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Evaluation of Yield and Nutritive Value of Kenaf (*Hibiscus cannabinus*) at Various Stages of Maturity

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Abstract: The objective of this study was to evaluate potential yield and chemical composition of kenaf as fodder for ruminants. Kenaf (*Hibiscus cannabinus*), variety Khon-Kaen 50, was planted at seed and row spacing of 30 and 50 cm, respectively. The plants were sampled at 6, 8, 10 and 12 weeks after planting. The findings revealed that dry matter yield and crude protein yield of 6-12 week-old kenaf were 0.12-2.14 and 0.02-0.14 t/ha, respectively ($p<0.05$). Crude protein (14.34-6.58%) content of kenaf decreased significantly ($p<0.05$) as harvesting age advanced. On the other hand, neutral detergent fiber (41.99-48.74%) and acid detergent fiber (27.20-30.57%) of kenaf increased statistically ($p<0.05$) with maturity advanced. The results indicated that 10 week-old kenaf with DM yield of 0.95 t/ha and contained 10% of CP could be used as fodder for ruminants.

Key words: Kenaf, nutritional composition, fodder protein, maturity stage, ruminant feed

INTRODUCTION

The expansion of the livestock production in developing countries relied mainly on importation of feed grains rather than on the exploitation of the available local feed resources (Calpe, 1992). Grain generally makes up between 55-85% of most of the conventional compound feed, where protein is normally supplied from oil seed cake or meal and animal or fish by-products (Machin, 1992). Intensification of livestock, particularly ruminant, production in the tropical regions should not rely solely on the intensive use of grains. Strategies for ruminant development should be based on the optimal utilization of local feed resources, to reduce feed cost as it makes up about 65 % of the production cost (Azizan and Eusof, 1996). Research results have demonstrated that it is possible to improve current ruminant production with the appropriate use of tropical feed resources such as legume and fodder. Protein fodders such as *Leucaena leucocephala*, *Gliricidia sepium* and *Calliandra calothysus* have received much attention in the tropics and in most cases the results have been encouraging (Bosma and Bicabe, 1997; Nherera *et al*., 1998; Stewart *et al*., 1998).

Kenaf (*Hibiscus cannabinus*) is normally produced for its fiber. The best fiber is usually obtained from kenaf harvested at about 17 week-old (Berger, 1969). However, immature kenaf has the potential as fodder protein because at the earlier growth stage its protein content is high (Phillips *et al*., 1996). The nutrient content in immature kenaf was found to be comparable to alfalfa hay (Swingle *et al*., 1978) and its production was relatively high (Phillips *et al*., 1999; Najid and Ismawaty, 2001). When harvested at 12 week-old, kenaf could be grown and harvested about four times a year and with a potential annual production of about 40.6 ton DM/ha (Najid and Ismawaty, 2001). Based on the optimum of forage quality and quantity, kenaf was best harvested between 10 and 12 weeks after planting (WAP), when CP is approximately 15% (Phillips *et al*., 1999). Furthermore, kenaf has been successfully tested in beef cattle (Rude *et al*., 2002) and small ruminants (Xiccato *et al*., 1998; Phillips *et al*., 2002a,b). However, the information of potential yield and chemical composition of kenaf as fodder for ruminants in the tropics is presently insufficient. Therefore, this study was conducted to evaluate yield and nutritive value of kenaf at 6, 8, 10 and 12 WAP.

MATERIALS AND METHODS

Kenaf variety Khon-Kaen 50 was planted at Mahasarakham University farm in Maha Sarakahm province located in northeastern Thailand, latitude 16°62'N, longitude 102°45'E. The kenaf was planted in plots (10x12 m) with seed and row spacing of 30 and 50 cm, respectively. The soil was loamy fine sand and its pH was 6. Fertilizer, NPK (8:8:8), was applied shortly after seeding at 300 kg/ha. Eradication of weed in experimental plots was carried out weekly.

Kenaf was sampled at approximately 5 cm above ground level using a 1x1m quadrant (two replicates for each sampling) on 6, 8, 10 and 12 WAP. Plants within the quadrant were immediately weighed to determine fresh weight. Five plants were selected randomly from each quadrant and measured for plant heights, number

Table 1: Production characteristics of 6, 8, 10 and 12 week-old kenaf

	Kenaf (week-old)				
Parameters	6	8	10	12	SEM
Fresh yield (t/ha)	0.75^{d}	2.47^{c}	2.96^{b}	4.96^{a}	1.57
DM Yield (t/ha)	0.12^{d}	0.47^{c}	0.95^{b}	2.14^{a}	0.80
Leaf DM yield (t/ha)	0.08^{d}	0.31^{c}	0.56^{b}	1.04^{a}	0.11
Stem DM yield (t/ha)	0.04^{d}	0.16^{c}	0.39^{b}	1.10^{a}	0.12
Protein DM yield (t/ha)	0.020^{d}	0.060^{c}	0.097^{b}	0.140^{a}	0.014
Plant height (cm)	33.22^{d}	47.87^{c}	74.53^{b}	123.93^{a}	7.93
Number of leaves	11.00^{d}	22.00^{c}	47.00^{b}	64.80^{a}	4.86
Leaf-stem ratio	2.24^{d}	1.95^{c}	1.47^{b}	0.95^{a}	0.15

^{a,b,c,d} Superscripts that differ are significant at $p<0.05$

Table 2: Chemical composition (%) of whole plant, leaf and stem of 6, 8, 10 and 12 week-old kenaf

	Kenaf (week-old)				
Parameters	6	8	10	12	SEM
Whole plant					
DM	15.82^{d}	18.88^{c}	31.89^{b}	43.19^{a}	4.12
CP	14.34^{a}	11.92^{b}	10.06^{c}	6.58^{d}	1.07
Ash	9.79^{a}	6.55^{b}	6.52^{b}	4.53^{c}	0.71
NDF	41.99^{c}	42.83^{bc}	45.14^{b}	48.74^{a}	1.02
ADF	27.20^{d}	28.23^{c}	28.57^{b}	30.57^{a}	0.46
Leaf					
CP	19.37^{a}	16.47^{c}	17.62^{b}	13.93^{d}	0.75
Ash	10.24^{a}	9.65^{b}	8.89^{c}	7.80^{d}	0.35
NDF	26.51^{d}	32.03^{c}	33.86^{b}	35.42^{a}	1.27
ADF	16.21^{b}	16.29^{b}	17.79^{a}	17.87^{a}	0.30
Stem					
CP	9.02^{a}	6.60^{b}	5.21^{c}	4.78^{d}	0.63
Ash	4.78^{b}	6.33^{a}	3.91^{c}	2.34^{d}	0.55
NDF	58.06^{b}	61.68^{a}	61.75^{a}	62.85^{a}	0.73
ADF	50.20^{b}	48.13^{d}	49.56^{c}	50.90^{a}	0.39

^{a,b,c,d}Superscripts that differ are significant at $p<0.05$

of leaves and later, separated the leaves and stems to determine leaf to stem ratio. The cumulative precipitation and the average temperature during the experimental period were 108.5 mm and 31.3°C, respectively.

Whole plant, leaf and stem samples from each quadrant were chopped and dried at 60°C to constant weight to determine DM. Dried samples were ground through a 1-mm screen and analyzed for the contents of Crude Protein (CP), ash (AOAC, 1990), Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) (Robertson and Van Soest, 1981). Yield of DM per unit area of whole plant, leaf and stem fractions and CP yield per unit area of whole plant were estimated from fresh weight, DM and CP contents of each fraction.

Statistical analysis: Data were analyzed in Completely Randomize Design using the general linear model procedure (SAS, 1996) according the following statistical model: $Y_{ij} = \mu + A_i + e_{ij}$, where A is effects of age of kenaf. The differences among means were compared by Duncan's New Multiple Range Test (Steel and Torries, 1980).

RESULTS AND DISCUSSION

Fresh and DM yield of whole plant, leaf and stem of kenaf increased significantly ($p<0.05$) with increasing age of cutting (Table 1). These results are in agreement with Chantiratikul *et al.* (2006). However, the DM yield of 6-10 week-old kenaf (0.12-0.95 t/ha) in present study was dramatically lower than that of previous studies which reported DM yield of 6-9 week-old kenaf ranged from 2 (Phillips *et al.*, 1999; Muir, 2002) to 5 t/ha (Killinger, 1969; Chantiratikul *et al.*, 2006). The discrepancy among the different reports could be due to differences in plant variety, seeding rate and environment. The leaf-stem ratio decreased ($p<0.05$) when cutting age of kenaf increased (Table 1). Normally, as kenaf increased in maturity, the lower leaves senesced and resulted in decreasing proportion of leaves, but increasing proportion of stems (Webber, 1993).

Plant height and number of leaves increased ($p<0.05$) as maturity advanced (Table 1). Height of 6-8 week-old kenaf (33.22-47.87 cm) was shorter than that of the same age kenaf (93-159.5 cm) in foregoing study (Chantiratikul *et al.*, 2006). Generally, rate of plant growth is mainly dependant on plant variety and other agronomic factors such as season of grown, quality of soil, fertilizer, temperature and rainfall (Rowell and Han, 1999). The number of leaves increased from 11/plant at week 6 - 22/plant at week 8 (Table 1). The result of number of leaves is consistent with previous study

which reported that the number of leaves of various varieties of 6-8 weed-old kenaf varied from 10-26 leaves (Adamson *et al*., 1972). However, number of leaves of 6-8 week-old kenaf, variety Khon-Kaen 60, ranged from 79.2-144.4 leaves (Chantiratikul *et al*., 2006). The results indicated that variety of kenaf had significant impact on number of leaves and Khon-Kaen 60 variety is leafier than Khon-Kaen 50 variety.

CP content of whole plant, leaf and stem decreased with maturity (Table 2), with CP content in leaf (13.93 - 19.37%) was higher than that in stem (4.78-9.02%). The similar results were found in previous studies (Swingle *et al*., 1978; Webber, 1993; Phillips *et al*., 1999, Chantiratikul *et al*., 2006). The reduced CP content in the stem as plant matured was mainly due to rapid accumulation of fibrous components (Table 2). Similar findings were reported previously (Suriyajantratong *et al*., 1973; Phillips *et al*., 1999; Wong and Vijasegaran, 2001). Maturity has a large influence on the CP content of kenaf and its reduction may be explained by two factors; I) fodder mature increase proportionally in the stem and ii) CP content fall in all fractions with maturity advanced (Minson, 1990).

Neutral detergent fiber and ADF of whole plant, leaf and stem increased ($p<0.05$) with increasing maturity stage (Table 2). The obtained fibrous contents of whole plant were similar to those in foregoing studies (Swingle *et al*., 1978; Phillips *et al*., 1996; 1999). In the those studies, NDF was reported to be between 28.6-42.9% while ADF varied from 23.6-32.6% (at between 9-12 WAP). Normally, fiber content increased with plant maturity but environmental factors, particularly rainfall and temperature play an important role in determining this component of plant (Muir, 2002; Minson, 1990).

Although proportionally CP content of each plant part decreased as harvesting stage, CP yield of kenaf increased ($p<0.05$) substantially. This is because of the progressive increased yield of the plant (Table 1). However, CP yield (0.02-0.14 t/ha) in this study was significantly lower than that of other researches. Chantiratikul *et al*. (2006) reported that CP yield of 8 week-old kenaf was approximately 1 t/ha. Webber (1993) revealed that 11 and 14 week-old kenaf produced 0.39 and 0.449 t CP/ha, respectively.

The objective of this study was to evaluate the quality of kenaf as fodder for ruminants, the current results indicated that immature kenaf Khon-Kaen 50 variety produced lower yield and CP content than Khon-Kaen 60 variety (Najid and Ismawaty, 2001; Chantiratikul *et al*., 2006). However, 10 week-old kenaf Khon-Kaen-50 variety with potential DM yield of 0.95 t/ha and contained 10% of CP could be used as supplemental fodder for ruminants when the shortage of high quality fodder occurs. Additionally, further studies are needed to determine *in situ* nutrient digestibility of kenaf at the different cutting ages.

Conclusion: Dry matter yield and CP yield of 6-12 week-old kenaf were 0.12-2.14 and 0.02-0.14 t/ha, respectively ($p<0.05$). Crude protein (14.34-6.58%) content of kenaf decreased significantly ($p<0.05$) as harvesting age advanced. On the other hand, NDF (41.99-48.74%) and ADF (27.20-30.57%) of kenaf increased statistically ($p<0.05$) with maturity advanced.

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