DRY MATTER YIELD AND COMPETITIVENESS OF ALANG-ALANG (*Imperata cylindrica*) AND GUINEA GRASS (*Panicum maximum*) IN INTERCROPPING

(Produksi Bahan Kering dan Daya Saing Tanaman Campuran Alang-alang (*Imperata cylindrica*) dan Rumput Benggala (*Panicum maximum*))

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ABSTRAK

Tujuan penelitian ini adalah untuk menentukan produksi bahan kering dan kemampuan bersaing tanaman campuran alang-alang (*Imperata cylindrica*) dengan rumput benggala (*Panicum maximum*). Penelitian disusun dalam kombinasi faktorial dengan empat proporsi tanam, dua tingkat pemupukan N dan tiga interval panen dengan tiga ulangan. Proporsi tanam adalah 0; 33,3; 66,7; dan 100% alang-alang (kepadatan 0, 1, 2 dan 3 tanaman/pot) yang dikombinasikan dengan 100; 66,7; 33,3 dan 0% rumput benggala (kepadatan 3, 2, 1 dan 0 tanaman/pot). Tanaman di pupuk dengan pupuk N dengan dosis 0 dan 250 kg/ha dan dipanen pada interval 30, 45 dan 90 hari. Hasil penelitian memperlihatkan bahwa dengan meningkatnya proporsi tanam alang-alang, produksi bahan kering total menurun. Pemupukan N meningkatkan bahan kering pada kedua spesies tetapi rumput benggala lebih responsif daripada alang-alang. Tanpa memperhatikan proporsi tanam dan pemupukan N, bertambahnya interval panen menurunkan produksi bahan kering tanaman campuran rumput benggala dengan alang-alang. Sistem pertanaman campur memberikan hasil yang lebih tinggi dari pada pertanaman tunggal yang dinilai dari nilai kesetaraan lahan dengan nilai maksimum diperoleh ketika rumput benggala ditanam dengan rasio 2 : 1, diberi pupuk N dan dipanen tiap bulan. Pada sistem pertanaman campur, rumput benggala merupakan tanaman dominan yang dinyatakan dalam tingginya nilai koefisien kerapatan relatif dan indeks agresifitas. Hal itu menunjukkan bahwa rumput benggala yang ditanam bersama dengan alang-alang menggunakan sumber daya lebih agresif daripada alang-alang.

Kata kunci: Rumput benggala, Alang-alang, Produksi bahan kering, Daya saing

ABSTRACT

The objectives of this experiment were to determine dry matter yield and competitiveness of *alang-alang* (*Imperata cylindrica*) and guinea grass (*Panicum maximum*) in intercropping. The experiment was arranged in factorial combinations of four planting proportions, two levels of nitrogen fertilization and three harvesting intervals with three replications. Planting proportions were 0, 33.3, 66.7, and 100% of *alang-alang* (planting densities of 0, 1, 2 and 3 plants/pot) combined with 100, 66.7, 33.3, and 0% of guinea grass (planting densities of 3, 2, 1 and 0 plants/pot). The plants fertilized with nitrogen fertilizer at the doses of 0 and 250 kg/ha and harvested at intervals of 30, 45 and 90 days. Results of experiment showed that as planting proportion of *alang-alang* increased in the mixtures, total dry matter yield of mixed plants decreased. N fertilization increased dry matter yield in both species, but guinea grass was more responsive than *alang-alang*. Regardless of planting proportion and nitrogen fertilization, increasing harvest interval decreased dry matter yield of guinea grass – *alang-alang* mixture. Intercropping system gave substantially higher yield advantage over sole cropping in terms of land equivalent ratio with the maximum value achieved when guinea grass – *alang-alang* mixture planted at the ratio of 2 : 1, fertilized with N and harvest monthly. In intercropping system, guinea grass appeared to be the dominant crop as indicated by its higher values of relative crowding coefficient and positive sign of aggressivity index. It reflects that guinea grass grown in association with *alang-alang* utilized the resources more aggressively than when *alang-alang* grown alone.

Key words: *Imperata cylindrica, Panicum maximum*, Dry matter yield, Competitiveness

INTRODUCTION

The area under *Imperata cylindrica* in Southeast Asia is estimated to be 20 million hectares. In Indonesia, the total area of Imperata dominated grassland is 10 million hectares, with a further 20 million hectares of land with brush/shrub cover associated with shifting cultivation. According to Forest Statistic of Indonesia 1996/1997, the total area of critical land dominated by *Imperata cylindrica* was 12.517.632 hectares (Murniati, 2013). This 10 million hectares of land invaded by *Imperata cylindrica* have become unsuitable for traditional soil management practices (Anonymous., 1990).

Alang-alang is very competitive plant and most commonly regarded as a weed rather than useful species and for this reason, the main emphasis of research has been on its control or eradication (Falvey, 1981).

As a animal feed, *alang-alang* generally only palatable and nutritious when it is young. Dry matter yield, crude protein content, fibre and digestibility of *alang-alang* were lower compared with improved grasses. Crude protein content is relatively low, only can provide enough nitrogen for livestock until four weeks of regrowth (Falvey, 1981). NDF and ADF contents of *alang-alang* hay is very high, 74.6 and 46%, respectively (Anonymous, 2013) and its *in vitro* dry matter digestibility was found to be 44.71%, the lowest value of 20 species studied by Nasrullah *et al*., (2003) in South Sulawesi.

Researches concerning to controlling of *alang-alang* have been conducted in many countries. Mechanical control by digging out of all rhizomes is very effective but it needs much labor and cost. Chemical control by using herbicides needs a high cost and repeated dressing to achieve eradication. Even a relative high herbicide application rates used, there is still a remnant population of viable rhizome that has the potential reinvest the treated area (Cliffs, 2013).

Due to the high cost eradication by mechanical and chemical controls, some researcher recommended to use fast growing plants to control the growth of *alang-alang*. *Alang-alang* is a shade intolerant plant and shading of *alang-alang* results in the reduction of several growth parameters such as carbohydrate storage, rhizomes and shoot production (Macdicken *et al*., 1997). Herbaceous crops in genera of *Calopogonium muconoides, Centrosema pubescens, Mucuna pruritis, Stylosanthes guyanensis* and *Pueraria spp* have been recommended to suppress *alang-alang* growth (Friday *et al*., 1999). The aim of present experiment was to assess the feasibility of using guinea grass as a means to control *alang-alang*.

MATERIALS AND METHODS

The experiment was arranged in completely randomized block design in factorial combination of four planting proportions, two levels of N fertilizer and three harvest intervals with three replications. The plant proportions were 0, 33.3, 66.7, and 100% of *alang-alang* (plant densities of 0, 1, 2 and 3 plants/pot) combined with 100, 66.7, 33.3; and 0% guinea grass (densities of 3, 2, 1 and 0 plants/pot). The plants fertilized with 0 and 250 kg urea/ha and harvested at intervals of 30, 45 and 90 days.

The plants sown into the pots measuring 30 cm tall with a top diameter of 22.5 cm and a bottom diameter of 13 cm. Each pot was filled with 1.4 kg air dried soils. The soil was clay loam texture of ultisol collected from Hasanuddin University campus. Top soil to a 10 cm depth was used. The soil was passed through 15 mm sieve and well mixed prior to use. The pots were placed in open field. During experiment all pots were hand weeded and watered as needed.

At each harvest, all plants of each pot were harvested 5 cm above ground level with manual shears. The harvested plants then were placed in the oven for 72 hours at 65^0C and weighed.

Parameters measured were dry matter yield and competitiveness of guinea grass and *alang-alang* in mixed planting system. The competitiveness was calculated using competition indices. The indices were relative yield, relative yield total, relative crowding coefficient and aggressivity index.

Relative yield (RY) and relative yield total (RYT) was computed using the following formula described by Willey (1979):

$$\text{RYGA} = \text{DMY GA/DMY GG},$$
$$\text{RYAG} = \text{DMY AG/DMY AA}$$
$$\text{RYT} = \text{RYGA + RYAG}$$

Relative crowding coefficient (RCC) were calculated according to the following equations (Willey, 1979):

$$\text{RCC GA} = \frac{\text{DMY GA} \times \text{Z AG}}{(\text{DMY GG} - \text{DMY GA}) \times \text{Z GA}}$$

$$RCC\ AG = \frac{DMY\ AG \times Z\ GA}{(DMY\ AA - DMY\ AG) \times Z\ AG}$$

$$RCC = RCC\ AG \times RCC\ GA$$

Aggressivity Index (AI) was calculated by formula proposed by McGilchrist (1965) as follows:

$$AI\ GA = DMY\ GA / DMY\ GG \times Z\ GA - DMY\ AG\ /\ DMY \times Z\ AG$$

$$AI\ AG = DMY\ AG / DMY\ AA \times Z\ AG - DMY\ GA\ /\ DMY \times Z\ GA$$

Where:

RYGA	=	Relative yield of guinea grass
RYAG	=	Relative yield of *alang-alang*
DMY GA	=	Dry matter yield of guinea grass intercropped with *alang-alang*
DMY AG	=	Dry matter yield of *alang-alang* intercropped with guinea grass
RCC GA	=	Relative crowding coefficient of guinea grass
RCC AG	=	Relative crowding coefficient of *alang-alang*
ZGA	=	Proportion of guinea grass in intercropping system
ZAG	=	Proportion of *alang-alang* in intercropping system

RESULTS AND DISCUSSION

Dry matter yield

Analysis of variance showed that plant proportion, defoliation interval and nitrogen fertilization were significantly ($P< 0.01$) influenced dry matter yields of *alang-alang* and guinea grass mixtures. Dry matter yield of *alang-alang* and guinea grass defoliated at different intervals and fertilized with N fertilizer were shown in Table 1.

Guinea grass monoculture and guinea grass – *alang-alang* mixture produced higher yield than *alang-alang* monoculture (Table 1). This might be attributed to vigorous nature of guinea grass growth and its ability to rapidly utilize nutrients in the soil compared to *alang-alang*. The low aerial dry matter yield of *alang-alang* may be due to greater amounts of its biomass partitioned to underground organs compared with that of guinea grass. This was in agree with Khybri and Mishra (1967) who found that among many grasses they investigated, *Imperata cylindrica* had the lowest top root ratio.

N fertilization significantly ($P<0.05$) increased dry matter yield of mixtures. Lack of responsiveness of *alang-alang* compared to improved soil fertlility is not unusual in nature. This might be due to the low nitrogen uptake, apparent N recovery and N use efficiency of *alang-alang* compared to guinea grass (Rusdy, 2010), the high proportion of photosynthates partitioned to underground plant parts (Khybri and Mishra, 1967) and presence of light respiration in *alang-alang* that reduces photosynthetic efficiency (Sajise, 1973).

Table 1. Dry matter yield (g/pot) of *alang-alang* and guinea grass planted at some proportions, fertilized without (N0) or with nitrogen (N1) and defoliated at different intervals (D1, D2 and D3)

Plant Proportion	N0	N1	D1	D2	D3	Mean
A0G3	29.99[c]	50.56[b]	31.08[c]	36.13[b]	42.60[b]	36.65[bc]
A1G2	24.68[b]	51.22[b]	28.33[c]	36.47[b]	49.95[c]	37.98[c]
A2G1	22.58[b]	48.17[b]	22.13[b]	34.18[b]	40.13[b]	33.44[b]
A3G0	17.10[a]	22.55[a]	18.42[a]	18.79[a]	14.85[a]	18.34[a]

[a, b, c]Mean values of each column sharing different superscript were different ($P<0.05$)

Harvest interval influenced dry matter yield of forage. In this experiment, grasses harvested at interval of 30 days appeared to produce a higher dry matter than those harvested at 45 or 90 days interval. This indicates that guinea grass can be categorized as heavy grazing resistant grass, because most tropical grasses can not resistant to defoliation interval of 40 days.

Competitiveness

Relative yield total

Relative yield and relative yield total of and guinea grass and *alang-alang* in mixtures are presented in Table 2.

Table 2. Relative yield (RY), relative yield total (RYT) relative crowding coefficient (RCC) and aggressivity index (AI) of guinea grass (G) and *alang-alang* (A)

Proportion	RYG	RYA	RYT	RRCG	RCCA	RCC	AIG	AIA
A2G1 N1 D3	0.84	0.74	1.58	11.66	1.41	16.44	1.38	-1.38
A1G2 N1 D3	0.89	0.52	1.41	4.47	2.15	9.6	10.22	-0.22
A1G2N0 D3	0.76	0.67	1.43	4.00	1.58	6.32	0.22	-0.22
A2G1 N0 D3	0.70	0.70	1.40	4.63	1.14	5.28	0.21	-0.21
A2G1N0 D2	0.64	0.67	1.31	3.55	1.02	3.62	0.28	-0.28
A1G2 N0 D2	0.77	0.46	1.23	1.72	1.68	2.89	0.19	-0.19
A2G1 N1 D2	0.72	0.48	1.20	2.28	1.05	2.40	1.54	-1.54
A1G2 N1 D2	0.82	0.34	1.16	4.90	0.30	2.40	0.19	-0.19
A1G2 N1 D1	0.89	0.11	1.00	4.11	0.26	1.07	0.99	-0.99
A2G1 N1 D1	0.73	0.23	0.96	5.46	0.08	0.43	0.26	-0.26
A1G2 N0 D1	0.71	0.21	0.92	1.23	0.52	0.31	0.42	-0.42
A2G1 N0 D1	0.38	0.38	0.72	0.76	0.31	0.24	1.05	-1.05

Relative yield total measures the extent to which components of a mixture share a common resources. RYT values of one suggest no competition among species in the mixture, relative yield total less than one connotes a situation where one species or both are more affected than might be expected when there is crowding for the same space. Relative yield total value greater than one indicate the advantage of mixture over sole cropping.

In this experiment, the high RYT total values obtained when grass harvested at 30 days interval, followed by harvest interval of 45 days and the lowest value obtained at 60 days harvest interval. This indicated that both grasses produced a higher dry matter yield when planted in mixture and harvested at 30 days of interval than when harvested at 45 and 90 days intervals. This was not in agree with Humphreys (1981) who reported that in most tropical grasses, harvested yield increase with increasing interval in excess 40 – 60 days. This might partly be attributed to the difference in morphological and physiological characteristic of guinea grass and *alang-alang* compared with most other grasses.

The range of relative yield totals of mixtures over sole cropping of guinea grass or *alang-alang* were between 16% and 58% with the highest value in the case of guinea grass – *alang-alang* with ratio of 1 : 2, fertilized and harvested at interval of 30 days (1.58). This indicates that when intercrop fertilized and harvest monthly, 58% more land area would be required for sole cropping system compared to intercropping. A review of intercropping literatures shows that in many experiments, the performance of intercrops was better than sole crops (Omoko and Hammond, 2010). Rezvany *et al.* (2011) reported that greater intercrop yield advantage from intercropping system at relative yield total higher than one indicating the advantage of mixtures over sole stands in regard to the use of agro-environmental sources for plant growth.

Relative Crowding Coefficient

Relative crowding coefficient plays an important role in determining the competition effects and advantages of intercropping. According to Willey (1979), in an intercropping system, each crop has its own RCC. Component of crop with higher RCC value is the dominant and that with low RCC value is dominated. To determine if there is a yield advantage in intercropping system, the product of coefficient of both component crops is obtained. If the product of RCC of the two species is equal, less or greater than one, it means that intercropping system has no advantage, disadvantage or advantage, respectively. In this experiment, RCC values for guinea grass intercrops were higher than those of *alang-alang* intercrops (Table 2). This indicates that guinea grass was more dominant than *alang-alang* in all experiment conditions. It may inferred that guinea grass utilized the resources more completely than *alang-alang*. Across the intercropping system, the maximum yield advantage was recorded for intercrops harvested every month as indicated by its maximum RCC value (16.44).

Aggressivity Index

Aggressivity index is an important competition function to determine the competitive ability of a crop when grown in association with another crop. An aggressivity index value of zero indicated that the component crops are equally competitive. For another situation, both crops will have the same numerical value but the sign of dominant species will be positive and that of dominated will be negative. The greater the numerical value, the higher is the difference in competitive abilities.

The data shown in Table 2 revealed that the component crops did not compete equally. Aggressivity index of all intercrops indicated that guinea grass showed dominant behavior over *alang-alang* as indicated by their positive sign (+) against negative sign (-) for *alang-alang*. Aggressivity index values were high when intercrops fertilized and harvested every month and the lowest when intercrops unfertilized and harvested trimonthly. This indicated that guinea grass attained the highest competitive ability over *alang-alang* when fertilized with N fertilizer and harvested at one month interval.

CONCLUSIONS

Presence of *alang-alang* in pasture is undesirable because it has a low dry matter potential and nutritive value. Cultural weed control using fast growing species has been recommended to control *alang-alang* because this plant is a shade intolerant plant that can be shaded out by fast growing species. In this study, guinea grass can be used to control *alang-alang*, provided it slashed intensively and applied with N fertilizer. Apparently, improvement of soil fertility and grazing management are very important to increase dry matter yield and competitiveness of guinea grass intercropped with *alang-alang*.

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