GROWTH, YIELD AND NUTRITIVE VALUE OF NEW INTRODUCED *BRACHIARIA* SPECIES AND LEGUME HERBS AS RUMINANT FEED IN CENTRAL SULAWESI, INDONESIA

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ABSTRACT:- Two simultaneous experiments were done to compare the growth, yield and nutritive value of grasses namely *Brachiaria brizantha*, *B. mulato*, and *B. mutica* and five legume herbs such as *Clitoria ternatea*, *Dolichos lablab*, *Macroptilium bracteatum, Centrosema pascuorum* and *Centrosema pascuorum* in Central Sulawesi, Indonesia using completely randomised block design. Each species was planted on 2.5m x 3m plot, and repeated 6 and 4 times in experiment 1 and 2, respectively. Parameters measured include plant height, tillage number, dry matter (DM) yield, in vitro digestibility and nutrient contents. Plant height and tillage number were monitored at week 4, 6 and 8 then harvested at week 8. Results revealed that the *Brachiaria mutica* (8 weeks old) had highest plant height (207 cm), but lowest tillage number (64), crude protein (CP) content (8.64%), in vitro organic matter (OM) digestibility (47.36%) On the other hand, *B. mulato* had highest tillage number (117) and DM yield (0.79 kg DMm^{-2}). Legume herb species affected significantly (P<0.05) plant height, yield, in vitro digestibility. At 8 weeks of age *Dolichos lablab* showed the highest plant height (189 cm), DM yield (0.45 kg DM m^{-2}) and in vitro OM digestibility (71.12%). The nutrient contents were not significantly affected (P>0.05) by legume herb species. In short *B. mulato* and *Dolichos lablab* showed the highest growth, DM yield and in vitro digestibility, therefore both forages are potentially to be scaled up in broader tropical region.

Key Words: Brachiaria; Grass; Legumes Herbs; Agronomic Characters; Yield Components; Nutrient; Indonesia.

INTRODUCTION

Forage is the main feed component of most ruminants in Central Sulawesi. Most ruminant livestock rely on local grasses for their roughage and much of their nutrition. Ruminants mainly beef cattle, goats and sheep graze on native grass which grow on waste-lands, roadsides, unplanted land and crop-stubbles. Despite the importance of forage to ruminants production and quality of forage in general are low which resulted in the low ruminant productivity. Poppi et al. (2009) reported that daily liveweight gain of Bali calf in Palu Central Sulawesi and other region in Indonesia were 24-173 g day^{-1} which is far below their genetic potential (700 g day^{-1}). This is because many of local grass species

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have low palatability, poor productivity and inadequate nutrients to maintain animals, especially during the dry season. The constraints leading to these poor cattle performances in the small scale farm are mainly from insufficient supply of protein or other nutrients for animals, especially in dry season, resulting in the low rate of productivity (Panjaitan et al., 2010). Amar (2008) reported that in Palu Central Sulawesi, in Indonesia, a natural grazing area, a cow with a liveweight of about 400 kg requires 14.4-17.5 ha year^{-1}. It was further stated that crude protein (CP) content of natural pastures in Palu Central Sulawesi was 4-6%.

One strategy to overcome the supply of forage production during the year is introduction of new improved forages either grasses or legumes. Several new forage species or varieties have recently been introduced to Indonesia and Central Sulawesi in particular. The newly introduced grass species that are popular in Indonesia includes *Brachiaria mulato* and legume herb species such as *Clitoria ternatea*, *Dolichos lablab*, *Macroptilium bracteatum* and *Centrosema pascuorum*. These new forage species mostly have high nutrient contents and biomass production. The new improved pastures can be used as cut and curry grasses or legumes that can be grown as forage banks in back yard or upland areas, rows or hedges on bunds (grasses) or living fences (tree legumes), companion plantings within crops or as annual or perennial pastures in spare cropland or upland areas (Pengelly and Lisson, 2001; Corfield et al., 2008).

Being newly introduced forages, little data on growth, production and nutritive value of *Brachiarias* and legume herbs under the soil and climate in Central Sulawesi is available. Testing of these new forages is needed to determine if they are adapted to the new environment in Central Sulawesi. These studies were therefore made to examine the growth, yield and nutritive value of *Brachiaria* species and legume herbs in Central Sulawesi. The first study focused on the comparison of three of *Brachiaria* species while the second study compared five legume herb species under new environment in Central Sulawesi.

MATERIALS AND METHOD

Location and Experimental Design

Experiments were carried out simultaneously at the farm site of Jonge, Sub district of Sigibiromaru district Sigi, Central Sulawesi, Indonesia (0°41'0"South; 119°44'0"East) from September to December, 2011.

Soil and Weather Conditions

The soil was classified as a sandy loam soil, with the following characteristics Soil Chemistry Lab. data: Sand = 14.84%; C = 2.28%; N = 0.24%; pHKCl = 4.75; Ca = 5.06 meq/100 g; Mg = 0.27 meq/100g). The average pH of soil was 5.8. Daily temperature varied mostly between 24 and 32°C, with a total rainfall of 890 mm year^{-1} and relative humidity was between 60 and 92%.

Brachiaria spp.

Three *Brachiaria* species (*Brachiaria brizantha, B. mulato* and *B. mutica*) were compared in a completely randomized block design with 6 replicates/plots. The trial was planted with freshly dug rooted tillers spaced 60 cm x 75 cm in 2.5 m x 3 m plot. Two weeks after planting, all plants at plots were cut to 10 cm above ground level for uniformity. The plant height and tiller number for each plant were monitored at weeks 4, 6 and 8 after cutting. All plants were harvested at week 8 and measurements were made for dry matter yield, stem and leaf proportion and chemical analysis. Stem and leaf of grass was separated and about 1 kg for each plot was taken and separated by hand into stem and leaf. Separated portions were dried in a forced air oven at 60°C and then weighed to determine the percentage of total plant DM in each portion. The soil was fertilised with organic fertilizer (0.3% N) at level of 12.5 kg plot^{-1} 3 week prior to the experiment. The pH and nutrient of soil were measured. The site was well irigated. Plots were weeded twice after planting, with hand hoes.

Legume Herb spp.

Five new introduced legume herb species namely *Clitoria ternatea, Dolichos lablab, Macroptilium bracteatum, Centrosema pascuorum molle, C. pascuorum* Bundey were compared in a completely randomized block design. Each species was initially planted by legume seed by lightly surface raked into the soil on the separated cocker. After growing for two weeks the plants were moved on plot 2.5m x 3 m. Each species was repeated 4 times plot^{-1} so there were four plots of each legume herb species. The plants were planted at distance of 60 cm x 75 cm. Plant height was monitored at week 4, 6 and 8, then harvested for DM yield and chemical composition. The site had access to irrigation facilities. Organic fertilizer (0.3% N) was applied @ 12.5 kg plot^{-1}. The nutrient content of the soil was noted in the soil laboratory of Tadulako University while the pH measurement of the soil was done using soil tester. Weeding for each plot was done twice by using hand hoes during experimental period.

Chemical Analysis

The samples of grass or legume herb were sorted from each plot, and a 200 g subsample of each species from each plot was dried at 70°C for 48h and dry weight was recorded. The chemical composition of the forage samples was analysed to determine its nutrient content by drying representative samples to a constant weight at 70°C. Samples of forage were ground using a blender before passing through a 1 mm screen. Forage samples were analysed for DM, OM (AOAC, 1990), neutral detergent fibre (NDF) and acid detergent fibre (ADF) and lignin (Goering and Van Soest, 1970). In addition, forage samples were also analysed for nitrogen, using the Kjeldahl method to determine crude protein (CP), and ether extract (EE) (AOAC, 1990). In vitro digestibility of DM and OM of forage were determined according to Van der Meer (1980).

Climate Data Collection and Statistical Analysis

Climate data were all collected from agrometeorological station located nearest the experimental site. Climate data collected include daily average temperature, daily maximum and minimum temperature, daily humidity and precipitation.

All data collected were subjected to analysis of variance (ANOVA) by using GenStat statistical package (GenStat, 2010). Least Significant Differences were used to analyse the difference among the treatments (Steel and Torrie, 1960)

RESULTS AND DISCUSSION

Growth, Yield and In Vitro Digestibility of *Brachiaria* Species

Brachiaria species showed significant effect (P<0.05) on plant height, tiller number, DM yield and DM and OM in vitro digestibility (Table 1). *Brachiaria mutica* had the highest plant height however there was no difference in the average plant height (P > 0.05) between *B. brizantha* and *B. mulato*. Tillage number and DM yield showed the same pattern in which *B. mulato* had the highest (P<0.05) tillage number and yield. The difference between *B.brizanta* and *B.mutica* was not significant (P>0.05). The DM and OM digestibility of three species of *Brachiaria* showed similar pattern, with no difference between *B.brizantha* and *B.mulato*, while *B. mutica* had the lowest either DM or OM digestibility. The major difference between two (*B. brizantha* and *B. mulato*) and *Brachiaria mutica* in DM and OM in vitro digestibility could be related to the chemical content of the plant material. Previous workers (Poppi et al., 1980; Minson, 1990) pointed out that digestibility of DM and OM were related to forage content of chemical constituents such as CP, EE, cell-wall constituents, NDF, ADF and lignin. Both *B. brizantha* and *B. mulato* consisted of higher CP content and lower NDF, ADF and lignin contents than *B. mutica*. Fibre contents such as NDF, ADF and lignin are likely to be a major limiting factor to the degradation of plant material (Poppi et al., 1980; Minson, 1990). Many

Table 1. Growth, yield and in vitro dry matter (DM) and organic matter (OM) digestibility of *Brachiaria* species in Central Sulawesi, Indonesia during 2011

Parameter	*Brachiaria* species		
	B. brizantha	*B. mulato*	*B. mutica*
Plant height 4 wk (cm)	80.70 ± 10.47 [b]	53.93 ± 13.42 [a]	101.23 ± 24.75 [c]
Plant height 6 wk (cm)	106.87 ± 11.07 [b]	78.13 ± 16.32 [a]	147.50 ± 22.39 [c]
Plant height 8 wk (cm)	145.43 ± 12.99 [b]	117.23 ± 25.22 [a]	207.47 ± 32.85 [c]
Tiller number 4 wk	18.20 ± 4.73 [a]	48.57 ± 5.66 [b]	44.63 ± 4.51 [b]
Tiller number 6 wk	38.50 ± 9.61 [a]	91.53 ± 6.02 [c]	59.77 ± 10.78 [b]
Tiller number 8 wk	57.57 ± 9.83 [a]	122.40 ± 9.13 [b]	63.73 ± 8.07 [a]
Yield (kg DM m^{-2})	0.51 ± 0.16 [a]	0.79 ± 0.18 [b]	0.55 ± 0.19 [a]
In vitro DM digestibility (%)	57.53 ± 2.62 [a]	56.54 ± 2.24 [b]	49.93 ± 0.69 [a]
In vitro OM digestibility (%)	57.23 ± 3.18 [a]	58.43 ± 2.52 [b]	47.36 ± 1.20 [a]

Means followed by same letters do not differ significantly (P<0.05).

studies (Oba and Allen, 2005; Chen et al., 2006) suggested that the higher CP content and the lower NDF and ADF content resulted in higher OM in vitro digestibility. Moreover, higher DM and OM in vitro digestibility of *B. mulato* and *B. brizantha* was also related to proportion of leaf and stem of the plant material. The current experiment showed that the proportion of leaf was higher for *B. mulato* (51%) and *B. brizantha* (45%) than *B. mutica* (27.25%). Poppi et al. (1980) and Minson (1990) suggested that leaf is more digestible than stem component of the plant material.

A significant difference in DM biomass production occurred bet-ween *B. mulato* and two *Brachiaria* species (Table 1). *B. mulato* produced higher DM biomass than the other species, averaging 0.79 kg m^{-2}, while *B. brizantha* and *B. mutica* produced 0.51 and 0.55 kg m^{-2}, respectively. The highest tillage number of *B. mulato* resulted in increased biomass production. Tillage number of *B. mulato* monitored at week 6 and 8 were always highest compared with two other *Brachiaria* spp. (Table 1). Measurement at week 6, the tillage number of *B. mulato* (91) were 138% and 53% higher than *B. brizantha* and *B. mutica*, respectively. Furthermore, at week 8, the number of tiller of *B. mulato* increased by 34% and was 113% and 93% higher than *B. brizantha* and *B. mutica*, respectively. The new tiller means more biomass was produced. These DM yields were similar to those reported in different agronomic evaluations of *B. mulato* carried out in Palu Central Sulawesi (Damry and Syukur, 2009) and *B. mutica* (Hare et al., 1999; 2009). However the biomass production of *B. brizantha* and *B. mutica* were higher than the data of Guenni et al. (2005). They reported biomass production of *B. brizantha* and *B. mutica* were 0.29 and 0.35 kg m^{-2}, respectively.

Nutrient Content of *Brachiaria* Species

No significant effect (P>0.05) of *Brachiaria* species on DM, OM, and EE contents were revealed (Table 2). However, the species influenced significantly (P<0.05) the CP, NDF and ADF and lignin contents. *B. mutica* had the lowest content of CP, while both *B. brizantha* and *B. mulato* contained higher (P<0.05) CP content, but the difference was not significant (P>0.05). In contrast, NDF, ADF and lignin contents of *B. mutica* were the highest, while the other two had the lower NDF, ADF and lignin content but no significant difference between these two species was recorded.

It was recorded that *Brachiaria* species did not influence the DM, OM and EE contents. The DM content of the three *Brachiaria* spp. ranged from 20.43 to 22.46%, while the OM and EE ranged between 86-87.78% and 1.55-1.88% respectively. The data indicated that DM content was lower with previous study (Damry and Syukur, 2009) who noted that range of DM content of *B. mulato* as 26-29%. However the OM and EE contents the current experiment were close to the data of Damry and Syukur (2009).

Brachiaria mulato and *B. brizatha* grasses had a significant higher CP content than *B. mutica*. Crude protein content of *Brachiaria* grasses ranged from 8.64% (*B. mutic*a) to 11.93% (*B. mulato*). In addition *B.mulato* grass had significant lower NDF and ADF contents than *B. mutica* (Table 2). The lower NDF and ADF content of *B.brizantha* and *B.mulato* was in line with proportion of leaf material of the plants. It was recorded that the proportion of leaf was higher for both *B.brizantha* and *B. mulato* (45 and 51%, respectively) than *B.mutica* (27.25%), leaf component was contributed in higher protein and less fibre concentration than stem (Minson, 1990). *Brachiaria mulato* is the result from crossing between *B.ruziziensis* clone 44-6 and *B.brizantha* CIAT 6297 (CIAT, 2001) therefore both species had some similarities. The CP content of three *Brachiaria* grassess were higher than 7%, which is the level considered critical for livestock production, because levels below 7% can depress voluntary intake of forage (Poppi et al., 1980).

Growth, Yield and In Vitro Digestibility of Legume Herbs

Legume herbs significantly affected (P<0.05) plant height, yield and in vitro digestibility. *Dolichos labab* showed the highest plant height at all monitoring period, followed by *Clitoria ternatea*, *Macroptilium bracteatum, Centrosema pascuorum* Bundey and *Centrosema pascuorum molle*. Dry matter yield and in vitro DM and OM digestibily showed the same pattern in which *D.labab* revealed the highest, followed by *C. ternatea*, then three *M. bracteatum*, *C. pascuorum* Bundey and *C. pascuorum* molle which were not different significantly (Table 3).

Under present conditions, *Dolichos lablab* performed better than other legume herbs. *Dolichos lablab* had the highest average plant height (89.52; 114.0 and 189 cm at weeks 4, 6 and 8, respectively, highest DM yield (0.45 kg m^{-2}) and in vitro OM digetibility (Table 3). Differences in growth and yield and OM in vitro digestibility between species appear to be primarily related to differences in physical characteristic of the plant. Physically, *Dolichos lablab* has purplish stems with large leaflets that enable to grow aggressively especially in the loam soil such as in the current experiment. However this biomass production of *Dolichos lablab* is rela-

Table 2. Nutrient contents of *Brachiaria* species harvested at 8 weeks in Sigi Central Sulawesi Indonesia during 2011

Parameter	*Brachiaria* species		
	B. brizantha	*B. mulato*	*B. mutica*
Dry matter (%)	20.43 ± 1.60[a]	21.13 ± 2.30[a]	22.46 ± 1.70[a]
Organic matter (% DM)	86.00 ± 0.80[a]	85.04 ± 1.10[a]	87.78 ± 0.85[a]
Crude protein (% DM)	11.77 ± 0.13[b]	11.93 ± 0.07[b]	8.64 ± 0.07[a]
Ether exctract (% DM)	1.58 ± 0.04[a]	1.88 ± 0.03[a]	1.68 ± 0.03[a]
Neutral detergent fibre (% DM)	65.28 ± 2.70[a]	63.66 ± 2.50[a]	71.96 ± 2.80[b]
Acid detergent fibre (% DM)	38.21 ± 2.40[a]	38.79 ± 2.70[a]	46.09 ± 2.20[b]
Lignin (% DM)	8.48 ± 0.10[a]	8.18 ± 0.09[a]	11.15 ± 0.11[b]

Means followed by same letters do not differ significantly (P<0.05).

tively higher than those of Hartutik et al. (2012). They found that biomass production of *Dolichos lablab* 90 days after planting was 0.46 kg DM m^{-2}. The difference in location would be the factor affecting the results.

Clitoria ternatea had the medium plant height (70.71, 106.33 and 133 cm after 4, 6 and 8 weeks, respectively) and average DM yield (0.28 kg m^{-2}), and in vitro OM digestibility (65.69%). The leaves of this plant were smaller than *Dolichos lablab* but bigger than to the other three legume herbs therefore this further support for the DM yield of *Clitoria ternate*a was at medium level. However the DM yield and in vitro OM digestibility of *Clitoria ternatea* are in the range of Hartutik et al. (2012) who reported that DM yield and in vitro OM digestibility of *Clitoria ternatea* at 90 days after planting were 0.66 kg DM m^{-2} and 66.28%, respectively.

Macroptilium bracteatum, Centrosema pascuorum Bundey and *Centrosema pascuorum* Molle had the lowest plant height, DM yield and DM and OM in vitro digestibility. At 4 week of age, these three legume herbs had lower plant height, about a half than *Clitoria ternatea* indicating that they may have taken a long time to adapt to environmental conditions. In addition these legume herbs are relatively short plant compared to *Dolichos lablab* and *Clitoria ternatea* with smallest leaves, caused the DM yield to be low. The smaller proportion of leaf also resulted in the low OM in vitro digestibilty as suggested by previous studies (Poppi et al., 1980; Minson, 1990).

Nutrition Content of Legume Herb

Basically there were no significant difference (P>0.05) among the species for all aspect of nutrient content studied (Table 4).

As would be expected for growing of leguminous plants, CP content in all legumes were high. The CP content ranged from 21.75 to 24.35%, were higher than Hartutik et al. (2012) which ranged from 18.38 to 18.89%.

Table 3. Growth, yield and in vitro dry matter (DM) and organic matter (OM) digestibility of five legume herbs planted in Sigi Central Sulawesi, Indonesia during 2011

Parameter	Legume herb species				
	Clitoria ternatea	*Dolichos lablab*	*Macroptilium bracteatum*	*Centrosema pascuorum* Bundey	*Centrosema pascuorum* Molle
Plant height 4 wk (cm)	70.71 ± 4.41[b]	89.52 ± 5.93[c]	40 .27 ± 5.42[a]	35.93 ± 6.20[a]	35.07 ± 5.26[a]
Plant height 6 wk (cm)	106.43 ± 9.54[b]	114.50 ± 9.17[c]	68.42 ± 8.54[a]	63.53 ± 8.06[a]	63.43 ± 8.77[a]
Plant height 8 wk (cm)	133.00 ±11.64[b]	189.00 ±15.54[c]	104.00 ± 5.23[a]	112.00 ±10.20[a]	110.00 ± 9.64[a]
Yield (kg DM m^{-2})	0.28 ± 0.04[b]	0.45 ± 0.03[c]	0.15 ± 0.01[a]	0.10 ± 0.02[a]	0.12 ± 0.01[a]
In vitro DM digestibily (%)	65.56 ± 4.37[b]	70.26 ± 3.14[c]	56.66 ± 3.20[a]	58.33 ± 6.66[a]	55.73 ± 0.83[a]
In vitro OM digestibily (%)	65.69 ± 4.60[b]	71.12 ± 2.12[c]	60.37 ± 3.06[a]	60.53 ± 8.50[a]	58.18 ± 2.81[a]

Means followed by same letters do not differ significantly (P<0.05).

Table 4. Nutrient contents of five legume herbs harvested at 8 week at farm in Sigi Central Sulawesi, Indonesia during 2011

Parameter	Legume herb species				
	Clitoria ternatea	*Dolichos lablab*	*Macroptilium bracteatum*	*Centrosema pascuorum* Bundey	*Centrosema pascuorum* Molle
DM (%)	22.67 ± 2.3[a]	19.50 ± 0.8[a]	20.02 ± 2.0[a]	20.82 ± 1.1[a]	21.25 ± 2.7[a]
OM (% DM)	85.79 ± 0.4[a]	83.81 ± 1.9[a]	83.83 ± 1.8[a]	85.86 ± 3.4[a]	84.24 ± 1.6[a]
CP (% DM)	24.35 ± 1.9[a]	22.08 ± 2.1[a]	21.75 ± 2.2[a]	22.77 ± 1.8[a]	23.38 ± 1.8[a]
EE (% DM)	2.97 ± 0.1[a]	2.70 ± 0.5[a]	2.01 ± 0.1[a]	2.36 ± 0.1[a]	2.27 ± 0.1[a]
NDF (% DM)	49.88 ± 2.6[a]	51.01 ± 2.8[a]	50.36 ± 2.5[a]	54.99 ± 2.6[a]	54.80 ± 2.6[a]
ADF (% DM)	35.30 ± 2.1[a]	37.16 ± 2.3[a]	32.74 ± 2.3[a]	32.81 ± 2.0[a]	32.63 ± 2.4[a]
Lignin (% DM)	9.49 ± 0.1[a]	7.55 ± 0.1[a]	8.65 ± 0.1[a]	9.64 ± 0.1[a]	9.22 ± 0.1[a]

DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre

This is because the plants of the current experiment were cut at younger age (56 days) than Hartutik et al. (2012) who cut at 90 days. They were even well above the 7% considered adequate to meet the protein requirements of ruminants (Poppi et al., 1980; Minson, 1990).

In brief, all species studied in these experiments grew and adapted well to the new enviroment in Sigi Central Sulawesi, Indonesia. *Brachiaria mulato* and *Dolichos lablab* appeared to be the best grass and legume herb in Sigi Central Sulawesi. These two forages should be scaled out to farmer level for increasing forage production system for their livestock. The use of forage legumes in agropastoral systems holds great promise for the tropics and is considered one of the sustainable land use options. Nevertheless, other legume herb such as CT must not be overlooked because of its drought resistance, adaptation to poor soils, and high productivity with low nitrogen fertilization.

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