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Effects of different forms nitrogen fertilizer on growth and yield of four tropical pasture grasses

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Abstract Nitrogen fertilizer is an essential plant nutrient of tropical pasture crops. The effect of nitrogen fertilizer in forms of urea and ammonium sulphate on growth and yield of four tropical pasture grasses was determined. The results showed that four tropical pasture grasses were significantly different for tiller number, SCMR, CGR during the regrowth, fresh weight yield and dry matter yield, when different forms of nitrogen fertilizer were applied. Application of urea resulted in higher fresh yield (9.6-10.7 t/ha/time) and dry matter yield (1.3–2.0 t/ha/time) than did application of ammonium sulphate and control. Application of urea also had higher tiller number and higher crop growth rate during the regrowth period after each cutting time than application of ammonium sulphate and un-fertilized control. Application of urea at the rate of 62.5 kg N/ha is recommended for growing Purple guinea, Mombasa guinea, Ruzi and Mulato II in Thailand. The interaction between pasture grass and nitrogen form was not significant in this study.

Keywords: Tropical pasture, *Panicum* spp., *Brachiaria* spp., Urea

Introduction

Although the largest country's income in Thailand is from industry and service sectors, agriculture sector is still important as the source of income in the rural areas. Thai farmers still rely heavily on few major crops such as rice, cassava, sugarcane and rubber, which repeatedly face price fluctuation. The prices of agricultural products are often slumped and the farmers usually suffer from loss.

The current government policies on agriculture are to diversify agricultural products and to reduce production areas of some major crops such as rice and rubber. Production of livestock is a promising option to substitute the poorly productive areas such as drought prone and poor soil areas. Livestock production in Thailand is currently increasing and the demand for tropical pasture grasses also increases. The types of pasture grasses that are most popular in Thailand are Purple guinea, Mombasa guinea, Ruzi and Mulato II. The pastures are used not only for direct grazing but also for making hay and silage for the animals in the dry season.

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The fluctuation in yield and quality of pasture grasses is the major problem of pasture crop growing because the growth and yield of pasture crops depend on various factors such as pasture type, genetic, its adaptation to the environment, soil fertility, weather condition and field management.

Application of fertilizer is an important method to stabilize yield and quality of pasture crops, and nitrogen fertilizer is most important for growth and yield of tropical pasture. Nitrogen is a component of chlorophyll, which is a green pigment important for photosynthesis. Moreover, nitrogen is also a component of amino acid and protein important for growth of ruminant animals.

The importance of nitrogen fertilizer and source of nitrogen fertilizer on pasture grasses has been highlighted in previous studies. Source of nitrogen fertilizer significantly affected dry matter yield, nitrogen yield, phosphorus yield, potassium yield and protein yield of guinea grass (Tongvinichsin, 1995). Application of minimum dosage of nitrogen fertilizer could attain acceptable yield of pasture grass (Madakadze *et al.*, 1999). Yield of switch grass could be increased through the application of nitrogen fertilizer and proper management of the pasture (Lemus *et al.*, 2008). Application of ammonium sulphate had higher chlorophyll content, SPAD chlorophyll meter reading and yield than that did application of non-fertilizer and cattle manure (Naenon *et al.*, 2017). The authors also found the positive and significant relationships between chlorophyll and both fresh yield and dry matter yield.

Therefore, the use of nitrogen fertilizer with correct dosage and appropriate source of nitrogen can increase plant growth and yield. For most effective use of fertilizers, the growers should have decided to use the correct types of nitrogen fertilizer and the correct rates of application. The principle of fertilizer application is to use fertilizers of the right types with the right rates and methods at the right times (Roberts, 2008). Mombasa guinea was better responsive to ammonium sulphate than urea and cattle manure, but the application must be at the rates required by plant (Athisaitrakun *et al.*, 2017). However, grass types or varieties may respond differently to forms of nitrogen fertilizer and the information on the responses to different forms of nitrogen fertilizer of pasture grasses that are popular among farmers in Thailand is limited. The objective of this study was to determine the effect of different forms of nitrogen fertilizer in urea and ammonium sulphate on growth and yield of four pasture grasses. The information obtained in this study will be useful for nitrogen fertilizer management in pasture grass production system for pasture growers in Thailand.

Materials and methods

Location and Experimental design

This experiment was conducted in the field at the Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, during August, 2017 to May, 2018. The 4×3 factorial experiment was arranged for in a randomized complete block design with four replications. Four pasture grasses including Purple guinea (*Panicum maximum* TD 58), Mombasa guinea (*Panicum maximum* cv. Mombasa), Ruzi (*Brachiaria ruziziensis*) and Mulato II (*Brachiaria ruziziensis* x *B. decumbens* x *B. brizantha*) were assigned as factor A, and three nitrogen forms consisting of non-fertilized control, urea at the rate of 62.5 kg N/ha and ammonium sulphate at the rate of 62.5 kg N/ha were assigned as factor B.

Land preparation and planting

Soil was obtained from Chachoengsao province, then dried for a week and crushed into small particles. The dry soil was loaded into square cement containers with 1×1 meter and 40 cm in height. Each plot contained 500 kg soil. Soil was also sampled for analysis of the physical and chemical properties before planting. Seedlings at the age of 30 days old were transplanted to cement containers at the rate of eight plants per container and each container had four hills (2 seedlings/hills). Chemical fertilizer formula15-15-15 of N-P_2O_5-K_2O at a rate of 312.5 kg/ha was applied to each plot before planting. Nitrogen fertilizer was urea or ammonium sulphate according to the treatments. The same fertilizer rates and types were applied to the treatments at 40 day intervals after cutting. Manual weed control was carried out at one month after cutting. Irrigation was applied by a sprinkler system every day after transplanting until grass seedlings well established and then irrigation was applied twice a day.

Plant data and data analysis

The first cutting was carried out at 60 days after transplanting for uniformity of the regrowth of four grasses. The subsequent harvests were carried out at 40 day intervals for four harvests on 4 December 2017, 27 February 2018, 9 April 2018 and 22 May 2018, respectively. The cutting was done at the ground level (0 cm), and the data were recorded for tiller numbers per plant, SPAD chlorophyll meter reading (SCMR) and fresh yield.

The plants were chopped into small pieces and the chopped sample of each plot was oven-dried at the 80 °C for 48 hrs or until dry weight was consistent. Dry weight yield was determined after drying. All data were then analyzed by analysis of variance and the difference between treatment means were compared by Duncan's New Multiple Range Test (DMRT) at 0.05 and 0.01 probability levels using M-STATC program from Michigan State University.

Results

Tiller number

Forms of nitrogen fertilizer were significantly (P≤0.05 and 0.01) different for tiller number of pasture grasses at all cutting times (Table 1). Application of urea had the highest tiller numbers of 209, 321, 361, and 412 tillers/m^2 at the 1st, 2nd, 3rd and 4th cutting times, respectively, whereas application of ammonium sulphate had tiller numbers of 188, 281, 303, and 345 tillers/m^2 at the 1st, 2nd, 3rd and 4th cutting times, respectively. Un-fertilized control had tiller numbers of 22.0, 37.1, 36.0 and 30.1 % lower than did urea at the 1st, 2nd, 3rd and 4th cutting times, respectively.

Four pasture grasses were significantly different (P≤0.05 and 0.01) for tiller number at all cutting times. Ruzi had highest tiller number. The interactions between pasture grass and nitrogen form were not significant for tiller number.

Table 1. Effect of different forms of nitrogen fertilizer on tiller number of four pasture grasses

Fertilizer form	Pasture grass	Tiller numbers/m^2 1st cutting	2nd cutting	3rd cutting	4th cutting
Non-fertilizer	Purple guinea	136^b	179^b	273^{ab}	312^a
	Mombasa guinea	152^b	189^b	188^b	307^{ab}
	Ruzi	212^a	275^a	292^a	273^{ab}
	Mulato II	151^b	165^b	208^{ab}	248^b
	Mean	*163^B*	*202^B*	*231^C*	*285^B*
Urea	Purple guinea	165^b	317^b	352^{ab}	483^a
	Mombasa guinea	197^b	271^b	343^b	412^{ab}
	Ruzi	274^a	385^a	368^a	407^{ab}
	Mulato II	200^b	324^b	351^{ab}	346^b
	Mean	*209^A*	*321^A*	*361^A*	*412^A*
Ammonium sulphate	Purple guinea	154^b	216^b	310^{ab}	378^a
	Mombasa guinea	160^b	239^b	225^b	364^{ab}
	Ruzi	236^a	373^a	350^a	331^{ab}
	Mulato II	203^b	283^b	328^{ab}	307^b
	Mean	*188^{AB}*	*281^A*	*303^B*	*345^{AB}*
F-Test					
Pasture grass (PG)		**	**	**	*
Fertilizer form (F)		*	**	**	**
PG x F		ns	ns	ns	ns
C.V. (%)		26.57	25.43	17.68	21.12

ns and *,** = non significant and significantly different at P≤ 0.05and P≤0.01, respectively
For pasture grass and fertilizer form, means in the same column followed by the same letter are not significantly different by DMRT.

SPAD chlorophyll meter reading (SCMR)

Nitrogen forms were significantly different (P≤0.05 and 0.01) for SCMR at all cutting times (Table 2). Urea had the highest SCMR ranging from 43.2 to 54.4 followed by ammonium sulphate (36.5 to 46.7) and non-fertilized control (33.3 to 45.8), respectively.

Pasture grasses were significantly different (P≤0.01) for SCMR at the 2nd, 3rd and 4th cutting times. However, the differences among pasture grasses were not clear and consistent across cutting times and nitrogen forms.

Table 2. Effect of different forms of nitrogen fertilizer on SPAD chlorophyll meter reading (SCMR) of four pasture grasses

Fertilizer form	Pasture grass	SCMR			
		1st cutting	2nd cutting	3rd cutting	4th cutting
Non-fertilizer	Purple guinea	32.5	26.6^{b}	43.7^{a}	39.3^{a}
	Mombasa guinea	30.6	36.4^{ab}	42.1^{ab}	33.4^{ab}
	Ruzi	37.5	35.9^{ab}	32.1^{b}	31.4^{b}
	Mulato II	32.8	41.2^{a}	30.5^{b}	36.9^{a}
	Mean	*33.3^{B}*	*41.0^{B}*	*39.1^{B}*	*45.8^{B}*
Urea	Purple guinea	43.9	44.0^{b}	49.4^{a}	60.3^{a}
	Mombasa guinea	41.2	48.9^{ab}	45.5^{ab}	52.0^{ab}
	Ruzi	42.2	48.2^{ab}	38.3^{b}	50.1^{b}
	Mulato II	45.7	49.2^{a}	43.4^{b}	55.7^{a}
	Mean	*43.2^{A}*	*47.6^{A}*	*44.2^{A}*	*54.4^{A}*
Ammonium sulphate	Purple guinea	39.5	37.7^{b}	44.9^{a}	48.0^{a}
	Mombasa guinea	35.3	39.7^{ab}	43.7^{ab}	47.9^{ab}
	Ruzi	34.5	43.7^{ab}	36.2^{b}	40.2^{b}
	Mulato II	36.5	45.3^{a}	32.3^{b}	50.7^{a}
	Mean	*36.5^{AB}*	*41.3^{B}*	*39.3^{A}*	*46.7^{B}*
F-Test					
Pasture grass (PG)		ns	**	**	**
Fertilizer form (F)		**	**	**	*
PG x F		ns	ns	ns	ns
C.V. (%)		19.59	11.97	14.61	13.31

ns and *,** = non significant and significantly different at P≤ 0.05and P≤0.01, respectively
For pasture grass and fertilizer form, means in the same column followed by the same letter are not significantly different by DMRT.

Crop growth rate (CGR) during regrowth

Table 3 showed the effect of nitrogen fertilizer forms on crop growth rate (CGR) during the regrowth of four pasture grasses. Nitrogen forms were significantly different (P≤0.01) for crop growth rate during regrowth after all cutting times. Urea could promote crop growth rates during planting to 1st, 1st to 2nd, 2nd to 3rd and 3rd to 4th periods of 20.4, 19.5, 23.1 and 19.8 g/m^2/d, respectively.

Ammonium sulphate had low crop growth rates during planting to 1st, 1st to 2nd, 2nd to 3rd and 3rd to 4th periods of 19.1, 17.6, 19.4 and 18.0 g/m^2/d respectively. Un-fertilized control had the lowest crop growth rates during planting to 1st, 1st to 2nd, 2nd to 3rd and 3rd to 4th periods of 16.2, 16.4, 15.4 and 15.1 g/m^2/d respectively.

Pasture grasses were significantly different ($P \leq 0.01$) for crop growth rate at first cut, second cut and fourth cut. In general, Purple guinea and Mombasa guinea showed similar crop growth rates in all nitrogen forms and they were rather higher than Ruzi and Mulato II. These grass types showed consistent crop growth rates across nitrogen forms, and the interactions between grass type and nitrogen form were not significant for all cutting times.

Table 3. Effect of different forms of nitrogen fertilizer on crop growth rate (CGR) during regrowth of four pasture grasses

Fertilizer form	Pasture grass	CGR during regrowth (g/m^2/d)			
		PT - 1st cutting	1st -2nd cutting	2nd -3rd cutting	3rd-4th cutting
Non-fertilizer	Purple guinea	16.4^{ab}	17.6^{a}	18.4	16.1^{ab}
	Mombasa guinea	16.9^{a}	17.8^{a}	14.1	16.7^{a}
	Ruzi	15.6^{b}	14.8^{ab}	13.5	14.2^{b}
	Mulato II	15.8^{b}	13.8^{b}	15.4	13.6^{b}
	Mean	*16.2^{B}*	*16.4^{B}*	*15.4^{C}*	*15.1^{C}*
Urea	Purple guinea	21.4^{ab}	21.7^{a}	22.6	20.1^{ab}
	Mombasa guinea	22.5^{a}	21.8^{a}	23.0	21.9^{a}
	Ruzi	18.6^{b}	17.0^{ab}	24.5	18.5^{b}
	Mulato II	19.2^{b}	16.5^{b}	22.1	18.9^{b}
	Mean	*20.4^{A}*	*19.5^{A}*	*23.1^{A}*	*19.8^{A}*
Ammonium sulphate	Purple guinea	19.9^{ab}	19.1^{a}	20.8	20.2^{a}
	Mombasa guinea	21.0^{a}	19.5^{a}	19.2	19.1^{ab}
	Ruzi	17.7^{b}	15.8^{ab}	19.8	16.2^{b}
	Mulato II	17.8^{b}	15.0^{b}	17.9	16.6^{b}
	Mean	*19.1^{A}*	*17.6^{B}*	*19.4^{B}*	*18.0^{B}*
F-Test					
Pasture grass (PG)		**	**	ns	**
Fertilizer form (F)		**	**	**	**
PG x F		ns	ns	ns	ns
C.V. (%)		10.19	9.31	15.23	9.31

ns and *,** = non significant and significantly different at $P \leq 0.05$and $P \leq 0.01$, respectively
For pasture grass and fertilizer form, means in the same column followed by the same letter are not significantly different by DMRT.
PT = Planting

Fresh yield

Nitrogen forms were significantly different ($P\leq0.01$) for fresh yield of four pasture grass (Table 4). Application of urea had the highest fresh yields of 10.7, 10.4, 9.6 and 9.7 t/ha at 1st to 4th cutting times, respectively. Application of ammonium sulphate had fresh yields of 9.7, 9.5, 8.9 and 9.1 t/ha at 1st to 4th cutting times, respectively. Un-fertilized control had the fresh yields of 14.9, 17.3, 13.6 and 17.5 % lower than did the application of urea at the 1st, 2nd, 3rd and 4th cutting times, respectively.

Pasture grasses were not significantly different at the 1st, 3rd and 4th cutting times, but they were significantly different at the 2nd cutting time. Purple guinea and Mombasa guinea seemed to have higher fresh yield than did Ruzi and Mulato II in all nitrogen forms. The interaction between pasture grass and nitrogen fertilizer form was significant only at the 1st cutting time.

Table 4. Effect of different forms nitrogen fertilizer on fresh yield of four pasture grasses

Fertilizer form	**Pasture grass**	**Fresh yield (t/ha/time)**			
		1st cutting	**2nd cutting**	**3rd cutting**	**4th cutting**
Non-fertilizer	Purple guinea	9.5	8.5^{ab}	8.6	8.8
	Mombasa guinea	8.6	9.2^{a}	8.0	8.1
	Ruzi	9.2	8.4^{bc}	7.8	7.7
	Mulato II	8.9	8.3^{c}	8.6	7.6
	Mean	9.1^{B}	8.6^{C}	8.3^{B}	8.0^{B}
Urea	Purple guinea	10.5	11.0^{ab}	9.5	10.0
	Mombasa guinea	11.7	11.6^{a}	9.4	9.8
	Ruzi	10.0	10.0^{bc}	9.2	9.3
	Mulato II	10.7	9.3^{c}	10.1	9.8
	Mean	10.7^{A}	10.4^{A}	9.6^{A}	9.7^{A}
Ammonium sulphate	Purple guinea	9.7	10.1^{a}	9.2	8.1
	Mombasa guinea	9.9	10.0^{ab}	8.5	9.1
	Ruzi	9.5	9.2^{bc}	8.5	8.7
	Mulato II	9.7	8.7^{c}	6.3	9.1
	Mean	9.7^{A}	9.5^{B}	8.9^{B}	9.1^{A}
F-Test					
Pasture grass (PG)		ns	**	ns	ns
Fertilizer form (F)		**	**	**	**
PG x F		*	ns	ns	ns
C.V. (%)		6.66	9.16	7.67	10.01

ns and *,** = non significant and significantly different at $P\leq 0.05$and $P\leq0.01$, respectively
For pasture grass and fertilizer form, means in the same column followed by the same letter are not significantly different by DMRT.

Dry matter yield

Nitrogen forms were significantly different (P≤0.01) for dry matter yield at all four cutting times (Table 5). Application of urea had the highest dry matter yields of 2.0, 1.9, 1.4 and 1.3 t/ha at the 1st, 2nd, 3rd and 4th cutting times, respectively. Application of ammonium sulphate had matter yields of 1.9, 1.7, 1.2 and 1.1 t/ha/times at the 1st, 2nd, 3rd and 4th cutting times, respectively, which were significantly lower than those of urea. Un-fertilized control had the dry matter yields of 20.0, 15.8, 28.6 and 23.1 % lower than did urea at the 1st, 2nd, 3rd and 4th cutting times, respectively.

Pasture grasses were significantly different (P ≤0.01) for dry matter yield at 1st, 2nd and 4th cutting times, but they were not significantly different at the 3rd cutting time. Mombasa guinea seemed to have the highest dry matter yield. The interactions between pasture grass and nitrogen form were not significant.

Table 5. Effect of different forms of nitrogen fertilizer on dry matter yield of four pasture grasses

Fertilizer form	**Pasture grass**	**Dry matter yield (t/ha/time)**			
		1st cutting	**2nd cutting**	**3rd cutting**	**4th cutting**
Non-fertilizer	Purple guinea	1.7^{ab}	1.7^{a}	1.1	1.2^{a}
	Mombasa guinea	1.8^{a}	1.8^{a}	0.9	1.0^{b}
	Ruzi	1.6^{b}	1.5^{b}	1.1	0.8^{c}
	Mulato II	1.5^{b}	1.4^{b}	1.2	0.8^{c}
	Mean	*1.6^{B}*	*1.6^{B}*	*1.0^{C}*	*1.0^{C}*
Urea	Purple guinea	2.1^{ab}	2.1^{a}	1.5	1.5^{a}
	Mombasa guinea	2.2^{a}	2.1^{a}	1.4	1.3^{b}
	Ruzi	1.9^{b}	1.7^{b}	1.5	1.1^{c}
	Mulato II	1.9^{b}	1.8^{b}	1.3	1.1^{c}
	Mean	*2.0^{A}*	*1.9^{A}*	*1.4^{A}*	*1.3^{A}*
Ammonium sulphate	Purple guinea	1.9^{ab}	1.9^{a}	1.3	1.3^{a}
	Mombasa guinea	2.1^{a}	1.9^{a}	1.2	1.2^{b}
	Ruzi	1.7^{b}	1.5^{b}	1.2	1.0^{c}
	Mulato II	1.7^{b}	1.5^{b}	1.1	1.0^{c}
	Mean	*1.9^{A}*	*1.7^{B}*	*1.2^{B}*	*1.1^{B}*
F-Test					
Pasture grass (PG)		**	**	ns	**
Fertilizer form (F)		**	**	**	**
PG x F		ns	ns	ns	ns
C.V. (%)		10.73	9.87	13.28	7.51

ns and *,** = non significant and significantly different at P≤ 0.05and P≤0.01, respectively
For pasture grass and fertilizer form, means in the same column followed by the same letter are not significantly different by DMRT.

Discussion

This study indicated that application of nitrogen fertilizer in different forms resulted in differences in growth and yield of tropical pasture grasses. Roberts, (2008) pointed out that growers should apply fertilizers at the right rate, time and method. If growers apply nitrogen fertilizer at the extreme rates, it will have negative effects on plant growth, yield and quality of tropical grass silage (Namihira *et al.*, 2011).

In this study, nitrogen forms showed significantly different for SCMR. Urea was highest for SCMR and un-fertilized control was lowest. Although the differences among pasture grasses were significant, it was still difficult to identify the best pasture grasses for this parameter because the differences were not consistent across cutting times and nitrogen forms. SCMR has been used for monitoring nitrogen deficiency in many crops such as rice (Sun *et al.*, 2018), sugarcane (Jangpromma *et al.*, 2010) and lentil (Zakeri *et al.*, 2015). In this study, SCMR was useful in identifying nitrogen deficiency but it was not good enough in identifying the differences among pasture grasses. In peanut, SCMR could clearly identify drought-stressed plants and non-stressed plants, but it failed to identify the differences among peanut genotypes (Arunyanark *et al.*, 2009). In this study, SCMR is still useful in identifying nitrogen deficiency in pasture grasses.

Normally, growers use nitrogen in a form of urea more than ammonium sulphate form. In this study, application of nitrogen fertilizer in the form of urea at the rate of 62.5 kg N/ha was the best method that contributed to higher growth and yield of Purple guinea, Mombasa guinea, Ruzi and Mulato II tropical pasture grasses than using nitrogen in a form of ammonium sulphate fertilizer. Martha *et al.* (2004) revealed that application of urea and application of ammonium sulfate in the short term would be equally effective in sustaining herbage dry matter yield of elephant grass (*Pennisetum purpureum*, Schum.).

However, there were contrasting results reported from several studies. Application of ammonium sulphate based on a soil test kit analysis tended to have higher tiller number and higher yield of guinea Mombasa grass than did the application of urea (Athisaitrakun *et al.*, 2017). Applied nitrogen in a form of ammonium sulphate followed soil test kit in Mombasa guinea grass tended to give higher chlorophyll contents than did application of urea (Naenon *et al.*, 2017). The authors also indicated that chlorophyll content was significantly correlated with fresh yield and dry matter yield of Mombasa guinea grass. Similarly, Monteiro *et al.* (2010) applied ammonium sulphate combined with sulphur resulted in significant changes in the Signal grass (*Brachiria decumbens*) productivity, SCMR values and nitrogen, and the concentrations of nitrogen and sulphur in leaves were increased by nitrogen and sulphur rates, respectively.

This study indicated that application of nitrogen in a form of urea promoted growth and yield of four pasture grass better than did application of ammonium sulphate. The results may be explained by few reasons. First, the pasture grasses were planted in cement plots and the environmental factors that may affect plant growth and yield were better controlled. Growing pasture grasses in a cement plots could reduce leaching and evaporation of urea fertilizer. However, the growing condition in cement plots is not the same as that in the field.

Secondly, seasonal variation could affect nitrogen use efficiency. Nitrogen fertilizer should be applied when nitrogen level in soil is not optimum for plant growth and application in the rainy season with sufficient rainfall is more efficient (Manning and Kesby 2008). In Brazil, application of ammonium sulphate would be preferable in late summer because of less NH_3 volatilization losses (Martha *et al*., 2004).

Chien *et al.* (2011) pointed out that application of ammonium sulfate may have some adversary effects on environments. Care must be taken when ammonium sulphate is applied to the crop as it can cause of high soil acidification and application of lime may be required to reduce soil pH. Also, application of ammonium sulphate is more expensive than urea. However, this work was conducted under the period that covered the rainy season and the dry season in Thailand. According to our results, application of urea at the rate of 62.5 kg N/ha is recommended for growing Purple guinea, Mombasa guinea, Ruzi and Mulato II grasses.

It is concluded that the effects of nitrogen fertilizer in the forms of urea and ammonium sulphate on growth and yield of four pasture grasses were noted. Application of urea was better than that of ammonium sulphate for tiller number, SCMR, CGR during regrowth, fresh yield and dry matter yields of four pasture grasses. Un-fertilized control was lowest for these characters. Using urea fertilizer at a rate of 62.5 kg N/ha is recommended for growing pasture grasses in Thailand.

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