

Response of *Paspalum atratum* to the Level of Urea Fertilisation and Mix Plantation with Legume Herbs

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Abstract: Two trials were carried out to evaluate the response new introduced grass *Paspalum atratum* with different management in Central Sulawesi, Indonesia. The first trial was done to examine the effects of levels of urea fertilization on growth, biomass production and nutritive value of *P. atratum*. A 4 × 8 completely randomized block design was employed in this study. The treatment imposed was four levels of urea fertilization namely 0, 100, 200 and 300 kg/ha. All treatments were repeated eight times. The runners of tillers of *P. atratum* were planted at separation of 75 cm × 75 cm in each 3 m × 3 m plot. Parameters such as plant height, tiller number, leaf width and nutritive value of *P. atratum* were measured at Days 28 and 56 after first cut. The second trial was conducted to study the effect of *P. atratum*, legume herbs mixture on growth and yield of *P. atratum*. A completely randomized block was designed with four treatments, eight replicates, with 32 total plots. Each plot comprised of 3 m × 3 m. The treatments tested in this study include *P. atratum* planted as monoculture (P), P mixed with *Dolichos lablab* (PDL), P mixed with *Centrosema pascuorum* (PCP) and P mixed with *Clitoria ternatea* (PCT). Parameters recorded include plant height, tillage number, leaf width and biomass dry matter (DM) production of *P. atratum*. The results of trial one demonstrated that levels of urea fertilisation significantly ($p < 0.05$) increased plant height, tillage number, DM production and crude protein (CP) content, and reduced significantly neutral detergent fibre (NDF) of *P. atratum*. No significant effect ($p > 0.05$) was detected of the level of urea fertilisation on leaf width, DM, organic matter (OM) and ether extract (EE) of *P. atratum*. Experiment two, exhibited that mix planting between *P. atratum* with legume herbs did not affect significantly ($p > 0.05$) plant height, tillage number, leaf width and biomass DM production of *P. atratum*.

Key words: Urea, plant growth, biomass production, intercrop, mixed crops, crude protein, neutral detergent fibre.

1. Introduction

The main constraint faced by smallholder ruminants producers in eastern part of Indonesia is forage quality and quantity as these regions rely on mainly native grass. The production of native grass is relatively low and decided by season. Under this condition forage production often cannot meet nutrient requirement of ruminants for the whole year. One of the strategies to overcome this problem is by introducing new forages. A number of improved tropical forages both legumes and grasses had been introduced to farmers in Central Sulawesi through the Australian Centre for International Agricultural Research projects. These forages include *Dolichos lablab*, *Clitoria ternatea*,

Arachis pintoi, *Macroptilium bracteatum* and *Centrosema pascuorum* (legumes group), *Brachiaria mulato*, *B. brizantha*, *Panicum maximum*, *Paspalum atratum* (grass group). Among the new introduced forages, *P. atratum* is the one which was accepted well by farmers for scaling up purposes [1].

There are some reasons for the high adoption of *P. atratum* by farmers including high animal palatability, high biomass production and nutrition content. In addition, this leafy perennial tussock grass is able to grow on different soil types from sands to clays and tolerant to poor drainage soil, acid soil and soil with low fertility. Moreover, *P. atratum* is able to adapt to areas with 20-27 °C temperature, tolerates drought and has capacity to grow rapidly under favourable conditions [2]. With its high adaptability to various soil and climate types, *P. atratum* is very suitable as

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cut and curry grass potentially to meet nutrient requirement of ruminants. In this study, Marsetyo [3] demonstrated that Kacang goats given *P. atratum* as single feed gained more weight (75 g/d) than goat fed *B. mulato* and native grass which gained their live weight 57 g/d and 33 g/d, respectively.

Despite higher adoption of *P. atratum* by farmers in Central Sulawesi, very limited work has been done related to growth, production and nutritive value of this grass under various management system, soil and climate in this region. For further wider adoption of *P. atratum* within new environment of Central Sulawesi, two studies were done to examine the response of *P. atratum* with various management systems. In the first study, response of *P. atratum* to the level of urea fertilisation was tested, while the second study was to assess the effect of different legume herbs (*D. lablab*, *C. pascuorum* and *C. ternatea*) on growth and dry matter (DM) production of *P. atratum*. The grass-legume mixture is expected to improve the production of forage per unit area.

2. Materials and Methods

2.1 Site and Time

Both experiments were conducted at the experimental farm situated at Sidera village, Sub District of Sigi Biromaru, District Sigi, Central Sulawesi Province, Indonesia (00°00'58" South to 01°01'00" South, 119°56'00" East to 119°58'00" East) from April to August 2017.

2.2 Experimental Design, Procedures and Treatment

In the first trial, levels of urea fertilisation (0, 100, 200 and 300 kg/ha) were examined in a completely randomized block design with 8 repeats/plot. There were 32 plots arranged for this trial, each plot consisted of 3 m × 3 m and isolated with ditches (50 cm) for the drainage. Prior to the initiation of trial, all planting areas were arranged and clear from undesirable material. The area was then ploughed thoroughly by utilizing cultivators manually. After the

plots were completely prepared, plantation of *P. atratum* was conducted by vegetative planting material (pols) in each hole arranged. There was one pol per hole, each plot comprised of three rows with 75 cm separation between row. Therefore, the total number of grass planting holes was nine in each plot. Plots were weeded twice after planting with hand cultivators.

For consistency, all plants were cut to 5 cm over the ground level, 14 d after planting. Urea then was applied for each plot according to the treatment designation 7 d after the plants were cutting. Urea manure was set in little gap located 5 cm from the plant. The experimental plots were irrigated every day during the establishment. The growth parameters (plant height, number of tiller and leaf width) for plant were measured at Days 28 and 56. Five plants for every plot were measured for growth parameters. All plants were harvested on Day 56, while measurement was done to calculate DM biomass production. Samples of *P. atratum* grass for each treatment were collected for chemical analysis. Several soil properties were also measured.

In the second trial, *P. atratum* was planted in companion with different legume herbs and arranged in a 4 × 8 completely randomised block design. Four treatments employed in this study include planting of *P. atratum* as monoculture (P), mix planting of *P. atratum* with *D. lablab* (PDL), *C. pascuorum* (PCP) and *C. ternatea* (PCT). Each treatment was replicated 8 times/plot (3 m × 3 m). Before planting in the plots, both *P. atratum* tiller (pols) and legume seed of *D. lablab*, *C. pascuorum* and *C. ternatea* were planted on the lightly surface raked into the soil on the separated cocker. After growing for 10 d the plants were removed on plot 3 m × 3 m based on treatment allocation. *P. atratum* pols were planted at distance of 75 cm × 75 cm with nine plants in each plot, while three legume herbs were planted on each plot based on the treatment allocation. There were five plants (*P. atratum*) in each plot taken to be measured for growth

parameters. Plant height, tillage number, leaf width were monitored on Days 28 and 56 after plantation and then harvested by cutting all plants for each plot, for DM biomass production at Day 56. The plot was irrigated every day. Weeds were removed from the plot by using hand hoes during experimental period. The samples of soil were collected at the beginning of experimental period and analysed at the soil laboratory of Tadulako University to determine the soil chemical composition, while the soil pH was measured by using soil tester.

2.3 Chemical Analysis

Samples of *P. atratum* grass were ground using a grinder before passing a 1 mm screen. Representative samples were analyzed for DM, organic matter (OM) content, ether extract (EE) [4], for neutral detergent fibre (NDF) [5]. The Kjeldahl laboratory procedure was employed to analyzed nitrogen content of grass to determine its crude protein (CP) value of samples.

2.4 Climate Data Collection and Statistical Analysis

Climate data were collected from the nearest agrometeorological station during experimental period. These data include daily average temperature, daily maximum and minimum temperature, daily humidity and rainfall.

Data collected from the trials were analyzed using two-way analysis of variance on the Minitab statistical program. Differences in mean values between parameters measured were compared by least significant differences test [6].

3. Results and Discussion

3.1 Soil and Weather Conditions

The soil of experimental site that was collected at the beginning of experiment, was identified as sandy loam soil, with sand component 14.32%. The proportions C and N were 2.24% and 0.28%, respectively. The soil pH KCl was 4.62; while components of Ca and Mg were 5.09 meq/100 g and

0.25 meq/100 g, respectively. The mean of soil pH was 6.35. The daily temperature recorded during experimental period, ranged 25-33 °C, with total precipitation of 870 mm/year and relative humidity 62%-90%.

3.2 Influence of Urea Fertilisation on Growth, Biomass Yield and Nutritive Value of *P. atratum*

The response of *P. atratum* to the level of urea fertilisation is presented in Table 1. Plant height and tillage number increased significantly ($p < 0.05$) in response to the increased level of urea fertilisation measured on Days 28 and 56. Moreover, increased level of urea fertilisation also increased significantly ($p < 0.05$) biomass production and CP content ($p < 0.05$) of *P. atratum* harvested at Day 56. However, NDF of *P. atratum* declined markedly ($p < 0.05$) as a result of increasing level of urea fertilisation. Leaf width, DM, OM, EE content of *P. atratum* was not significantly influenced ($p > 0.05$) by level of urea fertilisation.

Fertilisation of *P. atratum* with urea at level 100, 200 and 300 kg/ha, comparable with use of 48, 96 and 144 kg/ha nitrogen, increased significantly ($p < 0.05$) the growth and DM biomass yield of *P. atratum*. DM biomass production of *P. atratum* increased 14%, 16% and 34% compared to control treatment (without urea fertilisation). The grass may absorb progressively accessible nitrogen in the soil and use it to form new plants as demonstrated by increased tillage number in relationship with increasing level of urea fertilisation. In the meantime, plant additionally utilized accessible nitrogen to synthesise its tissue, so the plant height was likewise expanded in light of increased level of urea preparation. Increasing DM yield of grass in response to the increasing nitrogen fertiliser is in agreement with previous findings [7-12]. Havlin *et al.* [13] noticed that nitrogen application can stimulate the number and wide of leaf which can enhance the vegetative growth components, such as the plant height and the number of tiller, due to stimulation of

Table 1 Growth, dry matter (DM) biomass production and nutritive value of *Paspalum atratum* treated with different level of urea fertilisation.

Parameters	Urea levels (kg/ha)			
	0	100	200	300
Agromony				
Plant height 28 d (cm)	66.22 ± 1.67 ^a	71.45 ± 1.80 ^b	77.27 ± 2.26 ^c	78.53 ± 1.92 ^c
Plant height 56 d (cm)	88.76 ± 2.62 ^a	96.71 ± 2.15 ^b	102 ± 3.38 ^c	105.32 ± 2.50 ^c
Tillage number 28 d (per plant)	35.43 ± 2.45 ^a	41.88 ± 2.86 ^b	46.49 ± 2.63 ^c	49.68 ± 2.70 ^c
Tillage number 56 d (per plant)	87.14 ± 4.42 ^a	114.54 ± 3.51 ^b	118.72 ± 4.30 ^c	130.43 ± 5.63 ^c
Leaf width 28 d (cm)	2.33 ± 0.05	2.34 ± 0.05	2.31 ± 0.06	2.36 ± 0.04
Leaf width 56 d (cm)	2.56 ± 0.03	2.56 ± 0.03	2.62 ± 0.02	2.63 ± 0.02
DM biomass production 56 d (t/ha)	3.88 ± 0.32 ^a	4.45 ± 0.38 ^b	4.92 ± 0.28 ^c	5.50 ± 0.27 ^d
Nutritive value				
DM (%)	22.96 ± 0.67	21.87 ± 0.33	21.90 ± 0.67	21.07 ± 0.48
OM (% DM)	89.52 ± 3.44	90.24 ± 3.36	90.78 ± 3.65	91.62 ± 3.76
CP (% DM)	6.24 ± 0.19 ^a	8.58 ± 0.14 ^b	9.86 ± 0.10 ^b	11.96 ± 0.17 ^c
NDF (% DM)	67.30 ± 2.92 ^a	66.25 ± 3.20 ^a	63.56 ± 2.69 ^b	60.08 ± 3.05 ^c
EE (% DM)	1.54 ± 0.02	1.49 ± 0.03	1.59 ± 0.03	1.61 ± 0.03

OM: organic matter; CP: crude protein; NDF: neutral detergent fibre; EE: ether extract.

Means with different superscripts in same raw are significantly different ($p < 0.05$).

photosynthesis process of the plants. The DM biomass yield of *P. atratum* in the current experiment (3.87-5.47 t/ha) is in the range of biomass yield of similar grass in Thailand reported by previous workers [14, 15].

Rates of nitrogen application to *P. atratum* rate up to 48, 96 and 144 kg/ha increased CP content up to 37%, 58%, 92%, respectively, over control treatment (without fertilisation). This result indicated a rapid uptake of N by plant immediately after N application. Increasing CP content in association with increasing N application suggests that the uptake rates are increasing in relation with N application. This current finding is in agreement with previous studies [7, 9]. Prins [7] noted that the greater N uptake is followed by an accumulation of nitrate in the plant.

NDF of *P. atratum* decreased signifinatly ($p < 0.05$) with the fertilisation of urea at level 200 t/ha and 300 t/ha (Table 1). In both levels of urea application, NDF content declined by 5.56% and 10.73% over control treatment, respectively. This decline in NDF content could be related to the increasing proportion of leaf compared to stem of urea treated grass. Similar phenomenon was also found in previous studies [11,

12] in which NDF content of grass declined due to N fertilisation.

3.3 The Effect of Grass-Legume Herbs Mixture on Growth and Biomass Yield of *P. atratum*

The response of *P. atratum* planted in companion with different legume herbs is presented in Table 2. Although plant height, tillage number and DM biomass yield of *P. atratum* tended to be lower on tretament PDL, PCP and PCT than P, however, those parameters were not affected significantly ($p > 0.05$) by the grass-legume herbs mixture.

Grass-legume herbs mixture is targetted to improve biomass yield and herbage nutritive value compared with growing these species in monoculture. This is due to the addition of nitrogen captured from the air by the legume plants. The growth and DM biomass production of *P. atratum* in PDL, PCP and PCT treatments in the current study tended to be lower than P tretament but the differences were not significant ($p > 0.05$). The nitrogen captured by legumes in each plot may not be enough to lift up nitrogen availability for absorption by *P. atratum*. This may be one reason why *P. atratum* and legume herbs mixture in this study

Table 2 Growth and DM biomass yield of *P. atratum* planted in mixture with legume herbs.

Parameters	Treatments			
	P	PDL	PCP	PCT
Plant height 28 d (cm)	77.54 ± 1.48	74.30 ± 1.52	78.30 ± 1.43	74.42 ± 1.87
Plant height 56 d (cm)	91.76 ± 2.55	87.23 ± 2.70	89.90 ± 2.02	87.86 ± 2.57
Tillage number 28 d	28.24 ± 1.96	24.28 ± 1.32	26.45 ± 2.24	25.32 ± 1.82
Tillage number 56 d	70.47 ± 4.12	64.27 ± 3.66	69.52 ± 3.46	64.58 ± 3.08
Leaf width 28 d (cm)	2.28 ± 0.06	2.25 ± 0.04	2.26 ± 0.05	2.21 ± 0.04
Leaf width 56 d (cm)	2.49 ± 0.06	2.48 ± 0.05	2.54 ± 0.08	2.50 ± 0.05
DM biomass production 56 d (t/ha)	4.92 ± 0.69	4.49 ± 0.19	4.63 ± 0.30	4.59 ± 0.12

P: *P. atratum* planted as monoculture; PDL: P mixed with *Dolichos lablab*; PCP: P mixed with *Centrosema pascuorum*; PCT: P mixed with *Clitoria ternatea*.

Means with different superscripts in same row are significantly different ($p < 0.05$).

failed to increase growth and biomass production of *P. atratum*. In addition, these legume herbs grew creeping around *P. atratum* and physically covered the area of the grass. Due to this physical coverage, *P. atratum* at the treatment PDL, PCP and PCT may have lower light intensity compared with full light conditions on treatment P. This finding is in agreement with results reported in previous studies [16]. Suratmini *et al.* [16] demonstrated that mixed planting between *P. maximum* and *A. pintoii* failed to increase DM biomass production of *P. maximum*. In contrast to the current finding, many researchers reported that grass-legume herbs mixture increased DM biomass of the grass [17-19]. Valentine *et al.* [17], for example, demonstrated that mixed planting between *A. glabrata* and *P. notatum* increased DM production of *P. notatum* up 100%. Bahar *et al.* [19] noted an increase in biomass yield of grass component from mixed planting between *A. pintoii* and *Digitaria*. These authors reported that biomass production of *Digitaria* was 175 g/m² when planted as monoculture, and increased to 320 g/m² when planted in mixture with *A. pintoii*. This increase in biomass production is caused by the transfer of nitrogen from legume to the grass [18, 20]. Humphreys [20] pointed out that every 1,000 kg of top dried material of the legume can catch up about 15-40 kg nitrogen.

4. Conclusions

The level of urea fertilisation increased the height

of *P. atratum* plants, as well as, tillage number, DM biomass yield and CP content, and reduced NDF content. *P. atratum*-legume herbs (*D. lablab*, *P. atratum* and *C. ternatea*) mixture did not affect significantly growth and DM production of *P. atratum*.

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References

- [1] Corfield, J., Bahar, S., Lisson, S., and Rachman, R. 2008. "Improving Forage and Feeding Management Options for Smallholders: Recent Lessons from Eastern Indonesia." In *Proceedings of the National Seminar on Beef Cattle Development to Support the Acceleration of Beef Self-Sufficiency Program in 2008-2010*, Palu, November 2008, 20-9.
- [2] Hare, M. D., Saengkham, M., Kaewkunya, C., Tudsri, S., Suriyajantratong, W., Thummasaeng, K., and Wongpichet, K. 2001. "Effect of Cutting on Yield and Quality of *P. atratum* in Thailand." *Trop. Grasslands* 35 (3): 144-50.
- [3] Marsetyo. 2014. "New Grassess (*Brachiaria mulato* and *Paspalum atratum*) to Increase Growth Performance of Kacang Goats Raised by Small Holder Farmers." In

- Proceedings of the 16th AAAP Animal Science Congress, Vol II*, Gadjah Mada University, Yogyakarta, Indonesia, November 10-14, 2014, 437-40.
- [4] Association of Official Analytical Chemists (AOAC). 1990. *Official Methods of Analysis*, 15th ed. Arlington, Virginia.
- [5] Goering, H. K., and Van Soest, P. J. 1970. "Forage Fibre Analysis (Apparatus, Reagents, Procedures and Some Applications)." In *Agriculture Handbook*, No. 379. USDA, Washington: Agricultural Research Service.
- [6] Steel, R. G. D., and Torrie, J. H. 1989. *Principles and Procedure of Statistic*. New York: Mc Graw-Hill Book Company.
- [7] Prins, W. H. 1984. "Limits to Nitrogen Fertilizer on Grassland." *Neth. J. Agric. Sci.* 32 (4): 319-21.
- [8] Collins, M., Brinkman, M. A., and Salman, A. A. 1990. "Forage Yield and Quality of Oat Cultivars with Increasing Rates of Nitrogen Fertilization." *Agric. J.* 82 (4): 724-8.
- [9] Peyraud, J. L., and Astigarraga, L. 1998. "Review of the Effect of Nitrogen Fertilization on the Chemical Composition, Intake, Digestion and Nutritive Value of Fresh Herbage: Consequences on Animal Nutrition and N Balance." *Anim Feed Sci. Tech.* 72 (3-4): 235-59.
- [10] Guenni, O., Seiterand, S., and Figueroa, R. 2008. "Growth Responses of Three *Brachiaria* Species to Light Intensity and Nitrogen Supply." *Trop. Grasslands* 42 (2): 75-87.
- [11] Damry, Marsetyo, and Syukur, S. H. 2009. "Growth, Production and Nutritive Value of *Brachiaria mulato* as Affected by Level of Urea Fertilization." In *Proceeding of the 1st International Seminar on Animal Industry, Sustainable Animal Production for Food Security and Safety*, Bogor, November 23-24, 2009, 198-201.
- [12] Cui, J. H., Yang, H. J., Yu, C. Q., and Bai, S. 2016. "Effect of Urea Fertilization on Biomass Yield, Chemical Composition, *in Vitro* Rumen Digestibility and Fermentation Characteristics of Forage Oat Straw in Tibet of China." *J. Agric. Sci.* 154 (5): 914-27.
- [13] Havlin, J. L., Beaton, J. D., Tisdale, S. L., and Nelson, W. L. 1999. *Soil Fertility and Fertilizer*. New Jersey: Prentice Hall Upper Saddle River.
- [14] Hare, M. D., Lunpha, A., and Phengphet, S. 2008. "Effect of Foliar Applications of Trinexapac-Ethyl Plant Growth Regulator on Seed Yield in *Brachiaria* Hybrid cv. Mulato II and *Paspalum atratum*." *Trop. Grasslands*. 42 (3): 181-7.
- [15] Hare, M. D., Tatsapong, P., and Phengphet, S. 2009. "Herbage Yield and Quality of *Brachiaria* Cultivars, *Paspalum atratum* and *Panicum maximum* in North-East Thailand." *Trop. Grasslands*. 43 (2): 65-72.
- [16] Suratmini, P., Yuhaeni, S., Purwantari, N. D., and Sutedi, E. 1997. "The Effect of *Arachis* and Grass Mixed Cropping under Various Nitrogen Level on Feed Crop Production." In *Proceedings of the National Seminar on Animal Husbandry and Veterinary*, Bogor, December 18-19, 1997, 949-57.
- [17] Valentine, J. F., Ruelke, O. C., and Prine, G. M. 1986. "Yield and Quality Responses of Tropical Grasses, Alegume and Grass-Legume Associations as Affected by Fertilizer Nitrogen." *Soil and Crop Sci. Soc. Fla. Proc.* 45 (1): 138-43.
- [18] Roy, H., Hossain, A., Karim, S. M. R., Sarker, M. A. I., and Alam, M. A. 2009. "Effect of Grass-Legume Weeds Mixture on the Plant Growth, Dry Matter Accumulation and Competitive Ability of Grass Species." *Bangladesh J. Prog. Sci. Tech.* 7 (1): 93-6.
- [19] Bahar, S., Rahman, R., and Salam, R. 1994. "The Effect *Digitaria* Grass and Four Legume Herbs Mixture on Herbage Yield." *J. Gowa Scientific Research, Agricultural Department, Ministry of Agriculture*. 3 (1): 45-8.
- [20] Humphreys, L. R. 1995. "Diversity and Productivity of Tropical Legumes." In *Tropical Legumes in Animal Nutrition*, edited by Mello, J. P. F. D. and Devendra, C. UK: CAB International.