



## Growth of dwarf elephant grass (*Pennisetum purpureum* cv. Mott) at various levels of nitrogen fertilizer

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### Abstract

An experimental study was conducted to examine and determine the effect of urea fertilizer doses on the growth of dwarf elephant grass (*Pennisetum purpureum* cv. Mott) at a family farm in Loru Village, Sigi Biromaru District, Sigi Regency. The planting materials were the grass pols planted in plots of 12.5 m<sup>2</sup> each. The treatments were 4 implemented N-levels applied as urea fertilizer that equivalents to kg N/ha: 0; 50; 100; and 150, respectively, with five replications applied resulting 20 experimental units. All experimental units were arranged in according to the method of Randomized Block Design (RBD). Observed attributes are; plant vertical height, number of tillers/clump, leaf size (leaf-sheath and leaf-blade lengths, and leaf-blade width), and forage yields (fresh and dry-matter productions). Analysis of variance was applied to examine the effect of the treatment on each of the considered parameters. Then, the Least Significant Difference (LSD) test was done to compare between treatments on any plant attribute that significantly influenced by the treatment ( $P < 0.05$ ). The study results have shown that the observed plant attributes have been significantly increased by increasing levels of the fertilizer treatments, but plant height and leaf-sheath length did not. These are shown by increasing the growth and production attributes from the zero (0 kg N/ha) treatment to the highest applied nitrogen (equivalent to 150 kg N/ha), respectively: number of tillers (22.31 to 31.48 plants/clumps); leaf-blade length (55.20 to 62.17 cm); and leaf-blade width (3.05 to 3.26 cm); and forage production (22.52 to 38.36 tonnes fresh herbage/ha, and 3.51 to 6.57 tonnes dry-matter/ha). It is concluded, therefore, that this grass genotype is positively responsive to nitrogen fertilizer in such experimental condition.

**Keywords:** Urea, dwarf elephant grass, plant attributes, herbage production

### Introduction

Forage is still the main source of ruminant food, where grass-based feeds still play the dominant contribution as the primary ration ingredient to meet the basic needs, production, and reproduction of these groups of animals, particularly those in tropical regions. Herbage feeds are suited to utilization by herbivores that have a capacity for microbial digestion of cell wall constituents (Wilkins, 2000; Krause, *et al.*, 2003; Flint *et al.*, 2012; Giovannoni, *et al.*, 2020) [10, 14, 16, 37]. In ruminants, almost 90% of the feed comes from forage, with fresh consumption per day of 10-15% of body weight, while the rest is concentrated and additional feed (Abdullah, 2012) [11].

Native grasslands occupy a large part of the land area in many regions of this earth, and exist as important forage sources for livestock, especially ruminant keepers with low management practices in the developing countries (Solbrig and Young, 1993; Otte *et al.*, 2019) [22, 31] such as Indonesia. However, low animal productivity becomes the most implications of the low herbage availability and quality from of this nature (Mengistu, 2004; Amar and Damry, 2006; Tessema *et al.*, 2010) [3, 19, 34]. Along with these, decreasing land availability for grazing practices as implications of land conversion become a common phenomenon in the continuously growing world population (Singh and Ghosh, 1993; Balehegn *et al.*, 2021) [5, 30]. One of the approaches strategies to this situation is an improvement of herbage quality and availability per-unit area by planting forage crops whose provide higher herbage production that better in quality, and change growing animal systems, from grazing systems to cut-and-carry management systems.

Regarding the cut-and-carry system, dwarf elephant grass (*Pennisetum purpureum* cv. Mott) has increasingly become the choice of farmers in many regions, such as in Central Sulawesi, Indonesia. This trend is based on some logic reasons. Firstly, leafy or high leaf proportion on its above ground biomass made up the important reason for the livestock growers choose this grass for their animal feeds. This is suggested by some published reports that leaf to stem ratio mostly more than 1, meaning the proportion of leaves more than stems (Halim *et al.*, 2013; Santia *et al.*, 2017; Fauzi *et al.*, 2020) [9, 15, 27]; and the stems are short due to a much shorter internode (1–4 cm) compared to other *Pennisetum purpureum* genotypes with an internode length up to > 10 cm (Yasin *et al.*, 2003; Viana *et al.*, 2018; Fauzi *et al.*, 2020) [9, 35, 39]. Secondly, ample publications suggest for its high herbage productivity and good forage quality compared to many other grasses (Ali *et al.*, 2001; Budiman, *et al.*, 2012; Polakitan and Paat, 2013) [2, 7, 23]. In addition, it has also been reported to be able to grow well under shade of the plantation trees (Polakitan and Paat, 2013; Muhtarudin, *et al.*, 2020) [20, 23], that have indicated the reliability of this grass for uses in integrated management farming systems.

Nevertheless, it is well recognized that plant growth and productivity are highly affected by nutrient supplies from the soil (Delevatti *et al.*, 2019; Mukhtar, 2020; Souza, *et al.*, 2020; Bedaso *et al.*, 2021; Syamsuddin, *et al.*, 2021) [6, 8, 21, 32, 33], such as the essence of nitrogen (N) in grasses. Therefore, grass growth respond to N application is important to be evaluated. This reported study is dedicated to evaluating the growth responses of dwarf elephant grass to various levels

of urea application. Basic growth indicators, including plant height, number of tillers, leaf sizes, and herbage production, are compared between the dosages of nitrogen applied in various levels of urea applications. It is believed that the results of this study provide basic knowledge for animal growers, farmers, and students to better understand the plant of their choice.

## Research methods

### Time and site of the study

This research was conducted in the period of January–March 2018 at the CV. Santya, a family farm located in Loru Village, District of Sigi Biromaru, Sigi Regency, Sulawesi Tengah, Republic of Indonesia. The farm is located at 00° 57' 31,50" N, and 119° 56' 29,30" E, at 126 m above sea level. The study site has a sandy soil texture, pH range 5.44 – 6.24 (slightly acid), moderate in levels of both organic carbon 2.17 (2.12 – 2.46) and total-N 2.24 (2.22 – 2.26) contents. Sigi Regency Central Bureau of Statistics (2022) <sup>[29]</sup> shows some climate data. Mean annual rainfall 800 – 820 mm with 3 wet months that occur in the period of October to January, but it is not surprising if happen in June or August, and the lowest ever noted 495 in 2015 with only 1 wet month in June. Average mean temperature between 27,1°C – 29,5°C (mean minimum and maximum are 23°C and 32°C (rarely below 21°C, and above 34°C), with air relative humidity 78% (74-84 in 2014), 71,75% (55-79% in 2015), 75,75% (71-86% in 2019), or 75% (55-86%). The study site condition during this plot experiment were: mean air temperature 31,10°C, mean air relative humidity 63,52%, soil pH 5,7 (slightly acid); and 230 mm rainfall in the period of January – March 2018 (January was the only wet month with 137 mm rainfall).

### Research materials

The studied plant was dwarf elephant grass (*Pennisetum purpureum* cv. Mott). Planting material was in the form of shredded clumps (pols) taken from the experimental garden belong to the Sulawesi Tengah Center for the Study of Agricultural Technology (BPTP, Balai Pengkajian Teknologi Pertanian, Sulawesi Tengah). Urea fertilizer (46% N) was used as a nitrogen source.

Supporting tools used during the study were hoes to clear land and make plots; tape measures and rulers for measuring plant height and leaf size; hoses and buckets for watering plants; a thermo-hygrometer for measuring temperature and humidity; a pH meter to measure soil pH; an Adam Equipment digital scale with an accuracy of 0.1 grams is used to weigh urea fertilizer; a Morizt brand digital scale with an accuracy of 2 grams is used to measure the fresh weight of dwarf elephant grass; and sample envelopes are used to store forage samples that will be oven-dried.

### Experimental design

This field study was conducted as a plot experiment consisted of four treatments. Each of the treatments was replicated five times, thus resulting twenty experimental units that were arranged using the Randomized Block Design (RBD). The treatment is given in the form of urea fertilization with different doses, that are equivalent to 0, 50, 100 and 150 kg N/ha, respectively, as follows.

$N_0$  = Control (zero urea fertilizer);

$N_{50}$  = 50 kg N/ha (applied as 136 g urea/plot; equivalent to 108.70 kg urea/ha);

$N_{100}$  = 100 kg N/ha (272 g urea/plot; equivalent to 217.39 kg urea/ha);

$N_{150}$  = 150 kg N/ha (408 g urea/plot; equivalent to 326.09 kg urea/ha).

## The study procedure

### Land preparation

The land is cleared of weeds by plowing using a hand tractor to obtain uniform soil conditions. Then, the land is left for two weeks until the weeds grow so that it can be sprayed with herbicides. After the land is clear of weeds, then the land is harrowed. Twenty experimental plots were made, each with an area of 12.5 m<sup>2</sup>. In each plot, another hole was made to plant dwarf elephant grass pols with 0.5 m x 0.8 m spacing, resulting 40 plants from 4 rows x 10 plants in a row.

### Planting, plant care and application of the treatments

The observed dwarf elephant grass was planted using pols (shredded young clumps) that leaves were cut into 25 cm to reduce evaporation. The grass was planted in plots (20 prepared seedbeds), 12.5 m<sup>2</sup> each (5 m x 2,5 m), that have been perforated to form planting holes with 0.8 m x 0.5 m spacing (80 cm between planting rows, and 50 cm apart within a row). This planting arrangement made up 40 plants (4 rows born 10 plants). A pol was planted vertically to approximately 10 cm depth. Then, all plots were watering to proximity soil saturate level. This watering was done twice daily during the early growth, 14 days after planting, and once a day from the day 15 onward, and no watering when rain occurred. Nitrogen fertilization in the form of urea was applied in accordance with treatment levels, as explained above. The treatments were implemented in the 14 days after planting by immersing the fertilizer into the soil (approximately 2-3 cm in depth) in a circle with a distance of + 10 cm from each of the growing pols. Following this application, watering was done to proximity soil saturate level. Since then, watering is done once daily in the afternoon. Throughout the study period, treated plants were closely observed day-to-day in anticipation of caring actions required, such as weed and pest controls.

On the day 60 after planting, all of the experimental plants were cut at the ground level as trimming to uniformity at the starting regrowth. The trimming is aimed to *let all* of the grass plants started to regrow at the ground level of the same stage. The day of trimming was considered as day-0, and the following day was considered as day-1 of the experimental observation. Then, during the next 49 days of regrowth period, was considered as study period where by the end of the period data collections were undertaken. Data on plant attributes consist of; plant height, number of tillers per-clump, leaf size (leaf sheath and leaf blade length, and leaf-width), and herbage yields (fresh and dry-matter productions). Sampling of data collection was 50%, 20 clumps at each of the experimental units.

### Plant samples and attributes

Data collections were undertaken from 20 plant samples (50%) that randomly selected to represent 40 plants of each plot as an experimental unit. All plant attributes were based on observation undertaken at 49 days after uniform trimming, but plant height was measured every week. Plant measurements were done in time or chronological sequence as explain below.

**Plant height (cm)**

Plant height was the vertical height (cm) that measured from the ground surface to the tip of the tallest leaf after straightening it, then measuring it vertically on the highest part of the plant (see Gelayenew *et al.* 2020) [13].

**Number of tillers (saplings/clumps)**

The dwarf elephant grass saplings that are counted are the saplings that emerge from the ground or ground tiller (see Gelayenew *et al.* 2020; Walie *et al.* 2022) [13, 36].

**Leaf size (cm)**

Measurements of leaf size were carried out at the end of the field observation, at 49 days regrowth that consist of leaf length (sheath and blade), and leaf-width (Walie *et al.* 2022) [36]. All of these measurements were undertaken prior to plant harvesting for herbage sampling. The length of the leaf measured includes the length of the leaf sheath midrib and the length of the leaf blade. Since, the leaf-tongue (*legule*) of grasses develops at the inner junction between the sheath and the blade known as the boundary organ (Forage Information System, 2023) [11], therefore, the leaf-sheath length is measured from the base where the sheath attaches to the stem node to the legule, and from this border measured to the tip of the blade is the length of the leaf-blade. The width of the leaf is measured at the position where the widest part of the leaf blade.

**Forage production (tons/ha)**

Forage production was compared among the treatments in the form of both fresh herbage and dry-matter (kg/ha) after 49 days regrowth. The fresh herbage vegetative material was produced by weighing freshly harvesting vegetative parts that were cut at approximately 5 cm above ground, 20 clumps (50%) from in each plot that consisting 40 clumps. The fresh weight of forage is then converted to tons per hectare production units. Dry matter content (%) of the fresh herbage was determined as oven-dried of 3 samples from each of the experimental plots. The dry matter production (kg/ha) is then obtained by multiplying the fresh herbage production/ha with the mean dry matter percentage of each experimental unit.

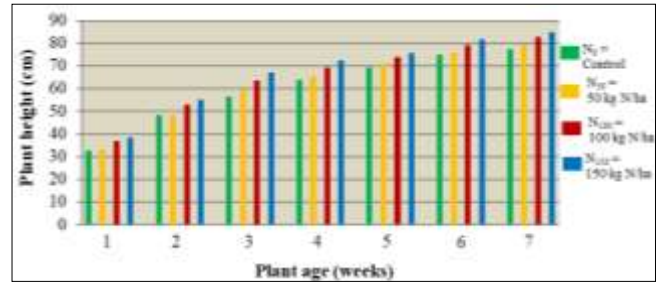
**Data analysis**

Analysis of variance was applied to examine the effects of the treatment on each of the measured variables. The data analysis was done by using the Microsoft Excel 2007 program. Further statistical analysis was undertaken for each of the variables that significantly affected by the treatment with the Least Significant Difference (LSD) test.

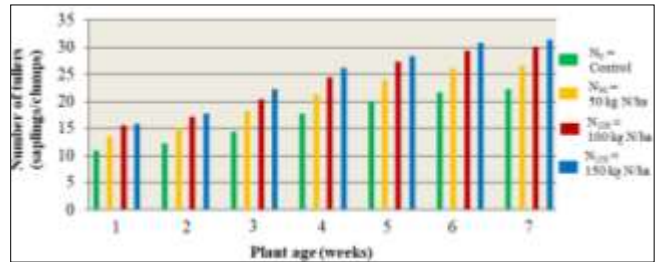
**Results and discussion**

**Results of the Study**

Most of the considered plant attributes have been influenced by the nitrogen treatment, but the plant height and leaf-sheath. Weekly recorded data on plant vertical height and number of tillers are respectively presented in Figure 1 and 2 below. These figures show the grass growth by ages, and fertilizer treatments. Both plant height and number of tillers show the trend of growth week by week, however significant different statistically ( $P < 0.05$ ) between treatments has only been shown by the amount of tillers in every week observation, while plant vertical height did not ( $P > 0.05$ ).



**Fig 1:** Average weekly increase in the vertical height of dwarf elephant grass



**Fig 2:** The average number of dwarf elephant grass saplings each week

The growth data of the studied grass (*P. purpureum* cv. Mott) after 49 days regrowth in response to nitrogen fertilizers is summarized in the Table 1 as follows. In general, the growth of the dwarf elephant grass was significantly affected by the application of nitrogen fertilizers, except for plant vertical height and leaf-sheath length.

**Table 1:** Growth of dwarf elephant grass at various doses of urea fertilization, 49 days after first cuts for initial uniformity of regrowth

| Variables                           | Treatments         |                    |                    |                    |
|-------------------------------------|--------------------|--------------------|--------------------|--------------------|
|                                     | N <sub>0</sub>     | N <sub>50</sub>    | N <sub>100</sub>   | N <sub>150</sub>   |
| Plant vertical height (cm)          | 77.29 <sup>a</sup> | 79.54 <sup>a</sup> | 82.68 <sup>a</sup> | 84.88 <sup>a</sup> |
| Number of tillers (saplings/clumps) | 22.31 <sup>a</sup> | 26.64 <sup>b</sup> | 30.05 <sup>c</sup> | 31.48 <sup>c</sup> |
| Leaf-sheath length (cm)             | 2.64 <sup>a</sup>  | 2.86 <sup>a</sup>  | 2.96 <sup>a</sup>  | 3.01 <sup>a</sup>  |
| Leaf-blade length (cm)              | 55.20 <sup>a</sup> | 56.32 <sup>a</sup> | 58.25 <sup>a</sup> | 62.17 <sup>b</sup> |
| Leaf-blade width (cm)               | 3.05 <sup>a</sup>  | 3.25 <sup>b</sup>  | 3.16 <sup>b</sup>  | 3.26 <sup>b</sup>  |
| Fresh forage productions (tons/ha)  | 22.52 <sup>a</sup> | 29.15 <sup>a</sup> | 33.81 <sup>b</sup> | 38.36 <sup>c</sup> |
| Dry matter production (ton/ha)      | 3.51 <sup>a</sup>  | 3.96 <sup>a</sup>  | 5.28 <sup>a</sup>  | 6.57 <sup>b</sup>  |

1. Treatments: N<sub>0</sub> = without fertilizer (control), N<sub>50</sub> = 50 kg N/ha, N<sub>100</sub> = 100 kg N/ha, and N<sub>150</sub> = 150 kg N/ha;
2. Values with the same letter in the same row are not significantly different ( $P > 0.05$ ); and
3. Values with different letters in the same row indicate significantly different ( $P < 0.05$ ).

**Discussion**

The vertical height of experimental grass increased by the plant age (Figure 1), though the nitrogen treatments have no significant effect on this attribute (Table 1). This does not surprising, since plant height in grasses has been reported by some publications inconsistently in response to fertilizer or soil fertilities. In Manado in North Sulawesi Indonesia, Lasamadi *et al.* (2013) [18] has shown significant effects of organic fertilizer on plant height of cv. Mott grass as increase from 108 cm (without fertilizer) to 114-125 cm tall with the application of 1-3 kg organic fertilizer/m<sup>2</sup>. Significant increase in plant height as the effect of 1.5 kg/m<sup>2</sup> goat compost application on this grass has also reported by Sarwanto and Tuswati (2018) [28]. Similarly, Rohayeti, *et al.* (2022) [26] found that tall size of dwarf elephant grass (cv. Odod) was increased by increasing the levels of organic quail dung fertilizer application. The insignificant effect of the fertilizer application on the grass tall

is in agreement with the findings reported by Syamsuddin, *et al.* (2022) [33], and Praing and Sudarma (2022) [24].

It is valuable to note that the treatment of nitrogen fertilizer increased the plant growth in the form of increases in the number of tiller/clumps, and forage yields (fresh and dry-matter). As well as, it was also confirmed by many previous studies. Bahar *et al.* (2020) [4] for instance, had observed positive effects of both organic fertilizer (goat urine) and inorganic fertilizers (NPK) on the number of tillers, the number of leaves, the leaf length and the fresh herbage production of the odot grass after 60 days regrowth, although the leaf length has only responded significantly to the organic fertilizer. Plant height, stem diameter, leaf-blade size (length and width), and the tiller numbers of dwarf elephant grass (cv. Odot) were significantly increased by the application of EM4 fermented organic fertilizer (Lasamadi, *et al.* 2013) [18]. Using cattle manure, Syamsuddin *et al.* (2022) [33] study showed significant increases in plant height, stem diameter, leaf-numbers, and the tiller numbers of the dwarf elephant grass. Similar responses of the odot grass were reported by Rohayeti *et al.* (2022) [26] with the treatments of quail manure organic fertilizer.

The present study results have shown the usefulness of nitrogen implementation to dwarf elephant grass (cv. Odot) in increments of herbage yield through some of the plant properties, such as number of tillers/clump and leaf-size. It is consistent with Laidlaw (2005) [17] reported study that tiller in grasses plays important roles in the chances of plant survival and quantity of herbage yield. These authors have also reported that higher numbers of tillers formed by many grasses allow the greater development abilities at the early age and faster regrowth after a cut or grazing. Indeed, the more number of tillers per-plant as well as the number of leaves. Further, larger leaf-sizes (the length and width of leaf-blade) add a contribution to the numbers of tillers and number leaves in the increasing forage production. In general, therefore, the more grass tillers, the more leaves would contribute to higher yielded forage (Bahar *et al.* 2020; Gelayenew *et al.*, 2020; Praing and Sudarma, 2022) [4, 11, 24]. Nevertheless, specific studies are required to allow a strong conclusion on this matter.

The non significant influence of fertilizer application to leaf-sheath may due to the nature of dwarf elephant grass with short-internodes, therefore, any small increment is not statistically significant. For examples, published articles shown range of average 1.3 cm (Fauzi *et al.* 2020) [9], and 3.9 cm (Viana *et al.* 2018) [35]. Fauzi *et al.* (2020) [9] compared internodes length between two genotypes of elephant grasses (*P. purpureum* cv. Mott and *P. purpureum* cv. Taiwan) as average 1.3 cm (1.1 – 1.4 cm), and 9.3 cm (8.5 – 10.2 cm), respectively. Much shorter internode, 0.7 – 1.5 cm has been reported under grazing situation (Rodrigues *et al.* 1986) [25]. As the consequences, the authors have also showed that the long internodes of cv. Taiwan has similar leaf to stem percentages, 50.6 to 49.4, while cv. Mott has higher leaf proportion (62.6%) than stem (37.4%). This short-internode attribute of cv. Mott implicates a beneficial value to its role as sources for ruminant feed, since leafy habits provide high, 1.22 – 1.72 (mostly >1) leaf to stem ratio (Halim *et al.* 2013; Santia *et al.* 2017; Fauzi *et al.* 2020) [9, 15]. Due to the lower nutritional value of a grass stem than its leaves, a higher leaf to stem ratio is a desirable attribute in forage crops (Viana *et al.* 2018) [35]. Considering this matter, therefore, cv. Mott is a better choice than the other elephant grass genotypes.

It is hardly to find published data on leaf-sheath length of this grass. Therefore, this study result has provided usefull information on this matter. Table 1 informs that leaf-sheath length ranged from 2.64 cm without N fertilizer to 3.01 cm on the treatment equivalent to 150 kg N/ha. This range (2.64 to 3.01) shows smaller differences in leaf sheath length than differences in leaf-blade length (55.20 to 62.17). Similarly, Fujii *et al.* (2014) [12] found that length variation in leaf-sheath is smaller than in leaf-blade. Nevertheless, leaf-sheath length of a grass plant is more or less comparable to its internode length.

Finally, number of tillers and leaf-sizes, particularly leaf-blade, were in agreement with herbage production. These plant attributes were significantly increased with the highest level of nitrogen applied. In addition, leafy habit and bigger leaf size have advantage implication to leaf area indexes. Further, it is suggested that this advantage contributes to the increase of photosynthetic capacity, improves plant vigor and productivity. This positive implication was emerged in such produce more tiller, bigger leaf size resulting more vegetative biomass yields (Laidlaw, 2005) [17].

## Conclusion

Dwarf elephant grass (*Pennisetum purpureum* cv. Mott) has positively responded to the implement nitrogen fertilizer. This is shown by all of observed plant attributes have been significantly increased by increasing levels of the fertilizer treatments, except plant height and leaf-sheath length. The administration of increasing levels of urea fertilizer had improved the grass growth and productivity. These are shown by increased number of tillers per-plant (number of new individual plants/clumps), leaf sizes (length and width of the leaf-blade), and further expressed in increasing fresh and dry-matter herbage yields of the dwarf elephant grass.

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