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Research Article
Effect Type and Levels of Manure on Forage Production and Nutrient Quality of Sorghum (*Sorghum bicolor* (L.) Moench) Plant

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Abstract

Background and Objective: The high price of chemical fertilizers encourages the use of livestock manure as a replacement, the use of various types and dosage of cattle dung on sorghum plants will have an impact on the production and quality of forage, it was necessary in order to use it as ruminants feed. This study aims to determine the type and level of manure on the productivity and nutritional value of sorghum. **Materials and Methods:** The design used in this research was split plot design with the basic design of complete randomized design. The main plot: Consisted of type of manure i.e., goats, cows and chickens (K1, K2 and K3). Subplot consisted of dose use of manure (t ha^{-1}): 0, 15, 20 and 25, each treatment was repeated three times. Each plot measuring 2×1.8 m^2. Parameters measured include the production of fresh forage, nutrient content (protein, crude fiber, acid detergent fiber, netral detergent fiber). The data were analyzed by analysis of variance. **Results:** The results of analysis of variance showed that the type of manure was not significant ($p>0.05$) to the production of fresh forage sorghum, but the level of manure doses significantly ($p<0.05$) to fresh forage sorghum production. The highest yield obtained at a rate of fertilizer 25 t ha^{-1} (R3), i.e., 57,250 t ha^{-1}. The results were not significant ($p>0.05$) to the proportion of sorghum stalks and leaves of plants. in the parameters nutrient content, the study showed significant effect on the water content and crude protein, while not significantly affect on crude fiber and netral detergent fiber content of sorghum. The highest yield in sorghum protein content (11.13%) contained in the fertilizer treatment cow manure at a dose of 25 t ha^{-1}. **Conclusion:** The results showed that the highest production of sorghum forage and protein content was obtained at doses of fertilizer was 25 t ha^{-1}.

Key words: Sorghum, manure, nutrients quality, forage, fertilizer, dose

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sorghum can be grown as important dual-purpose crop for grain and forage yields in many arid and semi-arid regions of the world. Sorghum (*Sorghum bicolor* L. *Moench*) is one type of grass that has significant potential to be developed in Indonesia. Grass is able to grow on land that is highly variable, resistant to pests and diseases, where adequate rainfall other cereal crops often fail due to lack of water[1,2] . Sorghum is a cereal crop that has high value nutrients, such as proteins, carbohydrates, fats, calcium, phosphorus. Besides can be used to replace as a food source. Sorghum (*Sorghum bicolor* L. *Moench*) is a crop similar to corn in regards to its agronomic and nutritional value. However, in terms of requirements, sorghum is an attractive alternative to corn because it is more adapted to drought and low soil fertility[3], also of low consumption of nitrogen[4], adapted to hot and dry environments[5] and high salt tolerance[5,6]. Stable nutritive and several harvests offers sorghum as alternative silage crops compared to corn[7]. These features are very important particularly with increased cost of unit value of water and chemical fertilizers.

Fertilizer is essential to support the growth of plants, especially the vegetative growth, without fertilizers, plant growth will be slow. The importance of plant nutrients is reinforced by the fact that the plant only carbon, oxygen and hydrogen are more numerous than nitrogen[8,9]. To meet the needs of plants against these elements, usually carried out by administering urea, TSP and KCl. But lately the chemical fertilizers difficult to obtain therefore the use of manure is the right alternative to replace the chemical fertilizers. Manure used as fertilizer cow dung, goat and poultry, each having a different nutrient content.

Cattle manure and poultry litter are the likely most utilized organic materials around the world due to steadily developing poultry and livestock industries which have been successfully used as sole or combination with inorganic fertilizers on cultivation of numerous cash crops, including maize, cotton, soybean, sorghum, pasture so far[10-12].

Based on research[13], manure/chicken manure is very rich in organic nitrogen to fertilize the soil, other than that of chicken manure has an important role to improve the properties of the biological, physical and chemical naturally on agricultural land. The use of some types of manure on a real cabbage plants improve yields and provide a high enough income. This is due to manure of chicken generally has a relatively higher nutrient levels and C/N ratio is lower so that more quickly available to plant cabbage[14]. In addition to the chicken droppings, cow dung and goat also potentially, because there are very abundance and spread on farm people, especially in Lampung. The weakness of the two types of fertilizer is the C/N ratio is high, so it needs the composting process first so that C/N ratio is about 20. Comparison of biological N and C in manure can affect plant maintenance purposes. If the high N content can help plants to grow and multiply the number of tillers, wherein N function generally as a source of nutrients for cell growth, cell growth and replace cells that have been damaged and die. The content of the C/N ratio below 10 will support the growth and development of sorghum plants that will increase forage production and seed production too. High N fertilizer content as well as the factors that can make the content of crude protein (CP) forage sorghum to be high[15,16]. The use of manure with different types and different levels are expected to restore the nutrient content of the soil so that the soil organic matter better. With adequate nutrient content suppressed the use of chemical fertilizers. This study is a basic research aimed at seeing the potential for quality and productivity of sorghum as animal feed.

MATERIAL AND METHODS

This study conducted for 5 months, located in Kemiling, Bandar Lampung (5.3971°S, 105.2668°E) Lampung Province, Indonesia. Characteristics of soil planting, soil nitrogen content of 0,4% and a carbon content of 1.41% with a ratio of C/N 3,78.

The study was carried out experimentally using research techniques completely randomized design (CRD) with method split-plot design (split plot design). The primary treatment in the form of other types of manure (three types), treatment subplots in each of the main treatment in the form of dosage use of manure (four doses).

In cattle and goat manure is composted before use for 2 weeks. Seeds of sorghum used in the form of seeds. Each treatment unit in the form of plots of land measuring 2×1.8 m and the distance between plots 1 m. Each unit experiment was repeated 3 times, thus obtained 36 experimental units. The composition of the treatment is as follows:

The primary treatment: The type of manure consists of three, namely:

K1: Cow dung
K2: Goat dung
K3: Chicken manure

Treatment subplots consist:

R0: 0 (t ha^{-1})
R1: 15 (t ha^{-1})
R2: 20 (t ha^{-1})
R3: 25 (t ha^{-1})

Variables to be observed in this study: Fresh forage sorghum production was measured by weighing the harvested forage sorghum, forage sorghum harvest was done at the beginning of flowering sorghum plant.

The proportion of stems and leaves, measured by separating the stem and leaves of the sorghum crop, then weigh it.

Nutritional content of sorghum were measured include moisture content, dry matter, crude protein, crude fiber, acid detergent fiber, netral detergent fiber. The nutritional content was measured using the method of proximate analysis and analysis of Van Soest[17].

Data analysis: Data were analyzed using analysis of variance (5 or 1%) and continued by least significant difference (LSD) for a significantly different variables or variables that are significant[18].

RESULTS AND DISCUSSION

Effect of treatment differences in type and dose manure production of fresh forage sorghum: According to analysis of variance results indicate that the type of manure was not significant ($p>0.05$) to the production of fresh forage sorghum, but the level of manure dose significantly ($p<0.05$) to fresh forage sorghum production. Average production of fresh forage sorghum as a result of the treatment can be seen in Table 1.

Based on LSD showed that doses of manure at the R3 highly significant ($p<0.01$) when compared with a dose of R0, R1 and R2, whereas among the dose R0, R1 and R2 give results that are not significantly different ($p>0.05$). This indicates that the cow dung manure, manure droppings of goats and even manure chicken manure at the rate of dose delivery of 25 t ha^{-1} can increase the yield of fresh forage sorghum. The increase in fresh produce is because there are significant increases in the content of nitrogen in the soil after treatment R3, so the need for nitrogen in plants can be met. According to Keraf *et al.*[19], the higher the content of nitrogen in the soil, the availability of nitrogen needed by the plants has also increased. Nitrogen is required for the growth process, so that along with increasing the nitrogen content of the fresh production also increased. This is in accordance with the opinion[20], that plants need nitrogen for growth especially during vegetative growth, ie growth of branches, leaves and stems.

Table 1: Production of fresh forage sorghum

	Treatment 2			
Treatment 1	K1 (t ha^{-1})	K2 (t ha^{-1})	K3 (t ha^{-1})	Average
R0	36.630	43.930	38.720	27.240^{a}
R1	28.870	38.570	32.510	33.320^{a}
R2	34.130	39.790	46.930	38.300^{a}
R3	58.630	48.970	64.160	57.250^{b}
Average	38.260	41.400	45.580	

Values with different superscript letters in the same column indicate significantly different ($p<0.05$) least significant difference (LSD) test. K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Table 2: Proportion of forage sorghum stems and leaves

	Treatment 2			
	Fresh weight of stem/leaf fresh weight (kg)			
Treatment 1	K1	K2	K3	Average
R0	2.36	2.77	2.06	2.40
R1	2.44	1.87	2.68	2.33
R2	2.93	2.16	3.08	2.72
R3	2.63	3.16	3.07	2.96
Average	2.59	2.49	2.72	

K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Effect of treatment differences in type and dose manure on proportion of stems and leaves of sorghum: Results of analysis of variance in this study is known, that the treatment type and dose of manure was not significant ($p>0.05$) on the proportion of stems and leaves of forage sorghum. The proportion of forage sorghum stems and leaves can be seen in Table 2.

However, in the treatment of R1 to R3, if seen from the rates tends to increase. It shows that any increase in dose, then the value of the proportion of stem and leaf increased, but good results are shown in the value of the smallest proportion of stems and leaves, namely R1. The result is suspected, because of the different N content in manure given dose. Nitrogen can slow ripening seeds (prolong vegetative). This condition causes the accumulation of photosynthesis in plants may last longer thus increasing the productivity of crops as feed. The nitrogen content also serves to spur the process of formation of the leaves of plants, because nitrogen is a nutrient-forming amino acids and proteins as raw material in the preparation of plant leaves[21]. That plants need nitrogen for growth especially during the vegetative growth, i.e., growth of branches, leaves and stems[20].

This is consistent with the statement Keraf *et al.*[19], that age appropriate plant fodder crops is 42 days after planting, as if passed that age, the plant will enter the generative phase, so that the elements of N which absorbed the plant is focused on the formation of flowers and plant seeds.

Table 3: Crude protein content of sorghum forage

	Treatment 2		
	Crude protein (%)		
Treatment 1	K1	K2	K3
R0	8.14[a]	7.91[a]	7.66[a]
R1	9.13[ab]	8.18[a]	9.34[b]
R2	10.25[bc]	8.90[ab]	10.17[b]
R3	11.13[c]	9.97[b]	8.14[a]

Values with different superscript letters in the same column indicate significantly different (P<0,05) Least Significant Difference (LSD) test. K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Table 4: Crude fiber content of forage sorghum

	Treatment 2			
	Crude fiber (%)			
Treatment 1	K1	K2	K3	Average
Control	35.41	35.13	34.33	34.96
R1	35.08	35.08	34.26	34.81
R2	35.50	35.32	33.61	34.81
R3	34.38	32.71	36.49	34.53
average	35.09	34.56	34.67	

K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Effect of treatment differences in type and dose manure against crude protein content of forage sorghum: Based on analysis of variance there was an interaction between the type of manure and the dosage level was highly significant (p<0.01), treatment types of manure significantly (p<0.05) and the treatment dose was highly significant (p<0.01) on the crude protein content of forage sorghum least significant difference test results show that when used manure cow manure (K1), then the proper dose for use is R3 (25 t ha^{-1}). This is because at the rate of 25 t ha^{-1} in the K1 produced the highest protein content (11.13%) compared to the other doses. The high protein content because the content of nitrogen resulting in too high doses, it is given that nitrogen is the most important element in the formation of proteins (Table 3).

The same with the use of fertilizers cow manure, manure-dose use goat manure (K2) is right is R3 (25 t ha^{-1}). At this dose produces the highest crude protein (9.97%) compared to the other doses at K2. This is because any increase in dose occurred then an increase in nitrogen content. The high content of nitrogen will produce high crude protein anyway. According Lingga[22] the nitrogen content of chicken manure had higher nitrogen (3.45%) in the dry matter) compared with cow and goat dung (1.5 and 1.94%).

Unlike the K1 and K2, if used manure chicken manure (K3) then the appropriate dosage is R2 (20 t ha^{-1}). This is because the highest crude protein content in the K3 produced in R2 (10.17%). In this K3, any increase in dose an increase in crude protein but the maximum achievement at a dose of R2 (20 t ha^{-1}) while the R3 (25 t ha^{-1}) a decline in crude protein. The high crude protein in R2 due to an increase in nitrogen content. But at the higher dose of 25 t ha^{-1} decline in crude protein.

Effect of treatment differences in type and dose manure against crude fiber content of forage sorghum: The results of analysis of variance showed manure treatment differences were not significant (p>0.05) to the crude fiber content of forage sorghum. Average crude fiber content of forage sorghum as a result of the treatment can be seen in Table 4.

The result shows that the use of fertilizers had no effect the content of crude fiber forage sorghum because it is more crude fibers of plants is influenced by other factors such as age, the longer the life of the crop harvest higher crude fiber content. This is in accordance with Widayanti[23] that the coarse fiber of plants is strongly influenced by age. Besides the ages, crude fiber content is also influenced by the ratio of the stem and leaves. The high crude fiber content because the proportion of stem higher than the leaves. The fiber content of forages should be related to the genotype of plants[24] or the leaf blade:stem+sheath ratio[25].

Generally affecting the content of crude fiber is the time of harvest, the longer the time of harvest the plants it contains fiber crude higher, because the increasing age of the plants causes crop entering the phase renaissance that phase of the plant has been during aging, causing parts of plants containing cellulose and lignin is high. According to the research Keraf *et al.*[19], that the effect of fertilizer dosage levels did not significantly affect crude fiber content, but the age difference was highly significant pieces, that the longer the life of the crop harvest higher crude fiber[23].

Effect of treatment differences in type and dose manure against NDF and ADF content of Sorghum forage: Forage dry ingredients rich in crude fiber, because it consists of approximately 20% of cell contents and 80% of cell wall. The cell walls are composed of two types of fiber that is soluble in acid detergent that is hemi cellulose and less protein cell wall and which does not dissolve in the acid detergent lingo cellulose, which is often called acid detergent fiber (ADF). Fill cells consist of substances that are easily digestible protein, carbohydrates, minerals and fats, while the cell wall made up mostly of cellulose, hemi cellulose, peptin, protein cell wall, lignin and silica. Crude fibers composed of cellulose, hemi cellulose, lignin and silica. Crude fiber affected the species, age and parts of plants[26].

Table 5: Content of acid detergent fiber (ADF) forage sorghum

	Treatment 2			
	ADF (%)			
Treatment 1	K1	K2	K3	Average
Control	58.53	54.21	52.67	55.14
R1	56.04	54.61	59.60	56.75
R2	57.74	57.34	55.22	56.77
R3	54.91	52.67	59.29	55.62
average	56.80[a]	54.70[b]	56.70[a]	

Values with different superscript letters in the same row indicate significantly different (P<0,05) Least Significant Differences (LSD) test. K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Table 6: Neutral detergent fiber content of forage sorghum

	Treatments 2			
	NDF (%)			
Treatment 1	K1	K2	K3	Average
Control	82.22	78.55	82.85	81.20
R1	84.13	83.74	84.75	84.20
R2	85.47	83.58	80.28	83.11
R3	81.75	78.43	82.61	80.93
Average	83.39	81.07	82.62	

K1: Cow dung, K2: Goat dung, K3: Chicken manure, R0: Dose of 0 (t ha^{-1}), R1: Dose of 15 (t ha^{-1}), R2: Dose of 20 (t ha^{-1}), R3: Dose of 25 (t ha^{-1})

Results of analysis of variance showed a significant effect of treatment fertilizers ($p<0.05$) on the ADF content of forage sorghum. The average content of ADF in forage sorghum can be seen in Table 5.

The LSD test results indicate that treatment of goat manure (K2) has a content of ADF value smaller than the K1 and K3. Results of analysis of variance showed the treatment had no significant effect ($p>0.05$) on NDF content of forage sorghum. The average content of NDF in forage sorghum can be seen in Table 6.

The results of the analysis of NDF was higher than that obtained by Praptiwi[27], was 76,89 and 72,85%, respectively for varieties Numbu, Hegari Dwarf and Kawali. This is consistent with the results of the analysis of coarse fiber average 32,71- 35%. According to Firdous and Gilani[28] content of NDF and ADF influenced of growth stage and cultivar, content of NDF between 40.37% at 2nd week to 69,76% at 14 week. Another research De Matos Teixeira *et al.*[29] content of NDF and ADF values ranged from 58.64-59.26 and 36.41-38.87%, respectively. The *in vitro* digestibility were 59.43, 62.56 and 59.22% for the hybrids of sorghum H1, H2 and H3, respectively.

The effect of harvesting time was significant for NDF and ADF content. NDF contents of sorghum cultivars were 670.4, 608.5, 554.6 and 482.1 g kg^{-1} at PE (panicle emergence stage), MS (milky stage), DS (dough stage) and PM (physiologic maturity) stages, respectively, while ADF contents were 354.9, 356.4, 334.4 and 286.4 g kg^{-1} at PE, MS, DS and PM stages, respectively[30]. The dry matter of sorghum silage contained 64.73% neutral detergent fibre (NDF) and 41.03% acid detergent fibre (ADF)[31], the NDF and ADF contents tended to be lower in corn silage than sorghum silages[32]. The low levels of ndf in the forage of sweet sorghum cultivars brs 506 and cmsxs 647 in the first crop might be due to the high wsc content in these plants, which are characterized by high content of non-structural carbohydrates that remain in the stem and leaves in the form of soluble sugars. the high ndf content for silage of sweet sorghum[33].

CONCLUSION

The results showed that the highest production of sorghum forage was obtained at doses of fertilizer was 25 t ha^{-1}. In proportion parameter stems and leaves and crude fiber content, NDF was not affected by treatment. The highest protein content was obtained at fertilizer using cow manure at a dose of 25 t ha^{-1}.

SIGNIFICANCE STATEMENT

The study discovered that use of a dose of 25 t ha^{-1} produced the best production. Hence justifying that the organic fertilizer from livestock manure can replace chemical fertilizers for sorghum production. This study to know the optimal dose of use for sorghum production and nutritional content for feed. Thus the best theory on it may be arrived at.

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