Agronomic Performance of Five Rice Varieties and Nutritive Value of the Straw from these Varieties

T. Ansah[1*], W. Dogbe[2], S. Cudjoe[1], A-R, Abdul-Basit Iddrisu[2] and A.S. Eseoghene[1]
[1] University for Development Studies, Faculty of Agriculture, Department of Animal Science, Tamale, Ghana
[2] *Council for Scientific and Industrial Research (CSIR)-Savanna Agricultural Research Institute (SARI)*
*Corresponding author; Email: tansah@uds.edu.gh

Abstract

Two separate experiments were conducted to assess the grain and straw yield (Exp. 1), chemical composition and *in vitro* gas production (Exp. 2) of five varieties of rice; Hybrid, Exbaika, Jasmine 85, IR841 and Long grain ordinary 2. Experiment 1 was conducted in a randomized complete block design with four replicates per variety. After harvesting, the rice straw from each variety was combined with Kapok leaf meal (KLM) at three inclusion levels (0, 25, 50%) to formulate a diet. The sole rice straw and formulated diets were analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and Ash. Approximately 0.2 g of each diet (sole and formulated) was incubated in a McDougall's buffered rumen fluid under anaerobic condition for the *in vitro* gas production. The varieties differed ($P < 0.05$) in relation to plant height, maturity days, percentage emergence, tiller number, straw yield and harvest index but did not differ in grain yield. The percentage emergence was in the range of 72.5 and 85.0%. with the highest ($P = 0.003$) recorded in the Hybrid variety. Plant height ranged from 90.5 to 110.8 cm with the highest ($P = 0.046$) reported in variety Long grain ordinary 2. Variety Long grain ordinary 2 had the longest ($P<0.001$) mean maturity days with the least recorded in the Hybrid variety. The highest ($P < 0.05$) straw yield was reported in variety Exbaika whilst Jasmine 85 had the least straw yield and harvest index. The CP concentration of the rice straw varieties increased numerically with an increase in the level of KLM. The NDF ranged from 622 g/kg DM to 913 g/kg DM for IR842 variety with 0% KLM and Long grain ordinary 2 variety with 25% KLM respectively. The ADF was in the range of 299.7 g/kg DM to 483.6 g/kg DM with the lowest reported in IR842 variety with 50% KLM. Mean asymptote gas production (b), fractional rate of gas production (c), *in vitro* gas production (IVGP) and *in vitro* organic matter digestibility (IVOMD) were not affected ($P <0.05$) by the variety x KLM inclusion level interaction. However, IVGP at 24 h and IVOMD both differed ($P < 0.05$) by variety. Varieties Jasmine 85, IR842 and Long grain ordinary 2 had higher IVGP and IVOMD as compared to the other two varieties. It was observed from the study that varieties IR841 and Long grain ordinary 2 provided higher grain and fodder production. The use of KLM as a replacement enhanced the nutrient composition, fermentation characteristics and digestibility.

Introduction

Rice has been reported as the fastest growing food source in Africa (Nwanze *et al*., 2006). In Ghana, it is one of the common cereal crop cultivated and consumed (MoFA, 2010). Apart from the grain derived from rice cultivation, the straw serves as an important energy source for most grazing livestock particularly in the long dry season when feed is in short supply.

Different varieties of rice are presently being evaluated for yield and other economic traits by the Savanah

Agricultural Research Institute (SARI) of the CSIR in Ghana. Whilst grain yield and other agronomic parameters like maturity days are essential, the nutrient composition and organic matter digestibility of straw is equally important due to its role is ruminant feeding. But very little attention has been given to it in most breeding programs. The nutrient composition and organic matter digestibility of rice straw has been found to be affected by variety, time between harvest and storage, N fertilization, plant maturity (lignin content increases with maturity), plant health and weather conditions (Göhl, 1982 and Drake *et al.,* 2005). Since breeding can reduce or prolong plant maturity and other agronomic factors, it is very likely it can influence the quality of the straw. Evaluating these varieties for straw quality alongside the agronomic performance is therefore justified.

Various treatments and supplementation strategies have been used in rice straw with the aim of improving the digestibility. Kapok is a common browse plant in most tropical countries and has been reported to have appreciable levels of crude protein (126.3 g/kg DM) to support rumen fermentation (Ansah and Nagbila, 2011; Ansah, 2015). In addition to that it also contains condensed tannin (102.8 g/kg DM) which could negatively affect fermentation or digestibility characteristics (Ansah, 2015). Supplementing rice straw with KLM at different inclusion levels could provide a useful information for ruminant feeding systems using these feed resources.

The objectives of this study were to investigate the effects of variety on grain and straw yield of five rice varieties and the effect of three levels (0, 25, and 50%) of KLM on the chemical composition and *in vitro* organic matter digestibility of straw from these varieties.

Material and methods

The rice varieties were cultivated on the trial field of the Savanna Agricultural Research Institute (SARI) in Nyankpala within the Tolon District of Ghana. The area lies in the Guinea savanna zone on latitude 9°25'41" N and longitude 0°58'42" W. The temperature recorded during the growing period was 24.1 °C and 34.2 °C for minimum and maximum respectively and the humidity was 55.0 (minimum) and 77.1 (maximum). The rainfall for the year 2014 is shown on Fig. 1. The chemical composition and *in vitro* gas production were carried out at the Forage Evaluation Unit of the Agricultural Sub-Sector Improvement Project (AgSsIP) Laboratory of the University for Development Studies located in Nyankpala in the Tolon District.

Experiment 1

The five rice varieties used in this study were S72180002 (Hybrid), Exbaika, Gbewaa (Jasmine 85), AGRA rice (IR841) and Long grain ordinary 2. The varieties were cultivated on a 3 × 5 m^2 plots arranged in a randomized complete block design (RCBD) with four replications. Experimental plots ware ploughed mechanically using disc plough and harrowed two weeks after ploughing before planting. Planting was manually done by dibbling at a rate of 2–3 seeds per hole with a plant spacing of 20 cm × 20 cm.

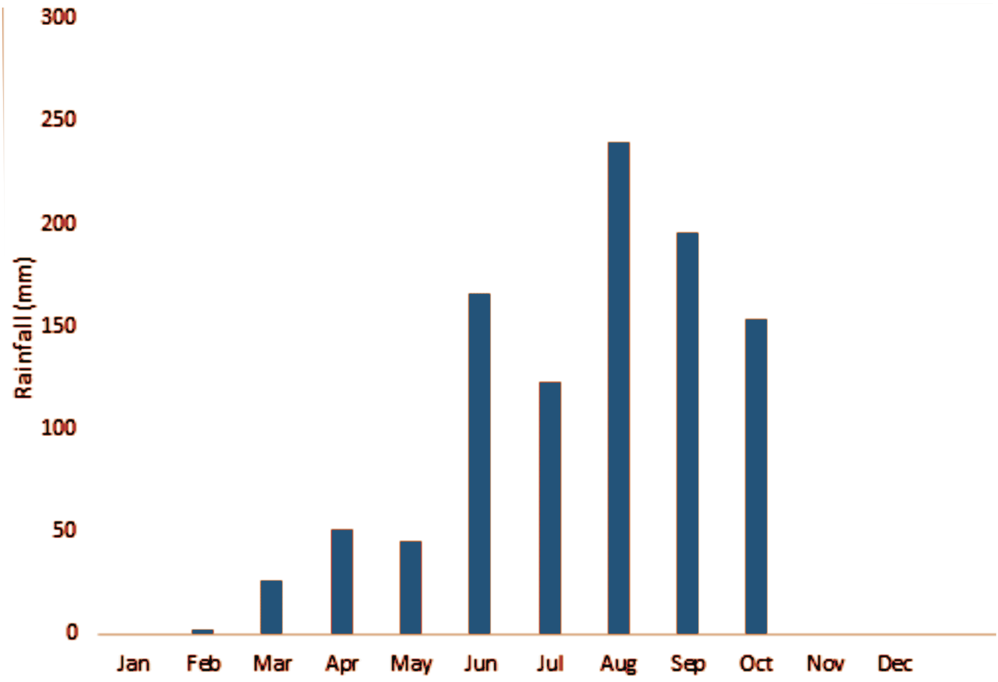

Fig. 1. Monthly rainfall during the year 2014 in Nyankpala

Chemical herbicide (Butachlor) was used as pre-emergence herbicide at a rate of 2 liters/ha a day after planting. Fertilizer (15:15:15 NPK) was applied at a rate of 90 kg /ha, 60 kg/ha, 60 kg/ha for Nitrogen, phosphorus and potassium respectively.

Harvesting was done manually by the use of sickle at 80% maturity. The harvested materials were dried and later threshed by beating in poly sack.

All agronomic data were collected according to the Standard Evaluation System (SES) for International Rice Research Institute (IRRI), (2002).

Plant emergence percentage was determined by dividing the number of emerged hills by the number of hills planted and multiplied by 100.

Tiller number and plant height were measured by selecting 20 hills per plot.

The tiller was counted 6 weeks after panting for each hill and plant height was measured at maturity using a plastic tape from the soil surface to the tip of the tallest panicle (awns were excluded).

Straw yield was calculated by dividing the weight of the air-dried straw by the area cultivated and was converted to hectares.

Grain yield was estimated by harvesting the entire field excluding border rows and the weight adjusted to a moisture content of 14%.

Kapok leaves were harvested from 10 different already established trees within the Nyankpala campus of the University for Development Studies.

Air dried samples of the rice straw and KLM were milled through 1 mm sieve screen and oven dried over night at 60°C for the chemical analysis and *in vitro* gas study.

Experiment 2

The rice straw was combined with 3 levels (0, 25, 50%) of KLM to conduct experiment 2.

Total Nitrogen (N) was determined using the micro Kjeldahl after which the CP was calculated by multiplying the N content by 6.25 (AOAC, 2000). The NDF was determined exclusive of residual ash with sodium sulfite and α- amylase whilst ADF was determined exclusive of residual ash. The procedure of Goering and Van Soest (1970) was followed in determining both NDF and ADF and was analysed using the Ankom^{200} fiber analyser. Duplicate samples of each treatment was used for these analysis.

The 5*3 factorial in a completely randomized block design was used for the *in vitro* gas production study. The factors were the 5 rice straw varieties (Hybrid, Exbaika, Jasmine 85, IR841 and Long grain ordinary 2) and 3 levels of KLM (0, 25, 50%) with four replications (run) each. Duplicate samples were incubated in each replicate (run).

Approximately 0.2 g of the milled and oven dried samples were weighed into 50 ml test tubes for incubation. Buffer was prepared following the procedure of McDougall (1984) and placed in a water bath with continuous supply of carbon dioxide (CO_2) until the rumen fluid was ready.

Rumen fluid was collected from 3 separate cattle after slaughter into pre-warmed vacuum flask at the Tamale abattoir. The animals had been grazing on natural pasture with very minimal supplementation prior to slaughter. The rumen fluid was strained through a four-layer cheese cloth and mixed with the buffer in a ratio of 1:4 with continuous supply of CO_2 to get the buffered rumen fluid.

Approximately 30 ml of the buffered rumen fluid was dispensed into each test tube containing the samples using 50 ml syringe and placed in water bath (39 °C).

The gas production was measured using a digital manometer (HT 1895, China) at 3, 6, 12, 24 and 48 h. The content of each test tube was agitated each time the gas was measured.

The gas readings were fitted to the exponential model of Ørskov and McDonald (1979) ($Y = b(1 - e^{-ct})$ to derive the degradation characteristics (b and c) where,

Y = gas volume at time t (ml)
b = asymptotic gas production (ml)
t = time (h)
c = fractional rate of gas production (ml/h)

In vitro organic matter digestibility was estimated using the formulae IVOMD = 14.88 + 0.889 GP + 0.45 CP + 0.651 XA according to Menke and Steingass (1988) where GP, CP and XA are total gas volume produced at 24 h per 0.2 g sample, crude protein and ash respectively.

One-way ANOVA in block design and two-ANOVA were used in analyzing the agronomic data and *in vitro* gas production data respectively. Means were separated using Fischer's protected LSD in Genstat 11th edition (Payne *et al*., 2009).

Results and discussion

Results on the grain yield, plant height, maturity days, percentage emergence of the rice varieties, straw yield and harvest index are shown in Table 1. The varieties differed ($P < 0.05$) in relation to plant height, maturity days, percentage emergence, tiller number, straw yield and harvest index but did not differ in grain yield.

The percentage emergence of the varieties was in the range of 72.50 and 85.0. with the highest ($P = 0.003$) recorded in variety hybrid.

The plant height ranged from 90.5 to 110.8 cm with the highest ($P = 0.046$) reported in variety Long grain ordinary 2.

Variety Long grain ordinary 2 had the longest ($P < 0.001$) mean maturity days (130.5) with the least recorded in Hybrid variety. The length of maturity period reported in this study is in line with what has been reported for some similar rice varieties cultivated in Ghana (Manful *et al*., 1996).

The mean straw yield was higher ($P < 0.05$) in Exabika (4146 kg/ha) and lowest in Jasmine 85 variety. The significantly lower straw yield in Jasmine 85 indicates that variety may only be promoted as a grain producing rice variety.

The chemical composition of the sole rice straw and the formulated diet is shown in Table 2. The numerical differences observed in the chemical composition of the sole rice straw varieties suggest some differences in the ability of the rice plants to take up nutrients from the soil. Variety Jasmine 85 had the highest crude protein (CP) with (92.1 g/kg DM) and without KLM (60.0 g/kg DM). The CP reported in the sole Jasmine 85 rice straw was higher than what has been reported for other rice straw varieties by Ngi *et al.* (2006) and Cheat *et al.* (2010) but still fell below the adequate levels of 110–130 g/kg required for maintenance and growth of small ruminants (NRC, 2007) and can therefore not be used as ruminant feed without supplementation. When these straws are fed to ruminants, it will be necessary to provide adequate amounts of rumen

TABLE 1

Mean grain yield, plant height, maturity days and percentage emergence of rice varieties

Variety	*Grain yield (kg/ha)*	*Plant height at maturity (cm)*	*Maturity days*	*Emergence (%)*	*Number Tiller at six weeks*	*Straw yield (kg/ha)*	*Harvest index*
Hybrid	3276.6	105.5	119.0	85.0	17.30	2910	0.53
Exbaika	4291.0	97.2	123.2	75.0	16.70	4146	0.51
Jasmine 85	3403.5	90.5	120.5	81.1	12.80	975	0.45
IR841	4331.5	108.5	123.2	72.5	13.30	3992	0.52
Long grain ordinary 2	4343.6	110.8	130.5	75.0	13.65	4116	0.51
SED	564.36	6.52	0.96	2.73	1.5	513.8	0.01
P Value	0.188	0.046	<.001	0.003	0.029	<0.001	<0.001

TABLE 2
Mean (±SD) Chemical composition of sole rice straw and KLM- rice straw mixture

Variety	KLM level	DM	CP	NDF	ADF	Ash
Hybrid	0%	91.2 ± 2.1	45.9 ± 2.2	746.8 ± 2.1	460.1 ± 0.9	120.0 ± 0.6
	25%	89.0 ± 1.0	64.4 ± 1.0	896.2 ± 3.3	402.6 ± 4.8	90.0 ± 0.0
	50%	90.8 ± 2.0	84.4 ± 5.3	864.4 ± 1.7	390.5 ± 2.3	80.0 ± 0.0
Exbaika	0%	90.5 ± 3.8	47.3 ± 0.9	688.4 ± 5.3	465.1 ± 1.5	135.0 ± 0.5
	25%	95.0 ± 2.8	65.7 ± 3.6	868.5 ± 2.2	410.3 ± 9.1	110.0 ± 0.0
	50%	96.2 ± 1.8	83.9 ± 2.5	801.2 ± 6.2	364.5 ± 3.9	105.0 ± 0.2
Jasmine 85	0%	91.2 ± 2.5	60.0 ± 0.4	693.8 ± 2.9	461.2 ± 1.2	165.0 ± 0.2
	25%	89.5 ± 1.0	65.7 ± 4.3	877.6 ± 4.4	404.1 ± 0.3	110.0 ± 0.0
	50%	87.2 ± 2.3	92.1 ± 4.2	815.9 ± 2.5	364.1 ± 1.2	90.0 ± 10
IR841	0%	90.2 ± 1.8	53.4 ± 2.6	622.8 ± 4.6	434.0 ± 1.3	157.5 ± 3.0
	25%	92.3 ± 2.0	68.7 ± 1.5	809.4 ± 2.6	381.8 ± 2.4	115.0 ± 5.0
	50%	88.2 ± 1.5	82.4 ± 0.4	740.2 ± 6.9	299.7 ± 1.6	95.0 ± 0.5
Long grain ordinary 2	0%	92.3 ± 1.2	45.1 ± 0.4	696.9 ± 1.2	483.6 ± 2.8	127.5 ± 4.0
	25%	89.5 ± 2.5	61.9 ± 2.6	613.0 ± 6.3	352.7 ± 8.1	85.1 ± 2.0
	50%	90.5 ± 1.8	78.0 ± 2.9	770.2 ± 6.9	350.6 ± 5.1	85.0 ± 2.5
KLM		845.3 ± 1.2	126.3 ± 2.7	271.3 ± 1.2	291.8 ± 0.4	86.0 ± 0.8

KLM; Kapok leaf meal, CP; Crude protein; NDF; Neutral detergent fiber; ADF: Acid detergent fiber

degradable protein in order to enhance voluntary intake and digestibility. There was a linear numerical increase in CP for all rice straw varieties with the addition of KLM.

Neutral detergent fibre (NDF) increased with the addition of KLM for all the rice straw varieties whilst the reverse was observed for acid detergent fiber (ADF). Both NDF and ADF have an effect on the overall digestibility of feed. The decrease in ADF with the addition of KLM can enhance voluntary feed intake and dry matter digestibility. Similar decreasing trend was observed in the ash concentration with increasing levels of KLM. The relatively higher ash concentration of the sole rice straw could be due to the high silica concentration reported in most rice straw (Van Soest, 2006) and could reduce digestibility when fed as sole diet.

The variety x KLM interaction did not significantly affect the *in vitro* degradation parameters (b and c), IVGP at 24 h and IVOMD (Table 3). However, there was a main effect ($P < 0.05$) of variety on IVOMD and IVGP at 24 h (Fig. 1). Varieties Jasmine 85, IR842 and Long grain ordinary 2 had higher ($P < 0.05$) mean IVOMD and IVGP compared to the other two varieties. The relatively higher IVOMD and IVGP reported in the sole Jasmine 85, IR842 and Long grain ordinary 2 could be an indication that plant cell wall degradation was not impeded in those varieties, possibly due to less lignin and silica concentrations.

Condensed tannin (CT) has been generally reported to be an inhibitor to the

TABLE 3

In vitro gas production and degradation parameters of sole rice and KLM- rice straw mixture

Variety	*KLM Levels (%)*	*b (ml/g M)*	*C*	*IVG (24 h)*	*IVOMD (g/kg)*
Hybrid	0	77.2	0.04	42.9	3233
	25	101.9	0.03	51.7	3633
	50	85.1	0.07	55.2	3830
Exbaika	0	46.5	0.03	50.5	3624
	25	96.1	0.04	44.2	3327
	50	66.0	0.06	51.6	3708
Jasmine 85	0	94.5	0.04	58.2	4068
	25	110.2	0.04	58.1	3982
	50	130.1	0.03	65.3	4006
IR841	0	87.9	0.06	60.6	4161
	25	99.9	0.05	56.3	3914
	50	103.2	0.04	65.3	4332
Long grain ordinary 2	0	69.8	0.06	60.5	4043
	25	82.2	0.06	52.8	3667
	50	75.0	0.05	60.0	4049
SED	32.05	0.02	6.09	286.3	
P-value	V	0.16	0.65	0.002	0.001
	KLM	0.26	0.82	0.137	0.096
	V*KLM	0.98	0.35	0.630	0.599

KLM; Kapok leaf meal; b: Asymptote gas production; c: fractional rate of gas production; IVG: In vitro gas production; IVOMD: In vitro organic matter digestibility.

functioning of rumen microbes including fibre degrading groups, which often results in decline in digestibility (McAllister *et al.,* 2005; Smith *et al.,* 2005; Hariadi & Santoso, 2010). The inclusion levels of KLM used in this study appear not to have increased the CT concentration in the treatments to levels that could have inhibited microbial degradation, hence the lack of KLM effect on IVOMD and fermentation parameters.

The mean asymptote gas production (b) reported in the sole rice straw varieties was lower ($P < 0.05$) than those supplemented with KLM. This may be attributed to the high ADF and ash concentration reported in the sole rice straw treatments.

Fig. 3 shows a dendrogram describing the similarities among the varieties in relation to straw crude protein, in vitro organic matter digestibility of straw, grain yield and straw yield. Variety IR481 and

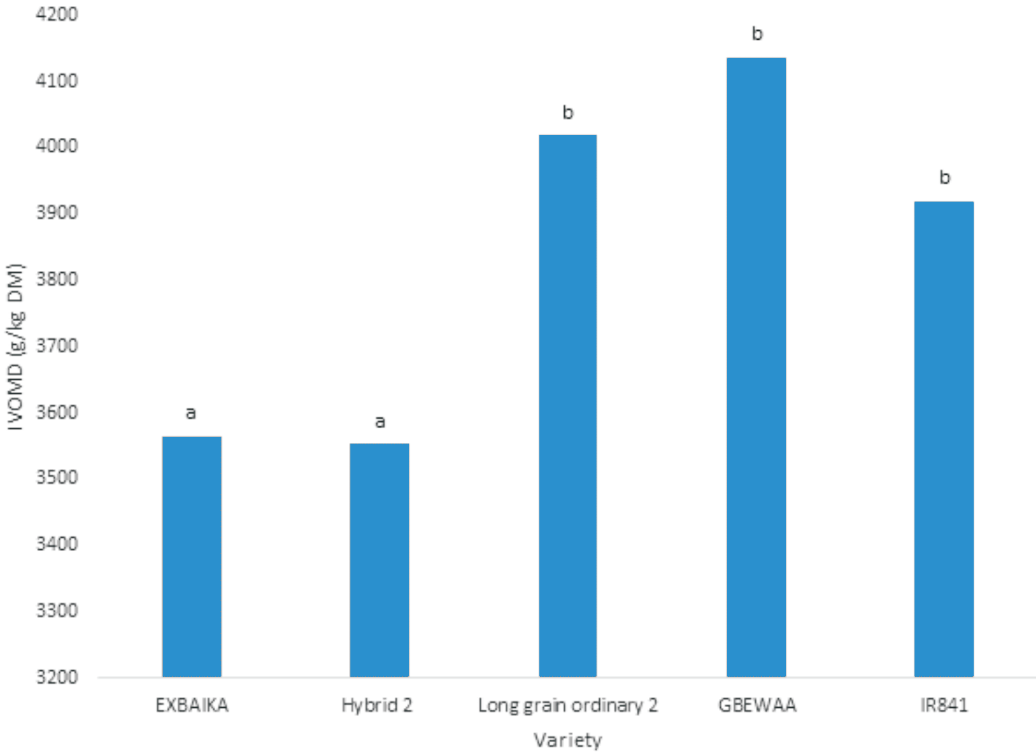

Fig. 2. Effect of variety on in vitro organic matter digestibility

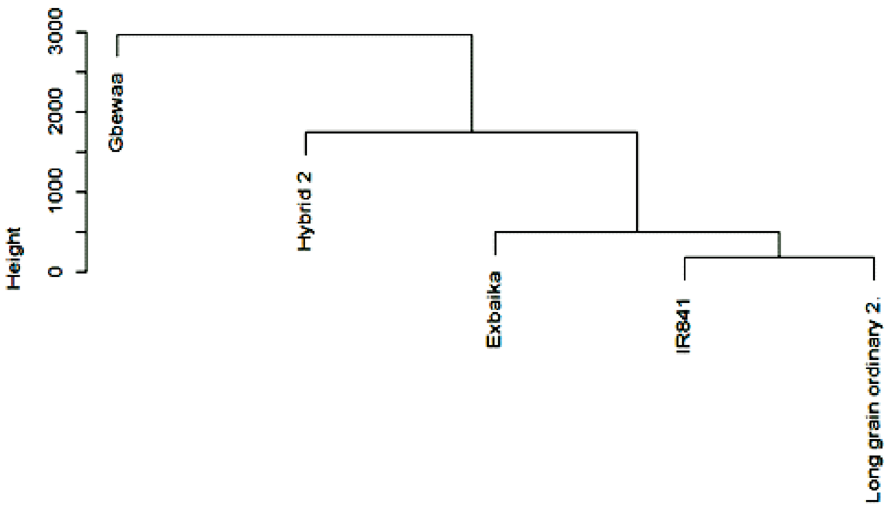

Fig.3. A dendrogram showing similarities among the rice varieties using the straw crude protein, in vitro organic matter digestibility of straw, grain yield and straw yield

long grain ordinary 2 showed similar potentials for grain yield, fodder quality and quantity.

Conclusion and recommendation

The agronomic study showed that Long grain ordinary 2 had the highest grain yield. The study revealed that combining of rice straw with KML has the potential to reduce ADF and improve crude protein concentration. The IVOMD was not negatively affected by the KLM inclusion.

Long grain ordinary 2 and IR841 are recommended as dual purpose (high grain yield and fodder yield and quality) rice varieties.

Acknowledgment

The authors are most grateful to *West Africa Agricultural Productivity* Programme –phase two (WAAP 2) for the financial support towards this study.

References

Ansah T., (2015). Nutritive value and greenhouse gas mitigation potential of eight browse plants from Northern Ghana. A Thesis submitted to the Department of Animal Science, University for Development Studies, in partial fulfillment of the requirements for the award of Doctor of Philosophy degree in Animal Nutrition.

AOAC. (2000). Official methods of analysis of AOAC international; 17th Edition.

Avornyo F .K., Karbo N. and **Addo-Kwafo A.** (2007). The performance of sheep fed fonio or rice straw in combination with two levels of whole cottonseed. Ghanaian Journal of Animal Science. **2** (3): 89–96.

Benchaar C., Pomar C. and **Chiquette J.** (2001). Evaluation of diet strategies to reduce methane production in ruminants: a modeling approach. *Can. J. Anim. Sci.* **81**: 563–574.

Cheat S., Khieu B. and **Preston T. R.** (2010). Effects of supplements of water hyacinth and cassava hay on the performance of local "yellow" cattle fed a basal diet of rice straw. *Livest. Res. Rural Dev*. **22**(9).

Drake D. J., Nader G. and **Forero L.** (2002). Feeding rice straw to cattle. Publication 8079 - University of California, Division of Agriculture and Natural Resources. 2002.

Goering H. K. and **Van Soest P. J.** (1970). Forage Fiber Analysis (apparatus, reagents, procedures and some applications). USDA Agricultural Handbook No. 379.

Göhl B. (1982). Les aliments du bétail sous les tropiques. FAO, Division de Production et Santé Animale, Roma, Italy.

Hariadi B.T. and **Santoso B.** (2010). Evaluation of tropical plants containing tannin on *in vitro* methanogenesis and fermentation parameters using rumen fluid. *Journal of Science Food and Agriculture*. **90**: 456–461.

McAllister T.A., Martinez T., Bae H. D, Muir A. D, Yanke L. J and **Jones G. A.** (2005). Characterization of condensed tannins purified from legume forages: chromophore production, protein precipitation and inhibitory effects on cellulose digestion. *J. of Chem. Ecol.*. **31**: 2049–2068.

McDougall E. I. (1948). Studies on ruminant saliva; the composition and output of sheep's saliva. *Biochem. J.* **43:** L 99–109.

Menke K. H. and **Steingass H.** (1988). Estimation of the energetic feed value from chemical analysis and in vitro gas production using rumen fluid. *Anim. Res. Dev.* **28**: 7–55.

Ngi, J., Ayoade, J. A. and Oluremi, O. I. A., (2006). Evaluation of dried cassava leaf meal and maize offal as supplement for goats fed rice straw in dry season. *Livest. Res. Rural Dev.* **18**: 127.

NRC (National Research Council). (2007). Nutrient requirements of small ruminants. sheep, goats, cervids and New World Camelids. Washington, DC, USA: National Academy of Science. 2007.

Ørskov E. R. and **McDonald I**. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. of Agric. Sci.* (Cambridge). **92**, 499-503.

Payne R. W., Murray D. A., Harding S. A., Baird D. B. and **Soutar D. M.** (2009). GenStat for Windows (12th Edition) Introduction. VSN International, Hemel Hempstead

Sarnklong C., Cone J. W., Pellikaan W. and **Hendriks W. H**. (2010). Utilization of Rice Straw and Different Treatments to Improve Its Feed Value for Ruminants: A Review. Asian-Aust. *J. of Anim. Sci.* **23**: 680–692.

Smith A. H., Zoetendal E. and **Mackie R. I.** (2005). Bacterial mechanisms to overcome inhibitory effects of dietary tannins. *Microbial Ecology.* **50**: 197–205.

Van Soest P. J. (2006). Rice straw, the role of silica and treatments to improve quality. *Anim. Feed Sci. and Technol.* **130**: 137–171.

Nwanze K. F., Mohapatra S., Kormawa P., Keya S. and **Bruce-Oliver S**. (2006). Rice development in sub-Saharan Africa. *J. Sci. Food Agric.* **86**: 675–677.

MOFA (2010). Agriculture in Ghana—Facts and Figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Manful J. T., Akatse J. K, Osei-Yaw A. (1996). Quality evaluation of rice cultivars grown in Ghana. *Ghana J. of Agric. Sci.* **29**: 53–58.