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Effects of Plant Spacing on Yields and Nutritive Values of Napier Grass (*Pennisetum purpureum* Schum.) Under Intensive Management of Nitrogen Fertilizer and Irrigation

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Abstract: There was a significant effect of plant spacing on total dry matter yield among 50 x 40, 50 x 40, 50 x 40 and 50 x 100 cm plant spacing of Napier Grass. The highest total dry matter yield of 70.84 t ha^{-1} was obtained from 50 x 40 planting configuration. There was significant effect of plant spacing on dry matter production of the grass from 8 harvests. In a 50 x 40 planting configuration, the range of dry matter production from 11 harvests was 2.6-10.19 t ha^{-1}. Plant spacing did not have significant ($p>0.05$) effect on Crude Protein (CP), Acid Detergent Fiber (ADF) and Dry Matter Digestibility (DMD) but Neutral Detergent Fiber (NDF) was significantly affected ($p<0.01$) by plant spacing. The ranges of CP, ADF, NDF and DMD under different planting configurations were 13.2-13.9, 41.5-43, 66.9-68.2 and 74.7-75.5%, respectively. Intensive management of Napier Grass pasture may help to overcome the problem of shortage and low quality of feed supply during the dry season.

Key words: Dry matter yield, irrigation system, King napier grass, nutritive values, plant spacing

INTRODUCTION

The increasing demand for meat consumption in South East Asia (Hall *et al.*, 2004; Quirke *et al.*, 2003) greatly offered opportunities for farmers within the region to intensify their livestock production system. However, the problems associated with shortage supply especially during the dry season and low nutritive quality of tropical forages have been frequently reported and these are major constraints limiting animal performance (Hennessy, 1980; Roothaert *et al.*, 2005; Preston, 1982). In order to overcome these problems, intensive forage management systems exploiting land, labor and water resources coupled with utilization of suitable forage species need to be developed for small farm holders (Millar and Photakoun, 2008; Roothaert *et al.*, 2003). Napier Grass (*Pennisetum purpureum* Schum.) is a productive, persistent and high-quality forage grass widely grown in tropics and subtropics (Macoon *et al.*, 2002). Yields of the grass vary depending on genotypes (Schank *et al.*, 1993; Cuomo *et al.*, 1996), edaphic and climatic factors and management practice (Chaparro *et al.*, 1995; Chaparro *et al.*, 1996; Woodard and Prine, 1993). Biomass yields from two cuttings ranged from 11.7-20.1 t ha^{-1} among genotypes (Schank *et al.*, 1993). Under rainfed condition, combination of cutting intervals and heights produced total dry matter of 8.0-16.2 t ha^{-1} in the year of establishment and the reduction of yield occurred when total rainfall decreased in the second year. Lower dry matter yields were associated with frequent defoliation and low cutting height (Chaparro *et al.*, 1995). Zero grazing system for Napier Grass in Kenya resulted in dry matter yields of 8.5-27.4 t ha^{-1} (Paterson *et al.*, 1998). Nitrogen fertilizer is also the important determinant of dry matter yield of Napier Grass. Under high amount of rainfall, the significant dry matter response to the rate of 400 kg N ha-1 was recorded (Pieterse and Rethman, 2002). Dry matter of Napier Grass significantly increased higher under higher rates of manure (Sunusi *et al.*, 1997).

Quality of the grass in terms of *in Vitro* Dry Matter Digestibility (IVOMD), Crude Protein (CP) and Neutral Detergent Fiber (NDF) Acid Detergent Fiber (ADF) may depend on genotype and management of the grass. The tall tetraploid Kinggrass was lower in *in vitro* organic dry matter digestibility and CF but higher in NDF than other genotypes (Schank *et al.*, 1993). Increasing intervals of cuttings resulted in higher CP and *in vitro* true dry matter digestibility but lower NDF and ADF (Cuomo *et al.*, 1996). Nevertheless, information on the productivity and quality of Napier Grass under intensive nitrogen in combination with manure and irrigation management in tropical environment is not well documented. The objective of this experiment was to investigate the effects of plant spacing on yield and nutritive values of King Napier Grass under intensive management of nitrogen in combination with manure and irrigation during the rainy and dry seasons.

MATERIALS AND METHODS

Napier grass plantation experiment: The experiment was conducted during April 2006 to September 2007 at Khon Kaen Animal Nutrition Research and Development

Center, Khon Kaen province (16°43' N, 102°83' E; elevation 162 m), Northeast Thailand. The soil is a sandy loam, Korat soil series (Oxic Paleustals). The pH of the soil was 5.2. Nutrient status of the soil was as follows: 0.032% N, 33.3 ppm of available P. The experimental area was first plowed in late March 2006 followed by disc harrowing to obtain fine and uniform seedbed. The experimental design was randomized complete block design with 4 replications. Treatments were four plant spacings; 50 x 40, 50 x 60, 50 x 80 and 50 x 100 cm. The plot size was 3 x 4 m. The grasses were grown from stem cuttings having 2 nodes. The cuttings were buried into a well-prepared seedbed with two cuttings per hill. The combined fertilizer 15-15-15 (N-P-K) was applied as basal fertilizer at a rate of 625 kg ha^{-1}. The manure was also applied as basal fertilizer at the rate of 6.25 t ha^{-1} and then applied at the rate of 1.56 t ha^{-1} every 3 months after the first of cutting. Urea at the rate of 125 kg ha^{-1} was applied after each cutting. Water was supplied adequately by sprinkler irrigation to saturate the 0-15 cm soil profile when there were no rains during the rainy and dry seasons.

The grasses were cut close to the ground level to get a uniform stand on day 70 after planting and then the cutting treatments at the interval of 35 days were carried out for 11 times. Before each harvest, numbers of tillers were counted using plants in 12 hills in the middle rows. The grass was cut close to the ground level in the area of 3 x 2 m^2. Fresh weight of the harvested materials was recorded and sample materials of 1 kg were taken and dried at 65°C for 72 h. Samples materials were ground to the size of 1 mm using the grinder (Willey mill). The ground samples were analyzed for Crude Protein (CP) (AOAC, 1984), Acid Detergent Fiber (ADF) and Neutral Detergent Fiber NDF (Goering and Van Soest, 1970) and Dry Matter Digestibility (DMD) by nylon bag technique (Orskov, 1982).

Analysis of variance in RCBD was performed and treatment means were compared using Dancan Multiple Range Test (DMRT) (Steel and Torrie, 1960). Analysis was carried out using SAS statistical computer package Ver. 6.12 (SAS, 1998).

RESULTS AND DISCUSSION

Climatic condition: Monthly maximum temperatures during September and December in 2006 were between 31-34°C while in 2007, monthly maximum temperatures were between 30-36°C. There were greater variations in monthly minimum temperatures. Lower monthly maximum temperature occurred during November and January (Table 1). During the experimental period, monthly minimums were 20.5 and 16.5°C. during November and December in 2006 and were between 16.0 and 18.8°C during January and February in 2007. Monthly minimum temperatures appeared to have some effects on productivity of Napier Grass.

Table 1: Monthly maximum and minimum temperature during the experimental period

Month	Max. temp (°C)		Min. temp (°C)	
	2006	2007	2006	2007
January	32.7	30.9	16.1	16.0
February	33.2	34.6	19.4	18.8
March	35.4	36.2	22.7	23.3
April	35.9	36.1	24.1	24.2
May	34.2	33.1	23.7	24.3
June	34.1	34.2	24.7	25.0
July	32.1	33.4	24.5	24.4
August	31.7	31.6	24.0	21.1
September	32.3	31.9	23.5	23.6
October	32.2	30.7	22.5	23.3
November	33.7	29.6	20.5	17.7
December	31.0	31.7	16.5	18.1

Yield of Napier Grass under different space of planting Dry matter yields of Napier Grass were lowest during January regardless of spacing configurations and dry matter yields were between 2.4 and 2.7 t ha^{-1} (Table 2). There were significant effects of spaces of planting on total dry matter yields. The highest total dry matter yield of 70.84 t ha^{-1} was obtained from a 50 x 40 planting configuration and this was significantly higher than that from other planting configurations. The 50 x 100 space, total dry matter yield was significantly lower than other spaces of planting and the yield was 55.8 t ha^{-1} (Table 2). There was significant effect of planting configuration in dry matter yields in 8 harvests and the 50 x 40 planting configuration resulted in higher yield than other configurations (Table 2). The highest dry matter yield in the year of establishment occurred in the first harvest with the range of yield 6.6-8.6 t ha^{-1} in all plant spacings. In the second year, the peak of the yield occurred in March and the range of yield was 8.2-10.2 t ha^{-1} for all plant spacing (Table 2). In the 50 x 40 planting configuration, dry matter yields were high and fairly uniform throughout the year except in January and the range of yields were 4.8-10.2 t ha^{-1} (Table 2). Nutritive qualities of Napier Grass were not affected by planting configurations except for NDF. The ranges of CF, ADF and DMD were 13.2-13.9, 41-43 and 74.7-75.5%, respectively. Although there was significant effect of space of plantings on NDF, the range was 66.9-68.2%. With intensive irrigation and nitrogen fertilizer management coupled with manure application under conditions of northeast Thailand, dry matter production of Napier Grass was relatively high comparable to that reported in Puerto Rico by Vicente-Chandler *et al.* (1959) and much higher than that reported in subtropical regions (Schank *et al.*, 1993; Chaparro *et al.*, 1995; Chaparro *et al.*, 1996).

The significant effect of planting configurations on total dry matter was due in part to different densities of hills m^{-2} and to different number of tillers per hill (Table 3). It appears that 50 x 40 plant spacing is the suitable for

Table 2: Dry matter yield (t ha^{-1}) of Napier grass under different spaces of planting

		Dry matter yield (ton ha^{-1})					
Cutting No.	Cutting date	50 x 40 cm	50 x 60 cm	50 x 80 cm	50 x100 cm	F- value	CV (%)
1^{st}	21 Sept 06	8.59$^{a\#}$	7.50^{a}	6.59^{b}	7.23^{b}	**	5.3
2^{nd}	26 Oct 06	6.92^{a}	4.07^{c}	6.42^{b}	3.35^{d}	**	5.7
3^{rd}	30 Nov 06	7.28^{a}	5.85^{bc}	2.56^{c}	2.40^{b}	**	9.9
4^{th}	4 Jan 07	2.60	2.75	2.56	2.40	NS*	13.6
5^{th}	8 Feb 07	4.90	4.83	4.46	4.21	NS	10.3
6^{th}	15 Mar 07	10.19^{a}	9.50^{a}	8.23^{b}	8.15^{b}	**	5.8
7^{th}	19 Apr 07	6.51^{a}	5.19^{b}	5.25^{b}	4.77^{b}	**	7.9
8^{th}	24 May 07	6.59^{a}	5.17^{b}	5.03^{b}	4.45^{b}	**	10.4
9^{th}	28 Jun 07	7.40	6.75	7.40	6.83	NS	9.5
10^{th}	2 Aug 07	5.49^{a}	5.49^{a}	5.21^{a}	4.42^{b}	**	6.4
11^{th}	6 Sept 07	4.76^{a}	4.34^{b}	4.25^{b}	3.83^{c}	**	5.6
Total		70.84^{a}	61.86^{b}	60.49^{b}	55.80^{c}	**	4.1

Means within a row followed by the same letters is not statistically different
NS = Non significantly different (p>0.05) ** = Significantly different (p<0.01)

Table 3: Number of tillers (tillers per hill) of Napier grass under different spaces of planting

		Number of tillers per hill					
Cutting No.	Cutting date	50 x 40 cm	50 x 60 cm	50 x 80 cm	50 x 100 cm	F-value	CV (%)
1^{st}	21 Sept 06	6	6	5	5	**	14.7
2^{nd}	26 Oct 06	15	6	9	9	**	6.1
3^{rd}	30 Nov 06	13	11	10	8	**	11.7
4^{th}	4 Jan 07	20	18	15	13	**	10.5
5^{th}	8 Feb 07	28	21	18	13	NS*	12.8
6^{th}	15 Mar 07	18	16	13	11	NS	11.7
7^{th}	19 Apr 07	18	16	14	11	**	7.7
8^{th}	24 May 07	12	12	11	10	**	9.6
9^{th}	28 Jun 07	12	11	10	8	**	11.6
10^{th}	2 Aug 07	18	16	14	12	**	13.4
11^{th}	6 Sept 07	20	18	15	13	**	15.7
Average	-	16	14	12	10	**	7.9

Means within a row followed by the same letters is not statistically different
NS = Non significantly different (p>0.05) ** = Significantly different (p<0.01)

Table 4: Crude Protein (CP), acid detergent fiber, Neutral Detergent Fiber (NDF) and dry matter digestibility of Napier grass under different plant spacing

Spacing	CP (%)	ADF (%)	NDF (%)	DMD (%)
50 x 40 cm	13.5	42.8	67.1$^{b\#}$	75.5
50 x 60 cm	13.9	41.5	67.4^{b}	74.9
50 x 80 cm	13.9	43.0	66.9^{b}	74.8
50 x 100 cm	13.2	43.0	68.2^{a}	74.7
F-Value	NS*	NS	*	NS
CV (%)	2.9	1.0	0.7	0.5

Means within a column followed by the same letters is statistically different. NS = Non significantly different (p>0.05)
** = Significantly different (p<0.05)

establishing Napier Grass pasture to be utilized under intensive management of nitrogen fertilization and under the 35 days cutting interval. This management system did not have any adverse effects on dry matter yields, number of tillers per hill or per plant and nutritive qualities even though it was found that cutting intervals of 21 or 42 days results in a decreased concentration of nonstructural carbohydrate, reduced number of tillers per plant that would result in lower dry matter yields (Chaparro *et al*., 1996). Moreover, the crude protein and dry matter digestibility of the grass were remarkably high which were 13.5% and 75%, respectively.

Based on the information provided by Burns and Fisher (2007) that the consumption of feed by steers was 2.48 kg dry matter 100 kg^{-1} BW, the daily dry feed intake of 200 kg steer would be 5 kg. The daily dry feed on offer during January would be about 75 kg and during March would be about 290 kg. This would be sufficient to feed 15 and 58 animals having body weight of 200 kg during January and March, respectively. Even one-fifth ha of the land area can provided adequate feed for 3 animals during the shortage period of feed. With the access to irrigation and other supporting facilities, even soil properties is relatively poor, small farmer holders in northeast Thailand occupying small acreage of land could establish and utilize Napier Grass pasture to intensify livestock production.

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