RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (3): 237-245.
Available from http://repository.ruforum.org

Research Application Summary

Effect of supplementing steers with graded levels of concentrate on rumen environment and degradation kinetics of *Chloris gayana* hay

Semwogerere, F., Kigozi, A. & Kabi, F.
Department of Agricultural Production, College of Agricultural and Environmental Sciences, Makerere University, P. O. Box 7062, Kampala, Uganda
Corresponding author: kabi.fred@gmail.com

Abstract

In order to improve utilization of low nutrient and high fibrous pastures, which are common in the tropics, supplementation with concentrates having readily available nutrients is recommended to improve livestock productivity. *Chloris gayana* is one of the predominant grasses in the cattle corridor of Uganda. However, its low nutritional content constrains animal production by causing unfavorable rumen environment for microbes for forage degradation. This study investigated the rumen environment and degradation kinetics of *Chloris gayana* hay fed as basal at maintenance levels to steers supplemented with graded levels of concentrate. Four Holstein-Friesian castrated steers weighing between 400 – 800 kg live body weights were used in the determination of *in sacco* degradability. The basal diet composed of *Chloris gayana* hay was supplemented with graded levels of concentrate at ratios of 10%, 20% and 30% to form the three treatments. In the control treatment, steers were fed a diet of 100% hay. *Chloris gayana* hay was placed in nylon bags and incubated in the rumen of four fistulated steers for 0, 3, 6, 12, 24, 48, 72, 96 and 120 hour. The data were analyzed using SAS (1998). The crude protein (CP), Metabolisable energy (ME) and acid detergent lignin (ADL) of formulated rations significantly increased (<0.0001) with an increase in concentrate inclusion from 4.8 to 7.5%, 5.8 to 6.6MJ/KgDM and 6.8 to 7.9%, respectively. The acid detergent fiber (ADF), neutral detergent fiber (NDF) and dry matter (DM) of the rations significantly decreased (P<0.0001) with an increase in the level of concentrate supplementation from 35.6 to 28.4%, 64.1 to 49.5%, and 92.8 to 92.1%, respectively. The highest effective dry matter degradability (33.86%) and organic matter degradability (33.9%) was observed at 20% inclusion level of concentrate into hay. Similar trends were observed for dry matter degradability at 48 hour (42.2%). The highest ME (5.8MJKg DM) of hay was obtained at 20% inclusion level of the concentrate into hay. The lowest ME (5.1MJKg DM) and DMD48h (37.4%) of hay were recorded at 0% concentrate supplementation. Subsequently, rumen pH (6.7) collected preprandial at 6:00h was closer to neutrality compared to the more acidic conditions of the rumen environment for the 0, 10, and 30% level of concentrate inclusion. Similarly, the highest level of ammonia concentration (89.3 (mg/L) was attained at 20% concentrate inclusion level. Supplementation of *Chloris*

gayana hay based diet with concentrate up to 20% inclusion level not only improved rumen environment but also rumen degradability and ME extracted from the hay.

Key words: *Chloris gayana*, rumen degradability, Uganda

Résumé

Dans le but d'améliorer l'utilisation des pâturages à faible teneur en éléments nutritifs et à forte teneur en fibres qui sont courants dans les tropiques, il est recommandé d'utiliser des concentrés de nutriments facilement disponibles pour améliorer la productivité du bétail. *Chloris gayana* est une herbe prédominante dans les zones de paturage en Ouganda. Cependant, sa faible valeur nutritive limite la production animale en créant, dans le rumen, un environnement défavorable aux microbes digesteurs du fourrage. La présente étude a examiné l'environnement du rumen et la vitesse de dégradation du foin de *Chloris gayana* appliqué comme régime de base à un niveau de maintenance et complétés avec des niveaux graduels de concentré. Quatre bouvillons Holstein-Friesian castrés, pesant entre 400 et 800 kg de poids vif ont été utilisés pour déterminer la digestibilité. Le régime de base composé du foin de *Chloris gayana* a été complété avec des niveaux graduels de concentré à des taux de 10%, 20% et 30% pour former les trois traitements. Pour le témoin, les bouvillons ont été nourris avec 100% de foin. Le foin de *Chloris gayana* a été placé dans des sacs en nylon et incubés dans le rumen de quatre bouvillons fistules pendant 0, 3, 6, 12, 24, 48, 72, 96 et 120 heures. Les données ont été analysées en utilisant SAS (1998). La protéine brute, l'énergie métabolisable (EM) et la lignine au détergent acide (LDA) des rations formulées ont augmenté significativement (<0,0001) avec une augmentation de l'ajout des concentrés de 4,8 à 7,5%, de 5,8 à 6,6MJ / Kg MS et de 6,8 à 7,9 %, respectivement. La fibre au détergent acide (FDA), la fibre au détergent neutre (FDN) et la matière sèche (MS) des rations ont significativement diminué (P <0,0001) avec une augmentation de la concentration en concentré de 35,6 à 28,4%, 64,1 à 49,5%, et 92,8 à 92,1%, respectivement. Les digestibilités de la matière sèche (33,86%) et de la matière organique (33,9%) les plus efficaces ont été observées avec un taux d'incorporation de 20% dans le foin. Des tendances similaires ont été observées pour la digestibilité de la matière sèche à 48 heures (42,2%). L'EM la plus élevée (5,8 MJKg DM) de foin a été obtenue à un niveau d'inclusion de 20% du concentré dans le foin. L'EM (5,1 MJKg MS) et la MS 48h (37,4%) les plus faibles ont été enregistrées avec un apport en concentré de 0%. Ensuite, le pH du rumen (6,7) prélevé à 6h00 était plus proche de la neutralité comparativement aux conditions plus acides de l'environnement du rumen pour des taux d'inclusion du concentré de 0, 10 et 30%. De même, le niveau le plus élevé de concentration d'ammoniac (89,3 mg / L) a été atteint avec un taux d'inclusion de 20% de concentré. Le régime à base de foin de *Chloris gayana* complété avec un concentré à hauteur de 20% améliore non seulement l'environnement du rumen, mais aussi la digestibilité du rumen et de l'EM extraite du foin.

Mots clés: *Chloris gayana*, digestibilité du rumen, Ouganda

Background

Poor nutrition is one of the major constraints to smallholder livestock production in Uganda (Katongole *et al.,* 2012). Ugandan farmers mainly rely on elephant grass to feed their animals (Kabirizi *et al.,* 2006). However, the elephant grass has of recent been threatened by Napier stunt disease (Nampijja *et al.,* 2013) and is difficult to preserve as hay to meet the challenges of dry season feeding. *Chloris gayana* is the predominant pasture species in the Uganda cattle corridor, which hold over 85% of the livestock population (Mugerwa *et al.,* 2012). Studies have previously indicated the nutrient composition of *Chloris gayana* as 8 – 18% crude protein and 7.5 - 10.5MJ/kg DM metabolisable energy.

In order to improve the utilization of *Chloris gayana* by ruminants, the use of supplements is essential. Use of home-made concentrate has been indicated to increase milk production (Moss *et al*., 1992) and weight gain (Huque and Talukder, 1995). However, limited studies have evaluated the effect of supplementation with homemade concentrate on nutrient utilization and rumen degradation characteristics of *Chloris gayana* hay when fed to livestock in Uganda. The objective of this study was to establish the optimum level of concentrate supplementation that provides the appropriate rumen environment, degradation kinetics and metabolisable energy by ruminants feeding on *Chloris gayana* hay as the basal feed.

Literature summary

Rhodes grass (*Chloris gayana*) is found in all agro-ecological zones and rangelands in Uganda (Sabiiti and Mugerwa, 1990). *Chloris gayana* grows under all soil and environmental conditions (Skerman and Riveros, 1990) and is usually found on fallowed land as one of the dominant natural pastures. *Chloris gayana* is also commonly found on roadsides and other areas of disturbance throughout the tropics and subtropics (Nitis, 1999). *Chloris gayana* readily spreads by seed and runners (Loch *et al.,* 2004). When fed as a sole feed, *Chloris gayana* pasture produces less live weight gain per hectacre in livestock than some other tropical grasses due its nutrient content especially when it has overgrown. However, supplementing *Chloris gayana* with legumes and concentrates can result in better animal production (Aguerre *et al.,* 2013).

The disappearance of feedstuff in the rumen has been associated with ruminal microbial degradation and digestion of these feeds. Feed degradation rate can be used to predict nutritional value since it is related to voluntary feed intake (Aguiar *et al*., 1997). A high rate of degradation has been implied to result in high voluntary intake and thus higher performance. This is because the extent to which feed components (dry matter (DM), organic matter (OM) and N) are degraded in the rumen is a function of both their rate of degradation and residence time (Dhanoa *et al*., 1995).

Study description

Four Holstein-Friesian castrated steers, four diets and four periods were used in the determination of *in sacco* degradability. *Chloris gayana* hay was placed in nylon bags and

incubated in the rumen according to Osuji *et al.* (1993) with sequential addition. The diets were then formulated with 100% hay and 0% concentrate, 90% hay and 10% concentrate, 80% hay and 20% concentrate and 70% hay and 30% concentrate on dry matter basis, as diet 1, 2, 3, and 4, respectively. The control diet 1 provided test sample feeds. Nylon bags with double sewn seams measuring 5x10 cm with mesh 50µm were used. Triplicate bags were incubated for 3, 6, 12, 24, 48, 72, 90 and 120 hours. All bags including the zero hour received a cursory wash. The exponential model of McDonald (1981) was fitted to the degradability data of the nutrients using the non-linear procedure of SAS (1998). Samples were analyzed for DM, ash, and CP using AOAC (1990) and fibre analysis by Van Soest (1991).

Results and discussion

There was significant difference ($P<0.05$) in the chemical composition of *Chloris gayana* basal diets with inclusion of concentrates with the exception of dry matter (DM) (Table 1). Concentrates contain high easily cell-soluble content than fibre (NDF and ADF). Although concentrates have less fibre, this fibre is high in insoluble ADL. This explains the trends in Table 1. The pH and temperature of rumen fluid followed NH_3 production trend as shown in Figures 1 and 2. The increase in NH_3 concentration was possibly attributed to increased breakdown of the CP in the diet resulting from increased CP in the diets. The low ammonia concentration may be responsible for lower effective degradability and the drop in ammonia concentration at 30% concentration inclusion level decreased both microbial population and degradation rate.

The DM and OM degradability kinetic parameters did not significantly differ ($P<0.05$) with an increase in concentrate level (Table 2). This may be attributed to an insignificant change

Table 1. Least square means of chemical composition (%) of *Chloris gayana* based diets as influenced by inclusion levels of concentrate

	Level of concentrate (%)				S.E.M.	P-values
	0	10	20	30		
Dry matter	92.8	92.6	92.1	92.4	0.72	<0.0001
Ash	11.8^{a}	11.1^{a}	7.7^{b}	11.0^{a}	0.41	<0.0001
Organic matter	81.0^{b}	81.5^{b}	84.4^{a}	81.5^{b}	0.34	<0.0001
ADF	35.6^{a}	33.0^{b}	30.8^{c}	28.4^{d}	0.38	<0.0001
ADL	7.7^{a}	6.8^{b}	7.7^{a}	7.8^{a}	0.26	<0.0001
NDF	64.1^{a}	61.1^{a}	54.4^{b}	49.5^{c}	1.15	<0.0001
Crude protein	4.8^{c}	5.7^{b}	6.9^{a}	7.5^{a}	0.17	<0.0001
ME* (MJ/Kg DM)	5.9^{c}	5.8^{d}	6.4^{b}	6.6^{a}	0.51	<0.0001

ADF: acid detergent fibre; ADL: acid detergent lignin; NDF: neutral detergent fibre; ME*: metabolisable energy estimated from formula 0.16* DOMD (AFRC (1993) (DOMD: digestible OM in dry matter as from 0.98*DM degradability at 48 hr (MAFF, 1977)); S.E.M.: standard error of means; Means with similar superscripts (a, b, c and d) within a row are not significantly different ($P < 0.05$)

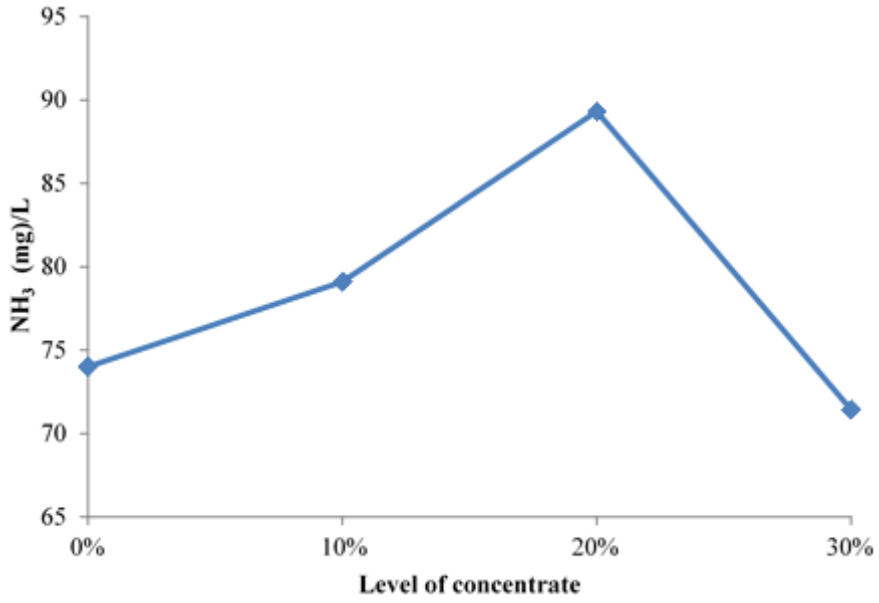

Figure 1. Ammonia concentrations (mg)/L in the rumen of steers fed *Chloris gayana* basal diet supplemented with graded levels of concentrate

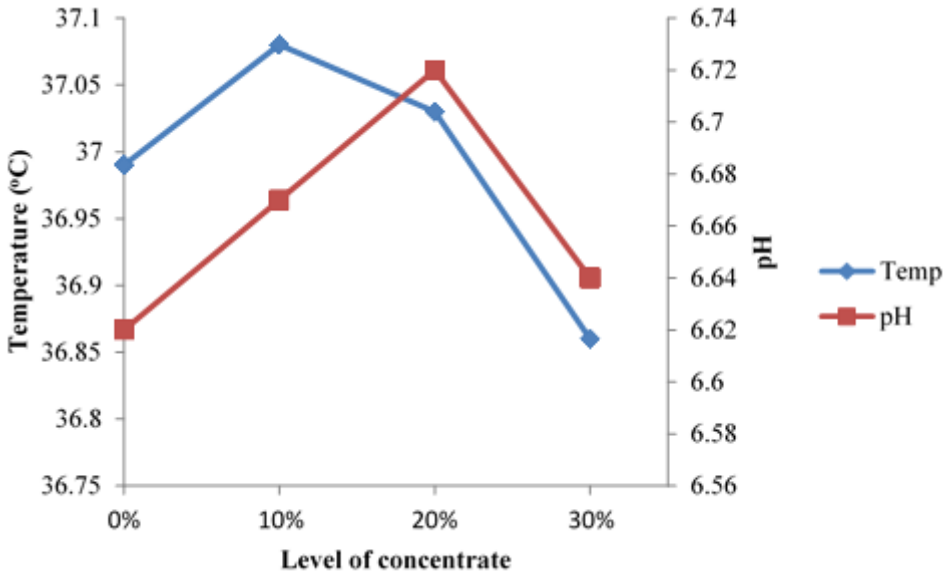

Figure 2. Temperature and pH of rumen fluid of steers fed *Chloris gayana* basal diets under graded levels of concentrate supplementation

in the DM of diets. The concentrate level of 20% had the highest DM degradability at 48 hour, Metabolisable energy, effective degradability of DM and effective degradability of OM (Table 2, Figs. 3 and 4). The increase in the concentrate inclusion level resulted in increased level of available nutrients as evidence by CP and ME content of the diets (Table 1). These nutrients increase microbial population thus increased breakdown of digesta in the rumen. However, as concentrate level surpass 20%, the increased rate of degradation of soluble carbohydrates provides a negative feedback on microbial population due to more volatile fatty acids responsible for reduced pH (Fig. 2).

Table 2. Least square means of rumen degradation kinetics (%) of *Chloris gayana* hay as influenced by graded levels of concentrate supplementation

	Level of concentrate (%)				S.E.M	P-values
	0	10	20	30		
DM degradability						
a	15.29	16.26	16.63	15.44	1.14	0.81
b	38.17	37.13	39.16	39.5	1.26	0.57
c	0.027	0.023	0.024	0.0235	0.003	0.85
lt (hr)	3.28	1.8	3.3	2.39	1.35	0.83
PD	53.46	53.39	55.79	54.95	1.52	0.63
ED	32.4	32.2	33.9	32.1	1.18	0.63
OM degradability						
a	14.6	14.01	15.08	14.19	0.7	0.72
b	40.92	41.73	42.34	46.62	2.02	0.29
c	0.028	0.022	0.025	0.09	0.003	0.35
lt (hr)	7.4	3.25	5.6	4.5	1.69	0.42
PD	55.52	55.74	57.4	60.81	1.93	0.29
ED	32.8	31.7	33.9	31.2	0.85	0.21
DMD (48Hrs)	37.37^{A}	37.81^{C}	42.17^{A}	38.82^{B}	0.98	<0.0001
DOMD	31.8^{D}	32.3^{C}	36.5^{A}	33.2^{B}	0.96	<0.0001
ME (MJ/Kg DM)	5.1^{D}	5.2^{C}	5.8^{A}	5.3^{B}	0.15	<0.0001

a: zero time intercept(immediately solubilized fraction); b: insoluble but slowly degradable fraction; c: degradation rate constant of fraction b; PD: potential degradability (a+b); lt: lag time (hr); ED: effective degradability (a+(b x c)/ (c+Kp)); DMD48h: DM degradability at 48hr; DOMD: digestible organic matter in dry matter ((0.98*DMD)-4.8); ME: metabolisable energy (0.16* DOMD) (MAFF, 1987; AFRC 1993); S.E.M.: standard error of means. Means with similar superscripts (A, B, C & D) within a row are not significantly different ($P < 0.05$)

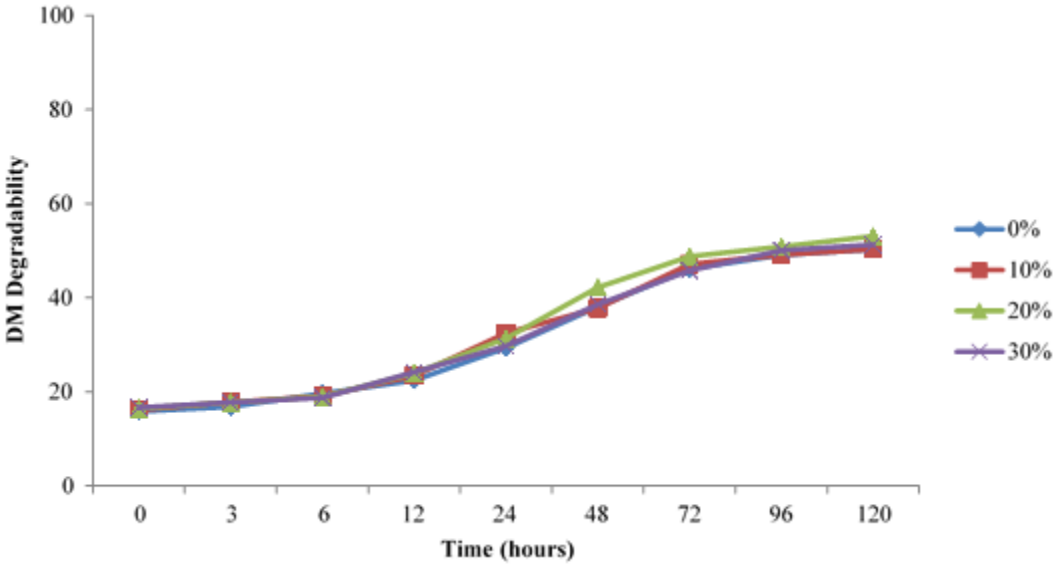

Figure 3. Dry matter degradability of *Chloris gayana* hay as influenced by graded levels of concentrate supplementation

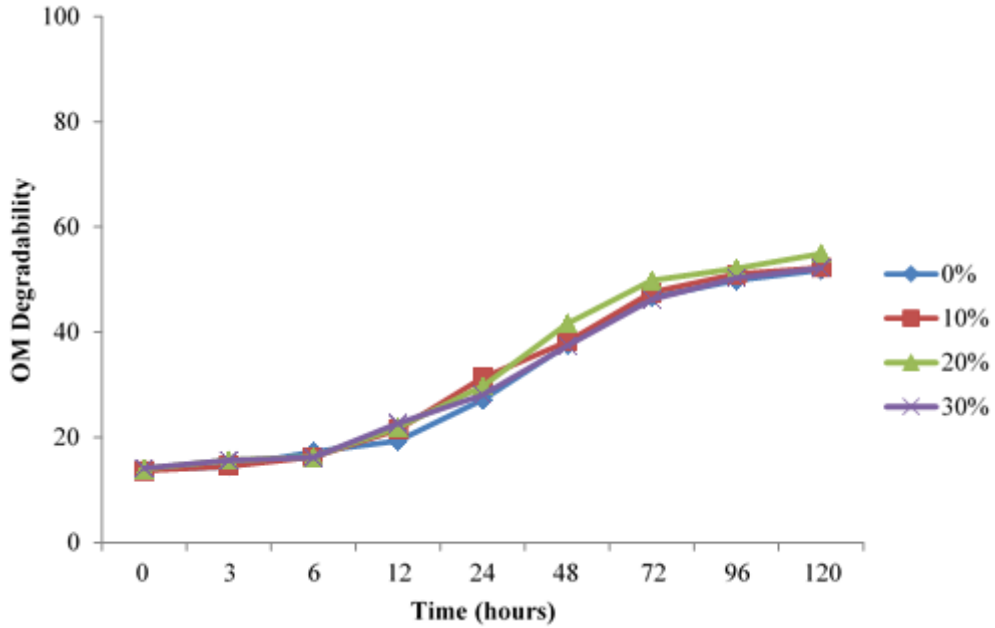

Figure 4. Organic matter degradability of *Chloris gayana* hay as influenced by graded levels of concentrate supplementation

Acknowledgement

Financial assistance of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) administered through School of Agricultural Sciences, Makerere University, Uganda, is gratefully acknowledged. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

References

Aguerre, M., Cajarville, C., Kozloski, G.V. and Repetto, J.L. 2013. Intake and digestive responses by ruminants fed fresh temperate pasture supplemented with increased levels of sorghum grain: A comparison between cattle and sheep. *Animal Feed Science and Technology* 186:12-19.

Aguiar, R.S., Maldonado, H. and Da Silva, J.F.C. 1997. Degradabilidade "in situ" da matéria seca, da protein bruta e da fibra em detergente neutron do capim-furachão (Panicum repens L.) em diferentes idades de corte. In: Reunião anual da sbz, 34, 1997, Juiz de Fora. Anais... 67.

AOAC, 1990. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, DC.

Dhanoa, M.S., France, J., Siddons, R.C., Lopez, S. and Buchanan-Smith, J.G. 1995. A non-linear compartmental model to describe forage degradation kinetics during incubation in polyester bags in the rumen. *British Journal of Nutrition* 73:3-15.

Huque, K.S. and Talukder, A.I. 1995. Effect of molasses supplementation of a roughage based diet on growth performances of cattle. *Australian Journal of Animal Science* 8:337 - 342.

Kabirizi, J., Mpairwe, D. and Mutetikka, D. 2006. Improving dairy cattle productivity in smallholder farms in Uganda: Incorporating leguminous forages in farming systems. *Uganda Journal of Agricultural Sciences* 12:1-12.

Katongole, C.B., Nambi-Kasozi, J., Lumu, R., Bareeba, F., Presto, M., Ivarsson, E. and Erik, J.L. 2012. Strategies for coping with feed scarcity among urban and peri-urban livestock farmers in Kampala, Uganda. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 113:165-174.

Loch, D.S., Rethman, N.F.G. and Van Niekerk, W. A. 2004. Rhodesgrass. pp. 833-871. In: Moser, L.E., Burson, B.L. and Sollenberger, L.E. (Eds.), Warm-season (C4) grasses. Agronomy Monograph No. 45. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, WI.

McDonald, I. 1981. A revised model for the estimation of protein degradation in the rumen. *Journal of Animal Science* 96:251-252.

Moss, R.J., Ehrlich, W.K., Martin, P.R. and Mclachlan, B.P. 1992. Responses to protein supplementation by dairy cows grazing nitrogen fertilised forages. In: Animal Production in Australia. Proceedings of the Australian Society of Animal Production, 19, La Trobe University, Melbourne.

Mugerwa, S., Mpairwe, D., Zziwa, E., Namutebi, S. and Peden, D. 2012. Improving livestock water productivity in semi-arid ecosystems: Restoration of pasture on degraded bare surfaces. *Novus Natural Science Research* 1:1-13.

Nampijja, Z., Kabirizi, J. and Zziwa, E. 2013. Evaluation of Napier grass clones for dry matter yield and tolerance to Napier stunt disease. African Crop Science Society Conference, 14th to 17th October, 2013. Imperial Royal hotel, Uganda.

Nitis, I.M. 1999. Production of forage and fodder. In: Falvey, L. and Chantalakhana, C. (Eds.), Smallholder dairying in the tropics. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Osuji, P.O., Nsahlai, I.V. and Khalili, H. 1993. Feed evaluation. ILCA Manual 5. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 40 pp.

SAS. 1998. User's Guide: Statistic, Version 6.12th Edition. SAS Inst. Inc., Cary, NC.

Skerman, P.J. and Riveros, F. 1990. Tropical grasses. FAO Plant Production and Protection Series No. 23. Rome: Food and Agriculture Organization of the United Nations Publishers.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74:3583-3597.