Comparison between Urea and Goat Manure as Sources of Nitrogen for Napier Grass Grown on Terraced Hill

Rahman, M.M., Wan Khadijah, W.E. and Abdullah*, R.B.
Institute of Biological Sciences, Faculty of Science,
University of Malaya, 50603 Kuala Lumpur, Malaysia
*Corresponding author: ramli@um.edu.my

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Abstract

Effects of two nitrogen (N) sources on dry matter (DM) yield and nutritive value of Napier grass were evaluated. The nitrogen (N) fertiliser (at rate of 300 kg N ha^{-1} $year^{-1}$) was applied by dividing the terraces of a hill under two treatments: T_1 (urea) and T_2 (goat manure). There were three replicates of each treatment arranged within three blocks in a completely randomised design. Grass was cut at about 60–day interval. In the first to fourth harvests, grass receiving manure had higher plant height than those with urea application. Grass receiving manure had higher DM yield than urea in almost all of the cuttings. In the fourth harvest, grass receiving urea contained higher DM and organic matter (OM) than manure. Similar result was found for fifth harvest where urea gave higher crude protein (CP) than manure. Irrespective of harvesting frequencies, average DM, OM, CP and neutral detergent fibre contents were not significantly different between grasses fertilised with manure and urea. In conclusion, manure is recommended for economical cultivation of Napier grass on terrace of hill.

Keywords: fertiliser, terraced hill, yield, Napier grass

Introduction

In ruminant production, there are chronic shortage of forage in most developing countries due lack of natural grasslands (Devendra and Leng, 2011). This leads farmers to grow fodder on the uphill or hill slopes and the rain fed forest to provide forage, for ruminants. However, there is great concern over soil fertility decline on arable land in the highlands (Swift *et al*., 1994). The forage production depends on many factors such as soil fertility, fertiliser application, water supply and cutting management (Carvalho *et al*., 2000).

Forage production depends on improving soil fertility, but smallholder farmers are unable to afford commercial fertilisers. Hence, the alternative is to use available resources like manure that can maximise productivity of smallholder farms. Manure improves the soils and increases the yield and quality of crops (Yolcu *et al*., 2010). Manure also reduces environmental pollution and has residual effect in the soil even after long time application (Barongo, 2003). The survey by Harris *et al*. (1997) gained the impression from farmers that inorganic fertiliser is feeding plants (i.e., short-term response), but manure is required to feed the soil (long-term sustainability). Bilal *et al.* (2000) reported that crop fertilised at a rate of 300 kg N ha^{-1} yr^{-1} produced the tallest plant along with maximum tillering in Mott grass. Napier grass is a popular fodder because of its high dry matter (DM) yield, and its high yield was attained by split application of fertiliser at a rate of 300 kg N ha^{-1} yr^{-1} (Wadi *et al*., 2004). It is also an effective means of controlling soil erosion when Napier grass is planted in rows along contours (Huque *et al*., 2001; Lekasi *et al*., 2001).

Although inorganic fertiliser usually uses in raising productivity, problem of scarcity and environmental sustainability have become an issue (Vanlauwe *et al*., 2011). More research is needed in matching specific soil condition with crop requirement or choice of fertiliser by farmers. However, there is little information on fodder production at the uphill or hill slopes using fertiliser. Livestock manure that could be supplied within the farmer's premises is an important source for forage production. It is reported that Napier grass fertilised with organic manure produced higher yield than those applied with inorganic fertiliser (Jayanthi, 2003). The total N contents of fresh goat manure (1.01%) is higher than those of dairy manure (0.35%) and swine manure (0.24%) (Wang *et al.*, 2006). Goat manure application is expected to obtain high forage yield in Napier grass. Therefore, an attempt has been made in this study to assess the relative performance of Napier grass under two sources of N using urea and goat manure to enhance their nutritive value and productivity.

Materials and Methods

Experimental Site

The experiment was carried out on the terraced hill at the goat farm in Rumpun Asia Sdn. Bhd., Selangor, Malaysia during April 2013-March 2014. The area is located at 3°28′ N latitude and 101°38′ E longitude at an elevation of 76 m above sea level. The soil texture is sandy clay loam and soil pH was 4.77 (before planting). Soil pH was determined in H_2O (1:2.5 weight/volume) as described by McLean (1982). Climatic data were collected from the Meteorological Station (Kuala Lumpur) about 45 km north from the experimental site (Figure 1). Mean daily temperature and monthly precipitation during the plant growing period were 28.3 °C and 139.6 mm, respectively, with maximum precipitation (277.1 mm) in November 2013. The mean maximum and minimum temperatures were 30.0 and 27.0 °C, recorded in May 2013 and January 2014, respectively.

Experimental Design

About 360 m^2 areas of hill terraces was cleared and perennial Napier grass was cultivated immediately using stem cuttings on a well prepared soil under rain fed conditions in April 2013 when the soil was moist. Entire dose of recommend P_2O_5 and K_2O (300 kg ha^{-1} for each) was applied at planting. The nitrogen (N) fertiliser was applied by dividing the terraces of a hill under two treatments: T_1 (urea: 300 kg N ha^{-1} $year^{-1}$) and T_2 (goat manure: 300 kg N ha^{-1} $year^{-1}$). There were three replicates of each treatment arranged within three blocks in a completely randomized design. The plot size was 10 m × 4.5 m with a space of 1 m between plots in each block, which were 2 m apart. One-fifth of the total urea (46% N) was applied initially at planting, and the rest was applied as equal split applications after each of four harvests. A half of total manure was applied initially, and the rest was applied at 6 months after planting. Two split applications were adopted for manure compared with five split applications for urea, because it is widely documented that manure has longer lasting effect than the equivalent nutrient levels to inorganic fertiliser. Mallory and Griffin (2007) observed that inorganic N applications became available quicker than N applications from manure. The goat manure

(30.5% DM, 2.21% N and 12.1% ash) was dried in the air and crushed. The plot size of each replication was 6 m × 8 m. All plots were made as similar as possible with respect to shade cover, soil type and slope. There were three blocks on the experimental areas according to elevation. The spacing between replications was 2 m. Stem cuttings were planted with a row to row spacing of 1m and plant to plant spacing of 0.5m. Weeding was done three times manually during the whole experimental period.

Sampling Procedure

The initial growth and regrowth of grasses were harvested at about 60 days of age at about 10 cm above the ground, except for the fifth regrowth which was harvested after 105 days (due to slow growth with less precipitation; Figure 1). Measurements were taken on plant height and fresh biomass yield. Plant height was measured from its base to where the last leaf on the stem emerges with the help of a meter rule on five randomly selected culms per plot before each harvest. Representative samples of the whole plants were collected and oven dried at 70 °C for 48 h to constant weight for DM analysis. The dried samples were ground to pass through a one-mm sieve and kept in plastic bottles for chemical analysis.

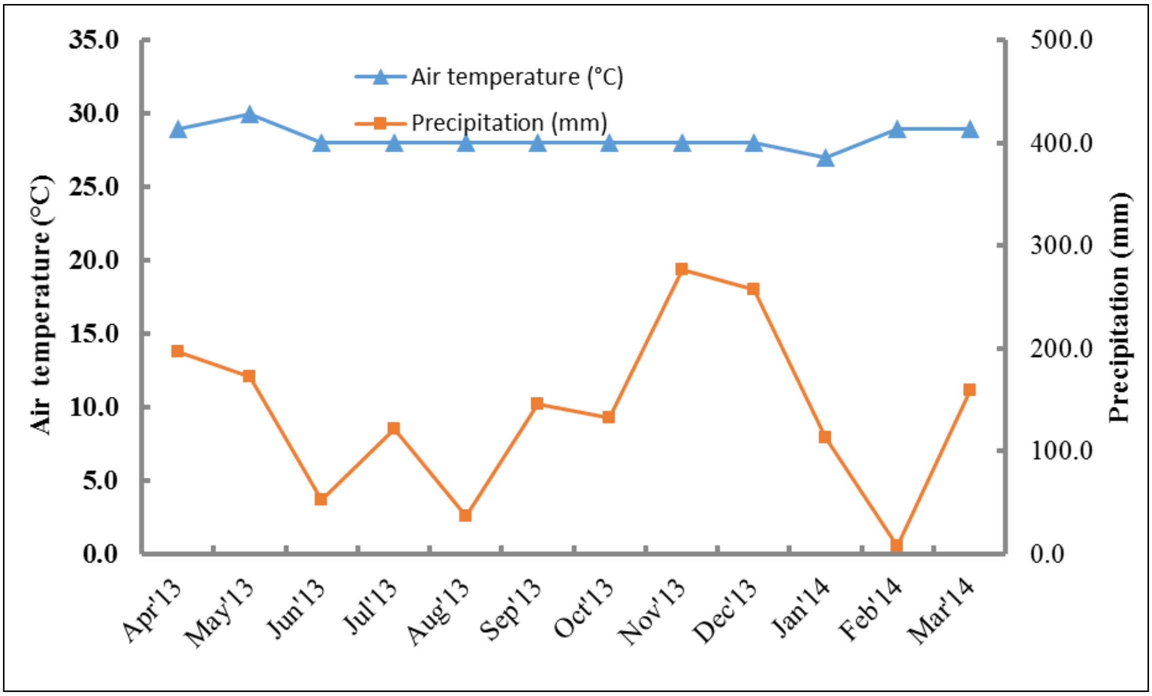

Figure 1: Monthly variation in air temperature (▲) and precipitation (■) during the experimental period in 2013-2014.

Chemical Analysis

Dried samples were used to determine ash and crude protein (CP) according to procedure of AOAC (2005). Crude protein was calculated as N x 6.25. Organic matter (OM) percentage was calculated from Total DM - Ash. Neutral detergent fibre (NDF) was determined as described by Van Soest *et al*. (1991). Samples of air-dried goat manure used were analyzed as for grass samples.

Statistical Analysis

Statistically significant differences among the plant height, DM yield and chemical composition of Napier grass for the two different N fertiliser applications were determined by the *t*-test (Steel and Torrie, 1982).

Results and Discussion

Plant Height and Dry Matter Yield

Height of Napier grass at different harvest cycles was affected by manure and urea fertiliser applications, except for the 5th harvest cycle (Table 1). Plant height of Napier grass receiving manure at the first to fourth harvest cycles was higher ($p<0.05$ or $p<0.01$) than the plant height of Napier grass receiving urea. This might be due to the improvement of the physic-chemical and biological properties of soil, because organic manure improves the structure of the soil and increases its ability to hold water and nutrients. The release of nutrients from manure is slow but long lasting (Plaster 1992). However, the soil texture and mineral contents in soil were not measured in this study. It is well known that manure is an excellent source of major plant nutrients, and also provides many of the secondary nutrients that plants require.

Table 1: Plant height (cm) of Napier grass as affected by two sources of nitrogen fertiliser application at different harvest cycles

Harvest cycle	Treatments		SEM	Significance
	Manure	Urea		
First harvest	228	184	10.74	**
Second harvest	216	193	5.45	**
Third harvest	206	190	4.09	*
Fourth harvest	199	185	3.44	*
Fifth harvest	133	129	5.53	NS

NS, not significant, *p<0.05, **p<0.01, SEM, Standard error of mean

The DM yield of Napier grass cultivated with manure and urea fertiliser is shown in Figure 2. The source of N had a significant effect ($p<0.01$) on DM yield. The DM yield of Napier grass receiving manure was higher ($p<0.05$) than the DM yield of Napier grass receiving urea in the all cuttings, except in the third harvest. In the 3rd harvest, no difference was observed on DM yield between manure and urea applications. Regardless of harvesting frequencies, cumulative annual DM yield of Napier grass receiving manure was higher ($p<0.05$) than the average DM yield of Napier grass receiving urea applied (Figure 3). The results on DM yield found in this study was in line with the findings of Huque *et al*. (2001) who reported that the annual DM yields of Napier grass, Para grass and Andropogan grass grown on sloping hilly land were 5.5, 4.1 and 10.5 ton/ha with similar rate of fertiliser application (urea at the rate of 57 kg N/ha before and after each cutting). The results in this study were similar to the work reported by Mikled *et al*. (1994) and they found that DM yield was higher with fermented slurry than chemical fertiliser in successive cuttings of Napier grass. Similar results were also observed by Halim (1993), who found higher DM yield of Napier grass with organic manure than chemical fertilizer. This might be due to an improvement of soil structure by addition of manure that released more nutrients for the higher DM yield of the Napier grass. The initial soil analysis data in this study revealed that soil of experimental plots was an acidic soil (pH 4.77), which may affect in overall growth and yield of plants (Miller and Donahue, 1990). However, Napier grass can grow in a wide range of soils with a pH of 4.5-8.2 (Rahman *et al*., 2008). In addition, organic fertiliser usually enhances the growth of plants by increasing soil organic matter which leads to improved soil physico-chemical properties (water holding capacity, aeration, structure, nutrient retention) and soil microbial activity enhancement (FAO, 1998).

In comparing DM yield after third harvest, the results showed that both manure and urea treatments gave a decline in DM yield significantly with time. The decline in DM yield for both treatments could have been partly attributed to the leaching of soil nutrients by rainwater, since highest precipitation was observed in November-December 2013 during the growth period of fourth harvesting grass (Figure 1). In addition, almost zero precipitation was observed in February 2014 that could also be affected the plant growth in fifth harvest. Dry matter yield of Napier grass over two harvests ranging from 7.73 to 12.14 ton ha^{-1} was recorded in the Highlands of Madagascar (Rahetlah *et al*., 2014). In another study, no changes in DM yields of the three perennial grasses were found due to differences in hill heights (Huque *et al*., 2001).

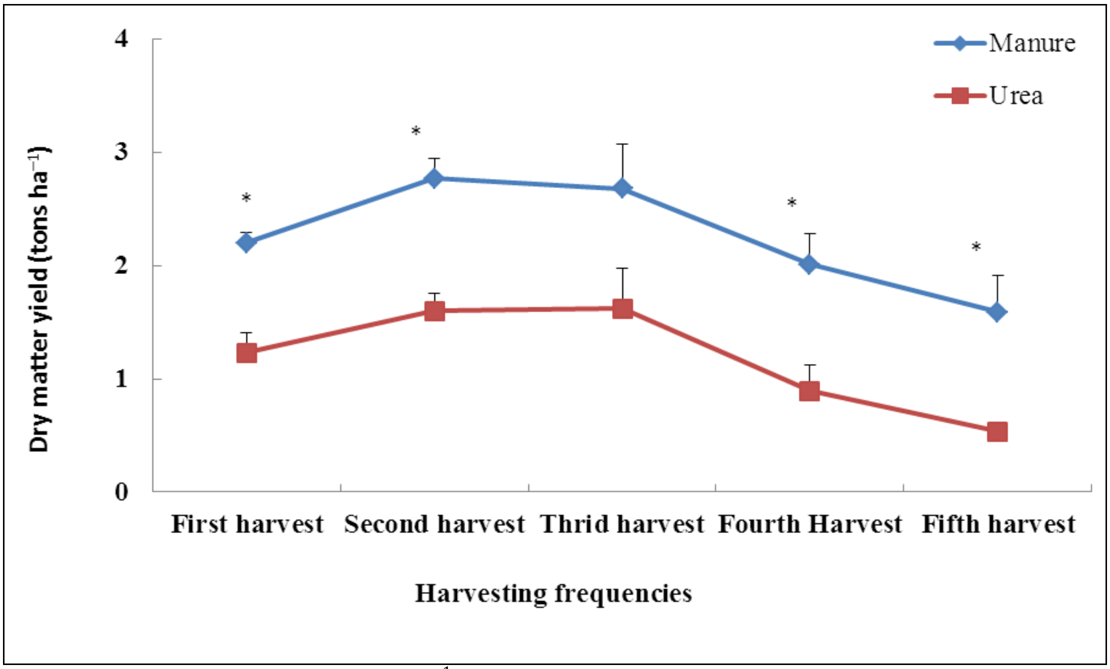

Figure 2: Dry matter yield (ton ha^{-1}) of Napier grass as affected by two sources of nitrogen fertiliser application at different harvest cycles.

The Star (*) marks indicate a significant difference between manure and urea applications at $p<0.05$. Data is the average ± standard error.

Chemical Composition

There was no significant ($p>0.05$) variation between different N sources in DM and OM contents in different harvest cycles of Napier grass, except the fourth harvest (Table 2). The DM and OM contents in the fourth harvest grass were higher ($p<0.01$) in urea application than manure application. Similar result was found for 5th harvest where urea application gave higher CP than manure application. It appears from Table 2 that the NDF content was not influenced ($p>0.05$) with N from different sources in all cutting frequencies of Napier grass. Regardless of harvest cycle, the average DM, OM, CP and NDF contents of Napier grass were not affected ($p>0.05$) by manure and urea fertiliser applications. The results of analysis of variance (ANOVA) for the fertiliser, harvest cycle and their interaction on plant height, dry matter yield and nutritive value of Napier grass are shown in Table 3. Except plant height, there were no significant interaction effects on DM yield, DM, OM, CP and NDF contents of Napier grass.

It is known that nutritional quality of forage depends on plant management. The DM content of Napier grass obtained at 60 days after each harvest in this study was much lower than that reported in the same grass at the same growth stage (Zetina-Córdoba *et al*., 2013). This might be due to the differences of soil fertility, moisture conditions, light intensity and temperature (Campos *et al.*, 2013). Crude protein is one of the major nutrients in forage for determination of nutritional quality, because DM intake and rumen microbial growth increase with increasing level of CP in a feed (Chanthakhoun *et al*., 2012). The CP contents of Napier grass under urea and manure applications in this study contrasted with the findings of Khan *et al*. (2008) who reported that CP was higher with urea than organic manures. The NDF content in forage is also one of the major components, which leads animal to eat less feed (Lardner *et al*., 2015). The NDF reported in Napier grass was similar (71.0%) (Zetina-Córdoba *et al*., 2013), when compared to present study (Table 2). Rahetlah *et al*. (2014) observed that DM, total ash, crude fiber and CP contents of Napier grass grown in highlands were not affected by different fertiliser applications.

Table 2: Chemical composition (g kg^{-1}) of Napier grass as affected by two sources of nitrogen fertiliser application at different harvest cycles

Harvest cycle	Chemical composition	Treatments		SEM	Significance
		Manure	Urea		
First harvest	DM	135	139	1.9	NS
	OM	905	915	3.7	NS
	CP	81	76	1.4	NS
	NDF	637	634	3.8	NS
Second harvest	DM	157	159	1.2	NS
	OM	923	925	2.2	NS
	CP	69	70	3.6	NS
	NDF	679	663	6.1	NS
Third harvest	DM	180	183	3.7	NS
	OM	940	934	3.8	NS
	CP	57	64	6.3	NS
	NDF	720	692	15.3	NS
Fourth harvest	DM	136	151	3.6	*
	OM	902	917	3.8	*
	CP	64	75	4.9	NS
	NDF	638	625	7.1	NS
Fifth harvest	DM	181	182	2.6	NS
	OM	934	932	2.0	NS
	CP	74	107	8.8	*
	NDF	659	635	7.8	NS
Average	DM	158	163	3.6	NS
	OM	921	925	2.5	NS
	CP	69	79	3.0	NS
	NDF	666	650	6.3	NS

DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fibre
NS, not significant
*$p<0.05$
SEM, Standard error of mean

Table 3: ANOVA of fertliser (F), harvest cycle (HC) and their interaction (H × HC) on plant height, dry matter yield, dry matter, organic matter, crude protein and neutral detergent fibre contents of Napier grass

Variable	Factor	d.f.	Mean square	*F*-value
Plant height	F	1	3001.5	34.1***
	HC	4	5830.9	66.2***
	H × HC	4	340.9	3.8*
Dry matter yield	F	1	8.6	47.6***
	HC	4	1.3	7.4**
	H × HC	4	0.01	0.04NS
Dry matter	F	1	1.7	4.1NS
	HC	4	25.8	63.2***
	H × HC	4	0.4	1.1NS
Organic matter	F	1	0.9	1.9NS
	HC	4	9.6	19.2***
	H × HC	4	1.1	2.3NS
Crude protein	F	1	6.7	6.7*
	HC	4	7.7	5.5**
	H × HC	4	3.1	2.2NS
Neutral detergent fibre	F	1	20.8	4.5*
	HC	4	56.9	12.3***
	H × HC	4	1.5	0.3NS

NS, not significant, *p<0.05, **p<0.01, ***p<0.001

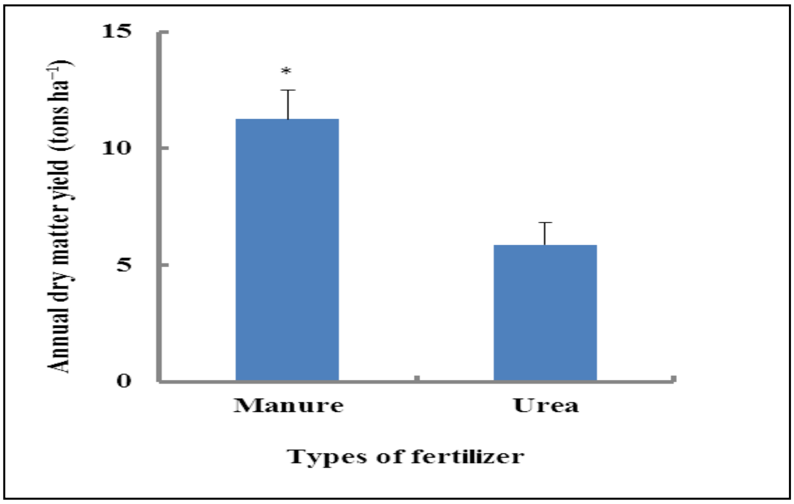

Figure 3: Annual dry matter yield (tons ha^{-1}) of Napier grass as affected by two sources of nitrogen fertiliser application.
The Star (*) marks indicate a significant difference between manure and urea applications at p<0.05. Data is the average ± standard error.

Conclusion

It can be concluded from this study that the Napier grass fertilised with goat manure had the highest result in terms of DM yield. However, no differences were observed on DM, OM, CP and NDF contents across harvesting frequencies. Based on results, goat manure is an effective source of nitrogen for forage production on terraced hill that can help to make nature farming using agro-waste products.

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