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The Growth Dynamics of King Grass (*Pennisetum purpureophoides*) in The Application of Beef Cattle Dung Enriched *Azolla microphylla*

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Abstract. Research on the cultivation of king grass (Pennisetum purpureophoides) was conducted to obtain information on growth, productivity, and continuity in providing forage for a sustainablee ruminant farming business. One of the cultivation factors is fertilization using beef cow manure as a renewable, inexhaustible natural resource or organic fertilizer. Improving the quality beef manure is important for better stimulation of plant growth and production. Fertilizer can be enriched with Azolla microphylla as a good nitrogen contributor. This study used beef cow dung fertilizer at doses of 10, 20, 30 tons per hectare per defoliation, and Azolla microphylla enrichment by 0%, 10%, and 20 % as treatments in a completely randomized design (CRD). The observed variables were plant growth (plant height, stem diameter, number of plants, and number of leaves as production), every 14 days until harvesting on day 42. The data obtained were analyzed descriptively based on the dynamics of plant growth. The result showed that the growth dynamics of the king grass were strongly influenced by fertilizer and plant's age but no interaction each other. In conclusion fertilizer made of beef cattle dung enriched with Azolla microphylla is a feasible nitrogen source. The optimum results were obtained from using 30 tons beef cattle dung enriched with 20% Azolla microphylla to fertilize per hectare per defoliation soil.

Key words: Azolla microphylla, growth dynamics, superior compost, king grass

Abstrak. Penelitian budidaya rumput raja (Pennisetum purpureophoides) dilakukan untuk memperoleh informasi pertumbuhan dan produktivitas serta kontinuitas dalam penyediaan hijauan agar usaha ternak ruminansia terus berkembang. Salah satu faktor budidaya adalah pemupukan. Kotoran sapi sebagai sumber daya alam terbarukan merupakan pupuk organik bermanfaat yang tidak pernah habis. Namun, kualitasnya masih perlu ditingkatkan untuk merangsang pertumbuhan dan produksi tanaman. Salah satu cara untuk memperkaya pupuk adalah dengan memberikan Azolla microphylla penyumbang nitrogen yang baik untuk pupuk. Perlakuan yang dicobakan adalah pupuk kotoran sapi potong dengan dosis 10, 20, 30 ton per hektar per defoliasi, dan pengayaan dengan Azolla microphylla sebesar 0, 10, dan 20 persen. Rancangan yang digunakan adalah rancangan acak lengkap (RAL) dengan perlakuan dosis pemupukan dan persentase pengayaan Azolla microphylla. Variabel yang diteliti adalah pengamatan pertumbuhan tanaman meliputi: tinggi tanaman, diameter batang, jumlah tanaman, dan jumlah daun sebagai produksi, yang diamati setiap 14 hari sampai panen 42 hari. Data yang diperoleh dianalisis secara deskriptif berdasarkan dinamika pertumbuhan tanaman. Hasil penelitian menunjukkan bahwa dinamika pertumbuhan rumput raja sangat dipengaruhi oleh pupuk dan usia tanaman tetapi tidak ada interaksi satu sama lain. Kesimpulannya, pupuk yang terbuat dari kotoran sapi potong yang diperkaya dengan Azolla microphylla merupakan sumber nitrogen yang layak. Pemupukan terbaik dilakukan dengan 30 ton per hektar per defoliasi kotoran sapi potong dengan 20 persen Azolla microphylla.

Kata kunci: *Azolla microphylla*, dinamika pertumbuhan, kompos superior, rumput raja

Introduction

Ruminant breeders covet forage plants with high production rates (Hendarto, 2011), such as king grass that is managed for more profitable efficiency (Jamaran, 2006). Fertilization strategies are implemented to obtain the desired growth and production rates. With enhanced features, king grass, will further support the activities of the ruminant livestock industry (Muchtar and Astawa, 2015).

Beef cow dung is an organic fertilizer with various components to produce superior compost with nutrient values needed by plants (Karyono et al., 2017). According to Soro et al., (2015), fertilization can maintain soil fertility levels to maintain high growth rates and plant production. *Azolla microphylla* plant is an abundant waste plant rich in nitrogen element (Noferdiman dan Zubaidah, 2012), and therefore, very potential for improving the dynamics of natural resources and ruminant livestock business (Surdina et al., 2016). The benefits of Azolla have inspired the studies to use Azolla to enrich beef cattle dung as fertilizer for king grass to obtain its optimal benefits.

Materials and Methods

Pennisetum purpureophoides was planted on a 2 x 1.5 square meter plot using the stem cuttings with a 30 x 80 cm spacing and a 1-meter distance between the plots. A factorial experimental method was carried out to three quantities of beef cattle manure (K1=10 ton/ha, K2=20 ton/ha, and K3=30 ton/ha) enriched with Azolla microphylla (A1=0%, A2=10%, and A3=20%). All 9 treatments were combined and repeated three times. The beef cattle manure was given 3 kg/3 m2, 6 kg/ 3 m2 and 9 kg/ 3 m2 seven days after the king grass were planted. The treatments cow manure namely K1, K2, K3 following 10, 20 and 30 tons per hectare, and combined with treatments A1, A2, A3 following *Azolla microphylla* 0, 10, and 20 percent respectively. Doses of manure 10, 20, and 30 ton/ha applied with 3 kg/3 m^2, 6 kg/ 3 m^2 and 9 kg/ 3 m^2. Each Treatment were applied at 7 days after planted. The observed variables were plant growth plant height, stem diameter, number of plants, and number of leaves as production on the growth days of 14, 28, and 42 days before harvesting to weigh the production. Data of plant growth were recorded from plant height measurements in the plot and, the number of plants from the number of plants per clump. The stem diameter measured about 10 cm from based and the number of leaves count of plants per clump. This procedure was done on the second defoliation. The obtained data subjected to a completely factorial randomized design followed by the Orthogonal and regression tests.

Results and Discussion

Research location

The research was conducted in Beji Village, Kedungbanteng District, Banyumas Regency. The soil texture of this area was classified as sandy loam, containing 0.260% available nitrogen (N), 0.007% available phosphorus (P), and 0.250% P2O5 Potassium (K), (see Table 1). The results of soil analysis indicated that the soil condition was relatively good, and the analysis of cattle manure showed that it contained high nitrogen, low phosphorus, and high potassium, pH 6,7 indicating normal soil.

The analysis results showed that while the soil's physical properties were easy to cultivate with the land structure to support plant growth. The soils aeration was not good. The soil pH was 6,7 which, according to Agus dan Irawan (2006) and Altintas and Acikgoz (2012) is relatively proper for plant growth. Also, the soil contained sufficient nutrients for plant growth. Accordingly, the research location was deemed suitable to grow *Pennisetum purpureophoides* and the treatment was expected to produce the desired results according to the objectives.

The Height Growth of King Grass (Penisetum purpuroider)

The average plant height at the age of 14, 28, and 42 days was 77.93 cm, 117.85 cm, and 182.52 cm, respectively (Table 2), indicating different plant height development despite being measured simultaneously every 14 days. According to Seseray et al., (2012), many factors are contributing to plant growth and development, such as the longer defoliation timing interval, the higher the plant. While plant size is crucial as it affects the photosynthesis, rainfall also affects plant development because it provides water for plants to live and grow. In this study, king grass (*Pennisetum purpureophoides)* grew to 77.93 cm on day 14, then grew higher by 39.92 cm on the next 14 days, and by 64.67 cm on day 42. The height difference is influenced by, among others, the absorbed nutrients by plants and the more intense photosynthetic process due to more chlorophyl as the plants mature (Sabrina et al., 2013).

Tabel 1. Results of soil analysis and beef cattle manure enriched with *Azolla microphylla.*

Number	Treatment	N (%)	P (%)	K (%)
1	Land location	0.260	0.250	0.007
2	K1A0	1.237	0.018	0.518
3	K1A1	1.063	0.013	0.465
4	K1A2	1.231	0.013	0.462
5	K2A0	1.070	0.014	0.495
6	K2A1	1.209	0.013	0.530
7	K2A2	1.134	0.026	0.633
8	K3A0	1.056	0.010	0.568
9	K3A1	1,038	0.003	0.568
10	K3A2	1.261	0.012	0.501

Note: K = beef cattle dung (10, 20, and 30 tonnes per hectare per defoliation); A = enrichment of *Azolla microphylla* (0, 10 and 20 percent); The results were analyzed in the Laboratory of Soil / Land Resources Faculty Of Agriculture, Unsoed

The varied increase in plant height is influenced by factors related to energy reserved in the stems that is remained after harvest and energy produced by plants in the photosynthesis process. According to Rahmi et al., (2007), energy reserves are used by plants for initial growth, namely regrowing the plant and increasing the plant size in the healing process after harvesting, Also, Paskalis et al., (2016) stated that plants would consistently grow taller to reach the sunlight in the photosynthesis process. In this study, the height of 28-day-old king grass increased by 39.92 using nutrition absorbed by the plants from the soil, whereas between 28 and 42 days old, the king grass grew taller by 64.67 cm. According to Kariuki et al., (2016), the final growth occurs when plants reach the highest increase in size, assuming the plants have used nutrients provided through fertilization.

Table 2. Observation of average plant height based on plant age.

Notes	Beef cow manure (ton ha^{-1})	*Azolla* (%)	14 days (cm)	28 days (cm)	42 days (cm)	Delta 0-14	Delta 14-28	Delta 28-42
K1A0	10	0	61.33	97.00	159,33	61.33	35.67	62.33
K1A1		10	69.00	107.00	171.67	69.00	38.00	64.67
K1A2		20	77.00	110.00	175.00	77.00	33.00	65.00
average			69.11 $^{a)}$	104.67 $^{d)}$	168.67 $^{k)}$	69.11	35.56	64.00
K2A0	20	0	70.00	105.67	178.67	70.00	35.67	73.00
K2A1		10	81.00	126.33	181.00	81.00	45.33	54.67
K2A2		20	87.67	130.67	190.00	87.67	43.00	59.33
average			79.56 $^{b)}$	120.89 $^{e)}$	183.22 $^{l)}$	79.56	41.33	62.33
K3A0	30	0	84.33	114.67	191.33	84.33	30.34	76.66
K3A1		10	85.67	130.00	191.67	85.67	44.33	61.67
K3A2		20	85.33	139.33	204.00	85.33	54.00	64.67
average			85.11 $^{c)}$	128.00 $^{f)}$	195.67 $^{m)}$	85.11	42.89	67.67
Treatment average			77.93	117.85	182.52	77.93	39.92	64.67

Note: Unequal superscripts in the same column show a very significant effect (P <0.01).

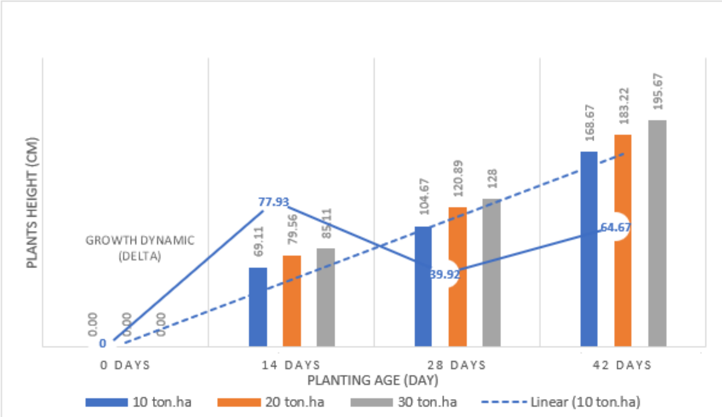

Fig. 1. Dynamic of King Grass Height

The fertilizer used in the form of beef cattle dung enriched with *Azolla microphylla* is believed to have stimulated a sharp increase in plant height. Kindomihou et al., (2014) stated that although organic fertilization is introduced to plants seven days after harvesting, organic fertilizers undergo decomposition and become ready to be absorbed by plants aged 28 to 42 days for a better growth rate. According to Guenni et al., (2008), the availability of nutrients, especially nitrogen, phosphorus and potassium as macronutrients substantially contributes to better plant development.

The results showed that the treatment affected (P> 0.01) the height of the king grass (*Pennisetum purpureophoides*) at each growth stage observed on day 14, 28 and 42, However, the interaction between beef cattle dung enriched with *Azolla microphylla* and harvesting age did not affect (P <0.05). This shows that each dose of beef cattle dung up to 30 tons per hectare per defoliation enriched with up to 20% of *Azolla microphylla* for beef cattle dung has affected the height of the king grass. The nitrogen content in beef cattle dung and *Azolla microphylla* has also promoted further growth, including plant height (Surdina et al., 2016).

Stem Diameter Growth of King Grass (Pennisetum purpureophoides)

The average stem diameter of king grass (*Pennisetum purpureophoides*) on 14, 28, and 42 days was 9.06 mm, 12.57 mm, and 19.40 mm, respectively (Table 3), indicative of non-uniform stem diameter over a 14-day growth. The stem diameter on the 14th day was 9.06 mm, then increased by 3.51 mm in the next 14 days, and increased again by 6.83 mm in the next 14 days at the age of 42 days. The contributing factors to plant growth include energy obtained through photosynthetic activities (Novo et al., 2016). Jamaran (2006) stated that at the initial growth phase, grass plants use the energy left on the unharvested stems until the 14th growth day. Fertilization measures in the previous growth, while nutrient energy from fertilization enriched with composted from *Azolla microphylla* is harnessed for plant growth from day 28 to day 42 in which stem diameter increases in size.

Table 3 shows the results of observation at each growth stage, indicating that the treatment has affected (P> 0.01) the stem diameter of king grass (*Pennisetum purpuroephoides*). In contrast, the interaction between beef cattle dung enriched with *Azolla microphylla* and harvesting age did not affect (P >0.05). It shows that utilizing up to 30 tons of beef cattle dung enriched with up to 20% of *Azolla microphylla* per hectare per defoliation has affected the stem diameter of king grass (*Pennisetum purpureophoides*), in which the plant growth is stimulated by nitrogen contained in beef cattle dung and *Azolla microphylla* (Surdina, et al 2016). According to Lestari et al., (2019), *Azolla microphylla* compost contain pH 6, 3.94% of Total Nitrogen, RC/N Ratio of 11, 1.21% of total P2O5, and 4.88% of total K2O5.

Table 3. Observation of Average Stem Diameter Based on Plant Age.

Notes	Beef cow manure (ton ha^{-1})	*Azolla* (%)	14 days (mm)	28 days (mm)	42 days (mm)	Delta 0-14	Delta 14-28	Delta 28-42
K1A0	10	0	7.21	11.12	16.93	7.21	3.91	5.81
K1A1		10	7.48	12.11	17.48	7.48	4.63	5.37
K1A2		20	8.65	13.50	18.56	8.65	4.85	5.06
average			7.78$^{a)}$	12.24$^{d)}$	17.66$^{g)}$	7.78	4.46	5.42
K2A0	20	0	8.42	10.73	18.30	8.42	2.31	7.57
K2A1		10	9.66	11.75	19.63	9.66	2.09	7.88
K2A2		20	10.11	13.17	20.63	10.11	3.06	7.46
average			9.39$^{b)}$	11.88$^{e)}$	19.52$^{h)}$	9.39	2.49	7.64
K3A0	30	0	9.78	11.43	17.36	9.78	1.65	5.93
K3A1		10	10.09	13.36	21.63	10.09	3.27	8.27
K3A2		20	10.18	15.98	22.05	10.18	5.80	6.07
average			10.02$^{c)}$	13.59$^{f)}$	21.01$^{i)}$	10.02	3.57	7.42
Treatment average			9.06	12.57	19.40	9.06	3.51	6.83

Note: Unequal superscripts in the same column show a very significant effect (P <0.01).

Grass diameter reflects the grass production because the larger the diameter of the grass stalk', the greater the plant's rigidity, and the more production potential (Jank et al 2007). Rigid plants are sturdy, not easily collapsed, and not blocking sunrays from other stalks, thus enabling photosynthesis process to occur in each plant. In turn, forage plants with a high level of forage production are generally preferred by farmers (Hendarto, 2005).

Plant growth of King Grass (Pennisetum purpureophoides)

The average number of plants at the age of 14, 28 and 42 days was 10.78 stems, 14.78 stems and 18.11 plants, respectively (Table 4), indicating that even in the same 14-day period, the plants grew different number of stems. From the initial growth after harvesting to the 14th day, the average clump of each plant was 10.78 plants, then increased to 14.78 stems, and again to 18.11 on the next 14 days

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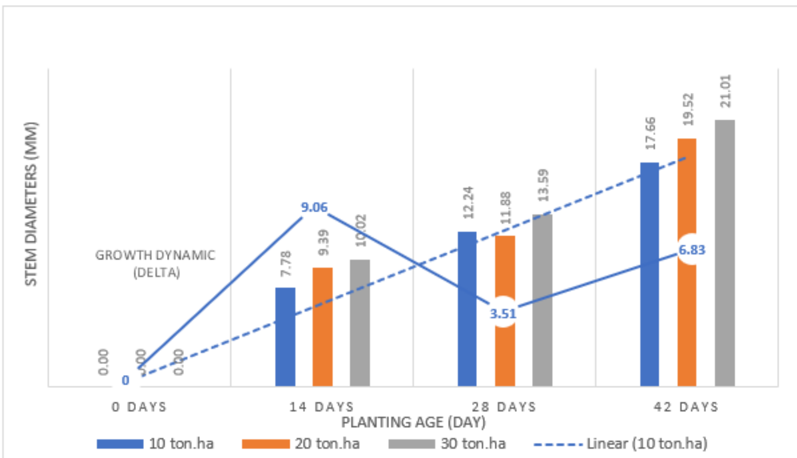

Fig. 3. Dynamic Stem Diameters of king grass

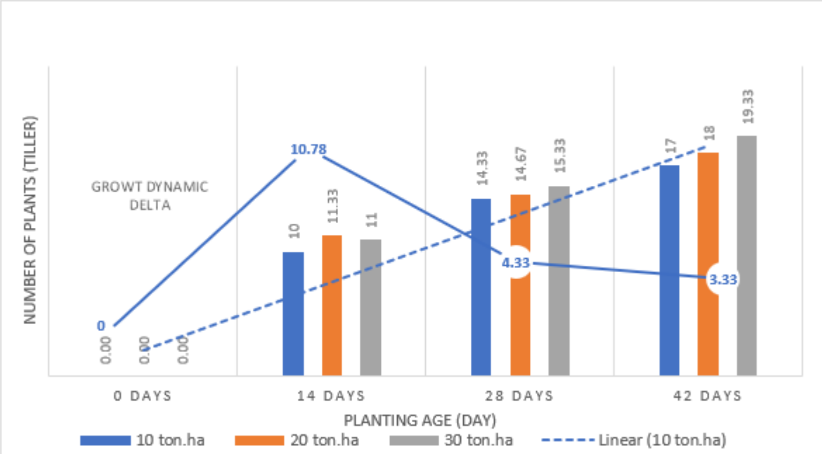

Fig. 3. Dynamic number of plants king grass

According to Huang et al., (2004), the dynamics of each growth stage in plants are attributed to multiple factors. In addition to the energy used, environmental factors such as temperature, sunlight, and nutrients play a role in the plants' growth. A thorough understanding of these dynamics is imperative to allow a directed effort of environment manipulations that help maximize plant growth. Modifying the pattern of fertilization is a solid example (Xiangyang et al., 2011).

This study demonstrated that each growth stage observed on day 14, 28 and 42 was affected by the treatment (P< 0.01), particularly the number of king grass plants *(Pennisetum purpureophoides)*. However, the interaction between beef cattle dung enriched with *Azolla microphylla* and harvesting age did not affect it (P >0.05). In other words, the dose of beef cattle dung enriched with *Azolla microphylla* has affected the yield of king grass (Pennisetum purphoides). Sanderson et al., (2007) have investigated the number of plants and reported that nitrogen nutrients found in beef cattle dung and *Azolla microphylla* has also encouraged additional growth of plants or tillers of king grass

Table 4. Observation of the Average Number of Plants by Plant Age.

Notes	Beef cow manure (ton ha^{-1})	*Azolla* (%)	14 days (tiller)	28 days (tiller)	42 days (tiller)	Delta 0-14	Delta 14-28	Delta 28-42
K1A0	10	0	9	13	15	9	4	2
K1A1		10	10	14	16	10	4	2
K1A2		20	11	16	20	11	5	4
Average			10.00 $^{a)}$	14.33 $^{k)}$	17.00 $^{x)}$	10.00	4.33	2.67
K2A0	20	0	10	13	16	10	3	3
K2A1		10	11	15	18	11	4	3
K2A2		20	13	16	20	13	3	4
Average			11.33 $^{b)}$	14.67 $^{l)}$	18.00 $^{y)}$	11.33	3.33	3.33
K3A0	30	0	10	13	16	10	3	3
K3A1		10	10	16	20	10	6	4
K3A2		20	13	17	22	13	4	5
Average			11.00 $^{c)}$	15.33 $^{m)}$	19.33 $^{z)}$	11.00	5.33	4.00
Treatment average			10.78	14.78	18.11	10.78	4.33	3.33

Note: Unequal superscripts in the same column show a very significant effect (P <0.01)

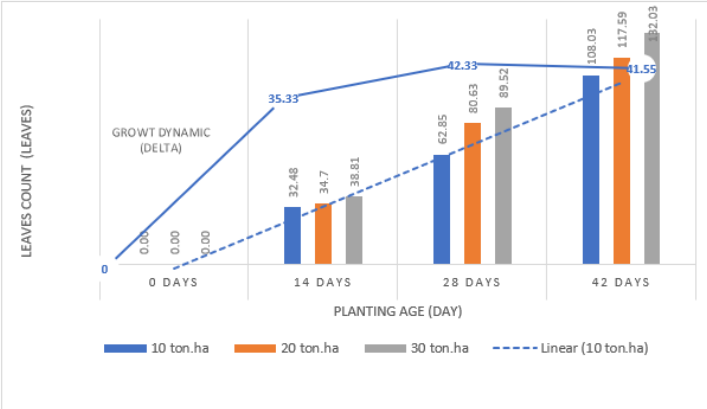

Fig. 4. Dynamic Leaf Count of King Grass

The Leaf Count of King Grass

The average number of the blades of king grass respectively on the ages of 14, 28, and 42 days was 35.33, 77.67, and 119.22 (Table 5). The development of plant growth every 14 days showed non-uniform number of blades. Table 5 shows that the supplying compost up to 30 tons enriched with up to 20% of *Azolla microphylla* has resulted in varying leaf counts on king grass. Similarly, Jamaran (2006) stated that each growth stage has shown a fairly wide variation of leaf count. The increase in leaf count was 42.34 and 41.55 every 14 days until the age of 42 days. According to Xiangyang et al., (2011), environmental factors, especially soil nutrients from organic manure creased the rate of photosynthesis and improved root activity of plants in late- stage of growth. On the first 14 days of growth, plants used the remaining nutrients, then started to use nutrients from the given fertilization in the next 14 days. It is the case due to fertilizers undergoing decomposition and thus absorbed by plants (Novo et al., 2016).

The results showed that at each growth stage observed on day 14, 28 and 42, all treatments using different doses of beef cattle dung and percentages of *Azolla microphylla* had affected (P> 0.01) the leaf count of the king grass, the interaction between beef cattle dung enriched with *Azolla microphylla* and harvesting age had no effect (P <0, 05). Nutrients found in beef cattle dung and *Azolla microphylla* also contributed to the increased leaf count.

Table 5. Observations of Average Leaf Count Based on Plant Age.

Notes	Beef cow manure (ton ha¹)	*Azolla* (%)	14 d (leaves)	28 d (leaves)	42 d (leaves)	Delta 0-14	Delta 14-28	Delta 28-42
K1A0	10	0	27	55	86	27	28	31
K1A1		10	31	65	112	31	34	47
K1A2		20	40	68	126	40	28	58
x̄			32.48 a)	62.85 k)	108.03 x)	32.48	30.37	45.19
K2A0	20	0	28	66	91	28	37	25
K2A1		10	34	86	121	34	51	35
K2A2		20	41	91	141	41	49	50
x̄			34.70 b)	80.63 l)	117.59 y)	34.70	45.93	36.96
K3A0	30	0	30	76	109	30	46	33
K3A1		10	39	92	129	39	52	37
K3A2		20	47	101	158	47	53	57
x̄			38.81 c)	89.52 m)	132.03 z)	38.81	50.71	42.52
Treatment average			35.33	77.67	119.22	35.33	42.33	41.55

Note: Unequal superscripts in the same column show a very significant effect (P <0.01).

Conclusions

Fertilizer made of beef cattle dung enriched with *Azolla microphylla* is a feasible nitrogen source. Fertilizing soil with 30 tons per hectare per defoliation of beef cattle dung and 20 percent *Azolla microphylla* is best and has resulted in uniform growth dynamic condition of the king grass (*Pennisetum purpureophoides*) across growth stages (ages 14, 28, and 42 days) observed from the parameters of plant height, stem diameter, number of plants, and number of leaves.

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