Evaluation, Productivity and Competition of *Brachiaria decumbens*, *Centrosema pubescens* and *Clitoria ternatea* as Sole and Mixed Cropping Pattern in Peatland

Ali A[1,4], Abdullah L[2], Karti PDMH[2], Chozin MA[3], Astuti DA[2]

[1]*Graduate Student of Bogor Agricultural University, Indonesia*
[2]*Faculty of Animal Science, Bogor Agricultural University, Indonesia*
[3]*Faculty of Agricultural, Bogor Agricultural University, Indonesia*
[4]*Faculty of Agriculture and Animal Science, UIN Suska Riau, Indonesia*
E-mail: ali_arsyadi@yahoo.com

(Diterima 27 Maret 2014 ; disetujui 6 Juni 2014)

ABSTRAK

Ali A, Abdullah L, Karti PDMH, Chozin MA, Astuti DA. 2014. Evaluasi, produktivitas dan daya saing dari *Brachiaria decumbens*, *Centrosema pubescens* dan *Clitoria ternatea* sebagai tanaman tunggal dan campuran pola pemotongan di lahan gambut. JITV 19(2): 81-90. DOI: http://dx.doi.org/10.14334/jitv.v19i2.1036

Penelitian ini dilakukan untuk mengetahui produktivitas, indeks kompetisi dan kandungan nutrisi dari *Brachiaria decumbens* (rumput), *Centrosema pubescens* dan *Clitoria ternatea* (leguminosa) pada sistem pertanaman tunggal dan campuran di lahan gambut Pekanbaru, Indonesia dari bulan Oktober 2011 sampai dengan November 2012. Penelitian ini menggunakan rancangan acak kelompok dengan 5 perlakuan dan 3 kelompok sebagai ulangan. Lima perlakuan yang dibandingkan adalah:*B. decumbens* pertanaman tunggal (Bd), *C. pubescens* pertanaman tunggal (Cp), *C. ternatea* pertanaman tunggal (Ct), *B.* decumbens dan *C. pubescen* pertanaman campuran (Bd+Cp) dan *B.* decumbens dan *C. ternatea* pertanaman campuran (Bd+Ct). Produksi bahan kering. *B. decumbens* adalah nyata meningkat (P<0,05) sebesar 147,9% pada pertanaman campuran dengan *C. pubescens* dan 74,1% pada pertanaman campuran dengan *C. ternatea* dibandingkan pertanaman *B. decumbens* tunggal. Nilai *land equivalent ratio* (LER) berkisar antara 1,04 (Bd+Ct) sampai dengan 1,58 (Bd+Cp). Nilai *crowding coefficient* (K) dari *B. decumbens* pada kedua pertanaman campuran adalah lebih tinggi dari nilai K *C. pubescens* dan *C. ternatea.* Sementara itu, nilai K total Bd+Cp lebih tinggi dari Bd+Ct. Nilai *competition ratio* (CR) *B. decumbens* pada pertanaman campuran dengan *C. pubescens* dan *C. ternatea* adalah >1. Nilai agresivitas (A) *B. decumbens* pada kedua pertanaman campuran adalah positif. Kandungan protein kasar *B. decumbens* adalah tidak meningkat dengan pertanaman campuran dengan leguminosa. Pertanaman campuran dengan *B. decumbens* nyata menurunkan (P<0,05) kandungan protein kasar *C. ternatea.* Sementara itu, pertanaman campuran dengan *C.pubescens* dan *C. ternatea* tidak menurunkan kandungan *neutral detergent fibre* (NDF) dan *acid detergent fibre* (ADF) *B. decumbens.* Dapat disimpulkan bahwa, pertanaman campuran dengan *C. pubescens* dan *C. ternatea* di lahan gambut dapat meningkatkan produksi bahan kering *B. decumbens*. Dan sebaliknya, pertanaman campuran dengan *B. decumbens* tidak mempengaruhi produksi bahan kering *C. pubescens* dan menurunkan produksi bahan kering *C. ternatea*. Pertanaman campuran *B. decumbens* dengan *C. pubescens* dan *B. decumbens* dengan *C. ternatea* di lahan gambut tidak meningkatkan total produksi bahan kering per satuan luas lahan dan kandungan nutrisi hijauan. *B. decumbens* lebih kompetitif dan dominant dibandingkan *C. pubescens* dan *C. ternatea* di lahan gambut.

Kata Kunci: Sistem Penanaman, Hijauan, Produksi, Kandungan Nutrisi, Lahan Gambut

ABSTRACT

Ali A, Abdullah L, Karti PDMH, Chozin MA, Astuti DA. 2014. Evaluation, productivity and competition of *Brachiaria decumbens*, *Centrosema pubescens* and *Clitoria ternatea* as sole dan mixed cropping pattern in peatland. JITV 19(2): 81-90. DOI: http://dx.doi.org/10.14334/jitv.v19i2.1036

This study was carried out to determine the productivity, competition indices and nutrient content of Brachiaria *decumbens* (grass), *Centrosema pubescens* and *Clitoria ternatea* (legumes) as sole and mixed cropping system in peatland in Pekanbaru, Indonesia from October 2011 to November 2012. The experiment was set up in randomized complete block design with five treatments and three blocks as replication. Five treatments compared: *B. decumbens* sole cropping (Bd), *C. pubescens* sole cropping (Cp), *C. ternatea* sole cropping (Ct), *B. decumbens* and *C. pubescens* mixed cropping (Bd+Cp) and *B. decumbens* and *C. ternatea* mixed cropping (Bd+Ct). The dry matter (DM) yield of *B. decumbens* was significantly (P<0.05) increased by mixed cropping. *B. decumbens* DM yield in *C. pubescens* intercrop increased by 147.9% and in *C. ternatea* intercrop increased by 74.1% compare to sole *B. decumbens.* Land equivalent ratio (LER) value range from 1.04 (Bd+Ct) to 1.58 (Bd+Cp). The crowding coefficient (K) value of *B. decumbens* in both mixed croping system was higher than K value of *C. pubescens* and *C. ternatea*. The total K value for Bd+Cp was higher than Bd+Ct. The competition ratio (CR) value of *B. decumbens* mixed cropping with *C. pubescens* and *C. ternatea* were >1. The aggressivity (A) value of *B. decumbens* in both mixed cropping was positive. The crude protein (CP) content of *B.decumbens* did not significantly (P>0.05) increased by mixed cropping with legumes. Intercropping with *B. decumbens* significantly (P<0.05) decreased CP content of *C. ternatea*. Meanwhile neutral detergent fibre (NDF) and acid detergent fibre (ADF) content of *B. decumbens* did not decrease by intercropping with *C.pubescens* and *C. ternatea.* In conclusion, mixed cropping with *C. pubescens* and *C. ternatea* in peatland increased DM yield of *B. decumbens*. Mixed cropping with *B. decumbens* did not influence DM yield of *C. pubescens* and decreased DM yield and CP content of *C. ternatea*. Mixed cropping of *B. decumbens* with *C. pubescens* and *B. decumbens* with *C. ternatea* in peatland did not increase total DM yield of forage per unit area of land and nutrition contents of forage. *B. decumbens* was more competitive and dominant than *C. pubescens* and *C. ternatea* in peatland.

Key Words: Cropping System, Forage, Nutrient Contents, Yield, Peatland

INTRODUCTION

Productivity of forage is influenced by species of forage, environmental and soil condition (Jayanegara & Sofyan 2008). The quality of pasture can be improved by improving pasture plant diversity (Whitehead 2000), intercropping pattern (Whitehead & Isaac 2012) and using the forage species that can grow well in dry season. *Brachiaria decumbens* is a high in production of dry matter when planted in areas with low rainfall (Mutimura & Everson 2012). *B. decumbens* will grow better if planted in a mixture with creeping legumes. *Centrosema pubescens* and *Clitoria ternatea* are creeping legume that are widely grown as animal feed and they can grows well in dry season (Nworgu & Ajayi 2005). Fresh production of *C. pubescens* reached 40 t/ha/yr and it is very rich in crude protein (19.6%) (Nworgu et al. 2001). Meanwhile, *C. ternatea* (butterfly pea) can grow on poor soils and contains high crude protein as well (19%) (Cook et al. 2005).

Legumes in forage intercrops can provide a more available N in soil for crops through biological N fixation (Crews & People 2004). Non-legume and legumes mixed cropping are mostly applied to develop sustainable pasture and supply high quality feed through the years (Javanmard et al. 2009). Grass-legume mixtures tend to provide a superior nutrient balance and produces higher forage yield (Albayrak et al. 2011). However, grass-legume intercroping are more difficult to manage than monoculture pasture because of competition for light, water and nutrients (Albayrak & Ekiz 2005), or allelopathic that occur between mixed crops (Lithourgidis et al. 2011; Santalla et al. 2001). The extent of competition induced yield loss of the main crop in intercropping is likely depends upon crop compatibility and establishment timing (Hirpa 2013).

In Indonesia, grasses and legumes are mostly cultivated on mineral soil. Cultivation of forage crops in mixed cropping system in peatland has not been frequently conducted by farmers due to lack of information and experience. Therefore, the productivity of *B. decumbens*, *C. pubescens* and *C. ternatea* as sole and mixed cropping and its cultivation management in peatland (*organosol*) need to be explored. Indonesian peatland approximately 20.6 million ha (Wahyunto et al. 2005), and it has not been used for the development of grasses, legumes and fodder tree. This study was conducted to determine the productivity, competition indices and nutritive value of *B. decumbens*, *C. pubescens* and *C. ternatea* as sole and mixed cropping patterns in peatland.

MATERIALS AND METHODS

Experimental site

This study was conducted during rainy season i.e. from October 2011 to November 2012, at research farm of Faculty of Agriculture and Animal Science of UIN Suska Riau Pekanbaru, which is located 101° 4´- 101°34´ East longitude and 0°25´- 0°45´ North latitude, with the altitude ranges from 5-50 meters. Average monthly rainfall, air temperature and relative humidity during experimental period is shown in Figure 1. During the study, maximium temperature ranged 31.2-33.7^{o}C and minimum temperature ranged 22.3-23.6^{o}C. The highest temperature (33.7^{o}C) was on June 2012 and the lowest temperature (22.3^{o}C) was on May 2012. Maximum humidity between 94.3-97.5%. Minimum humidity between 56.2-68.9%. Monthly average rainfall was 227.1 mm and total rainfall per year was 2660 mm. The lowest (66.7 mm) and the highest (341.2 mm) rainfall were on January 2012 and December 2011, respectively.

Experimental design

The forages studied were *B. decumbens* (grass), *C. pubescens* and *C. ternatea* (legumes). The experiment was set up in randomized block design with five treatments and three blocks as replication. Five treatments compared were: *B. decumbens* sole cropping (Bd), *C. pubescens* sole cropping (Cp), *C. ternatea* sole cropping (Ct), *B. decumbens* and *C. pubescens* mixed cropping (Bd+Cp) and *B. decumbens* and *C. ternatea* mixed cropping (Bd+Ct).

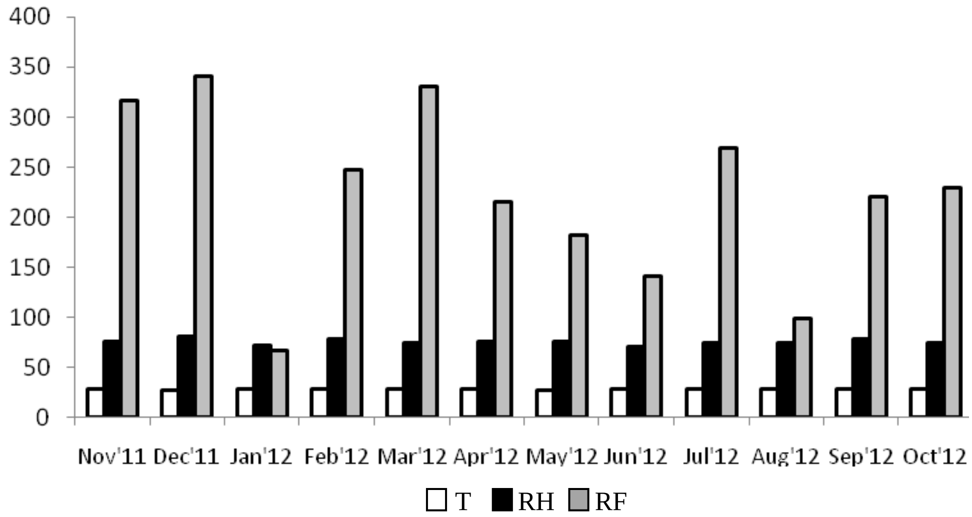

Figure 1. Average monthly rainfall, air temperature, and relative humidity at the location of experiment
T = temperature (^oC); RH= Relative Humidity (%); RF= Rainfall (mm)

Plot, planting density, liming and fertilizing

This experiment was conducted in peatland (sapric type). The soil chemical properties were as follow: pH 5.54, N 0.14%, C 7.20%, C/N 51.43, K 2.48 me/100g and P 30.18 ppm, respectively. The size of experimental land was 11.5x17 m and divided in three blocks. Each block was sub-divided into five plots (each plot size of 2.5x5m), namely Bd, Cp, Ct, Bd+Cp and Bd+Ct. The forages were planted in September 2011. The plant density was 50 plants/plot (planting space was 50x50 cm) and was maintained under rain-fed condition. The proportion of grass and legume in mix culture plots was 1:1 according to dry matter production potential. Dolomit lime was applied at 3 t/ha and was applied 1 month before planting. The basal organic fertilizer (cattle manure) was applied at 10 t/ha and was applied two weeks before planting (Agus & Subiksa 2008), while inorganic fertilizers (NPK) at the rate of 50 kg/ha/yr was applied two weeks after planting (surrounding the plant).

Propagating, pruning, harvesting and sample procedure

Grass (*B. decumbens*) was propagated by stolons while, legumes (*C. pubescens* and *C. ternatea*) was propagated by seed. Pruning was done 2 months after planting in experimental plot by trimming approximately 20 cm above the ground using a pair of garden shear. This would allow a new and uniform re-growth of the plant of which will be harvested as experimental samples. Grass and legume foliages were harvested six times a year with 60 days cutting interval. The plants were cut approximately 20 cm from the ground from each plot (n=24 plant) and directly weighed to determine the fresh yield.

Competition Indices

The competitiveness of grass and legume mixed cropping was determined in terms of land equivalent ratio (LER), competition ratio (CR), crowding coefficient (K) and Aggressivity (A). The LER, measures the effectiveness of mixed cropping in using the environmental resources compared to sole cropping (Banik et al. 2006; Yilmaz et al. 2008; Dhima et al. 2007; Oseni 2010). The LER values were calculated as: LER = (LER_{grass} + LER_{legume}), where LER_{grass} = (Y_{gm}/Y_{ls}), and LER_{legume} = (Y_{lm}/Y_{gs}), where Y_{gs} and Y_{ls} are the yields of grass and legume as sole crops respectively, and Y_{gm} and Y_{lm} are the yields of grass and legume as mixed cropping, respectively. LER >1, indicates yield advantage. The relative crowding coefficient (K) measures of the relative dominance of one species over the other in a mixed cropping and calculated as: K = (K_{grass} x K_{legume}), where K_{grass} = Y_{gm} x Z_{lp} / [(Y_{gs}-Y_{gm}) x Z_{gp}], and K_{legume} = Y_{lm} x Z_{gp} / [(Y_{ls}-Y_{lm}) x Z_{lp}] (De Wit 1960 in Banik et al. 2006), where Z_{gp} and Z_{lp} are the proportion of grass and legume in a mixed cropping. The value of K is > 1, indicated yield advantage; when K is = 1, indicated no yield advantage; and, when K < 1 indicated disadvantage.

The CR gives a clear idea about which forage is more competitive in association (Mahapatra 2011). The

CR values were calculated by following the formula as described by Willey & Rao (1980) in Banik et al. (2006): $CR_{grass} = (LER_{grass}/LER_{legume}) \times (Z_{lp}/Z_{gp})$, and $CR_{legume} = (LER_{legume}/LER_{grass}) \times (Z_{gp}/Z_{lp})$. If CR grass >1, grass is more competitive than legume and if the value is <1, grass is less competitive than legume. The reverse is true for CR legume. The aggressivity (A) is a nother index for measuring competitive relationships between two forages in mixed cropping. This was calculated by following the formula as recommended by Dhima et al. 2007: $A_{grass} = (Y_{gm}/Y_{gs} \times Z_{gp}) - (Y_{lm}/Y_{ls} \times Z_{lp})$ and $A_{legume} = (Y_{lm}/Y_{ls} \times Z_{lp}) - (Y_{gm}/Y_{gs} \times Z_{gp})$. Thus if $A_{grass} = 0$, both crops are equally competitive, If A_{grass} is positive, then the grass is dominant, and if A_{grass} is negative, the grass is subdominat.

Chemical analysis

Fresh samples of grass and legume from each plot (about 500 g) were dried in air-forced oven at 60^{o}C for 48 h, and ground to pass through a 1 mm sieve for chemical analysis. The dry matter (DM) and crude protein (CP) contents were determined according to the AOAC (2005) procedure. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were estimated according to the method of Van Soest et al. (1991).

Crude protein content of forage was analysed at Laboratory Research Center of Biological Resources and Biotechnology, PAU, Bogor Agricultural University. NDF and ADF content of forage were analysed at Laboratory Nutrition and Chemistry, Faculty of Agriculture and Animal Science of UIN Suska Riau Pekanbaru.

Statistical analysis

Data was analyzed by analysis of variance (ANOVA) based on a randomized complete block design. Significant differences were tested using Duncan's Multiple Range Test (DMRT) at 5% level of significance differences.

RESULT AND DISCUSSION

Dry Matter (DM) yield of forages

Annual DM Yield per Plant

The effect of intercropping on DM yield per plant (g/yr) of *B. decumbens*, *C. pubescens* and *C. ternatea* are shown in Table 1. The DM yield of *B. decumbens* significantly (P<0.05) increased with mixed cropping. The DM yield of *B. decumbens* mixed cropping with *C. pubescen* increased 147.9% and mixed cropping with *C. ternatea* increased 74.1% compared to sole *B. decumbens*. The increasing in DM yield could be attributed to the presence of forage legumes that contribute to soil available N for *B. decumbens* growth (Bakhashwain 2010). The forage legumes provided a more sustainable source of N to cropping systems through biological N fixation (Crews & Peoples 2004; Strydhorst et al. 2008), decay of dead root nodules and mineralization of shed leaves (Njoka-Njiru et al. 2006).

DM yield of *B. decumbens* was significantly (P<0.05) higher in intercropped with *C. pubescens* than those *C. ternatea*. Such result showed that *C. ternatea* was worse than *C. pubescens* when mixed with *B. decumbens*, so it did not contribute much to the increased growth of *B. decumbens*. Mixed cropping with *B. decumbens* decreased 67.3% DM yield of *C. ternatea* and 32.4% DM yield of *C. pubescens.* The decreasing in DM yield due to the impact of the interspecific competition (Hirpa 2013). A competition increases yield of dominant species, but decreases yield of sub-ordinate species (Li et al. 2001). Limited growth of *C. pubescens* and *C. ternatea* in intercropping system may be caused by extending growth of *B. decumbens*. It led to extensive nutrient uptake by *B. decumbens* from

Table 1. DM yield per plant (g/yr) of *B. decumbens* (Bd), *C. pubescen* (Cp) and *C. ternatea* (Ct) on sole and mixed cropping

Forages	DM yield
Bd sole cropping	$348^{c}\pm61$
Bd in mixed cropping with Cp	$863^{a}\pm269$
Bd in mixed cropping with Ct	$606^{b}\pm218$
Cp sole cropping	$145^{cd}\pm13$
Cp in mixed cropping with Bd	$98^{d}\pm2$
Ct sole cropping	$205^{c}\pm77$
Ct in mixed cropping with Bd	$67^{d}\pm5$

Means in the same column with different superscript differ significantly at 5% level (Duncan's multiple range test),
DM yield per plant of Cp and Ct sole cropping refers to Ali et al. (2013)

the soil than *C. pubescens* and *C. ternatea*. Depending on crops in the mixture, competition for light, water and soil nutrients, that may occur between mixed crops, it could be reduce yields of weak crop (Olowe & Adeyemo 2009; Lithourgidis et al. 2011).

Annual DM yield per plot

The effect of cropping system on DM yield per plot is shown in Table 2. It was recorded that mixed cropping in peatland did not significantly (P>0.05) increase the total DM yield of forage.

Mixed copping with *B. decumbens* ihibited the growth of *C. pubescens* and *C. ternatea* due to competition in uptaking nutrient elements in soil, water and light (Oseni 2010; Lithourgidis et al. 2011). *B. decumbens* grew by forming stolons so that more nutrient were absorbed than *C. pubescens* and *C. ternatea*. Mixed cropping with *C. pubescens* and *C. ternatea* increased DM yield of *B. decumbens* 147.9% and 74.1%, respectively, so the lack production of both legumes on the mixed plot was supplied by excess production of *B. decumbens*. Moreover, intercropping with legume improves soil fertility through biological nitrogen fixation with the use of legumes, increases soil conservation through greater ground cover than sole cropping, and provides better lodging resistance for crops susceptible to lodging than when grown in monoculture (Lithourgidis et al. 2011; Pozdisek et al. 2011)

Competition Indices

Land Equivalent Ratio (LER)

The total value of LER was >1 in both mixed croppings (Table 3), showing a yield advantage over sole cropping. LER values ranged from 1.04 (Bd+Ct) to 1.58 (Bd+Cp), so that 0.4 to 58% more land should be used in sole cropping in order to obtain the same yield of mixed cropping (Eskandari 2012). This indicated a superiority of the intercrops over pure stand with regard to the use of environmental resources for plant growth (Dhima et al. 2007; Mahapatra 2011).

Crowding coefficient (K)

The K value of *B. decumbens* in both mixed cropping systems was higher than K value of *C. pubescens* and *C. ternatea* (Table 3), indicating an absolute yield advantage of *B. Decumbens* over the both legumes. *C. pubescens* and *C. ternatea* has less competitive ability than *B. decumbens* in intercropping system, and may require higher planting densities to *B. decumbens* to achieve intercropping benefit (Strydhorst et al. 2008). The total K value for Bd+Cp was higher than Bd+Ct, indicating that *B. decumbens* mixed cropping with *C.pubescens* contributed to the high productivity per unit of land compared to mixed cropping with *C. ternatea* (Yilmaz et al. 2008).

Competition Ratio (CR)

Table 3 reveals that the CR value of *B. decumbens* mixed cropping with *C. pubescens* and *C. ternatea* were >1, indicating that *B. decumbens* was more competitive than both legumes, resulting in impaired growth of *C. pubescens* and *C. ternatea*. Mixed cropping led to interspecific interaction, which an impact on increasing of growth, nutrient uptake and yield of dominant species and decreases growth and nutrient uptake of the subordinate species (Zhang & Li 2003). The CR value of *C. pubescens* was higher than *C. ternatea*, suggesting that *C. pubescens* was more competitive than *C. ternatea* in *B. decumbens* mixture.

Aggressivity (A)

The A value of *B. decumbens* in both mixed cropping was positive (Table 3), indicating *B. decumbens* was more dominant than *C. pubescens* and *C. ternatea*. Such a result was expected since grasses are likely to be more competitive than legumes. In addition, dominance of *B. decumbens* was probably due

Table 2. Dry matter yield (t/ha/yr) of forage per plot based on cropping system

Cropping System	Plot	DM
Monoculture	*B. decumbens* (Bd)	13.9^{ab}±2.4
	C. pubescens (Cp)	5.8^{c}±0.5
	C. ternatea (Ct)	8.2^{b}±3.1
Mixculture	Bd+Cp	19.2^{a}±5.3
	Bd+Ct	13.5^{ab}±4.5

Means in the same column with different superscript differ significantly at 5% level (Duncan's multiple range test)
Annual DM yield of Cp and Ct plots refers to Ali et al. (2013)

to forming stolons and large canopy that could drastically overcrowd legumes (Yilmaz et al. 2008)

Proportion in DM yield of Grass and Legume in Mixture

Figure 2 (a) and (b) show that the proportion of *B. decumbens* to *C. pubescens* and *B. decumbens* to *C. ternatea* in mixture plot increased from first harvest (December 2011) to last harvest (October 2012). Lower proportion of *C. pubescens* and *C. ternatea* than *B. decumbens* at each harvest probably due to the both legumes has weak competitive ability in intercropping with grass (Tosti & Thorup-Kristensen 2010). Low ability of *C. pubescens* and *C. ternatea* in competing with *B. decumbens* in intercropping was reflected in the value of K, CR and A (Table 3).

Nutrient Composition

Dry Matter (DM)

The DM content of forage was not affected by cropping system and plant species (Table 4). The result of study found that DM content of legume was comparable to grass. This study revealed that legume and grass are about equal in moisture content.

Crude Protein (CP)

There were great variations among the plant species for CP (Table 4). The higher CP content in legumes (*C. pubescens and C. ternatea*) than grass (*B. decumbens*) may be due to the advantage of the legume-*Rhizobium* symbiosis that can provide N to the legume (Crews & People 2004). Increased in N supply will improve crude protein content of forage. Njoka-Njiru et al. (2006) reported that legumes fix atmospheric N_2 and therefore have a higher protein and feed value than grasses.

The CP content of *B. decumbens* was not significantly (P>0.05) increased by mixed Cropping with legumes. This result was disagree with those reported by several researches (Chen et al. 2004; Javanmard et al. 2009; Lithourgidis & Dordas 2010; Lithourgidis et al. 2011; Eskandari 2012; Njad et al. 2013) that intercropping non-legume with legume improved dry matter yield and CP content of nearby non-legume.

Table 3. Competition indices of *B. decumbens, C. pubescen* and *C. ternatea* on mixed cropping system

Competition indices	Bd+Cp				Bd+Ct			
	Bd	:	Cp	Bd+Cp	Bd	:	Ct	Bd+Ct
Land equivalent ratio (LER)	1,24		0,34	1,58	0,87		0,16	1,04
Crowding coefficient (K)	5,13		0,5	2,59	6,81		0,2	1,36
Competition ratio (CR)	3,7		0,27		5,31		0,19	
Aggressivity (A)	1,81		-1,81		1,42		-1,42	

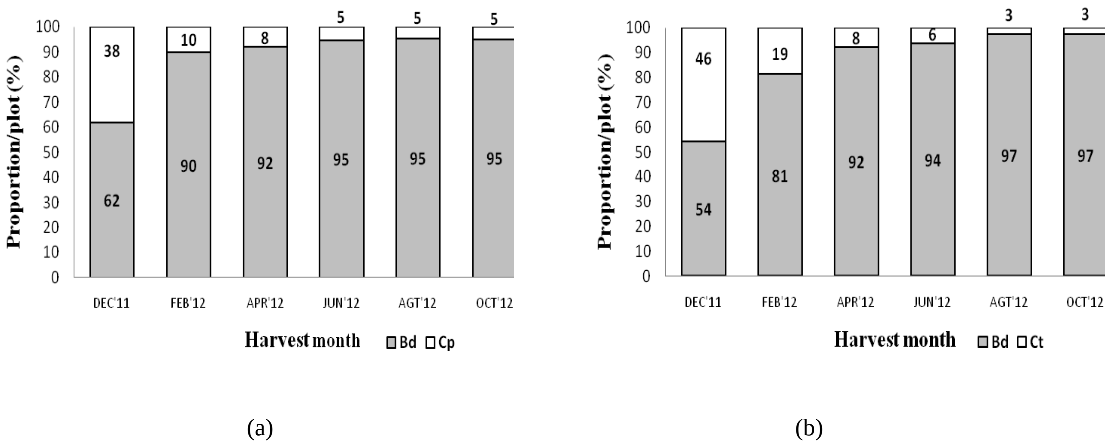

Figure 2. (a) Proportion of *B. decumbens* (Bd) and *C. pubescens* (Cp) in Bd+Cp plot at each harvest within one calender year of production
(b) Proportion of *B. decumbens* (Bd) and *C. ternatea* (Ct) in Bd+Ct plot at each harvest within one calender year of production

Table 4. The content of dry matter (DM), crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) of *B. decumbens* (Bd), *C. pubescens* (Cp) and *C. ternatea* (Ct) under sole and mixed cropping

Forage	DM (%)	% DM		
		CP (%)	NDF (%)	ADF (%)
Bd sole cropping	24,7±1.4	4.7^{d}±0.3	72.0^{a}±1.2	36.1^{cd}±4.8
Bd in mixed cropping with Cp	25,6±1.5	6.3^{d}±1.0	74.0^{a}±3.6	39.7^{c}±1.0
Bd in mixed cropping with Ct	24,4±0.9	5.0^{d}±0.3	71.7^{a}±3.2	40.3^{bc}±2.7
Cp sole cropping	24,3±0.4	17.5^{a}±.2.2	67.8^{b}±2.1	45.6^{a}±1.6
Cp mixed in cropping with Bd	24,5±0.7	18.5^{a}±0.8	63.9^{bc}±9.1	44.6^{ab}±0.7
Ct sole cropping	23,0±1.3	14.8^{b}±2.8	55.7^{d}±1.4	39.2^{cd}±0.6
Ct in mixed cropping with Bd	24,5±0.9	12.7^{c}±1.2	58.1^{cd}±1.0	35^{d}±2.3

Means in the same column with different superscripts differ significantly at 5% level (Duncan's multiple range test).
The DM, CP, NDF and ADF contents of Cp and Ct sole cropping refers to Ali et al. (2013)

The result of present study showed that intercropping with *B. decumbens* significantly (P<0.05) decreased CP content of *C. ternatea*, indicating that *B. decumbens* not only inhibited growth but also decreased quality of *C. ternatea*. The CP content of *B. decumbens* was relatively lower compared to the CP content of *B. decumbens* reported by Evitayani et al. (2004a) and Aregheore et al. (2006) i.e. 6.5-7.8% and 10.8%, respectively. The present studies showed that CP contents of *C. pubescens* planted in peatland was slightly lower than those found by Martens et al. (2012) and Omole et al. (2011) who obtained that CP content of *C. pubescens* varied from 23.6 to 25.5%. However, it was very comparable with the study of Aregheore et al. (2006) and Evitayani et al. (2004) who showed that CP content of *C. pubescens* was 17.3% and 18.9%, respectively. The present study also showed that CP content of *C. ternatea* was lower than those found by several researchers. Mahala et al. (2012), Nasrullah et al. (2003) and Heinritz et al. (2012) reported that CP content of *C. ternatea* was 17%, 18.28% and 19%, respectively. The present studies demonstrated that CP content of forage was influenced by forage type, cropping system, environmental condition and land condition (Jayanegara & Sofyan 2008; Dahmardeh et al. 2009).

Neutral Detergent Fibre (NDF)

As commonly reported, NDF content of forage was significantly (P<0.05) influenced by forage species (Table 4). The NDF content of *B. decumbens* was significantly (P<0.05) higher than *C. pubescens* and *C. ternatea*. As expected, there was a negative relationship between CP and fiber content, in which low crude protein was associated with high fibre fraction (Evitayani et al. 2004). Jung & Casler (2006) reported that low NDF content of legume is because legume has particularly large amount of pectin in primary walls, resulting in more pectin in legume forages than grasses in both leaves and stem. Lower in NDF content may indicate higher in forage intake. The fact that the NDF content of *B. decumbens* did not decrease by intercropping with *C. pubescens* and *C. ternatea*. In This experiment results was on contrary with reports by Lauriault & Kirksey (2004), Eskandari et al. 2009 and Lithourgidis et al. (2011) that mixed cropping with legume reduced NDF content of forage. These study showed that the NDF content of sole *C. pubescens* was significantly (P<0.05) higher than *C. pubescens* in mixed cropping with *B. decumbens*, indicating that intercropping causes an increased intake of *C. pubescens*. Eskandari et al. 2009 stated that the NDF content of forage is negatively related to rate of intake consumption by an animal and rate of cell walls from the rumen by digestion and passage. NDF content of *B. decumbens* in this experiment was higher than those found by Nasrullah et al. (2003), Evitayani et al. (2004), Evitayani et al. (2004a) and Aregheore et al. (2006) who reported that NDF contents of *B. decumbens* was 68.16%, 57.8%, 59.8-69.3% and 61.5%, respectivelly. The NDF content of *C. pubescens* and *C. ternatea* in this study was also slightly higher than those reported by other researchers. Aregheore et al. (2006) reported that NDF content of *C. pubescens* was 45.2% and Nasrullah et al. (2003) noted that NDF content of *C. ternatea* was 42.30%. These result demonstrated NDF content of forage was affected by environmental factor, forage species, and soil type.

Acid Detergent Fibre (ADF)

ADF is the percentage of higly indigestible plant material present in forage. Low ADF values means higher digestibility (Eskandari et al. 2009). The ADF content of forage in this study was not affected by cropping pattern (Table 4). In sole cropping, the ADF content of *C. pubescens* was higher than *B. decumbens* and *C. ternatea*, indicating that *C. pubescens* has lower digestibility than *B. decumbens* and *C. ternatea*. The

ADF content refers to the cell wall portion of the forage. These portion consist of cellulose and lignin. As the ADF increases, the digestibility of the forage usually decrease (Albayrak et al. 2011), causing consumption of the forage by animal to reduce (Aydin et al. 2010). The present study also indicated that the ADF content of *B. decumbens* and *C. ternatea* was relatively comparable. This probably due to the relatively constant amount of cellulose among *B. decumbens* and *C. ternatea*. Cellulose is the primary constituent of ADF (Eskandari et al. 2009). Therefore, grasses and legumes may have similar ADF values (Weiss et al. 2002; Karabulut et al. 2007). The ADF content of *B. decumbens* obtained in this study was comparable to those found by Nasrullah et al. (2003), Evitayani et al. (2004), Evitayani et al. (2004a) and Aregheore et al. (2006) who reported that the ADF content of *B. decumbens* varied from 26.5 to 43.9%. The results showed that the ADF content of *C. pubescens* in the present study was higher than those obtained by Nasrullah et al. (2003) and Aregheore et al. (2006) who reported that the ADF content of *C. pubescens* was 37.36% and 39.8, respectively. Meanwhile, the study also showed that the ADF content of *C. ternatea* planted in peatland was higher than the finding of Nasrullah et al. (2003) who found that ADF content of *C. ternatea* which grows naturally in South Sulawesi was 31.91%.

CONCLUSION

Mixed cropping with *C. pubescens* and *C. ternatea* in peatland increased DM yield of *B. decumbens*. Mixed cropping with *B. decumbens* did not influence DM yield of *C. pubescens* and decreased DM yield and CP content of *C. ternatea*. Mixed cropping of *B. decumbens* with *C. pubescens* and *B. decumbens* with *C. ternatea* in peatland did not increase total DM yield of forage per unit area of land and nutrition contents of forage. *B. decumbens* was more competitive and dominant than *C. pubescens* and *C. ternatea* in peatland.

REFERENCES

Agus F, Subiksa IGM. 2008. Lahan gambut: potensi untuk pertanian dan aspek lingkungan. Balai Penelitian Tanah. Badan Penelitian dan Pengembangan Pertanian. Bogor (Indones): ICRAF. hlm. 36.

Albayrak S, Ekiz H. 2005. An investigation on the establishment of artificial pasture under ankara's ecological conditions. Turk J Agric Forest. 29:69-74.

Albayrak S, Turk M, Yuksel O, Yilmaz M. 2011. Forage yield and the quality of perennial legume-grass mixtures under rainfed conditions. Not Bot Hort Agrobot Cluj. 39:114-118.

Ali A, Abdullah L, Karti PDMH, Chozin MA, Astuti DA. 2013. Production, competition indices, and nutritive values of *Setaria splendida*, *Centrosema pubescens* and *Clitoria ternatea* in mixed cropping systems in peatland. Med Pet. 36:159-236.

[AOAC] Association of Official Analytical Chemist. 2005. Official methods of analysis. AOAC International. 18th ed. Airlington [USA]: Association of Official Analytical Chemist.

Aregheore EM, Ali I, Ofori K, Rere T. 2006. Studies on grazing behavior of goats in the cook islands: the animal-plant complex in forage preference/palatability phenomena. Int J Agric Biol. 8:147-153.

Aydin N, Mut Z, Mut H, Ayan I. 2010. Effect of autumn and spring sowing dates on hay yield and quality of oat (*Avena sativa* L.) genotypes. J Anim Vet Adv. 9:1539-1545.

Bakhashwain AA. 2010. Fodder yield and quality of rhodes grass-alfalfa mixtures as affected by sowing rates In Makkah region. Met Env Arid Land Agric Sci. 21:19-33.

Banik P, Midya A, Sarkar BK, Ghose SS. 2006. Wheat and chickpea intercropping systems in an additive series experiment: Advantages and weed smothering. Eur J Agron. 24:325-332.

Chen C, Westcott M, Neill K, Wichman D, Knox M. 2004. Row configuration and nitrogen application for barleypea intercropping in Montana. Agron J. 96:1730-1738.

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R. 2005. Tropical forages. CSIRO, DPI&F(QLD), CIAT and ILRI, Brisbane, Australia. [accessed August 28, 2013]. http://www.tropicalforages.info.

Crews TE, Peoples MB. 2004. Legume versus fertilizer sources of itrogen: Ecological tradeoff s and human needs. Agric Ecosyst Environ. 102:279-297.

Dahmardeh M, Ghanbari A, Syasar B, Ramrodi M. 2009. Intercropping maize (*Zea mays* L.) and cow pea (*Vigna unguiculata* L.) as a whole-crop forage: Effects of planting ratio and harvest time on forage yield and quality. J Food Agr Environ. 7:505-509.

Dhima KV, Lithourgidis AA, Vasilakoglou IB, Dordas CA. 2007. Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crop Res. 100:249-256.

Eskandari H, Ghanbari A, Javanmard A. 2009. Intercropping of cereals and legumes for forage production. Not Sci Biol. 1:07-13.

Eskandari H. 2012. Yield and quality of forage produced in intercropping of maize (*Zea mays*) with cowpea (*Vigna *sinensis*) and mungbean (*Vigna radiate*) as double cropped. J Basic Appl Sci Res. 2:93-97.

Evitayani, Warly L, Fariani A, Ichinohe T, Fujihara T. 2004. Study on nutritive value of tropical forages In North Sumatra, Indonesia. Asian-Aust J Anim Sci. 17:1518-1523.

Evitayani, Warly L, Fariani A, Ichinohe T. Fujihara T. 2004a. Seasonal changes in nutritive value of some grass species in West Sumatra, Indonesia. Asian-Aust J Anim Sci. 17:1663-1668.

Heinritz SN, Hoedtke S, Martens SD, Peters M, Zeyner A. 2012. Evaluation of ten tropical legume forages for their potential as pig feed supplement. Livest Res Rural Dev. 24. [accessed August 28, 2013]. http://www.lrrd.org. lrrd24/1/cont2401.htm.

Hirpa T. 2013. Maize productivity as affected by intercropping date of companion legume crops. Peak J Agric Sci. 1:70-82.

Jayanegara A, Sofyan A. 2008. Penentuan aktivitas biologis tanin beberapa hijauan secara *in vitro* menggunakan hohenheim gas test dengan polietilen glikol sebagai determinan. Med Pet. 31:44-52.

Javanmard A, Nasab ADM, Javanshir A, Moghaddam M, Janmohammadi H. 2009. Forage yield and quality in intercropping of maize with different legumes as double cropped. J Food Agr Environ. 7:63-166.

Jung HG, Casler MD. 2006. Maize stem tissues: Cell wall concentration and composition during development. Crop Sci. 46:1793-1800.

Karabulut A, Canbolat O, Kalkan H, Gurbuzol F, Sucu E. Filya I. 2007. Comparison of *in vitro* gas production, metabolizable energy, organic matter digestibility and microbial protein production of some legume hays. Asian-Aust J Anim Sci. 20:517-522.

Lauriault LM, Kirksey RE. 2004. Yield and nutritive value of irrigated cereal forage grass-legume intercrops in the Southern High Plains, USA. Agron J. 96:352-358.

Li L, Sun JH, Zhang FS, Li XL, Rengel Z, Yang SC. 2001. Wheat/maize or soybean strip intercropping. ii. recovery or compensation of maize and soybean after wheat harvesting. Field Crops Res. 71:173-181.

Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN. 2011. Annual intercrops: An alternative pathway for sustainable agriculture. Aust J Crop Sci. 5:396-410.

Lithourgidis AS, Dordas CA. 2010. Forage yield, growth rate, and nitrogen uptake of faba bean intercrops with wheat, barley, and rye in three seeding ratios. Crop Sci. 50:2148-2158.

Mahala AG, Amasiab SO, Monera, Yousif A, Elsadig. 2012. Effect of plant age on dm yield and nutritive value of some leguminous plants (*Cyamopsis tetragonoloba*, *Lablab purpureus* and Clitoria (*Clitoria ternatea*). Int Res J Agric Sci. 2:502-508.

Mahapatra SC. 2011. Study of grass-legume intercropping system in term of competition indices and monetary advantage index under acid lateritic soil of India. Am J Exp Agric. 1:1-6.

Martens D, Tiemann SDTT, Bindelle J, Peters M, Lascano CE. 2012. Alternative plant protein sources for pigs and chickens in the tropics-nutritional value and constraints: A review. J Agr Rural Develop Trop Subtrop. 113:101-123.

Mutimura M, Everson TM. 2012. On-Farm evaluation of improved *Brachiaria* grasses in low rainfall and aluminium toxicity prone areas of Rwanda. Int J Biodiver Conserv. 4:137-154.

Nasrullah, Niimi M, Akashi R, Kawamura O. 2003. Nuritive evalution of forage plants grown in South Sulawesi, Indonesia. Asian-Aust J Anim Sci. 16:693-701.

Njad AK, Mohammadi S, Khaliliaqdam N, Yousef MP, Nejad NJ. 2013. Barley-Clover intercropping: Advantages and competition indices. Adv Crop Sci. 13:497-505.

Njoka-Njiru EN, Njarui MG, Abdulrazak SA, Mureithi JG. 2006. Effect of intercropping herbaceous legumes with napier grass on dry matter yield and nutritive value of the feedstuffs in semi-arid region of Eastern Kenya. Agric Trop Et Subtrop. 39:255-267.

Nworgu FC, Egbunike GN, Osayomi OJ. 2001. Performance of growing rabbits fed a mixture of leaf meals and concentrates. Tropic Anim Prod Invest. 4:34-48.

Nworgu FC, Ajayi FT. 2005. Biomass, dry matter yield, proximate and mineral composition of forage legumes grown as early dry season feeds. Livest Res Rural Dev. 17. [accessed August 30, 2013]. http://www.lrrd.org/ lrrd17/11/nwor17121.htm.

Olowe VIO, Adeyemo AY. 2009. Enhanced crop productivity and compatibility through intercropping of sesame and sunflower varieties. Ann Appl Biol. 155:285-291.

Omole AJ, Ogungbesan AM, Fayenuwo JA, Popoola YA. 2011. Comparative utilization of *Centrosema pubescens* or *Mucuna purensis* as a substitute for pawpaw leaf by growing snails. Livest Res Rural Dev. 23. [accessed August 18, 2013]. http://www.lrrd.org/lrrd23 /3/omol23063.htm.

Oseni TO. 2010. Evaluation of sorghum-cowpea intercrop productivity in savanna agro-ecology using competition indices. J Agric Sci. 2:229-234.

Pozdisek J, Henriksen B, Ponizil A, Loes AK. 2011. Utilizing legume-cereal intercropping for increasing self-suffiency on organic farms in feed for monogastric animal. Agron Res. 9:343-356.

Santalla M, Rodino AP, Casquero PA, De Ron AM. 2001. Interactions of bush bean intercropped with field and sweet maize. Eur J Agron. 15:185-196.

Strydhorst SM, King JR, Lopetinsky KJ, Harker K. 2008. Forage potential of intercropping barley with Faba bean, lupin, or field pea. Agron J. 100:182-190.

Tosti G, Thorup-Kristensen K. 2010. Using coloured roots to study root interaction and competition in intercropped legumes and non-legumes. J Plant Ecol. 3:191-199.

Van Soest PJ, Robertson JB, Lewis BA. 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J Dairy Sci. 74:3583-3593.

Wahyunto S, Ritung, Suparto, Subagjo H. 2005. Peatland distribution and its C content in Sumatra and Kalimantan. Wetland Int'l - Indonesia Programme And Wildlife Habitat Canada. Bogor, Indonesia.

Weiss WP, Eastridge ML, Underwood JF. 2002. Forages for dairy cattle. Ohio State University Extension. [accessed August 19, 2013]. http://ohioline.osu.edu/as-fact/0002.html.

Whitehead C. 2000. Nutrient elements in grassland. Soil-Plant-Animal Relationship. UK. CABI Publishing.

Whitehead M, Isaac ME. 2012. Effect of shade on nitrogen and phosphorus acquisition in cereal-legume intercropping system. Agriculture. 2:12-24.

Yilmaz S, Atak M, Erayman M. 2008. Identification of advantage of maize-legume intercropping over solitary cropping through competition indices in the East Mediterranean region. Turk J Agric Forest. 32:111-119.

Zhang F, Li L. 2003. Using competitive and facilitative interactions in intercropping system enhances crop productivity and nutrient-use efficiency. Plant Soil. 248:305-312.