade in Table 1, could be as a result of reduction in the plant photosynthetic capability as considerable part of the grass would have been denied optimum light that would have lead to an increase in the grass yield under shade. It has also been recorded that most tropical grasses are poorly shade tolerant and the growth advantage they have largely disappear under shade, since plant growth is a function of its photosynthetic ability (Humphrey, 1991). Result obtained is contrary to the report of (Samarakoon *et al*., 1990) that has the highest yield of *Pennisetum clandestinum* under shade rather than in full sunlight.

In table 2, the crude protein value obtained for leaf under shade was (11.12%) which was higher than that of sunlight (10.40%), the higher crude protein of leaf under shade could have been as a result of nutrient that was returned to the soil via plant litter as reported by (Beetz,2002).Wilson, (1990) reported that soil organic matter breakdown is increased under shade which leads to increase in the soil Nitrogen just as observed in table 4 in which the highest numeric value (0.69%) of Nitrogen was under shade after establishment, it could also be as a result of the increase in the percentage organic matter of the soil which was explained by Beetz, (2002) that it increases plants productivity. The crude protein contents of the grass under sunlight and shade are within the acceptable range for ruminant performance (ARC, 1980). The fiber contents (ADF, ADL and NDF) in Table 3 have implications on the digestibility of plants. The NDF, which is a measure of the plants cell wall contents, is the chemical component of the feed that determine its rate of digestion. NDF is inversely related to the plants digestibility (McDonald *et al.,* 1995*;* Gilliespie, 1998). As observed, NDF is above 50% which implies the higher the NDF, the lower the plants digestible energy. The ADF consist mainly of lignin and cellulose and it is known that hemi-cellulose is more digestible than cellulose (Gilliespie, 1998).

Increase in the Organic Composition, Organic Matter, Carbon, Phosphorus, Potassium and Nitrogen before establishment in shade and after establishment in shade in table 4, could be as a result of the contributions from leaf

litter that leads to a greater organic matter breakdown and Nitrogen turn over (Ola_Adams and Egunjobi, 1992). There are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fibre, the presence of secondary metabolites (Babayemi *et al*., 2004a) and potency of the rumen liquor for incubation. Gas production is a function and mirror of degradable carbohydrates and therefore, the amount of gas produced depends on the nature of the carbohydrate (Blummel and Becker, 1997).

This study did not determine the presence of secondary metabolites in the grass, although high crude protein in the feed enhances microbial multiplication in the rumen which in turn determines extent of fermentation. (Babayemi *et al*., 2004b). The range of values (0.060 – 0.019 ml/hr) obtained for the fractional rate of gas production 'c' of *Chloris gayana* under sunlight and shade were similar to 0.169 - 0.056ml/hr reported by Getachew *et al.* (2004) for fractional rate of gas production in corn grain and canola meal. Higher values obtained in this study may be attributed to higher nutrient composition of the *Chloris gayana*.

T1, T2 T3and T4 were significant for ME and OMD but T1, T2, T3 for SCFA were significantly higher than T4. In all the parameters T1 was observed to be the highest and T4 the lowest. The values were however lower than the values reported for tea leaf and spent tea leaf (Babayemi *et al.,* 2006) and also lower than the value reported for dry season forages observed by (Babayemi 2007). Feed stuff that are inherent with anti-nutritive factors had been reported to be low in metabolizable energy and organic matter digestibility (Aregheore and Abdulrazak, 2005). The in vitro gas production pattern of the *Chloris gayana* under sunlight and shade shown in Figure 1 indicated that more degradation of dry matter were still possible beyond 24h. The highest gas production was obtained from T1 and the reason for this was not was not very clear. Lowest volume of gas that was recorded for T4 could be as a result of high fiber content of the grass which would take longer time to degrade in the rumen. The present study established the potential of trees interplanted with pastures for grazing animals serving as shade for the animals during high ambient temperature. Trees are also capable of fixing organic Nitrogen to the pasture soil thus improving the agronomic performance of the companion grass which ultimately translates into an increase in the nutritive value of such companion grass. It can be recommended grass can be planted under shade to reduce the effect of heat stress on the animals and improve nutrient content of grass planted under shade which can improve ruminal function when fed by animals except for reduction in biomass yield.

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Table 1: Yield of *Chloris gayana* under full sunlight and shade

	Sunlight	**Shade**	**SEM**
Biomass yield (g)	859.00	48.70	118.23
Weight of Fresh leaf (g)	306.07	20.83	18.33
Weight of Fresh stem (g)	552.93	27.87	45.96
Weight of Dry leaf (g)	34.00	5.00	3.46
Weight of Dry stem (g)	67.33	5.00	9.14

SEM= Standard error of mean.

Table 2: Proximate composition of *Chloris gayana* under Sunlight and Shade.

	Leaf		**Stem**		
	Sunlight	**shade**	**Sunlight**	**Shade**	**SEM**
Crude protein	10.40	11.12	10.40	7.89	0.46
Crude Fiber	22.59	20.25	21.54	23.81	0.47
Ether Extract	5.72	2.33	10.60	3.55	0.44
Ash	11.35	11.37	11.21	10.76	0.45

Means with the same value are not significantly different $P<0.05$

SEM= Standard Error of Mean

Table 3: Fiber fractions of *Chloris gayana* under Sunlight and Shade

	Leaf		Stem		
	Sunlight	**Shade**	**Sunlight**	**Shade**	**SEM**
ADF	44.89	47.56	53.68	57.96	0.48
ADL	12.58	12.92	13.86	14.23	0.47
NDF	61.80	63.87	66.77	71.06	0.49

Means with the same value are not significantly different P<0.05

SEM = Standard Error of Mean

(ADF: Acid Detergent Fibre, ADL: Acid Detergent Lignin, NDF: Neutral Detergent Fiber)

Table 4: Soil composition of *Chloris gayana* under full Sunlight and Shade

	PH	**%O.C**	**%O.M**	**mol/kgC**	**mgkgP**	**%K**	**%N**
AESun	7.12	1.46	2.51	1.18	2.49	0.76	0.54
AESh	6.92	1.59	2.74	1.26	2.61	0.89	0.69
BESun	6.74	1.79	3.09	1.42	4.85	1.13	0.94
BESh	6.56	1.87	3.22	1.51	4.97	1.29	0.97
SEM	0.37	0.34	0.35	0.34	0.36	0.31	0.32

means in the same value are not significantly different(P<0.05)

AESun After establishment in Sunlight

AESh After establishment in Shade.

BESun Before establishment in Sunlight.

BESh Before establishment in Shade

P^h is the hydrogen concentration, O.C represents the Organic Composition, O.M is the Organic Matter, C represents the carbon, P is the Phosphorus, K is the Potassium and N is the Nitrogen concentration in the soil**.**

Table 5: Gas production characteristics of Chloris gayana incubated for 24hrs.

Treatment	**Fermentation characteristics**					
	a	**a+b**	**b**	**c**	**t**	**Y**
T1	1.67[a]	5.00[a]	3.33 [a]	0.056	9.00[b]	3.00 [a]
T2	1.00[b]	2.00[c]	1.67[c]	0.019	13.00[a]	2.33 [b]
T3	1.00 [b]	3.67[b]	2.60[ab]	0.046	11.00[ab]	2.00 [b]
T4	0.00 [c]	2.00[c]	2.00 [bc]	0.060	12.00[ab]	1.00 [c]
SEM	0.167	0.236	0.289	0.012	1.18	0.167

a,b,c,d, means on the same column with different superscripts are significantly different($P<0.05$).

a= Soluble fractions; b=Potential Gas Production; a+b= Potentially degradable fractions; c= Rate of fermentation; t= time of fermentation; $Y= a + b (1 – e^{-ct})$; Volume 0f gas produced at time 't'.

SEM= Standard error of mean.

T1 Sunlight leaf

T2 Sunlight stem

T3 Shade leaf

T4 Shade stem

Table 6: Effect of In-vitro fermentation on Metabolizable Energy, Organic Matter Digestibilty, Short Chain Fatty Acid for *Chloris gayana* under sunlight and shade.

Treatment	Fermentation characteristics		
	ME	OMD	SCFA
T1	3.53[a]	31.40[a]	0.18[a]
T2	3.22[c]	29.23[c]	0.12[c]
T3	3.40[b]	30.52[b]	0.15[b]
T4	2.99[d]	27.21[d]	0.11[bc]
SEM	0.032	0.210	0.001

a,b,c,d, means on the same column with different superscripts are significantly different($P<0.05$).

ME= Metabolisable energy; OMD=Organic matter digestibility; SCFA=Short chain fatty acids. SEM= Standard error of mean

T1 Sunlight leaf

T2 Sunlight stem

T3 Shade leaf

T4 Shade stem

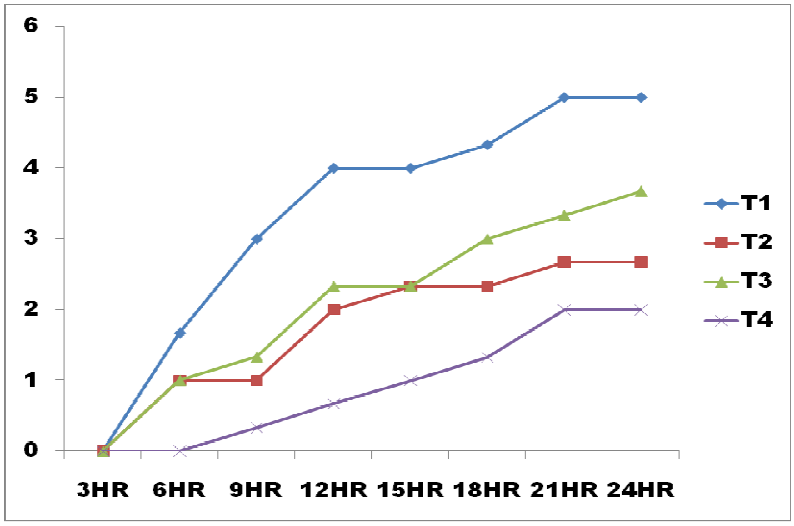

Figure 1: In vitro gas production of *Chloris gayana* under Sunlight and Shade.

T1 Sunlight leaf

T2 Sunlight stem

T3 Shade leaf

T4 Shade stem