Pertanika J. Trop. Agric. Sci. **35 (1)**: 55 - 65 (2012)

ISSN: 1511-3701

Evaluation of the Use of Farmyard Manure on a Guinea Grass (*Panicum maximum*) - Stylo (*Stylosanthes guianensis*) Mixed Pasture

Ahmed S. A., Halim, R. A.* and Ramlan, M. F.

Department of Crop Science,
Faculty of Agriculture, Universiti Putra Malaysia,
43400 UPM Serdang, Selangor, Malaysia
**E-mail: ridzwan@agri.upm.edu.my*

ABSTRACT

The effects of different levels of farmyard manure (FYM) and inorganic phosphorus (P) and potassium (K) fertilizer application on the physiology, forage yield and quality of Stylo (*Stylosanthes guianensis* cv. Pauciflora) – guinea grass (*Panicum maximum* cv. Green panic) pasture grown on an acid soil in Malaysia were evaluated in this study. The treatments were six rates of FYM application (0, 10, 20, 30, 40, 50 t FYM/ha and a combined application of 50 kg P with 50 kg K/ha) as triple-superphosphate and muriate of potash, respectively. Four consecutive cuttings were taken at 6-week intervals. Dry matter (DM) yield of guinea increased linearly with increasing levels of FYM with rates of increase from 239 to 457 kg/ha per tonne increase of the FYM applied. On the other hand, the DM yield of Stylo was found to decline with the increasing rates of FYM. Crude protein (CP) concentration of guinea increased linearly from 9.27% to 11.93% from 0 to 50 t FYM applications, while the CP concentration of Stylo increased from 17% to 20%. The photosynthetic rate, leaf area index and stomatal conductance of guinea significantly increased with the increasing rates of the FYM applied. On the contrary, acid detergent fibre and neutral detergent fibre concentrations of guinea declined with the increasing rates of the FYM used. Meanwhile, the use of inorganic P and K fertilizers gave a higher yield and higher quality of both the species compared to the control at the first cut but they were not significantly different from the control at the fourth cut.

Keywords: Forage, guinea, manure, organic, Stylo, quality, physiology, yield

INTRODUCTION

Shortage of feeds is one of the major problems that the ruminant industry is facing in Malaysia. In 2008 alone, the country spent more than RM2.14 billion (USD 621 million) to import animal feeds (Ministry of Agriculture and Agro-Industry, Malaysia, 2009). This method of ruminant production that is based on formulated concentrates is expensive, indicating that the production of ruminants has to rely on conventional green feeds or pasture and some substitutes. However, the productivity of pasture is low mainly due to the low soil fertility (Coulter, 1972). In Malaysia, Ultisols and Oxisols occupy about 72% of Peninsular Malaysia (IBSRAM, 1985). In these soil types, the efficiency of applied fertilizer is relatively low because the root uptake of nutrients is inhibited by the acidic pH of the soil (Baligar & Bennett, 1985).

Research on plant nutrition carried out on representative soil has shown that phosphorus deficiency is an important factor limiting legume establishment in sedentary soil (Oxisols and

Received: 25 June 2009
Accepted: 4 March 2010
*Corresponding Author

Ultisols). Widespread deficiencies of nitrogen, potassium, and molybdenum were also recorded, while calcium, magnesium and sulphur are also deficient in some soil series (Tham, 1976; Tham & Kerridge, 1979). A grazing trial was conducted in Serdang, in which guinea and other grass species were evaluated in the soil fertilized at 150 and 300 kg N/ha/year. All the grasses produced had higher live weight gain when the fertilizer rate was increased to 300 kg N/ha/year (Chen *et al*., 1982). This finding indicated that the application of fertilizer is needed to improve the fertility of the soil and consequently, the productivity and quality of the pasture. Thus, the general recommendation is to apply inorganic fertilizers, including urea, to meet the nutrient requirements of the pastures. An alternative method is to make use of organic fertilizer, such as farmyard manure (FYM), because it is available locally and it can avoid pollution of water resources from leaching and runoff of inorganic fertilizer.

Since animal performance is directly related to forage quality, information is therefore needed on the effects of the FYM on forage quality. However, little information is available on the effects of the FYM application on forage quality, particularly on the fibre content. Studdy *et al.* (1995) reported that the total N of reed canarygrass was increased with the increasing rate of dairy manure. On the other hand, the applications of 112 and 336 kg N/ha from dairy manure and 112 and 336 kg/ha from ammonium nitrate fertilizer immediately after the first cutting of alfalfa were found to have no effect on the herbage N concentrations (Daliparthy *et al.,* 1994). The common viewpoint has been that manure should be applied to row crops or grasses rather than legumes since the latter can fix their own nitrogen. Klausner (1995) reported that when manure has to be applied, grasses should have the first priority because they are nitrogen accumulators.

Organic fertilizers, such as green manure, have been investigated for their effects on forage yield and they have shown promising results (Tham & Kerridge, 1982; Eng, 1983). Comparative studies on the effects of the rates and frequencies of animal manure application on forage quality have not previously been conducted. Therefore, the objective of this study was to evaluate the effects of various rates of FYM application on forage growth and quality of a Stylo-guinea mixed pasture.

MATERIALS AND METHODS

The experiment was conducted on acidic (pH5.5) ex-tin mine soil at the Faculty of Agriculture, Universiti Putra Malaysia. Each of the plots has an area of $4m^2$. Seven fertilizer treatments were applied, namely control (zero fertilizer), 50 kg P and 50 kg K/ha, and 10, 20, 30, 40, 50 t FYM/ha, in four randomized complete blocks. The FYM application was done only once, i.e. before planting. Dairy cattle bedded pack manure from a covered barn was broadcast on the soil surface of each plot and immediately incorporated manually on 20 July 2002. The manure contained 10.5, 2.3 and 10.2 kg/t (wet basis) of the total N, P and K, respectively. *Stylosanthes guianensis* cv. Pauciflora and *Panicum maximum* cv. green panic were planted in 0.5 x 0.5 m spacing using rooted tillers, while Stylo was sown in between planting rows of guinea using seeds hand sown at the rate of 2 kg/ha.

Yield and Physiology

Photosynthetic rate (Pn) of the plants leaf was monitored using a LCA-3 portable infrared gas analyzer between 10 and 11 am. It was an open system used with Parkinson broad leaf cuvette with a leaf area of 6.2 cm^2. The leaf area index (LAI) was measured using LAI-2000 plant canopy analyzer for both Stylo and guinea during different stages of growth. The reading was taken separately for each species. The plots were harvested manually using a sickle, followed by fresh weight measurement for both the species. The samples were cut in 0.5 x 1.0 m quadrate, and the fresh weight of the shoot components was determined using an electronic balance. The plants were immediately enclosed in paper bags after they had been cut to prevent dehydration.

After weighing and determining their fresh weights, the plant parts were enclosed in paper bags and placed in an oven at 85°C for 72 hours. After that, the dried samples were re-weighed for dry matter determination.

Chemical Composition

The dried samples were ground and sieved (0.2 mm sieve) for the NDF and ADF analysis (Goering & Van Soest, 1970). The NDF is a measure of the cell wall constituent of the plant cell and is inversely correlated to the voluntary intake of feed by ruminants, while the ADF is the cell wall after removal of hemicellulose component and is inversely correlated with digestibility of forages (Van Soest & Robertson, 1980). Crude protein was determined by Kjeldahl digestion (AOAC, 1990) with concentrated sulphuric acid, followed by steam distillation and acid titration.

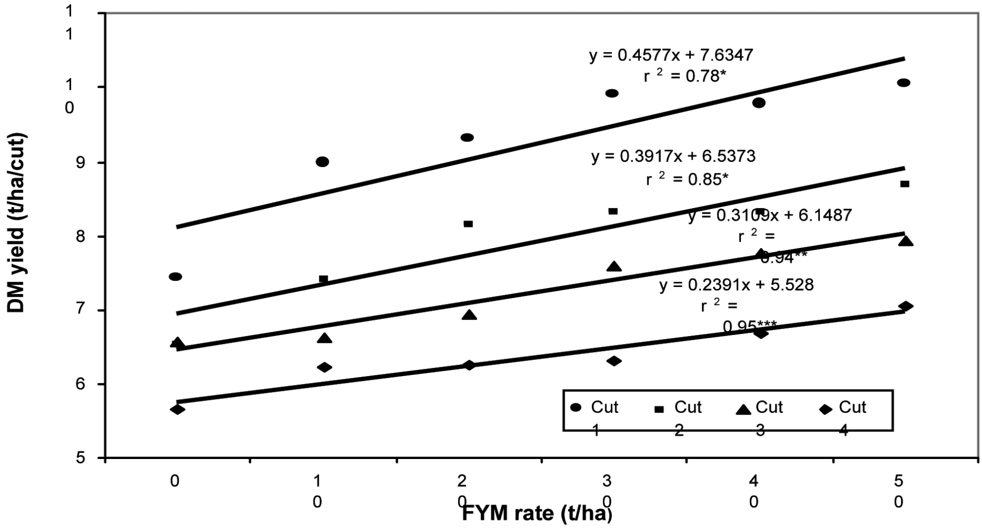
Statistical Analysis

The results obtained were subjected to an analysis of variance for a randomized complete block design, with the aid of SAS software (SAS, 2001). The differences between inorganic and organic fertilizer treatments were tested using the LSD, while a linear regression was fitted for the different levels of organic fertilizer used.

RESULTS

Dry Matter Yield

There was a significant linear increase in the dry matter yield of guinea, with an increasing rate of the FYM application at all harvests (*Fig. 1*). The highest rate of FYM (i.e. at 50 t/ha) produced the highest mean DM yield (10.05 t/ha). The treatment receiving inorganic fertilizer showed a yield that was equivalent to an application of 20 t/ha of FYM. The lowest DM yield of guinea was obtained from the control, where no fertilizer was applied (7.43 t/ha). During the second cut, the DM yield of guinea showed the same trend of a linear increase in the DM yield with the increasing rate of FYM applied (P<0.001). At the third and the fourth cut, the DM yield obtained at 50 t FYM/ha (7.94 and 7.04 t/ha/harvest, respectively) was significantly



*P<0.05 **P<0.01 ***P<0.001 for the regression

Fig. 1: Regressions of dry matter yield of guinea on the rates of farmyard manure (FYM) applications at four consecutive cuttings

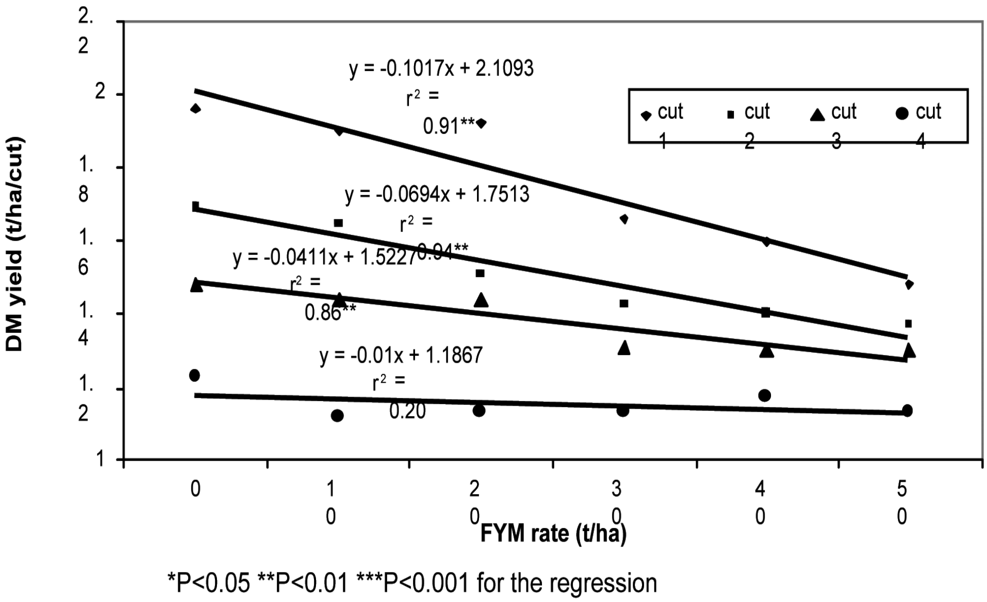


Fig. 2: Regressions of dry matter yield of Stylo on the rates of FYM application at four consecutive cuttings

higher (P<0.01) than those of the control and inorganic fertilizers.

As compared to guinea, Stylo showed a linear decrease in the DM yield with the increasing rate of FYM applied at the first three harvests (*Fig. 2*). However, at the fourth cut, Stylo yield was shown to be not affected by the FYM rates.

The total dry matter yield (sum of guinea and Stylo) showed a significant linear increase with the increasing rate of the FYM applied. This finding indicated that the decline in the Stylo yield was more than offset by increasing guinea yield with the increase in the FYM rates. Meanwhile, the use of inorganic fertilizer was shown to be equivalent to the application of the FYM at 10 t/ha in all the harvest (Table 1).

PHYSIOLOGY

Photosynthesis Rate

There was a significant linear increase in Pn of guinea with the increasing rate of FYM used (P<0.01) at both the first and the fourth cut. At the first cut, Pn increased from 24.7 to 32.0 µmol m^2 s^{-1} from 0 to 50 t/ha FYM (*Fig. 3*). The Pn of guinea at 40 and 50 t FYM/ha was significantly higher than that of the inorganic fertilizer. The Pn of guinea was greater in cut one than in cut four. In contrast, there was a significant linear decrease in Pn of Stylo from 21 to 15 µmol m^2 s^{-1}, with the increasing rate of FYM applied (P<0.001) (*Fig. 4*).

Leaf Area Index

There was a significant linear increase in the LAI of guinea with the increasing rate of FYM application (p<0.001) (*Fig. 5*). Correspondingly, the LAI of Stylo declined with the increasing rates of the FYM used (*Fig. 6*).

Crude Protein (CP)

There was a significant linear increase in the CP concentration of guinea with the increasing rate of FYM application (P<0.01) (Table 3) and the value ranged from 9.27% (control) to 11.93% (50 t FYM/ha).

TABLE 1
Dry matter yield of total herbage at four cuttings

Treatment	Cut 1	Cut 2	Cut 3	Cut 4
		$t\ ha^{-1}\ cut^{-1}$		
50 kg/ha P, 50 kg/ha K	10.58	8.69	8.01	7.12
Control (0 FYM)	9.39	8.22	8.06	6.89
10 t/ha FYM	10.88	9.06	8.06	7.35
20 /ha FYM	11.22	9.67	8.37	7.37
30 t/ha FYM	11.56	9.77	8.90	7.46
40 t/ha FYM	11.37	9.72	9.06	7.86
50 t/ha FYM	11.52	10.06	9.24	8.17
$LSD_{0.05}$	0.65	0.58	0.34	0.22
R	0.81^{*}	0.90^{**}	0.97^{**}	0.96^{**}
Slope	0.36	0.32	0.27	0.23
SE	0.756	0.835	0.694	0.934

FYM= Farmyard Manure; P=phosphorus; K=potassium; LSD0.05=least significant difference at P<0.05; SE=standard error of mean; r=correlation coefficient (for linear regression of dry matter yield on FYM application rate *, ** regression significant at P< 0.05, 0.01, respectively)

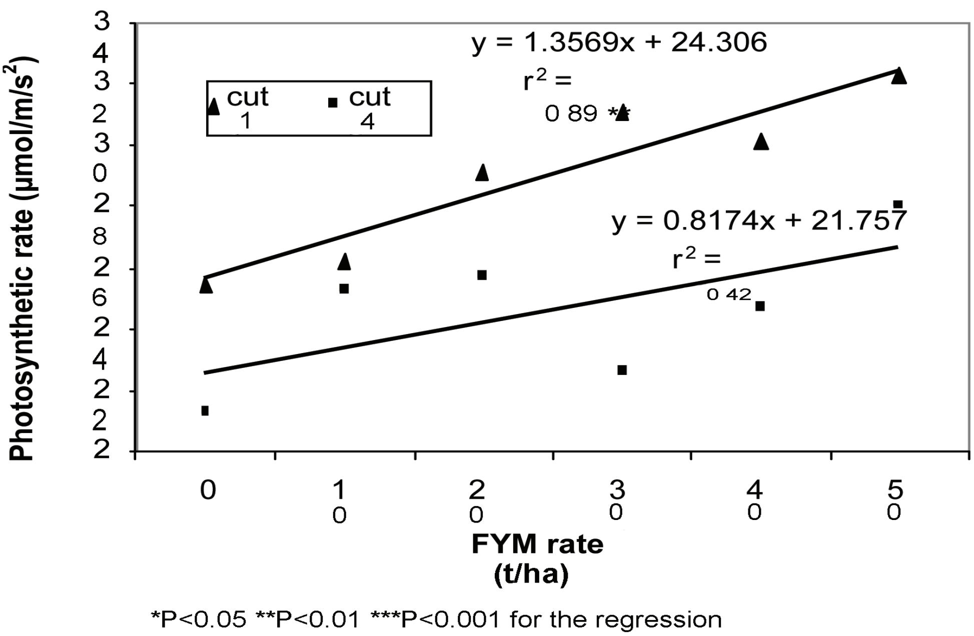


Fig. 3: Regressions of the photosynthetic rate of guinea on the rate of FYM application at the first and fourth cycles of vegetative growth

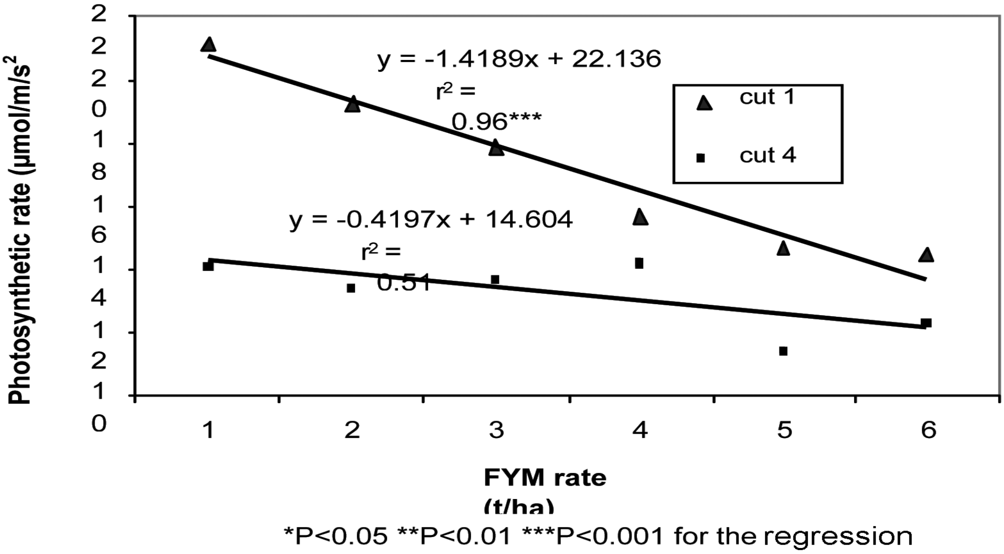


Fig. 4: Regressions of the photosynthetic rate of Stylo on the rate of the FYM application at the first and fourth cycles of vegetative growth

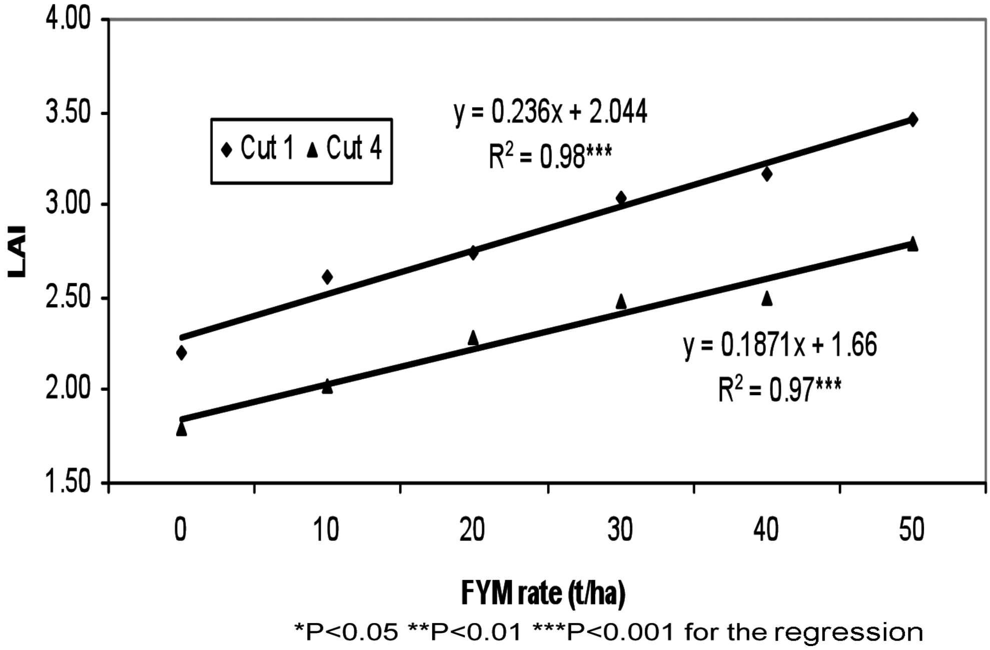


Fig. 5: Regressions of the leaf area index (LAI) of guinea on the rate of application of FYM at the first and fourth cycles of vegetative growth

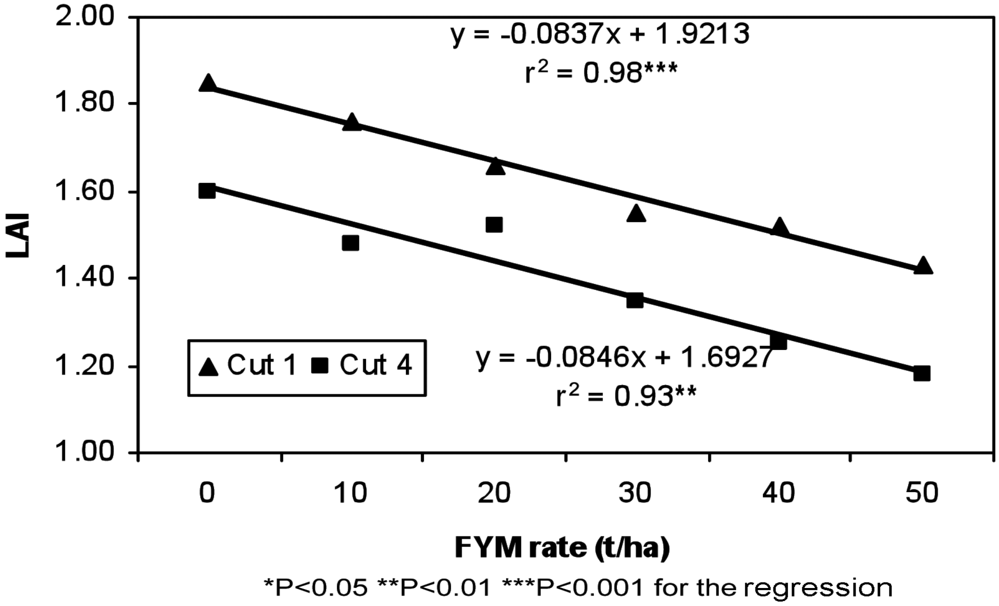


Fig. 6: Regressions of the leaf area index (LAI) of Stylo on the rate of application of FYM at the first and fourth cycles of vegetative growth

In Stylo, the CP concentration increased with the increasing rates of the FYM application for both the cuttings (Table 4). At the first cut, the CP increased from 17 to 21% and this was from 16 to 17% in the fourth cut.

Neutral Detergent Fibre (NDF)

There was a significant effect of the FYM on the fibre concentration of the pasture whereas the NDF concentration declined significantly (from 69.78 to 61.89 % for guinea, and this was 52.56 to 51.31% for Stylo) with the increasing rate of FYM application (Tables 3 and 4).

Acid Detergent Fibre (ADF)

The ADF concentration of guinea declined with the increasing rate of the FYM used (i.e. from 43.87 to 40.20 %). The results showed an increase in the ADF concentration from the first to the fourth cut (Table 3). The ADF concentration of Stylo, however, did not show any significant variation with the increasing rate of the FYM applied (Table 4).

DISCUSSION

The composition of guinea was found to have been affected by the input of plant nutrients which were available in the manure. This input might be substantial to maintain plant growth by improving leaf growth and photosynthesis. A similar result was also reported by Jarvis (1993) as a pasture land in the UK cycled and recycled N input through animal excreta alone.

The results obtained in this study showed the contribution of FYM on the growth of guinea. The fodder yield of guinea increased linearly with the increasing rates of the FYM applications for all the cuttings. The nutrient from FYM, particularly N, plays a major role in leaf growth via its involvement in cell division and as a primary component of enzymes for all the living systems and processes (Duru *et al.,* 1997). In addition, the FYM also increased

TABLE 2
Crude protein, NDF and ADF concentrations of guinea at cut 1 and cut 4 under different fertilizer treatments

Treatment	*Crude protein (CP) %*		*Neutral Detergent Fibre (NDF) %*		*Acid Detergent Fibre (ADF) %*	
	Cut 1	Cut 4	Cut 1	Cut 4	Cut 1	Cut 4
50 kg/ha P, 50 kg/ha K	11.60	8.76	67.99	72.00	44.22	46.31
Control (0 FYM)	9.27	8.74	70.93	74.03	45.62	46.58
10 t/ha FYM	9.96	8.89	69.78	71.41	43.87	45.93
20 /ha FYM	10.20	8.97	67.34	71.37	41.85	45.63
30 t/ha FYM	11.19	9.10	66.40	69.13	41.74	44.77
40 t/ha FYM	11.70	10.20	63.89	69.10	40.19	43.71
50 t/ha FYM	11.93	10.49	61.89	65.44	40.20	43.50
$LSD_{0.05}$	0.95	1.12	3.28	3.24	0.99	1.17
R	0.93^{**}	0.90^{**}	-0.99^{***}	-0.95^{***}	-0.95^{***}	-0.98^{***}
Slope	0.59	0.19	-1.82	-1.49	-1.09	-0.66
SE	0.402	0.377	0.888	1.478	0.551	0.461

FYM= Farmyard Manure; LSD0.05=least significant difference at P<0.05; SE=standard error of mean; r=correlation coefficient (for linear regression of quality variables on FYM application rate *, **, *** regression significant at P< 0.05, 0.01, and 0.001, respectively)

TABLE 3
Crude Protein, NDF and ADF concentrations of Stylo at cut 1 and cut 4 under different fertilizer treatments

Treatment	*Crude protein (CP) %*		*Neutral Detergent Fibre (NDF) %*		*Acid Detergent Fibre (ADF) %*	
	Cut 1	Cut 4	Cut 1	Cut 4	Cut 1	Cut 4
50 kg/ha P, 50 kg/ha K	19.02	16.34	52.48	55.84	37.36	39.09
Control (0 FYM)	17.44	16.16	52.62	56.32	38.74	39.62
10 t/ha FYM	17.50	16.30	52.55	56.42	37.07	38.45
20 /ha FYM	17.55	16.20	51.95	55.22	37.37	37.97
30 t/ha FYM	18.67	16.58	52.24	55.17	36.44	35.42
40 t/ha FYM	19.97	16.60	51.24	54.08	35.64	34.71
50 t/ha FYM	19.87	17.15	51.31	52.70	35.04	34.12
$LSD_{0.05}$	1.24	1.28	1.28	1.68	2.66	1.59
r	0.98^{***}	0.92^{**}	-0.89^{**}	-0.95^{**}	-0.69	-0.95^{***}
Slope	0.56	0.37	-0.52	-0.71	-0.38	-1.20
SE	0.65	0.514	0.75	0.561	2.93	0.536

FYM= Farmyard Manure; LSD0.05=least significant difference at P<0.05; SE=standard error of mean; r=correlation coefficient (for linear regression of quality variables on the FYM application rate *, **, *** regression significant at P< 0.05, 0.01, and 0.001, respectively)

both plant growth and photosynthesis directly. The increased rate of extension of leaves on the existing tillers in turn stimulates greater light capture and photosynthesis (Lemaire & Chapman, 1996; Gastal *et al.,* 1992). Nitrogen has also been shown to have the same positive effect on the tillering of tropical tufted species at the beginning of the growth stage (Coris, 1984;

Gastal *et al.,* 1992). The fact that the treatment using inorganic P and K fertilizers gave yields similar to the use of only 20 t/ha FYM indicated that N obtained from the legume fixation was less than that obtained from the higher rates of FYM application.

Plots which had a higher LAI were faster in sward growth. The increasing rates of FYM also increased with the rates of photosynthesis and a similar result was also reported by Bisoondat *et al.* (2002) who stated that the total annual forage DM yield increased from 21.0 t/ha at the low dairy manure level to 23.1 t/ha at the high manure level during Year 1, and similarly from 22.3 to 25.5 t/ha during Year 2.

Meanwhile, the use of inorganic fertilizer gave the CP concentration in grass of 11.6%, which was similar to that of 40 t FYM/ha at the first cut. However, the CP concentration of grass treated with inorganic fertilizer (8.76%) was equivalent only to the control at the fourth cut. This finding showed that the effects of inorganic fertilizer did not last long in terms of the CP concentration. The reason for the decline in the CP could probably be due to early availability of inorganic fertilizer to the plant, followed by rapid losses due to leaching or fixation in the later harvests.

In contrast to the response of guinea, high rates of the FYM application decreased the yield of Stylo. The shade effect of the grasses might have depressed the growth of legume through reduction in photosynthesis. Even during short periods of low light intensity, photosynthesis and the supply of materials for growth were also reduced (Volenec & Nelson, 1994). Stylo leaves developed in low light, under higher canopy of the grass, had a poorer photosynthetic capacity (*Fig. 4*). The same results have been reported by many researchers (see for example, Woledge, 1971; Prioul *et al.,* 1975). Leaves expanded in low light were thinner (Woledge, 1971), and they might have fewer stomata (Wilson & Cooper, 1969) and fewer mesophyll cells per unit leaf area, fewer and smaller chloroplasts, and reduced activities of RuBP carboxylase (Prioul *et al.,* 1980).

There was an overall decline of the DM yield from cut one to cut four and this might be due to the mineralization of FYM, the reduction in vegetative growth of the grass and the slow growth of the legume after cutting. Guinea dry matter yield was highly and positively correlated with the rates of FYM (*Fig. 1*). The applications of the manures at higher rates could therefore immensely improve fertility of slightly acidic soil and others with similar properties.

However, there have been contradictory reports on the effects of inorganic and organic fertilizer on fibre content of forage crops. Min *et al. (*2002) reported that the application of inorganic and organic fertilizers did not decrease the fibre content of grasses. In the present study, on the other hand, both the NDF and ADF of guinea were found to have decreased with the increasing rates of FYM applied. Similar results were also reported by Getnet and Inger (2001), as NDF and ADF contents of oats and vetches pasture slightly decreased with the increasing fertilizer rate. Valk *et al.* (1996) also reported that the undegradable NDF fractions decreased by using more N fertilizer. In addition, Cox and Cherney (2001) reported that the NDF and ADF contents of corn showed a negative linear-plus-plateau response to increased N fertilizer. Other researchers (Cox *et al.,* 1998) also reported a negative linear relationship of the fibre content with high rate of fertilizer application.

The effect of FYM on the fibre content of grass might depend on the rate of organic fertilizer application, soil type, climatic condition and plant species. Meanwhile, the effect of FYM on the soil properties, particularly on water retention characteristics, might cause less fibre accumulation by grass. On top of that, at a high rate of FYM application, vegetative growth of guinea was denser and less exposed to direct sunlight, and this in turn might be one of the reasons for the difference in the rates of lignification. The plants at higher FYM rate were in active growth as compared to other treatments.

CONCLUSION

The application of FYM resulted in the improvement of both the productivity and quality of guinea. The dry matter yield was significantly higher at high FYM rates. Unlike inorganic fertilizer, which showed a high CP concentration only in the first cut, the FYM consistently gave a high concentration of CP even at the fourth cut. This result demonstrates that the effect of FYM lasts longer than that of inorganic fertilizer. In addition, the FYM also gave a significant improvement on the mixed pasture by reducing the fibre content (NDF). The lowest values of NDF were obtained at a higher rate of application (50 t FYM/ha). This findings reveals that recycling nutrient in cattle-mixed pasture system could help maintain the quality of the feed. Meanwhile, the utilization of animal wastes as organic fertilizer would have a great potential to recycle the nutrients in cattle-pasture production system and this in turn could avoid dependence on chemical fertilizer. As shown in the present study, at a rate of 50 t/ha and above, FYM could be applied to improve grass productivity and quality.

ACKNOWLEDGEMENTS

The authors would like to express our gratitude to ARTP for the funding and the staff of Plant Physiology Division, Universiti Putra Malaysia, for their assistance during field data collection. In particular, Mandefro, Masturi and Mainul Hassen provided a great deal of time while assisting with the laboratory experiments.

REFERENCES

AOAC (Association of Official Analytical Chemists) (1990). *Protein (crude) determination in animal feed: semi-automated method (976.06) Official methods of analysis.*

Baligar, V. C., & O. L. Bennett. (1985). Outlooks on fertilizer efficiency in the tropics. *Fertilizer Research 10*(1), 83-96

Bisoondat M., R. W. Kenneth, E. S. Lynn, C. F. Edwin, P. M. Kenneth, A. G. Donald., M. P. Gordon, & H. J. Harold. (2002). Dairy effluent effects on herbage yield and nutritive value of forage cropping systems. *Agronomy Journal,* 94, 1043-1049.

Chen, C. P., S. S. Ajit, & T. R. Evans. (1982). Beef production from three nitrogen fertilized grasses in Peninsular Malaysia. *MARDI Resource Bulletin*, 9, 207-224.

Coulter, J. K. (1972). Soils of Malaysia. A review of investigation on their fertility and management. *Soils and Fertilizer, 35*, 475-498.

Coris, M. (1984). Effects of nitrogen rates and harvesting intervals on dry matter production, tillering and quality of the tropical grass *Panicum maximum* Jacq. Dissertation Abstracts *International Sciences and Engineering*, *45*, 1-24.

Cox, W. J., & Cherney, D. J. R. (2001). Row spacing, plant density and nitrogen effects on corn forage. *Journal of Agronomy*, *93*, 597-602.

Cox, W. J., D. J. R., Cherney, & J. J. Hancher. 1998. Row spacing, hybrid, and plant density effects on corn silage yields and quality. *Journal of Production Agriculture. 11*, 128-134

Daliparthy, J., Herbert, S. J., & Veneman, L. M. (1994). Dairy Manure Applications to Alfalfa: Crop Response, Soil Nitrate, and Nitrate in Soil Water. *Agronomy Journal*, *86*(6), 927-933.

Duru, M., G. Lemaire, & P. Cruz (1997). The nitrogen requirement of Major agricultural crops: and grasslands. In Lemaire, G. (Eds.), *Diagnosis of N Status in Crops. Advanced Series in Agricultural Sciences* (pp. 59-72). Berlin, Springer-Verlag.

Eng, P. K. (1983). *Effect of phosphorus on pasture yields, botanical composition and live weight from guinea grass-mixture.* Paper presented at the 7th Malaysian Society of Animal Production Conference, Port Dickson, Malaysia

Gastal, F., C. J. Nelson, & J. M. Coutts, (1992). *Role of N on leaf growth of grasses: assessment of a root signal hypothesis*. Paper presented at the Annual Meeting of the American Society of Agronomy, Minneapolis, USA.

Goering, H. K., & Van Soest P. J. (1970). Forage fiber analysis (Apparatus, reagent, procedures and some applications). In *Superintendent of*

Document, Agriculture Handbook No. 378. US Department of Agriculture, Washington, DC, USA.

Getnet, A., & L. Inger (2001). Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and VI by cattle of oats and vetches cultivated in pure stands and mixture. *Journal Animal Feed Science and Technology. 92* (1-2): 95-111.

IBSRAM (1985). *Report of Inaugural Workshop and Proposal for Implementation of the Acid Tropical Soils Management Network*. Bangkok : International Board of Soil Research and Management, Bangkok.

Jarvis, S. C. (1993). Nitrogen cycling and losses from dairy farms. *Soil Use and Mangement 9,* 99-105

Klausner, S. D. (1995). *Nutrient Management: Crop Production and Water Quality*. Department of Soil, Crop, and Atmospheric Sciences, Cornell University, 95CUWFP1

Lemaire, G., & D. Chapman (1996). Tissue flows in grazed plant communities. In: Hodgson, J., & A.W. Illius, (eds.). *The Ecology and Management of Grazing Systems* (pp. 3-36). CAB International, Wallingford

Min, D. H., L. R. Voughb, & J. B. Reeves. (2002). Dairy slurry effects on forage quality of orchardgrass, reed canarygrass and alfalfa-grass mixtures. *Journal of Animal Feed Science and Technology, 95*(3-4): 143-157.

Ministry of Agriculture and Agro-Industry, Malaysia (2009). *Agriculture Statistical Handbook, 2008*. Malaysia, MARDI.

Prioul, J. L., A. Reyss, & P. Chartier (1975). *Relationship between carbon dioxide transfer resistances and some physiological and anatomical featyres*. In: R. Marcelle (Ed.). *Environmental and Biological Control of Photosynthesis*, 17-28. Junk. The Hague

Prioul, J. L., J. Brangeon, & A. Reyss, (1980). Interaction between external and internal conditions in the development of photosynthetic features in a grass leaf. I. Regional response along a leaf during and after low-light or high-light acclimation. *Plant Physiology, 66*, 762-769.

Tham, K. C. (1976). Nutrient response by pasture legumes on older rubber land soil of the Serdang series. *Malaysian Agriculture Journal 50*, 452-461.

Tham, K. C., & P. C. Kerridge (1979). Nutrient responded by *Stylosanthes guianensis* on coastal marine sands (Bris) of Peninsular Malaysia. *MARDI Res. Bull. 7*, 43-54.

Tham, K. C., & Kerridge, P. C. (1982). Response to lime, K, Mo, and Cu by grass-legume pasture on some Ultisols and Oxisols of Peninsular Malaysia. *MARDI Res. Bull., 10*, 350-369

Studdy, C. D., Morris, R. M., & Ridge, I. (1995). The effects of separated cow slurry liquor on soil and herbage nitrogen in *Phalaris arundinacea* and *Lolium perenne*. *Grass Forage Sci. 50*, 106–111.

Wilson, D., & J. P. Cooper, (1969). Effect of light intensity during growth on leaf anatomy and subsequent light-saturated photosynthesis among contrasting. Lolium genotypes. *New Physiologist, 68*, 1125-1135.

Woledge, J. (1971). The effect of light intensity during growth on the subsequent rate of photosynthesis in leaves of tall fescue (*Festuca arundinacea* Schreb). *Annals of Botany 35*, 311-312.

Valk, H., L. E., Kappers, & S. Tamminga (1996). In Sacco degradation characteristics organic matter and nutrient detergent fiber on fresh grass fertilized with different amount of N. *Journal of Feed Science and Technology, 63*(1-4), 63-67.

Van Soest, P. J., & J. B. Robertson (1980). Systems of analysis for evaluating fibrous feeds. pp. 49-60 In Pigden *et al*. (Eds.) *Standardization of Analytical Methodology for Feeds*. Proceedings of Workshop in Ottawa, Canada, 12-14 March 1979. International Development Research Center and International Union of Nutritional Sciences.

Volenec, J. J., & C. J. Nelson (1984). Carbohydrate metabolism in leaf meristems of tall fescue.II. Relationship to leaf elongation rates modified by nitrogen fertilization. *Plant Physiology, 74*, 595-600.