Leucaena leucocephala and *Gliricidia sepium* Supplementation in Sheep Fed With Ammonia Treated Rice Straw: Effects on Intake, Digestibility, Microbial Protein Yield and Live-Weight Changes

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ABSTRACT : Two experiments were conducted to determine the effects of *Leucaena leucocephala* (leucaena) and *Gliricidia sepium* (gliricidia) supplementation on intake, digestion, outflow rates, microbial protein yield and live-weight changes in sheep fed with ammoniated rice straw (ARS). In experiment 1, three rumen cannulated Japanese Corriedale wether (mean body weight of 35.6 kg) in 3×3 Latin Square Design were used. Animals were fed *ad libitum* ARS alone, or supplemented with 200 g of either leucaena or gliricidia. In experiment 2, twenty-four growing native Philippine sheep with average body weight of 13.5±0.25 kg were used in a completely randomized design (CRD) and offered similar diets to those of experiment 1. Supplementation increased total dry matter intake and nutrient digestibility except for fiber ($p<0.05$) without affecting ARS consumption. Nitrogen balance revealed that absorbed and retained N was significantly higher in leucaena and gliricidia. The significant improvement in N utilization and more digestible OM intake brought about by the inclusion of leucaena and gliricidia to ARS resulted in increased ($p<0.05$) microbial N yield. Efficiency of microbial N supply in supplemented group was not significantly different, but higher ($p<0.05$) than the 24.92 g N/kg DOMR for ARS group. Liquid outflow rate was 7.8 and 6.8 %/h, while the solid phase of rumen digesta was 4.4 and 3.8 %/h for the leucaena and gliricidia group respectively, which were significantly higher than 5.30 and 2.50 %/h in the control diet. The increase in total DMI resulted to higher ($p<0.01$) growth performance and efficient feed utilization. Average daily gain (ADG) was 19.3, 34.6 and 33.9 g/d for the ARS, leucaena and gliricidia respectively. It is therefore concluded that addition of leucaena and gliricidia to ARS in could increase nutrient intake and digestibility, subsequently improving N utilization and livestock performance. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 12 : 1659-1666*)

Key Words : Leucaena, Gliricidia, Sheep, N-Balance, Ammoniated Rice Straw, Microbial Protein Yield, Live Weight Gain

INTRODUCTION

Feeding small ruminants under rice-based farming system in the Philippines and other Asian countries is highly dependent on low quality crop residues, particularly rice straw. However livestock productivity under this system is constrained by the low dry matter (DM) intake and poor digestibility of rice straw. Although ammoniation had offered avenues to improve feeding value of straw, numerous studies (Castrillo et al., 1995; Chiquette et al., 1991; Mgheni et al., 1993) had pointed out that supplementation is still required to attain optimum level of production. The use of leguminous multipurpose trees, such as *Leucaena leucocephala* and *Gliricidia sepium* could be an alternative to unavailable and expensive protein concentrates (Bonsi et al., 1994; Ondiek et al., 2000; Van Eys et al., 1986). Aside from improved intake and nutrient digestibility, recent findings (Abdulrazak et al., 1996; Masama et al., 1997) have shown that these tree legume supplements can provide both degradable and undergadable protein for ruminants. Supplementing poor quality roughage with graded levels of fresh *Leucaena leucocephala* or *Gliricidia sepium* leaves could also result to faster outflow rates, thereby increasing intake and providing more degradable organic matter (OM). The changes in the supply of fermentable OM in the rumen could eventually lead to higher microbial protein (MP) yield. Fujihara et al. (1999), reported that urinary excretions of purine derivatives (PD) which is used in estimating microbial protein production, is affected either by changes in outflow rate from the rumen or by the intestinal flow of MP or both of them. The objective of this study is to determine the effects of *Leucaena leucocephala* (leucaena) and *Gliricidia sepium* (gliricidia) supplementation on the intake, digestibility, nitrogen retention, and microbial protein yield of sheep offered ammoniated rice straw (ARS) diet.

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MATERIALS AND METHODS

Feed preparation

Rice straw treatment. About 5 kg of chopped rice straw (2-3 cm length) were placed in polyethylene sacks. Air was removed from each sack using a vacuum pump; immediately after a 25% ammonia solution was infused at the rate of 3 g nitrogen/kg DM (Sundstøl, 1984) using 10 liter capacity knapsack sprayer. The bags were then tightly secured with a rope and incubated at room temperature of about

28-32℃. After 30 days, the bags were opened and the treated straw was spread on a concrete floor to allow drying for 2-3 days, and to ensure evaporation of excess ammonia.

Leaf meal preparation. Sufficient amount of leucaena and gliricidia leaves were collected during the months of November and December, 1997 at the 30 ha experimental area of the Small Ruminant Center, Central Luzon State University, Munoz, Nueva Ecija, Republic of the Philippines. The institution is situated at 15° 43' North latitude, 120° 54' East longitude and with elevation of 76 m. The maturity of the forage was not considered during the gathering process in order to collect sufficient amount for the experiment. Leaves were sundried for 3-5 days and ground to pass through a Wiley mill with 3 mm screen before shipping to Japan for the feeding trial.

Animals, experimental design and diets

In experiment 1, three rumen cannulated Japanese Corriedale sheep with mean body weight of 35.6 kg were used. The animals were kept individually in stainless metabolic crates and were fed *ad libitum* with ARS, giving 15% as allowance. ARS was fed alone or supplemented with 200 g of either leucaena or gliricidia leaf meal in a 3×3 Latin Square Design, with 10 day adjustment and 5 day collection period. The animals were first offered supplement prior to ARS feeding. Daily feed allowance was given in two equal proportions, at 09:00 and 17:00 h. Animals had free access to a multi-mineral salt lick (Nippon Zenyaku Kogyo Co. Ltd. Fukushima, Japan). During live weight changes trial (experiment 2), twenty four growing native Philippine lambs (4-5 months old) with an average weight of 13.5 kg were randomly distributed into three different treatment groups using completely randomized design (CRD). The experiment lasted for 104 days (14 days adjustment and 90 days of intake and growth measurement). Animals were housed individually in floor pens equipped with feeder and water troughs. They were fed *ad libitum* with ARS, giving 15% as allowance. Ammoniated rice straw was fed alone or supplemented with 200 g of either leucaena or gliricidia leaf meal. The amount of supplement was calculated (assuming a minimum daily intake of 520 g DM per day) to be about 200 g/kg DM intake. Daily forage requirement was cut in the afternoon and fed the following day to allow wilting to about 28-30% DM. Supplements were offered first in the morning, while ARS was given *ad libitum* upon complete consumption of the forage legume. Deworming was done before the start of the experiment and every month thereafter.

Measurements

In experiment 1, total fecal and urine excretion were determined during the last 5 days of each period. Feces and urine were collected daily, pooled and stored at -10℃ for further analysis. Except for urine, all samples were oven-dried at 60℃ for 48 hours and ground to pass through 1-mm mesh before analysis. Also during the collection period about 10 ml of cobalt ethylene diamine tetra acetic acid (CoEDTA) solution (1.72 g Co/10 ml water) was infused through the rumen cannula before the morning feed to estimate liquid outflow rate. Rumen fluid samples were taken at 0.5, 2, 4, 6, 12 and 48 h after dosing and representative sample was centrifuge and the supernatant stored for cobalt determination. The fluid outflow rate was calculated as the slope of the line defined by plotting the natural log of Co concentration vs. time. Determination of solid outflow rate, was done using Dy-mordanted straw, by soaking 300 g chopped ARS into a Dy solution (20 g dysprosium chloride, hexahydrate/2 L water) overnight following the procedure of Uden et al. (1980). After the CoEDTA dosing on the first day of each collection period, about 30 g of Dy-mordanted ARS was administered orally in each animal before the morning feeding. Unconsumed Dy-mordanted ARS after 30 min was placed into the rumen through the cannula. Thereafter, fecal samples were taken at 6h interval during the 5-day collection period. The solid outflow rate was estimated by plotting the natural logarithm of Dy concentrations in feces against time. Feed offered and orts were weighed everyday, and a representative sample was collected and analyzed for DM (oven drying at 60℃ for 48 h). During experiment 2, feed intake was recorded and initial weight was measured at the start of the experiment, and final weight, 90 days thereafter to determined live-weight increment.

Chemical analysis

Representative sample of feeds, and orts were subjected to DM and organic matter (OM) determination following the AOAC (1984) procedure. Nitrogen content of the samples was determined by the Kjeldahl method. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) and were analyzed following the method of Goering and Van Soest (1970). N bound to NDF (NDIN) and ADF (ADIN) was measured following the procedure of Licitra et al. (1996). Co and Dy concentrations in the rumen fluid and feces, respectively were determined using Inductively Coupled Plasma Spectrophotometry (ICPS-Shimadzu 2000). Fecal samples were subjected to wet ashing by nitric and perchloric acids (3:1) prior to ICPS reading. The ammonia-nitrogen (NH_3-N) concentration of rumen fluid was measured by the procedure of Oser (1965). Allantoin was determined by the method of Young and Conway (1942) while xanthine, hypoxanthine and uric acid were analyzed

following the method of Fujihara et al. (1987). Microbial purines absorbed and microbial N yield was calculated from total urinary PD as described by Chen and Gomes (1992).

Statistical analysis

All data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Statistica for Windows™ Released 4.3 (StatSoft, Inc., Tulsa, OK., 1993). Mean comparison was done using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Chemical composition

Chemical composition of ARS, leucaena and gliricidia used in experiment 1 is presented in table 1. The N content of the leaf meals was almost three times higher than that of the basal diet, with leucaena containing more N than gliricidia. Similar trend in nutrients composition was recorded in the diets used in experiment 2 with ARS, leucaena and gliricidia containing 13.2, 40.5 and 37.6 g N/kg DM respectively. About 32% of the N in leucaena was bound to NDF (NDIN) as compared to 38% in gliricidia, while the N attached to ADF (ADIN) in gliricidia was higher that that of leucaena. Licitra et al. (1996) described NDIN as N that is insoluble in NDS but soluble in ADS and its susceptibility to microbial digestion is highly variable. On the other hand, ADIN is least soluble and indigestible cell component because it is highly lignified. NDF content of gliricidia was 10% higher, while ADL was almost double than that of leucaena. Previous works (Reed et al., 1990; Richards et al., 1994; Abdulrazak et al., 1996) indicated that although gliricidia contains less N, its fiber components are relatively lower than leucaena. The opposite trend observed in this study could be attributed to the method used in gathering the leaves, where age of the vegetative parts was not considered due to the amount of leaf meal needed to carry out the experiment. Plant maturity contributes largely to the variability in chemical components of forage legumes. Thus, the more fibrous nature of gliricidia could have been due to the variability imposed by the plant itself. Wood et al. (1998) observed a highly significant variation in the CP and ADF contents of gliricidia as affected by genetic and provenance differences. Fall-Toure and Michalet-Doreau (1995) also reported large variability in the chemical composition of tropical browses resulting in significant differences in the degradability of its fiber components.

Polyphenolic compounds were higher in leucaena, with soluble and condensed tannin contents of 175.6 and 23.9 g/kg DM respectively, as compared to the 146.5 g soluble tannin and 15.3 g condensed tannin per kg DM in gliricidia. These values were higher than those reported by Abdulrazak et al. (1997) but still within the normal range of values reported with other tree forages (Abdulrazak et al., 2000; Reed et al., 1990), and were not expected to affect nutrient utilization.

Nutrient intake

The DM intake, diet digestibility and digestible nutrient intake from experiment 1 are presented in table 2. The addition of leucaena and gliricidia did not effect straw DM intake, however, leaf meal supplementation increased ($p<0.05$) total DM consumption. Although no significant difference was noted between the intake of leaf meal diets, animals offered with gliricidia encountered palatability problem during the early stage of the adjustment period. The same condition was observed by Abdulrazak et al. (1996) in comparing the intake of leucaena and gliricidia among growing steers receiving napier grass (*Pennisetum purpureum*) as the basal diet. The unusual odor in the leaves of gliricidia could be the most plausible reason for its poor acceptability (Stewart et al., 1998; Tjandraatmadja et al., 1993).

The higher consumption in supplemented groups could be attributed to the significantly higher ($p<0.01$) outflow rate of both the liquid and solid phase of the rumen digesta. The solid outflow rates in leucaena group was 0.044 per h and gliricidia 0.038 per h, which are significantly higher than the 0.025 per h in ARS fed group. Forage intake by ruminants is influenced by the extent of fiber digestion and outflow rate (Waldo et al., 1972). Thus, with the addition of leucaena or gliricidia, containing more degradable OM, total DM consumption was enhanced although no

Table 1. Chemical composition of experimental feeds

Nutrients	ARS	Leucaena	Gliricidia
Dry matter (g/kg)	882.0	874.0	868.0
Organic matter (g/kg DM)	830.0	920.0	868.0
Nitrogen (g/kg DM)	14.24	42.0	34.4
Cell contents (g/kg DM)	311.0	716.0	584.0
NDF (g/kg DM)	611.0	272.0	393.0
NDIN (g/kg DM)	58.65	18.74	46.64
ADF (g/kg DM)	411.0	160.0	259.0
ADIN (g/kg DM)	21.24	5.94	17.04
Hemicellulose (g/kg DM)	200.0	112.0	134.0
Cellulose (g/kg DM)	359.0	94.0	140.0
Lignin (g/kg DM)	52.0	66.0	119.0
Soluble tannins (g/kg DM)	-	175.60	146.5
Condensed tannins (550 nm/g NDF)	-	23.87	15.34

ARS: ammoniated rice straw.

positive response on straw DM intake was observed. Results support the conclusion of Bamualim et al. (1984) and Bonsi et al. (1994) that one of the major effects of tree legume forage supplementation is increased outflow rate, eventually resulting to greater consumption. The same reason was given by Abdulrazak et al. (1996) in explaining the increased ($p<0.05$) intake of napier grass among crossbred cattle with the incorporation of graded levels of leucaena and gliricidia. Although, factors controlling passage of particles out of the rumen are poorly defined (Gasa et al., 1991), the theory of sieving action of reticulo-ruminal mass (Bruining and Bosch, 1992) and fractional specific gravity (Welch, 1986) provide that finer particles would leave the rumen faster (Welch and Smith, 1978). Therefore, the effect of ammoniation on the straw diet could have greatly enhanced break-down of its fiber components coupled with the addition of more degradable DM fractions from the forage supplements resulting in better intake.

Nutrient digestibility

Except for NDF and ADF, nutrient digestibility increased ($p<0.05$) with the addition of leucaena or gliricidia. Digestible OM and N intake were also higher in the supplemented groups than the control. The more lignified characteristics (table 1) of leucaena and gliricidia might have caused these results on fiber digestibility. Similar responses were observed in goats (Richards et al., 1994) and cattle (Abdulrazak et al., 1997) when leucaena and gliricidia were fed in combination with napier grass.

Gliricidia could effect better response on digestibility by ruminants than leucaena as reported previously (Abdulrazak et al., 1997; Richards et al., 1994), they concluded that the greater amount of potentially degradable fraction (A+B) and faster rate of degradation (*c*) in gliricidia contributed to this improvement. In this study, animals receiving leucaena and gliricidia had similar fiber digestibility. It is possible that the type of forage legume supplement do not directly affect ruminal degradability and *in vivo* digestibility, but rather the nature of its structural components as suggested by the previous work of Bonsi et al. (1994). With more lignified cell walls in gliricidia, fiber digestibility was negatively affected resulting to similar effect with that of leucaena.

Greater passage of the solid particles in leucaena and gliricidia supplemented groups might have caused the insignificant differences in the whole tract digestibility of its fiber fractions. Suggesting that although supplementation increased digestible nutrient intake, the increase in total DM consumption may have reduced the retention time in the rumen allowing limited time for NDF digestion (Bonsi et al., 1994), particularly with greater lignin concentration in the structural components of the forage legume.

Nitrogen balance

Results showed that supplementing ARS with leucaena and gliricidia resulted to higher ($p<0.05$) N retention compared with the control group (table 3). In both supplemented groups, leaf meals contributed approximately 41% of the total N intake. The difference between total N intake in the supplemented group almost reach significant ($p<0.08$) level, with the leucaena fed group having slightly higher value. The significantly higher ($p<0.05$) rumen NH_3-N in the supplemented group suggests that both forage legumes provided additional degradable N on top of the readily soluble N from ARS. Rumen NH_3-N levels were higher ($p<0.05$) in supplemented than the control group, reflecting better N supply when leucaena or gliricidia leaf meals, which provided similar rumen NH_3-N concentrations, were added to ARS. The 80.40 mg NH_3-N/l of rumen fluid in the control group is way above the recommended 50 mg/l (Satter and Slyter, 1974) for maximum microbial growth that could effect optimum fiber digestibility, though slightly higher than our previous study using ARS as control diet (Orden et al., 1999).

Although total N output was higher in leucaena and gliricidia groups, the difference between fecal N voided tended to approach significant level ($p<0.07$). This explains the slightly higher N digestibility in leucaena compared with gliricidia supplemented group (table 2). The added N from the legume forage promoted higher N digestibility and retention. Total N loss (fecal+urinary) as proportion of the daily N intake in the ARS fed group was about 84.4%, while the supplemented groups had only 65.9%. Almost half of the N consumed from ARS was voided through the feces, supporting the conclusion of Males (1987) that only 50% of the total N added through ammoniation could be made available to animals during digestion. Nevertheless, the amount of N lost from ARS is far less than the 97% N lost from teff straw through feces among Ethiopian Menz sheep which resulted to negative N balance (Bonsi et al., 1994).

The fecal N loss in gliricidia supplemented group was significantly higher than that of leucaena group. This could be due to greater proportion of N is attached to the cell walls (table 1), which typically had lower degradability. Licitra et al. (1996) reported that forage supplement that degrade slowly (e.g. leucaena) has the tendency for greater fecal N losses when fed at lower levels than those rapidly degraded. On the other hand, leucaena fed group had greater ($p<0.05$) amount of N voided out through the urine, thus supports the earlier contention that the leucaena forage used in this study provided more digestible components than gliricidia. The greater urinary N

Table 2. Dry matter intake, *in vivo* digestibility and digestible nutrient intake and outflow rates of sheep fed ARS alone or plus leucaena or gliricidia

Nutrients	ARS	ARS+leucaena	ARS+gliricidia	SEM	Level of significance
DM intake (g/kg $W^{0.75}$)					
Straw	47.75	45.25	41.18	1.16	ns
Leaf meal	0	10.93	10.89	1.84	ns
Total	47.75[a]	56.18[b]	52.07[b]	2.88	*
Nutrient digestibility (%)					
DM	50.41[a]	58.15[b]	57.76[b]	1.32	**
OM	57.20[a]	63.37[b]	64.63[b]	1.16	**
N	56.42[a]	67.97[b]	64.68[b]	1.91	**
NDF	56.59	60.49	58.55	1.68	ns
ADF	55.74	57.62	56.94	0.517	ns
Outflow rate (%/h)					
Liquid outflow rate	0.053[a]	0.0775[b]	0.0676[b]	0.0051	**
Solid outflow rate	0.025[a]	0.0438[b]	0.0376[b]	0.0037	*

Means with common letter superscript within rows are not significant.
ns: not significant; * $p<0.05$; ** $p<0.01$.
ARS: ammonia treated rice straw.

Table 3. Nitrogen balance, rumen ammonia (NH_3-N), purine derivative (PD) excretions, microbial N yield and outflow rates in sheep fed ARS alone or plus leucaena or gliricidia meal

Parameters	ARS	ARS+leucaena	ARS+gliricidia	SEM	Level of Significance
N intake (g/d)	10.63[a]	18.22[b]	14.70[b]	1.142	*
Fecal N (g/d)	4.61[a]	5.84[b]	5.18[b]	0.216	*
Urinary N (g/d)	4.37[a]	6.02[b]	4.38[a]	0.311	*
Retained N (g/d)	1.70[a]	6.36[c]	5.14[b]	0.750	*
Rumen NH_3-N (mg/dl)	8.14[a]	14.01[b]	13.21[b]	1.400	*
Total PD (mmol/d)	5.62[a]	9.97[b]	9.35[b]	0.865	*
Allantoin (mmol/d)	4.04[a]	7.89[b]	7.23[b]	0.741	*
Xanthine+hypoxanthine (mmol/d)	0.13	0.17	0.15	0.009	ns
Uric acid (mmol/d)	1.45	1.91	1.97	0.138	ns
Microbial N (g/d)	4.80[a]	8.61[b]	8.33[b]	0.619	*
DOMI (kg/d)	0.63[a]	0.77[b]	0.77[b]	0.024	*
RDOM (%)	30.73[a]	34.47[a]	35.28[b]	0.013	*
RDOM (kg/d)	0.19[a]	0.27[b]	0.27[b]	0.013	*
EMNS (g MN/kg RDOM)	24.92[a]	32.51[b]	30.82[b]	0.013	*

DOMI: Digestible OM intake (kg/d), EMNS: Efficiency of Microbial N synthesis.
RDOM (%) calculated from actual *in-situ* nylon bag disappearance using the equation $p=a+b(1-e^{-ct})$ (Ørskov and McDonald, 1979).
RDOM: Rumen degradable OM (from nylon bag data using outflow rate of 0.02) × DOMI.
Means with common superscripts within rows are not significant; ns: not significant ($p>0.05$); * $p<0.05$; ** $p>0.01$; ARS, ammoniated rice straw.

output in leucaena reflects the inability of the rumen microorganism to utilize the large influx of degraded N. The fact that rumen NH_3-N production in leucaena was slightly higher than gliricidia supplemented group, although the difference did not reach significant level ($p>0.05$), could have contributed to this result.

Microbial protein yield

Tree forage supplementation promoted higher PD excretions, estimated microbial N supply and the EMNS (table 4) with allantoin contributing more than 70% of the total PD excreted. EMNS were 32.5 and 30.8 g MN/kg RDOM for leucaena and gliricidia

Table 4. Dry matter intake (DMI), growth performance and feed conversion efficiency of growing lambs fed with ARS alone or plus leucaena or gliricidia meal

Nutrients	ARS	ARS+leucaena	ARS+gliricidia	SEM	Level of significance
Feed intake (g/kg $W^{0.75}$)					
Straw DMI	57.50	56.05	58.60	1.11	ns
Leaf meal DMI	0	14.02	14.88	1.04	ns
Total DMI	57.50[a]	70.07[b]	73.48[b]	1.22	**
Feed intake (g/d)					
Straw DMI	445.42[a]	420.0[b]	385.67[b]	10.18	**
Leaf meal DMI	0	105.03	104.91	0.34	ns
Total DMI	445.42[a]	525.02[b]	490.58[b]	18.16	**
Live-weight (kg)					
Initial	13.54	13.64	13.26	0.248	ns
Final	15.27[a]	16.75[b]	16.31[b]	0.25	*
Growth rate (g/d)	19.3[a]	34.6[b]	33.9[b]	2.18	**
FCE[1]	22.27[a]	13.46[b]	13.26[b]	1.87	*

[1] FCE: feed conversion efficiency calculated as g total DMI per g live weight gain per day.
Means with common superscripts within rows are not significant.
ARS: ammoniated rice straw; ns: not significant; * $p<0.05$; ** $p<0.01$.

supplemented groups respectively, and significantly higher ($p<0.05$) than 24.9 g MN/kg RDOM of ARS group. Urinary PD excretion is affected either by the changes in outflow rate from the rumen or by the intestinal flow of microbial protein (Fujihara et al., 1999). Moreover, variations in urinary PD excretion are mainly related to the supply of microbial nucleic acid (Verbic et al., 1990). The higher ($p<0.05$) N utilization and DOMI in the forage supplemented group resulted to more purine absorbed as indicated by the higher MN yield. Moreover, the faster flow rate of both solid ($p<0.05$) and liquid ($p<0.01$) ingesta from the reticulo-rumen contributed to the more ($p<0.05$) efficient synthesis of tissue protein. According to Fujihara et al. (1999) the constant influx of feed in the rumen that maintained the passage of digesta could result to increased ($p<0.05$) microbial synthesis and absorption in the lower gut.

The improvement in N utilization and greater amount of DOMI brought about by leucaena and gliricidia supplementation resulted to more bacterial N production (purine absorbed). Despite the similarity in fiber digestibility among treatments, the higher amount of cell contents (table 1) in the leucaena and gliricidia could have provided the energy needed for microbial N synthesis, which was two times lower in ARS. The significant increase in MPY was due to greater N supply and intake of digestible OM in response to the increasing level of foliage from multipurpose tree. Our findings of the increase in MPY are in agreement with those of Masama et al. (1997) using sheep and Abdulrazak et al. (1996 and 1997) among cattle when fed with graded levels of leucaena and gliricidia.

Growth performance

Total gain and ADG of growing lambs were higher ($p<0.05$) in supplemented than the control group after 90 days of feeding (table 4). The significant improvement in the liveweight of lambs resulted to a more efficient feed utilization. Animals fed with leucaena and gliricidia required only about 13 g DM to produce one g of gain per day, which is 10 units better ($p<0.05$) than 22.3 in the unsupplemented group. The higher growth rate of animals fed with either leucaena or gliricidia was associated with higher ($p<0.05$) DMI. The inclusion of leucaena and gliricidia improved the N utilization of the diet and provided rumen undegradable N that resulted to increased consumption with a corresponding increase in liveweight gain and feed efficiency. The additional N from the forage legume must have contributed to the increased live weight gains. Abdulrazak et al. (1996) concluded that the higher growth performance of steer offered napier grass was due mainly to improved N status as a result of leucaena and gliricidia supplementation that also elicited higher intake. Ferret et al. (1998) gave the same reason in explaining the higher intake of alfalfa hay than ryegrass among pregnant goats bearing multiple fetuses.

CONCLUSION

The addition of leucaena and gliricidia leaf meal to ARS in sheep resulted to increased total dietary consumption; *in vivo* OM and N digestibility, which eventually improve N retention and microbial protein synthesis. With no positive associative effect of forage

supplementation on fiber digestibility, the observed increased in outflow rate was probably the mechanism that triggered higher DM consumption. The similar response of animals between the supplemented group suggests that either leucaena or gliricidia could improve N utilization and animal performance when offered crop residues.

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