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DAFTAR ISI

BIOMASS PRODUCTIVITY OF 4 *PENNISETUM* SPECIES AS AFFECTED BY CUTTING INTERVAL AND CUTTING HEIGHT FOR TWO YEARS AFTER ESTABLISHMENT

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Abstract: Biomass Productivity of 4 *Pennisetum* Species as affected by Cutting Interval and Cutting Height For Two Years After Establishment. The effect of cutting interval and cutting height on dry matter productivity were compare among 4 *Pennisetum* species, napiergrass, kinggrass, hybrid napiergrass and pearl millet in the established year to examined the suitable cutting practice for the productivity and persistence. The cutting interval were 60 and 90 days, and the cutting height were 0 and 30 cm above the ground. From the 4 species showed that, annual herbage dry matter yield (HDMY) was the highest in kinggrass followed by hybrid napiergrass, napiergrass and pearl mille, and was the higher in the plants at a 90-day interval and 0-cm height than at a 60-day interval and 30-cm height, respectively. The plants cut at a 90-day interval at a 0-cm height had the highest in mean tiller weight, crop growth rate, net assimilation rate and HDMY, but the lowest tiller number and percentage leaf blade to whole harvested plant. It can be concluded that, the correlation coefficients between HDMY and plant characters were positive for correlation for mean tiller weight, leaf area index and crop growth rate in all 4 species. and were negative for tiller number and percentage leaf blade except for pearl millet.

Abstrak: Produksi Biomass 4 Spesies *Pennisetum* Sebagai Efek Interval dan Tinggi Pemotongan Selama Dua Tahun Pembentukan. Efek interval dan tinggi pemotongan terhadap produksi bahan kering akan dianalisis terhadap 4 spesies *Pennisetum* yaitu, napiergrass, kinggrass, hybrid napiergrass and pearl millet selama dua tahun pembentukan untuk menguji kesesuaian tingkat pemotongan terhadap produktivitas dan persistensi empat jenis rumput. Interval pemotongan adalah 60 dan 90 hari, sedangkan tinggi pemotongan adalah 0 dan 30 cm diatas permukaan tanah. Dari keempat varitas yang diuji terlihat bahwa, produksi tahunan forase bahan kering segar sangat tinggi dicapai oleh varitas oleh kingrass kemudian hybrid napiergrass, napiergrass dan pearl millet. Produksi forase bahan kering pada tinggi pemotongan dicapai pada interval pemotongan 90 hari dengan tinggi pemotongan 0 cm dibanding dengan interval pemotongan 60 hari dengan tinggi pemotongan 30 cm. Rata-rata berat tunas, crop growth rate dan net assimilation rate serta produksi bahan kering keseluruhan dicapai sangat tinggi pada pemotongan rumput pada interval 90 hari dengan tinggi pemotongan 0 cm, namun hasilnya sangat rendah pada jumlah tunas dan persentase berat daun. Dapat disimpulkan bahwa korelasi koefisien produksi bahan kering dan segar beberapa karakter tanaman seperti berat tunas, leaf area index dan crop growth rate adalah korelasi positif pada 4 varitas dan terlihat berkorelasi negative pada jumlah tunas dan persentase berat daun kecuali pada pearl millet.

Kata Kunci : interval pemotongan, *pennisetum*, produksi biomas, tinggi pemotongan

Pennisetum species, especially napiergrass or elephantgrass are widely grown in tropical and sub-tropical regions for forage as well as for grain (Ito and Inanaga, 1998). Among *Pennisetum* species, there are many relatives which were bred by reciprocal crossing, such as kinggrass or banagrass (napiergrass (*Pennisetum purpureum*) x pearl millet (*P. thypoides*). Napiergrass was precisely examined for the wide profitability at several sites in tropical areas. However, since the stem of napiergrass is easily hardened after elongation, the plants for forage should be cut at intervals before stem elongation. This growth characteristics obstructs the popularization of napiergrass among farmers. Thus, in the normal napiergrass the optimum cutting interval was determined to be 2 months on quality bases, and 3 months on a yield basis (Sunusi et al, 1997). Usually, the farmers cut plants at 30 cm above the ground level, when the

stem elegotaed.

The forage quality of napiergrass is improved by introducing the characters of crossing-bred *Pennisetum* to pearl millet (Pietense et al, 1993) or by introducing the dwarfism to napiergrass (Mukhtar, 2006). The productivity and quality of *Pennisetum* species markedly varies with the method of cutting practice (Siregar, 1989 and Mukhtar, 2006). Defoliation is known as important factors for the forage grass production. Defoliation of grass has multiple influences on the growth characters as well as the forage quality of plant, especially depending on the various conditions such as the growth stage, climatic factors and defoliation intensity.

This study aimed to examine the suitable cutting interval and cutting height for obtaining high biomass productivity especially for herbage dry matter yield (HDMY) in napiergrass, kingggrass, hybrid napiergrass and pierl millet after established year.

MATERIALS AND METHODS

Grass species examined were napiergrass (*Pennisetum purpureum*, cv. Wruk wona) that is promising high yielding napiergrass variety, kinggrass (*Pennisetum purpureum* x *Pennisetum thypoides*, named from Indonesia), hybrid napiergrass (*Pennisetum thypoides* x *Pennisetum purpureum*, hybrid hexaploid named from University of Florida, USA) and pearl millet examined in 2006 and hybrid napiergrass in 2007.

Rooted tiller of 4 *Pennisetum* species were transplanted at 50 cm x 50 cm spacing (4 plants/m^2). The plants of each species were divided into two groups, and cut at 60-day and 90-day intervals (main plots) and each groups was subdivided into two groups (subplot) and cut at 0 cm and 30 cm from ground level. The area of each subplot was 2.5 m x 2.5 m. Subplots were set for each species in Latin square method with three replications. As a basal fertilizer, manure at 2 ton/ha and lime at 1 ton/ha were applied 2 weeks before planting. Top dressing of 300 kg/N/ha/year was applied equally by split-application 6 times during investigation.

Fresh matter weight of harvested plants was recorded for 9 plants, and dry matter weight and some plant characters such as tiller number and leaf area were measured for 3 plants from each subplot at each sampling time. Harvested plants were divided into leaf blade, stem with leaf sheath and dead part, and dried at 70° C for more than 3 days to determine dry matter weight. Fresh and dry matter yield were the product of fresh matter weight and dry matter weight of each harvested plant with plant density, respectively.

RESULTS AND DISCUSSION

Results

Annual herbage dry matter yield (HDMY) was the highest in kinggrass (100 %) followed by hybrid napiergrass (93 %), napiergrass (85 %) and the lowest in pearl millet (54 %) on the average of all plants cut at various heights in kinggrass (Table 1).

Table 1. Effect of variants on annual herbage dry matter yield (HDMY) and coefficient of variance (CV) in HDMY.

Variants		Kg	Hn	Na	Pm
Species[1)]	HDMY (kg/m^2 /yr)	2.26[a2)]	2.09[a]	1.91[a]	1.23[b]
		(100)[3)]	(92.5)	(84.5)	(54.4)
	CV (%)	29.93	25.42	33.87	13.6
Cutting interval		90-day interval		60-day interval	
	HDMY (kg/m^2 /yr)	2.26[a]		1.48[b]	
		(100)		(65.5)	
	CV (%)	28.59		21.38	
Cutting height		0-cm height		30-cm height	
	HDMY (kg/m^2 /yr)	2.04[α]		1.70[β]	
		(100)		(65.5)	
	CV (%)	34.41		32.12	

1) Na: Napiergrass, Kg: kinggrass, Hn: hybrid napiergrass, Pm: pearl millet

2) Figures with different letters of a, b and α, β denote the significant difference between elements of each variant at 5% and 10%, respectively.

3) Values in parentheses are percentage of HDMY to that in the maximum elements.

The annual HDMY of the plants cut at a 90-day interval was superior cut at a 60-day interval and that of plants cut at a 30-cm height was superior to that the plants cut at a 0-cm height in all 4 species examined. The coefficient of variants (CV) at HDMY was the smallest in pearl millet. It was smaller in the plants cut at a 60-day interval than that at 90-day interval, and was smaller in the plants cut at a 30-cm height than at a o-cm height. The smaller CVs in pearl millet and in the plants cut at a 60-day interval were partly due to a smaller value of HDMY.

The annual total of herbage fresh matter yield was higher in the plants cut at a 90-day interval than at a 60-day interval and in the plants cut at a 0-cm height than at a 30-cm height. Thus, the highest herbage fresh matter yield and HDMY (161 ton/ha and 29.7 ton/ha, respectively) were obtain by cutting at a 90-day interval at a 0-cm cutting height in kinggrass, and the lowest annual HDMYs (about 11.0 – 11.2 ton/ha) by cutting at a 60-day interval than at a 0-cm or 30-cm in pearl millet.

The difference in annual HDMY among species was smaller in the plants cut at a 60-day interval than at a 90-day interval, which was due to the reduced difference in HDMY in the aftermath, although regrowth in pearl millet was quite poor under both 60-day and 90-day cutting intervals. The plants cut at 90-day interval at a 0-cm height had the highest HDMY, mainly due to the highest HDMY at the first cutting in all 4 species.

The percentage dry matter was the highest in pearl millet followed by napiergrass, kinggrass and hybrid napiergrass, on the average of plants under all cutting practices. The percentage dry matter was higher in the plants cut at a 90-day interval than at a 60-day interval and in the plants cut at a 30-cm height than at a cut 0-cm height. The CV in percentage dry matter was the smallest in napiergrass and tended to be smaller in the plants cut at a 0-cm height than cut at a 30-cm height (Table 2). There was a significantly positive correlation between the percentage dry matter and its CV ($r = 0.714$, $P>0.05$). However, the difference in percentage dry matter between the plants cut at 90- and 30-day intervals were small in all 4 species, except hybrid napiergrass and pearl millet at the time of second cutting with a 90-day interval, which had a high percentage dry matter due to the leaf drying.

Table 2. Effect of variants on percentage dry matter (PDM) and coefficient of variance (CV) in PDM.

Variants		Pm	Na	Kg	Hn
Species[1)]	PDM	21.7[a2)]	16.15[b]	15.77[b]	14.65[b]
		(100)[3)]	(74.4)	(72.7)	(67.5)
	CV (%)	35.14	13.92	14.39	17.48
Cutting interval		90-day interval		60-day interval	
	PDM	19.76[a]		15.27[b]	
		(100)		(77.3)	
	CV (%)	28.59		26.86	
Cutting height		0-cm height		30-cm height	
	PDM	17.99[α]		16.14[β]	
		(100)		(89.7)	
	CV (%)	33.57		22.26	

1) Na: Napiergrass, Kg: kinggrass, Hn: hybrid napiergrass, Pm: pearl millet

2) Figures with different letters of a, b and α, β denote the significant difference between elements of each variant at 5% and 10%, respectively.

3) Values in parentheses are percentage of PDM to that in the maximum elements.

Table 3 shows the annual means of the plant characters of 4 species cut at different cutting intervals and t different height. In the plant cut at a 90-day interval, mean tiller weight, percentage dry matter, HDMY, leaf area index and crop growth rate were higher, but tiller number and percentage leaf blade were lower than in those cut at a 60-day interval. In the plants cut at a 0-

cm height, mean tiller weight, HDMY, crop growth rate and net assimilation rate tended to be higher, but tiller number and percentage leaf blade were lower than in those cut at a 30-cm height and percentage dry matter and leaf area index were not responsive to the cutting height.

HDMY in the aftermath decreased at the second and third cutting times and was lower when cut at a 30-cm height than at a 0-cm height at both cutting intervals in all species, except for pearl millet that had a limited number of tillers at the final cutting at a 0-cm height (data not shown). Most of the tillers whose shoot apices remained as stubble after cutting, regrew rapidly whereas the cutting at a 0-cm height at a 90-day interval possible removed the shoot apices of many tillers. Since many new tillers appeared from the nodes below at a 30-cm height in all species, regrowth was less variable in the plants cut at a 30-cm height.

Table 3. Annual mean in plant characters[1)] in 4 *Pennisetum* species grown by cutting at different intervals and different heights.

Cutting interval	Species[2)]	Cutting height	TN (No/m^2)	MTW (g/tiller)	PLB (%)	PDM (%)	HDMY (g/m^2)	LAI	CGR (g/m^2/d)	NAR (g/m^2/d)
90-day	Na	0-cm	29	51.3	33.3	18.4	1360	7.6	13.4	1.8
		30-cm	32	38.6	40.1	18.2	1066	6.9	10.6	1.6
	Kg	0-cm	27	58.6	34.0	18.1	1484	7.5	14.6	1.9
		30-cm	34	45.4	40.8	17.9	1332	8.4	13.1	1.5
	Hn	0-cm	73	28.3	26.1	21.5	1392	6.9	15.6	2.3
		30-cm	76	20.6	35.1	16.6	1060	7.5	11.8	1.5
	Pm	0-cm	36	18.8	18.1	20.3	732	2.5	6.5	3.8
		30-cm	52	14.6	17.9	30.5	606	2.3	5.5	3.0
60-day	Na	0-cm	48	16.0	48.1	14.3	582	4.1	8.6	2.0
		30-cm	73	11.4	62.0	15.1	446	4.4	6.7	1.4
	Kg	0-cm	62	16.1	47.6	13.9	636	4.9	9.5	1.8
		30-cm	79	12.0	62.1	14.7	499	4.4	7.4	1.6
	Hn	0-cm	121	11.2	49.7	13.0	652	5.9	11.2	1.8
		30-cm	126	8.4	63.0	12.8	500	5.2	8.6	1.4
	Pm	0-cm	44	7.7	39.3	16.6	368	3.2	4.9	2.4
		30-cm	76	6.1	34.0	21.9	373	3.3	5.6	2.4

1) TN: tiller number, MTW: mean tiller weight, PLB: percentage leaf blade, PDM: percentage dry matter, HDMY: herbage dry matter yield, LAI: leaf area index, CGR: crop growth rate, NAR: net assimilation rate.
2) Na: Napiergrass, Kg: Kinggrass, Hn: Hybrid napiergrass, Pm: pearl millet

Discussion

This experiment showed the effect of reciprocal crossing between napiergrass (*Pennisetum purpureum*) and pearl millet (*P.* thypoides) on HDMY. Since the crossing between napiergrass and pearl millet produced kinggrass and the reciprocal crossing between pearl millet and napiergrass produced hybrid napiergrass. HDMY in napiergrass was increased by the crossing with pearl millet and the HDMY was higher in kinggrass than in hybrid napiergrass (Tabel 1). The effect of cutting interval and cutting height on annual HDMY were similar in napiergrass, kinggrass and hybrid napiergrass, but extremely low in pearl millet, as shown by the lowest in HDMY.

In banagrass which was produced by the same crossing as kinggrass, annual HDMY of the plants cut at a 40-day interval was 23 t/ha in Nigeria (Cheda et al., 1993) and 24-26 t/ha under irrigation in Pretoria, South Africa (Koster et al., 1992). Annual of kinggrass was also reported to be 10-19 t/ha when cut at 4- or 14-week intervals in Indonesia (Reksohadiprojo, 1994) and be 21 t/ha when cut at a 6-week interval in Gainesville, Florida (Shank et al., 1993). The yielding data for kinggrass in the present study (15.0 – 29.7 t/ha) were almost in the same range as in these previous data for banagrass and kinggrass.

In the hybrid napiergrass, annual HDMY was higher than that in Krish (*Sorgum* sp), *S. almun* cv. Crooble and pearl millet, and this hybrid napiergrass had superior plant characters such as disease resistance, high percentage of leaf blade to whole harvested plant, high nitrogen content in the stem and high stem digestibility compared to other *Sorgum sp* and pearl milletgrown by cutting at 8-, 10-, 12- and 15-week intervals at Lawes, Australia (Pritchard, 1971). The annual HDMY was higher in the plants cut at a 2-month interval than in those cut at a 1- or 1.5 month interval in hybrid napiergrass in Thailand, and was 11- 18 t/ha and 20-25 t/ha under the dry and irrigated condition, respectively (Nern-Urai, 1998). The annual HDMY in hybrid napiergrass cut at 6-week interval in Gainesville, Florida was 17 t/ha (Shank et al., 1993). These yield data were consistent with annual HDMY in the plants cut at a 60-day interval (15.0 – 19.6 t/ha) in the present study. However, in the tropics, the annual HDMY in hybrid napiergrass was as high as 50 t/ha when grown with stress management for cutting 4 times at a 50-day interval in Bet-Dagan, Israel (Kipnis et al., 1985), and was 43 t/ha when grown by cutting at a 1 month interval throughout the year in Srilangka (Appadurai and Goonnewardene, 1994).

The CV in HDMY among 4 different cutting practices was 34% in napiergrass and 30% in kinggrass, but it was 25% in hybrid napiergrass and 14% in pearl millet as shown in Table 1. The high CV suggested a high response oh HDMY to the method of cutting. On the other hand, the low CV in pearl millet was derived from the inferior regrowth and possibly from the early heading (Table 3).

The CV of percentage dry matter in the plants cut by 4 different method was the highest in pearl millet (35%) followed by hybrid napiergrass (17.5%), and was about 14% in kinggrass and napiergrass. The flexible increase in percentage dry matter was principally derived from the drop in water content of stem by hardening during stem elongation in pearl millet and hybrid napiergrass, which was directly related with the annual habit of pearl millet. The drop in water content or increase in percentage dry matter, caused by stem hardening decreased the digestibility and palatability of stem at maturity in pearl millet and hybrid napiergrass (Schank et al., 1993).

HDMY was positively correlated with mean tiller weight, leaf area index, crop growth rate and cutting interval and negatively with tiller number and percentage of leaf blade to whole harvested plant, except for pearl millet. HDMY is calculated by several ways, for example, as the product of tiller number with mean tiller weight and the product of cutting interval with crop growth rate that is equal to the product of leaf area index with net assimilation rate.

Thus, the change in HDMY was closely correlated with that in mean tiller weight, that in cutting interval and leaf area index in the 4 *Pennisetum* species. However, the change in net assimilation ratedid not closely correlate with that in HDMY and the increase in HDMY often led to the decrease in percentage leaf blade. Since heading reduced tiller number and leaf production especially at the second and third cuttings in the plants cut at a 90-day and 60-day interval, respectively when HDMY was quite low in pearl millet, HDMY were significantly correlated neither with tiller number nor percentage leaf blade in pearl millet.

CONCLUSION

It can be concluded that, the correlation coefficients between HDMY and plant characters were positive for correlation for mean tiller weight, leaf area index and crop growth rate in all 4 species and were negative for tiller number and percentage leaf blade except for pearl millet.

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