Growth Evaluation of Mutant Lines Sorghum as Forage with Different Fertilizer Levels on Podzolic Soil

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ABSTRACT
Two mutant lines G5 and G8 are sorghum lines from mutation breeding techniques by gamma-ray irradiation, especially sorghum varieties for forage in Indonesia. The objective of this research is to evaluate the agronomic characteristics of sorghum mutant lines at different fertilizer levels on podzolic soil. Completely randomized design with 2 factors was applied in this research. The first factor was the fertilizer levels. The second factor was the mutant lines/ variety of sorghum. The Numbu variety was compared with G5 and G8 mutant lines. The treatment of fertilizer levels were conducted to 3 levels : 0 (control), 10 and 20 ton ha^{-1} fertilizers. Variables measured were stem diameter, plant height, total leaves, leaf width, and leaf length. The results show that Numbu variety and G5 have the highest stem diameter ($P<0.05$). Numbu variety at fertilizer level 10 ton ha^{-1} has the highest plant height with 305.03 cm. The highest total leaves are found at Numbu at fertilizer level 10 ton $ha^{-1}$and G5 at control fertilizer level ($P<0.05$). The highest width leaf are found at fertilizer level 10 and 20 ton ha^{-1}at G8 mutant lines, whereas the highest length leaf are found at fertilizer level 10 and 20 ton ha^{-1} at Numbu variety ($P<0.05$). Based on those results, it can be concluded that fertilizer level 10 ton ha^{-1} at Numbu variety and mutant lines had higher plant growth for the agronomic characteristics of sorghum.

Keywords: *Sorghum, Mutant lines, Fertilizer levels, Podzolic soil, and Plant growth.*

1. INTRODUCTION

Forage plants as ruminants feed which are grown on marginal land often face problems of low quality and quantity. Marginal land is almost 60% of the entire territory of Indonesia [1]. An example is a land in East Kalimantan which is podzolic soil. Characteristics of podzolic are lower C organic and pH soil. The addition of organic matter is needed to increase the fertility of the soil. Organic material that is easily obtained comes from livestock manure as fertilizer. Soil condition improvement with application of organic fertilizer from livestock manure is necessary to maximize plant potential. The use of forage varieties that have adaptability to marginal soil conditions is also developed in various ways, for example gamma irradiation to produce mutant lines specifically for forage plants. One of the plants that has adaptability to marginal soils and is drought resistant as a potential plant to become a feed crop is sorghum.

Sorghum is cereal crop that is used as staple food for many countries. Sorghum has ability to adapt a drought condition at the lack fertile land [2][3]. Sorghum variety has different nutrient digestibility [4]. The classification types of sorghum in Indonesia are grain sorghum for food, forage sorghum as ruminant feed, and sweet sorghum for bioethanol materials. Improvement of the agronomic characteristics of forage plants with mutation breeding technique results forage mutant lines that is tolerant to soil conditions and higher quality nutrients. Sorghum G5 and G8 are the potential promising forage mutant lines from The National Research and Innovation Agency of Indonesia (BRIN).

G5 and G8 mutant lines when compared to conventional sorghum has lower lignin content and lower tannin at the sorghum grain [5]. Investigation on nutrient digestibility for sorghum G5 and G8 shows promising result that is higher than Numbu and Pahat variety at hard dough phase of harvesting [6]. The different maturity stages of harvesting on sorghum affects nutrient digestibility [7].

The agronomic characteristics of sorghum mutant lines in Indonesia have potential for production forage. Sorghum brown midrib (BMR) as mutant lines has resulted the highest agronomy parameters at hard dough stage of maturity in Ultisol [8]. The climate, soil pH, soil fertility will affect to productivity of sorghum [9]. The agronomic characteristic of G5 and G8 mutant lines in Podzolic has not been reported yet. So, the objective of this study is to evaluate agronomy characteristic of two mutant lines at different fertilizer levels. Sorghum G5 and G8 are compared to Numbu as national variety in Indonesia. The different fertilizer levels were also investigated to determine the best level of fertilizer with agronomy parameters of sorghum.

2. MATERIALS AND METHODS

2.1. Planting and Sampling

Experiment fields were conducted during September to December 2021 at laboratory field in Kelua Campus, Agricultural Faculty, Mulawarman University, Indonesia. Organic fertilizer from cow manure as treatment of fertilizer levels was used in this research. Before planting, the field was formed with size 4m x 5m per plot. Fertilizers in 3 levels (0, 10 and 20 ton ha^{-1}) with 3 replications were applied in this research.

After application of organic fertilizer, the field was rested for 1 week before planting. Sorghum variety/mutant lines using in this research were Numbu variety and two mutant lines G5 and G8. Sorghum seeds were sown in 20x40 cm planting area at 3-5 cm depth with 3 seeds per hole. After one week, seed would be replanting. The Chemical fertilizing was done at 15 and 30 days after planting with urea, tri sodium phosphate and potassium chloride at 270 kg ha^{-1}. Harvesting was done with height around ± 10 cm above the ground and during flowering stage. Variables agronomy were measured stem diameter, plant height, number of leaves, width leaf, and length leaf [9]. Stem diameter (mm) was measured with calliper at the widest part of sorghum stem, whereas plant height was done with stem above the ground surface at harvesting. Number of leaves was measured by counting leaves on the sorghum samples. Width leaf was measured at the widest part of leaf at harvesting, whereas length stem was measured by the leaf base up to edge. Evaluation of agronomy characteristics data was obtained with measurement 3 samples of plant on each treatment.

2.2. Data Analysis

Data of the agronomic characteristics: stem diameter, plant height, total leaves, width leaf, and length leaf were analyzed using a completely randomized design with 2 factors. The first factor was the fertilizer levels (0 (control), 10 and 20 ton ha^{-1}), whereas the second factor was the mutant lines/ variety of sorghum. Data were analyzed using analysis of variance (ANOVA) and tested by Duncan Multiple Range Test with SPSS 16 [8].

3. RESULTS AND DISCUSSIONS

3.1. Stem Diameter and Plant Height

The average means of stem diameter can be seen in table 1, whereas the average means of plant height can be seen in table 2. There is significant interaction in stem diameter and plant height between variety/mutant lines and fertilizer levels ($P<0.05$). The stem of Numbu and G5 sorghum has the highest diameter average at different fertilizer levels. The average means of stem diameter of sorghum was 14.12 mm to 17.68 mm. The result of this study is lower than the previous study at 16.6 mm to 17.4 mm [10]. Numbu variety at 10 ton ha^{-1} fertilizer is the highest of plant height with 305.03 cm. The means of this result is higher than previous study at 205.49 cm to 220.75 cm [11]. The difference results might be caused by variety/mutant line, climate, maturity stages of harvesting and soil fertility [8].equations.

Table 1. Stem diameter (mm) of sorghum at different fertilizer levels on podzolic soil

Fertilizer Levels (ton ha^{-1})	Sorghum Variety/Mutant Lines			Means
	Numbu	G5	G8	
0	15.45±2.03^{bc}	17.44±1.16^{a}	15.28±1.35^{bc}	16.06±1.79
10	17.68±1.91^{a}	14.12±1.39^{c}	15.22±1.68^{bc}	15.67±2.21
20	14.45±1.52^{c}	17.34±1.60^{ba}	16.43±0.44^{ab}	16.07±1.75
Means	15.86±2.24	16.30±2.06	15.65±6.97	15.94±1.91

Means with different superscripts within row or column in same parameters are different ($P<0.05$).

Table 2. Plant height (cm) of sorghum at different fertilizer levels on podzolic soil

Fertilizer Levels (ton ha^{-1})	Sorghum Variety/Mutant Lines			Means
	Numbu	G5	G8	
0	249.53±15.17^{b}	218.62±10.76^{c}	255.12±22.69^{b}	241.09±23.08
10	305.03±19.42^{a}	116.98±9.55^{d}	245.19±13.30^{b}	222.40±81.17
20	254.83±13.50^{b}	221.09±13.14^{c}	259.44±9.10^{b}	245.12±20.93
Means	269.80±29.87	185.56±50.60	253.25±123.78	236.20±50.56

Means with different superscripts within row or column in same parameters are different (P<0.05).

Table 3. Number of leaves sorghum at different fertilizer levels on podzolic soil

Fertilizer Levels (ton ha^{-1})	Sorghum Variety/Mutant Lines			Means
	Numbu	G5	G8	
0	7.33±0.71^{c}	9.89±0.78^{a}	8.11±1.05^{bc}	8.44±1.37
10	9.78±0.67^{a}	7.78±0.67^{c}	7.33±0.71^{c}	8.30±1.27
20	7.33±0.50^{c}	8.67±1.12^{b}	7.89±0.78^{bc}	7.96±0.98
Means	8.15±1.32	8.78±1.22	7.78±2.94	8.23±1.22

Means with different superscripts within row or column in same parameters are different (P<0.05).

Table 4. Leaf width (cm) of sorghum at different fertilizer levels on podzolic soil

Fertilizer Levels (ton ha^{-1})	Sorghum Variety/Mutant Lines			Means
	Numbu	G5	G8	
0	7.08±1.08^{b}	6.96±0.48^{b}	7.53±0.71^{ab}	7.19±0.80
10	7.77±1.07^{ab}	5.64±0.42^{c}	7.97±0.90^{a}	7.13±1.34
20	7.01±0.27^{b}	7.36±1.06^{ab}	7.92±0.34^{a}	7.43±0.74
Means	7.29±0.92	6.65±1.01	7.81±2.93	7.25±1.00

Means with different superscripts within row or column in same parameters are different (P<0.05).

Table 5. Leaf length (cm) of sorghum at different fertilizer levels on podzolic soil

Fertilizer Levels (ton ha^{-1})	Sorghum Variety/Mutant Lines			Means
	Numbu	G5	G8	
0	85,85±7.35^{b}	79,54±3.29^{cd}	83,61±4.41^{bc}	83,00±5.74
10	96,77±4.75^{a}	68,58±6.79^{e}	87,16±3.49^{b}	84,17±12.93
20	92,66±2.92^{a}	76,58±6.69^{b}	82,43±5.13^{bc}	83,89±8.39
Means	91,76±6.87	74,90±7.32	84,40±38.75	83,69±9.39

Means with different superscripts within row or column in same parameters are different (P<0.05).

3.2. Number of Leaves, Width and Length Leaf

The number of leaves was showed in Table 3. There is significant interaction in number of leaves (P<0.05). G5 mutant lines at control fertilizer level and Numbu variety at 10 ton ha^{-1} fertilizer level are the highest number of leaves between combination treatment with 9.89 and 9.78 leaves, respectively.

The measuring for leaf width and leaf length is shown in Table 4. and Table 5. There are significant interaction in leaf width and leaf length between variety/mutant lines and fertilizer levels (P<0.05). G8 mutant line has the highest leaf width between variety/mutant lines with different fertilizer levels at 7.92 cm and 7.97 cm respectively. Fertilizer level 10 ton ha^{-1} tends to increase leaf width at G8 mutant lines. The result for leaf length has the highest length leaf at Numbu variety with fertilizer levels 10 ton ha^{-1} and 20 ton ha^{-1}. Leaf length is measured between combination of treatment at 68.58cm to 96.77 cm. Fertilizer level 10 ton ha^{-1} has tendency to resulting longest leaf. This results study is similar to previous report. So far, the previous study reported the leaf width of sorghum 5-9 cm and the leaf length data at 69-73 cm [8][10].

4. CONCLUSION

The different level of fertilizer and sorghum variety /mutant lines at this research have interaction that the fertilizer level 10 ton ha^{-1} on Numbu variety and G5 mutant line shows promising agronomic characteristics as forage in marginal conditions at podzolic soil.

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