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Application of soil test kit for evaluating nitrogen fertilizer requirement of Napier Pakchong 1 grass in Thailand

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Abstract A soil test kit may be applicable for nitrogen management in pasture grass production. The nitrogen fertilizer requirement of Napier Pakchong 1 grass (*Pennisetum purpurem* × *Pennisetum amenicanum* cv. Pakchong 1) was evaluated by using a soil test kit (STK). Result showed that the application of nitrogen fertilizer in the forms of urea and ammonium sulphate increased in dry mater yield of Napier Pakchong 1 grass, whereas application of cattle manure at both recommended rates and the recommended rate by STK gave the dry matter yield similar to the unfertilized control. Application of ammonium sulphate gave better than application of urea. The clay soil with moderate soil fertility and high soil moisture content, the soil test kit provided the acceptable guideline for nitrogen management in Napier Pakchong 1 grass. The application of the soil test kit for nitrogen fertilizer management of Napier Pakchong 1 grass in other soil types are noted.

Keywords: Ammonium sulphate, Urea, *Penisetum purpureum*, Forage crop

Introduction

Napier Pakchong 1 (*Pennisetum purpurem* x *Pennisetum amenicanum* cv. Pakchong 1) is a forage grass with high potential for use as an energy crop and a pasture crop. It is currently becoming an important economic crop in Thailand because of its fast growth, having high tillers, and tolerance to drought. The crop has high protein for ruminant animals and good responses to water and fertilizer and can be produced throughout the year. It is also suitable for making silage for feeding the animals in the dry season.

Napier grass persists for 8-9 years after planting and can be cut at 45-60 day intervals. Cutting at 45-60 day intervals resulted in the optimum yield but too frequent cutting at 30 day intervals could reduce yield (Lounglawan *et al.*, 2014). Cuttings the crop at 5, 10, 15, 20 and 25 cm from soil surface were not significantly different for the chemical compositions and digestibility, but cuttings at high levels did reduce ash content and protein content (Tessema *et al.*, 2010).

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In the pasture crop production system, nitrogen is the most important plant nutrient and Napier grass has high nitrogen requirement. Nitrogen is a component of chlorophyll, which is important in the photosynthetic process. Therefore, if Napier grass receives high nitrogen, nitrogen can contribute to higher photosynthetic rate. Moreover, nitrogen is also a component of amino acids and proteins, which are important for growth of ruminant animals such as cattle, cow, buffalo, goat and sheep.

Department of Livestock Development of Thailand has recommended the general rate of nitrogen fertilizer for Napier Pakchong 1 grass production and the comparative data on the efficiency of nitrogen fertilizer in the different forms and types are not available. General rate of fertilizer is not suitable for all growing areas as soils are different in soil fertility. According to Ullah *et al.* (2010), applications of nitrogen fertilizer at the rates of 80 and 120 kg/ha together with cutting at 60 day intervals could provide acceptable yield in Napier grass.

However, application of nitrogen at the excessive doses would result in un-necessary payment on high fertilizer cost. The application of nitrogen fertilizer at the correct rate will help reduce the production cost. A soil test kit is currently developed by Kasetsart University and the test kit can help the farmers to evaluate soil fertility in the field as it can tell the residues of elements such as nitrogen, phosphorus and potassium in the field. The soil test kit is user-friendly, rapid and not expensive.

However, the instructions in the manual of the soil test kit are available only for important economic crops such as cassava, rice, sugarcane, legumes, vegetables and fruits, but the instructions are not available for tropical pasture crops. To provide the instructions for Napier grass, the soil test kit should be evaluated for nitrogen requirement in Napier Pakchong 1 grass by applying a guide of sugarcane because they have similar morphology and might have a similar response. The objective of this study was to evaluate the nitrogen fertilizer requirement of Napier Pakchong 1 grass by using a soil test kit. The information obtained in this study is useful for giving the suggestions for Napier Pakchong 1 grass.

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 November, 2017 to August, 2018. Seven treatments consisting of unfertilized control, urea at the rate of 62.5 kg N/ha, ammonium sulphate at the rate of 62.5 kg N/ha, cattle manure at a rate of 62.5 kg N/ha, urea at the rate recommended by soil test kit, ammonium sulphate at the rate recommended by soil test kit and cattle manure at the rate recommended by soil test kit were assigned in a

randomized complete block design with four replications. The detailed applications of fertilizers for the treatments recommended by soil test kit are available in Table 1. The weather data during the growing season were obtained from the Bangna agrometeorogical station, which is the nearest station to our field and the data are available on the website (http://www.aws-observation.tmd.go.th/web/climate/climate_past.asp) of the Meteorological Department of Thailand.

Table 1. Rates of fertilizers applied to the grass at three cutting times

Fertilizer	Application time (kg N/ha)		
	1st cutting	2nd cutting	3rd cutting
Unfertilized control	00.0	00.0	00.0
46-0-0 at a rate 62.5 kg N/ha	62.5	62.5	62.5
21-0-0 at a rate 62.5 kg N/ha	62.5	62.5	62.5
Cattle manure at a rate 62.5 kg N/ha	62.5	62.5	62.5
46-0-0 recommended by STK[1/]	27.5	32.5	32.5
21-0-0 recommended by STK[1/]	27.5	32.5	37.5
Cattle manure recommended by STK[1/]	22.5	32.5	22.5

[1/] = Soil test kit

Soil preparation and cultural practices

The soil in this study is Bangkok soil series, which is characterized by clay soil with high organic matter and medium soil fertility. Soil samples were taken at initial condition for chemical analysis. The soil was ploughed two times and the soil surface was levelled. Cattle manure was also sampled for analysis of the nitrogen content prior to application to the experiment.

The experimental site was further divided into 28 plots or raised beds with a size of 2×3 m, leaving the alley of 1 meter between each plot for good drainage. Napier Pakchong 1 grass was planted on November 6, 2017 with a spacing of 1.2 m between rows and 0.8 m between plants. Clones with healthy buds at the age of 90 days were used as planting materials. Irrigation was supplied to the crops twice a day to avoid drought stress during the dry spell and there was also rainfall during growing period. For the treatments recommended by the Department of Livestock Development (2006) the fertilisers in the forms of urea, ammonium sulphate and cattle manure were applied at the rate of 62.5 Kg N/ha at all three cutting times. For treatments recommended by soil test kit, the fertilizers in the forms of urea, ammonium sulphate and cattle manure were applied at the rates calculated for nitrogen requirements at three cutting times (Table 1).

Plant data and data analysis

The grass was cut for first time at the soil surface at 75 days after planting for uniformity of the regrowth. The cut grass was removed from

the plots and it was not used for data collection. Data collection was carried out for the next three cutting times at 60 day intervals on 24 March 2018, 23 May 2018 and 22 July 2018. The plants were cut at the soil surface and the data were recorded for plant height, tiller number per plant and fresh weight in the field.

The cut grass was removed from the plots, then the sample in each plot was chopped into small pieces and then the chopped sample of each plot was oven-dried at the 80 ^{o}C for 48 hrs or until dry weight was consistent. The dry matter yield was then recorded. All data were then analyzed for 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

Soil initial condition

Soil samples were collected for chemical analysis before planting. The soil chemical properties among the soil samples of the plots were rather uniform (Table 2). Soil pH values were in the narrow range between 6.9 and 7.1, whereas the values of electrical conductivity (EC) were between 291 and 492 (µs/cm). The values of organic matter (OM) were rather high, ranging from 3.55 to 3.95 %). Macro and micro elements such as phosphorus (P) and potassium (K) and calcium (Ca) nutrients were sufficient for the plant, ranging from 533 to 693, 330 to 432 and 2,278 to 2,378 ppm, respectively. However, nitrogen (N) was deficient in the soil before planting.

Table 2. Chemical properties of soil analysis before planting

Fertilizers	pH	EC (µs/cm)	OM (%)	P (ppm)	K (ppm)	Ca (ppm)
Unfertilized control	7.1	291	3.55	631	413	2,298
46-0-0 at a rate 62.5 kg N/ha	6.9	405	3.88	632	385	2,347
21-0-0 at a rate 62.5 kg N/ha	7.0	327	3.95	693	432	2,300
Cattle manure at a rate 62.5 kg N/ha	6.9	355	3.76	600	416	2,319
46-0-0 recommended by STK[1/]	6.9	492	3.89	533	330	2,378
21-0-0 recommended by STK[1/]	7.0	292	3.69	597	405	2,278
Cattle manure recommended by STK[1/]	7.0	401	3.73	537	407	2,369
F-test	ns	ns	ns	ns	ns	ns
C.V. %	1.85	39.49	14.14	11.84	5.65	4.85

ns = non significant
[1/]STK = Soil test kit

Weather condition

Monthly total rainfall, monthly maximum temperature, monthly minimum temperature and monthly mean temperature of each month from planting to the 3rd cutting are shown in the Figure 1. The monthly temperatures were rather smooth during the growing season. The maximum temperatures ranged from 33.9 to 35.6 ℃, minimum temperatures ranged from 16.1 to 24.0 ℃ and average temperatures ranged from 26.0 to 29.4 ℃. The heavy rainfalls of 316.4 and 320.8 mm occurred during the crop season in January and April, 2018, respectively. The heavy rainfalls of 121.8, 150.8 and 189.2 mm also occurred during the 2nd to 3rd cuttings in May and July, 2018, respectively. However, the rainfalls of 74.6 and 103.6 mm after the cut before harvest in February to March, 2018 were rather low.

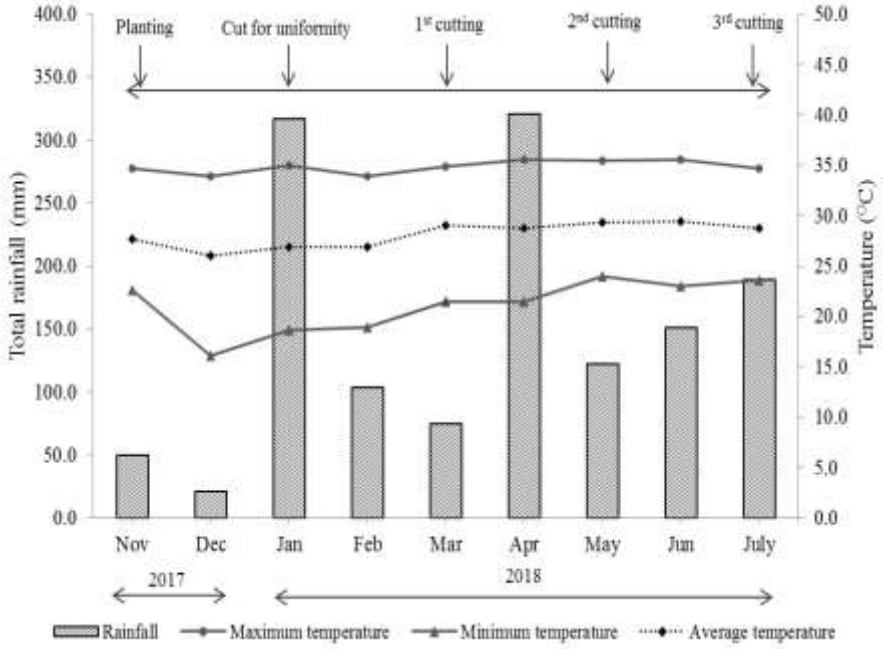

Figure 1. Weather data during planting to the 3rd cutting time

Plant height

The fertilizer treatments were significantly different (P≤0.01) for plant height at the first cutting time, but they were not significantly different at the second and the third cutting times (Table 3). Plant heights ranging from 156 cm in unfertilized control and 194 cm ammonium sulphate recommended by STK were observed among the fertilizer treatments in the first cutting times. However, there were only two treatments including

ammonium sulphate at the rate 62.5 kg N/ha and ammonium sulphate recommended by STK, which were significantly higher than unfertilized control.

The treatments combined from the three cutting times were also not significantly different for plant height, ranging from 144 cm in unfertilized control and 173 cm in ammonium sulphate recommended by STK. However, other fertilizer treatments were higher than unfertilized control.

Table 3. Plant height of Napier Pakchong 1 grass receiving different forms and rates of nitrogen fertilizer evaluated at three cutting times at 60 days intervals

Fertilizer	**Plant height (cm)**			
	1st cutting	**2nd cutting**	**3rd cutting**	**Mean**
Unfertilized control	156[c]	158	117	144
46-0-0 at a rate 62.5 kg N/ha	170[abc]	180	149	167
21-0-0 at a rate 62.5 kg N/ha	190[ab]	169	137	165
Cattle manure at a rate 62.5 kg N/ha	163[bc]	161	128	152
46-0-0 recommended by STK[1/]	169[abc]	168	166	168
21-0-0 recommended by STK[1/]	194[a]	179	146	173
Cattle manure recommended by STK[1/]	161[c]	179	156	165
F-test	**	ns	ns	ns
C.V. %	6.70	10.85	21.61	10.36

ns and ** = non significant and significantly different at P≤ 0.01
Means in the same column followed by the same letter(s) are not significantly different by DMRT
[1/]STK = Soil test kit

Table 4. Tiller number of Napier Pakchong 1 grass receiving different forms and rates of nitrogen fertilizer evaluated at three cutting times at 60 days intervals

Fertilizer	**Tiller number per plant**			
	1st cutting	**2nd cutting**	**3rd cutting**	**Mean**
Unfertilized control	10.4	10.4	6.8	9.2
46-0-0 at a rate 62.5 kg N/ha	12.1	10.9	12.1	11.7
21-0-0 at a rate 62.5 kg N/ha	12.5	12.7	8.8	11.3
Cattle manure at a rate 62.5 kg N/ha	10.1	9.5	7.4	9.0
46-0-0 recommended by STK[1/]	13.7	11.1	10.8	11.7
21-0-0 recommended by STK[1/]	12.6	12.2	10.1	11.6
Cattle manure recommended by STK[1/]	9.7	9.8	10.4	10.0
F-test	ns	ns	ns	ns
C.V. %	17.65	15.51	27.88	17.32

ns = non significant
[1/]STK = Soil test kit

Tiller number

The fertilizer treatments were not significantly different for tiller number at all cutting times and the treatments from combined data of the three cutting times were also not significantly different (Table 4). As the treatments were not significantly different at all cutting times and the values of all treatments were not consistent across cutting times, the means from three cutting times were used to explain the performance of the crop for this parameter. Although they were not significantly different, however, urea and ammonium sulphate fertilizer both at the rate recommended by the Department of Livestock and the rate recommended by the soil test kit had higher number of tillers than did unfertilized control and cattle manure, whereas applications of cattle manure at both rates were similar to unfertilized control for this parameter.

SPAD chlorophyll reading meter (SCMR)

The fertilizer treatments were significantly different ($P \leq 0.05$) for SPAD chlorophyll meter reading (SCMR) at the first cutting time and the second cutting time, and they were also significantly different ($P \leq 0.05$) for the combined data of three cutting times (Table 5). Most fertilizer treatments were significantly higher than unfertilized control for SCMR at least at one cutting time except for ammonium sulphate at the rate recommended by STK. The combined data also indicated that most fertilizer treatments were significantly different from unfertilized control except for ammonium sulphate at the rate recommended by STK.

Table 5. SPAD chlorophyll meter reading (SCMR) of Napier Pakchong 1 grass receiving different forms and rates of nitrogen fertilizer evaluated at three cutting times at 60 days intervals

Fertilizer	**SCMR**			
	1st cutting	**2nd cutting**	**3rd cutting**	**Mean**
Unfertilized control	34.8[b]	28.1[b]	30.2	31.0[b]
46-0-0 at a rate 62.5 kg N/ha	41.0[ab]	48.6[a]	31.5	40.4[a]
21-0-0 at a rate 62.5 kg N/ha	49.9[a]	37.9[ab]	28.3	38.7[a]
Cattle manure at a rate 62.5 kg N/ha	49.1[a]	40.3[a]	33.9	41.1[a]
46-0-0 recommended by STK[1/]	44.9[a]	41.3[a]	31.6	39.2[a]
21-0-0 recommended by STK[1/]	40.3[ab]	38.5[ab]	29.5	36.1[ab]
Cattle manure recommended by STK[1/]	48.7[a]	37.6[ab]	33.2	39.8[a]
F-test	*	*	ns	*
C.V. %	13.33	18.62	11.73	10.69

ns and *= non significant and significantly different at $P \leq 0.05$
Means in the same column followed by the same letter(s) are not significantly different by DMRT
[1/]STK = Soil test kit

Fresh yield

Significant differences (P≤ 0.01) among the fertilizer treatments were of served for fresh yield of the grass at the first cutting time and the third cutting time, and they were also significantly different (P≤ 0.05) when the data of three cutting times were combined (Table 6). At the first cutting, most fertilizer treatments were not significantly different from unfertilized control (13.7 t/ha) except for ammonium sulphate recommended by STK (25.8 t/ha). At the third cutting, most fertilizer treatments were significantly different from unfertilized control (11.1 t/ha) except for urea at the rate of at the rate 62.5 kg N/ha (recommended rate) (14.9 t/ha). For the combined data of three cutting times, most fertilizer treatments were not significantly different from unfertilized control (39.2 t/ha) except for ammonium sulphate at the rate of 62.5 kg N/ha (58.6 t/ha) and ammonium sulphate at the rate recommended by STK (57.9 t/ha).

Table 6. Fresh yield of Napier Pakchong 1 grass receiving different forms and rates of nitrogen fertilizer evaluated at three cutting times at 60 days intervals

Fertilizer	**Fresh yield (t/ha)**			
	1st cutting	**2nd cutting**	**3rd cutting**	**Total**
Unfertilized control	13.7^{c}	14.4	11.1^{c}	39.2^{c}
46-0-0 at a rate 62.5 kg N/ha	17.4^{abc}	20.2	14.9^{abc}	52.5^{abc}
21-0-0 at a rate 62.5 kg N/ha	24.8^{ab}	16.0	17.8^{a}	58.6^{a}
Cattle manure at a rate 62.5 kg N/ha	14.9^{bc}	15.3	12.9^{b}	43.1^{bc}
46-0-0 recommended by STK[1/]	17.5^{abc}	15.3	14.0^{ab}	46.8^{abc}
21-0-0 recommended by STK[1/]	25.8^{a}	16.7	14.4^{ab}	57.9^{ab}
Cattle manure recommended by STK[1/]	13.5^{c}	17.0	14.6^{ab}	45.1^{abc}
F-test	**	ns	**	*
C.V. %	26.03	25.49	13.25	17.49

ns and *,** = non significant and significantly different at P≤ 0.05 and P≤0.01, respectively
Means in the same column followed by the same letter(s) are not significantly different by DMRT
[1/]STK = Soil test kit

Dry matter yield

The fertilizer treatments were significantly different for dry matter yield at the first cutting time (P≤ 0.01) and the second cutting time (P≤ 0.05), and they were also significantly different (P≤ 0.01) when the data of three cutting times were combined (Table 7). At the first cutting time, most fertilizer treatments were not significantly different from unfertilized control (2.3 t/ha) except for ammonium sulphate at the rate 62.5 kg N/ha (4.2 t/ha) and ammonium sulphate at the rate recommended by STK (4.4 t/ha). At the

second cutting time, most fertilizer treatments were significantly different from unfertilized control (1.6 t/ha) except for ammonium sulphate at the rate of 62.5 kg N/ha (2.4 t/ha) and Cattle manure at the rate of 62.5 kg N/ha (2.0 t/ha).

The combined data of three cutting times indicated that applications of nitrogen fertilizer of urea and ammonium sulphate and at the rate of 62.5 kg N/ha and the rate recommended by STK were significantly higher than unfertilized control (4.9 t/ha), whereas applications of cattle manure at the rate of 62.5 kg N/ha (6.2 t/ha) and the rate recommended by STK (6.6 t/ha) were not significantly different from unfertilized control (4.9 t/ha).

Table 7. Dry matter yield of Napier Pakchong 1 grass receiving different forms and rates of nitrogen fertilizer evaluated at three cutting times at 60 days intervals

Fertilizer	**Dry matter yield (t/ha)**			
	1st cutting	**2nd cutting**	**3rd cutting**	**Total**
Unfertilized control	2.3[b]	1.6[c]	1.0	4.9[b]
46-0-0 at a rate 62.5 kg N/ha	3.0[ab]	3.2[a]	2.0	8.2[a]
21-0-0 at a rate 62.5 kg N/ha	4.2[a]	2.4[abc]	1.9	8.5[a]
Cattle manure at a rate 62.5 kg N/ha	2.4[b]	2.0[bc]	1.8	6.2[ab]
46-0-0 recommended by STK[1/]	3.1[ab]	2.7[ab]	2.1	7.9[a]
21-0-0 recommended by STK[1/]	4.4[a]	2.9[ab]	2.2	9.5[a]
Cattle manure recommended by STK[1/]	2.0[b]	2.7[ab]	1.9	6.6[ab]
F-test	**	*	ns	**
C.V. %	24.99	24.88	30.04	18.59

ns and *,** = non significant and significantly different at P≤ 0.05 and P≤0.01, respectively
Means in the same column followed by the same letter(s) are not significantly different by DMRT
[1/]STK = Soil test kit

Discussion

The questions underlying the research project was one of the best among urea, ammonium sulphate and cattle manure for Napier Pakchong 1 grass and soil test kit is useable for guiding nitrogen application in Napier Pakchong 1 grass. In this study, the grass responded poorly to cattle manure, but it responded very well to urea and ammonium sulphate. Application of ammonium sulphate both at the recommended rate and the rate recommended by the soil test kit tended to better growth and dry matter yield than application of urea at the recommended rate and the rate recommended by the soil test kit. The results were in agreement with those reported previously. According to Martha *et al.* (2004), urea and ammonium sulphate were equally effective in sustaining herbage dry matter of Napier grass if they are used in short term. Application of cattle manure is reasonable if cattle manure is the on farm waste. It is not recommended to

buy cattle manure to replenish soil fertility in pasture grass production because it has very low plant nutrients and not economical.

In this study, application of ammonium sulphate at a rate of 62.5 kg N/ha (recommendation rate) in Napier Pakchong 1 grass had dry matter yield ranging from 1.9 to 4.2 t/ha/time, and application of ammonium sulphate at the rate recommended by STK could increase yield up to 2.2-4.4 t/ha/time and the amounts of nitrogen were only about 27.5-37.5 kg N/ha. The results of this study indicated that using of nitrogen fertilizer recommended by the soil test kit could reduce the amount of nitrogen fertilizer almost one time compared to the rate recommended by the Livestock Department.

The results implied that the growers could reduce the cost of chemical fertilizer in Napier grass production system if they use nitrogen fertilizer according to the recommendation by the soil test kit. The study pointed out that applications of nitrogen fertilizer at the rates of 27.5 to 37.5 kg N/ha in forms of urea and ammonium sulphate had dry matter yield similar to those of nitrogen at the rate of 62.5 kg N/ha (recommendation rate). According to Ullah *et al.* (2010), the highest yield of Napier grass (*Pennisetum purpureum*) was obtained by application of urea at a high rate of 80-120 kg N/ha together with cutting at 60 day intervals. Although application of high rates might provide the highest yield, the crop responds better to the low rates and, therefore, application at the low rates is more economical than application of the high rates.

However, Peterson *et al.* (1998) pointed out that the levels of pasture crop productivity varied greatly depending upon many factors such as climate, soil type and management practices. In this study, the soil was rather fertile and suitable for growing pasture grasses as indicated by high organic matter and other chemical properties. However, the clay soil had poor drainage and heavy rainfall in some growing periods would affect the variation in crop growth because of water logging problem.

Annual rainfalls suitable for growing Napier grass range between 600 and 1,000 mm (Sandhu *et al.,* 2015), and the crop does not tolerate to the excessive soil water content (Figueira *et al.,* 2015). Manning and Kesby (2008) indicated that seasonal rainfall could affect the application of ammonium sulphate and dry matter yield of tropical grasses. Pholsen *et al.* (2005) revealed that total dry matter of signal grass (*Brachiaria decumbens* Stapf. cv. Basilisk) in the rainy season was significantly higher for urea treatment than manure treatment, but they were not significantly different when the crop was grown in the dry season. Nitrogen form, soil type, soil fertility, and weather condition are important factors affecting production systems of Napeir Pakchong 1 grass. The results in this study would be applicable to the soil types and growing conditions that are similar to that in this study. Care must be taken when the results are applied to different

growing conditions and soil types, and more studies in different soil types are still required to verify the results.

This study can be concluded that the recommendation for using a soil test kit in sugarcane can be applied to use for Napier Pakchong 1 grass. It was also found that the use of ammonium sulphate both at the recommended rate and followed soil test kits were more likely resulted in better growth and dry matter yield. However, it was not a significant difference from urea fertilizer.

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