

THE EFFECT OF UREA FERTILIZER DOSAGE ON THE GROWTH AND YIELD OF SOME VARIETIES OF SWEET SORGHUM (*SORGHUM BICOLOR L.*)

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ABSTRACT

This study aims to explore the potential of sorghum development in Indonesia by evaluating the interaction between different sorghum varieties and urea fertilizer dosages. The research employed a Randomized Complete Block Design (RCBD) with two treatment factors: three sorghum varieties (Bioguma 1, Bioguma 2, Bioguma 3) and four urea dosages (0, 50, 100, 150 kg/ha), resulting in 12 treatment combinations replicated three times. Conducted over four months in a sub-urban area of Jakarta, the site was characterized by warm temperatures, high humidity, and unstable weather conditions including rain and strong winds. Despite these challenges, sorghum plants showed consistent growth. The results revealed that the interaction between sorghum varieties and fertilizer dosages significantly influenced plant development. Among all combinations, Bioguma 3 treated with 150 kg/ha urea demonstrated the best performance. These findings emphasize the importance of selecting optimal variety and fertilizer combinations to enhance sorghum cultivation in similar agro-climatic regions.

ABSTRAK

Penelitian ini bertujuan untuk mengkaji potensi pengembangan sorgum di Indonesia melalui evaluasi interaksi antara varietas sorgum dan dosis pupuk urea. Penelitian menggunakan Rancangan Acak Kelompok Lengkap (RAKL) dengan dua faktor perlakuan: tiga varietas sorgum (Bioguma 1, Bioguma 2, Bioguma 3) dan empat dosis pupuk urea (0, 50, 100, 150 kg/ha), menghasilkan 12

kombinasi perlakuan yang diulang sebanyak tiga kali. Penelitian dilakukan selama empat bulan di wilayah pinggiran Jakarta yang memiliki suhu hangat, kelembaban tinggi, dan kondisi cuaca yang tidak stabil seperti hujan dan angin kencang. Meskipun demikian, tanaman sorgum menunjukkan pertumbuhan yang stabil. Hasil penelitian menunjukkan bahwa interaksi antara varietas dan dosis pupuk urea berpengaruh nyata terhadap perkembangan tanaman. Kombinasi Bioguma 3 dengan 150 kg/ha urea memberikan hasil terbaik. Temuan ini menekankan pentingnya pemilihan kombinasi varietas dan dosis pupuk yang optimal untuk meningkatkan budidaya sorgum di wilayah agroklimat serupa.

INTRODUCTION

Sorghum is well recognized in Indonesia but the progress is not consistent with rice and corn. The cultivation of this plant as a food crop continues to experience various socio-economic and technical challenges. The government's regional expansion plans do not accord priority to sorghum, given its non-staple food status. Therefore, there is an absence of land expansion in the strategic plan, and no dedicated budget has been allocated. A known challenge in cultivation is related to the insufficient development of superior varieties. Obtaining premium local seeds is difficult due to the limited advancement in defining the identity and characteristics. (Susilowati et al., Salim, 2013). Sorghum is a cereal crop with significant potential for development in Indonesia. This plant has good adaptability and tolerance to drought and can be grown in marginal lands. Additionally, sorghum is relatively resistant to pests and diseases (Ruminta, 2017). Another potential lies in its utilization as animal feed and a plant-based energy source.

Fertilization is adding one or more nutrients in the field when their availability is insufficient for the growth and development of plants. Nitrogen is a crucial nutrient for most plants and is needed more than others. Therefore, continuous nitrogen application affects the soil's carrying capacity (Suminarti, 2019). Based on the results of Ardian Saputra et al. (2021), the optimal sorghum fertilization dosage ranges from 50 kg/ha to 250 kg/ha.

The sweet sorghum used is a recently released variety, and its adaptability should be tested in various regions, such as the Cibubur seed garden. The land is used for developing fruit seedlings, and the nutrient content is suspected to have decreased. This means that fertilization needs to be conducted to ensure the land's condition meets the fertility expectations for the studied sweet sorghum plants. According to the Center for Biotechnology Research and Natural Resources, one of the varieties used is the superior sweet sorghum, Bioguma 2 Agritan variety. This plant has advantages such as reaching a height of approximately ± 262 cm, with biomass potential of ± 54.30 tons/ha, resistance to leaf rust and spot diseases, as well as moderate and high resistance to anthracnose and stem rot (Unpublished Ekowahyuni et al. (2023). Moreover, the variety was released by the Center for Research and Development of Biotechnology and Genetic Resources in

2019 as an improvement of Numbu through gamma-ray irradiation of 50 Gy, grown through in vitro culture methods. The advantages include a plant height reaching ± 262 cm, a biomass potential of ± 54.30 tons/ha, and resistance to rust and leaf spot diseases. Additionally, this shows tolerance to anthracnose and strong resistance against stem rot. Besides the seeds, another useful part is the stalk, which has a relatively high sugar content (Almodares et al., 2008, as cited in Jamaluddin et al., 2022).

METHOD

This research was conducted at the Plant Protection Center (Cibubur Seed Garden), Jl. Jambroe Raya No.1 RT 01/06, Cibubur Village, Ciracas Sub-district, East Jakarta, from October 2022 to January 2023. The materials used are three varieties of sweet sorghum, namely Bioguma Agritan 1, 2, and 3. The fertilizers include Urea fertilizer, SP-36 fertilizer, and KCL. The tools used were hoe, sickle, rope, raffia scissors, ruler, hammer, label paper, nameplate, bamboo, meter, scale, digital camera, and writing tools. This research uses a Randomized Complete Block Design (RCBD) with 2 treatment factors and 3 replications, namely, (a) The first factor is the sweet sorghum varieties (V), consisting of V1=Bioguma 1, V2=Bioguma 2, and Bioguma 3, V3. (b) The second factor is Urea fertilizer, consisting of 4 levels (Dosages): N0=No urea, N1=50 kg/ha, N2=100 kg/ha, N3=150 kg/ha.

The total number of treatment combinations is	3×4	= 12 combinations
Number of replication		= 3 replications
Experimental Unit		= 36 experimental unit
Planting spacing		= 75 cm x 25 cm
Plot Area		= 1 m x 2 m
Distance Between Plots		= 1 m

Each experimental unit consists of 12 plants, and 5 of the best are sampled from each. The total number of sampled plants is 180 and the experimental design model is as follows:

$$Y_{ijk} = \mu + V_i + P_j + VP_{ij} + K_k + \xi_{ijk}$$

Where:

Y_{ijk}	= Observation value for variety i and fertilizer dosage j in group k
μ	= Overall mean
V_i	= Effect of variety i
V_j	= Effect of fertilizer dosage j
K_k	= Effect of group k
ξ_{ijk}	= Error effect for variety i (B=1,2,3), fertilizer dosage j (N=0,1,2,3), and group k (k=1,2,3)

The stages of the research implementation are as follows:

1. Land Preparation

The area had been prepared by clearing remnants from previous crops, followed by double plowing using a rotary plow. Furthermore, the land was plowed to a depth of approximately 15 cm. The plots were established with dimensions of 1 x 2 m, consisting of 3 replications and a total of 36 plots spaced 1 meter apart. Drainage channels were constructed around the plots and the beds were oriented east-west to ensure uniform light distribution.

2. Planting

Before planting sorghum seeds were soaked in water for 1 hour to expedite germination. Planting was conducted by creating holes in the soil, approximately 5 cm deep. Subsequently, sorghum seeds were inserted into the holes, with 4 per hole, and were covered with a spacing of 75 x 25 cm.

3. Base Fertilization

Base fertilization was carried out using organic material in the form of goat manure. Organic material was applied 14 days before planting. The base fertilizer was added by weighing the required amount, with 1 kg per plot in each bed, evenly spread.

4. Fertilization Treatment

In sorghum plants, the fertilization treatment was carried out using urea fertilizer (150 kg/ha). During planting, 1/3 of the base fertilizer, SP-36, and KCL were applied. The remaining 2/3 of urea fertilizer was administered on the 30th day after planting (HST), with SP-36 (100 kg/ha) and KCL (50 kg/ha). Subsequently, urea fertilizer was added when the plants were 40 days old, following the prescribed treatment. This comprised creating furrows 7 cm away from the planting hole's right and left sides. Urea and SP-36 were placed in the same furrow, while KCL was on the other side. The second fertilization was also carried out by creating furrows 10 cm away from the row and covering with soil.

5. Plant Maintenance

Watering was conducted based on soil moisture conditions. The process was carried out in the morning or evening, using a hose and watering can when there was no rain. Meanwhile, weeding was performed manually by pulling out weeds and using a hoe in the plots or drainage ditches. Pest and disease control were implemented when an infestation occurred, and the timing and dosage of application were adjusted according to field conditions.

6. Harvesting

Sorghum harvesting was conducted when the plants had matured. Sorghum plants were harvested approximately 100-110 Days After Planting (DAP) when mature, characterized by fully developed and hardened seeds, yellowing, and dry leaves. Meanwhile, harvesting occurred in the evening by uprooting the plants from the roots before cutting about 10-15 cm below the panicle stem.

Observation Variables

The observation variables conducted on sorghum plants are as follows: Plant height, stem diameter, leaf width, leaf length, leaf count, leaf color, flowering age, seed color, and biomass weight (dry and wet).

1. Plant Height (cm)

Measurement of sorghum plant height from the base of the stem to the tip of the highest leaf in centimeters. The measuring tools used are rulers and a meter and the processes are carried out every week or when the plants are 14, 21, 28, and 35 days old.

2. Stem Diameter (mm)

Measurement is taken at the middle part of the sorghum stem in centimeters using calipers. Meanwhile, observations are made when the plants are 14, 21, 28, and 35 days old.

3. Leaf Width (cm)

Leaf width is calculated by measuring the widest part of the middle using a ruler. Leaf Area (cm) measurement is conducted when the plants are 35 and 40 days old by measuring each length and width as well as multiplying the variables.

4. Leaf Count (number)

The leaf count is calculated from the first emergence until the appearance of the flag. Furthermore, the counted leaves are still present on the sorghum plant.

5. Leaf Length (cm)

To determine leaf length, measurements are taken when the plants are 14, 21, 25, and 35 days old, using a ruler.

6. Wet Plant Weight

The wet plant weight is calculated by weighing the entire sample plant, including the roots, stem, and leaves, after harvesting.

7. Dry Plant Weight

The dry plant weight is calculated by weighing the stem and leaves in all harvested plants, which are dried in an oven at a temperature of 70°C for approximately 3 days.

RESULT AND DISCUSSION

Observation Variables

The research was conducted at the Plant Protection Center (Cibubur Seed Garden), Jl. Jambroe Raya No.1 RT 01/06, Cibubur Village, Ciracas Sub-district, East Jakarta. The general condition of the Cibubur Seed Garden area was 106,307.46 m², consisting of low-lying terrain with an elevation ranging from 60 to 78.75 meters above sea level (masl).

The garden had a warm climate with an average temperature of 24-34°C and humidity level between 60-73%. During the period, the climatic conditions were relatively unstable, experiencing occasional rain and heat. However, under these conditions, sorghum plants showed relatively normal growth as describe in Fig. 1.



Fig. 1 Average Temperature Conditions in the Research Area from October 2022 to March 2023

Then, the climate conditions from October 2022 to January 2023 are shown in Fig.2.



Fig. 2 Plant Conditions in December 2022

Observation Results of Plant Growth

The research results include plant height, stem diameter, leaf width, leaf count, leaf color, leaf length, wet biomass weight, and dry weight.

1. Plant Height

Observations were conducted on sweet sorghum plants (*Sorghum bicolor* L.) every week, from transplanting until 12 weeks after planting (WAP). Sorghum plants were measured from the base of the stem to the tip of the highest leaf using a ruler and meter. The observation results for plant height and the effect of UREA fertilization from October 2022 to January 2023 are shown in Fig. 3.



Fig. 3 Average Humidity Conditions from October 2022 to March 2023

In Jakarta's climate conditions, sweet sorghum growth remained good each month from October 2022 to January 2023. The highest and lowest growth was in January and October 2023 at a fertilizer dosage of 150 kg/ha, reaching 400 cm and 250 cm, respectively. Therefore, the continuous application of N fertilizer affects the loss of soil-bearing capacity (Suminarti, 2019). Based on Saputra's research (2021), the best dosage is between 50 kg/ha and 250 kg/ha.

According to Ardian Saputra et al. (2021), Dillon (2007) stated that plant height was a selection criterion in sorghum breeding programs to determine the level of adaptability. The genetic differences in each variety led to variations in responses to various environmental conditions, resulting in different growth activities. Jumin (2015) added that in adapting, plants were subjected to physiological and morphological changes in their new environment. Different plant varieties show growth and yield even when planted in the same environmental conditions.

The interaction between fertilizer dosage and varieties on plant height can be observed in the Fig. 4.



Fig. 4 Shape of Sweet Sorghum Fruit

As shown in Figure 3, the best interaction of fertilizer dosage and variety is shown at a dosage of 150 kg/ha and the Bioguma 2 variety. Bioguma 2 Agritan sorghum has advantages such as reaching a height of ± 262 cm, with biomass

potential of ± 54.30 ton/ha, resistance to leaf rust and spots, as well as moderate and high resistance to anthracnose and stem rot (Unpublished Ekowahyuni et al., 2023, "The Effect of Plant Spacing on Sweet Sorghum Variety Bioguma 2 in the Ciganjur Experimental Garden, West Jakarta"). The effect of varieties on fertilization from October to January 2023 can be observed in the Fig. 5.



Fig. 5 Effect of Urea Fertilization Dosage from October 2022 to January 2023

The above figure shows the growth conditions among superior varieties, and the plant height is almost the same each month. The highest plant height is in January 2023 for the Bioguma 3 variety. These three varieties are superior sweet sorghum varieties resulting from radiation. This was released by the Center for Research and Development of Biotechnology and Agricultural Genetic Resources in 2019 as improvements from the Numbu variety through gamma-ray irradiation of 50 Gy. The advantages include plant height reaching ± 262 cm, biomass potential of ± 54.30 ton/ha, and resistance to leaf rust and leaf spots, as well as tolerance to anthracnose and strong resistance to stem rot (Unpublished Ekowahyuni et al., 2023).

In the above figure, the interaction between the Bioguma 2 variety and a fertilizer dosage of 150 kg/ha resulted in the best interaction compared to the Bioguma 2 and 1 varieties. This finding is based on research conducted from October 2022 to January 2023.11.21

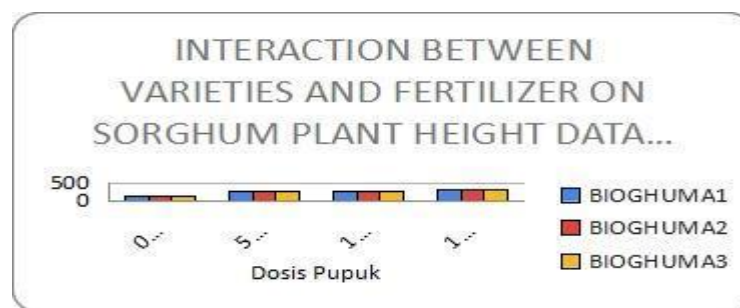


Fig. 6 Interaction of Variety and Dosage Treatments on Plant Height from October 2022 to January 2023

2. Stem Diameter

Figure 6 shows that all three varieties (Bioguma 1, 2, and 3) positively responded to urea fertilizer applied at 150 kg/ha in January 2023. These varieties are superior supported by research. The varieties were developed as improved versions of Numbu through irradiation with a 50 Gy gamma ray, cultivated through in vitro culture methods. The advantages included plant height reaching ± 262 cm, biomass potential of ± 54.30 tons/ha, resilience to rust and leaf spot diseases, as well as tolerance to anthracnose, and strong resistance against stem rot diseases (Unpublished Ekowahyuni et al. 2023).

The best Interaction in the above image is with Bioguma 2 and 3 sorghum varieties at a fertilizer rate of 150 kg/ha. Therefore, the continuous application of N fertilizer affects the loss of soil-bearing capacity (Suminarti, 2019). Based on Saputra's research (2021), the best dosage is between 50 kg/ha and 250 kg/ha. Ardian Saputra et al. (2021) and Dillon (2007) stated that plant height was a selection criterion in sorghum breeding programs to determine the plant's robustness level. The different genetic characteristics of each variety cause variations in responses to different environmental conditions, resulting in growth activities.

3. Width and Length of Leaves

In Figure 10, the results show that leaf parameters such as width and length are the metrics with the most significant growth. This growth is particularly evident from December to January when the width and length of the leaf increased rapidly from 0.5 mm to 4 mm and 25 cm to 40 cm. The leaf quantity data shows a more constant growth, as shown in the following figure.

The effect of dosage and varieties on the wet and dry weights of sweet sorghum plants showed statistically insignificant differences. However, the application of urea fertilizer at 150 kg/ha resulted in a higher wet weight of 0.93 g, followed by the application of 100 kg/ha and 50 kg/ha urea with the same weight of 0.93 g. Similarly, the treatment at 150 kg/ha produced better dry weight with a weight of 0.24 g, while 100 kg/ha and 50 kg/ha resulted in 0.22 g and 0.20 g, respectively. Regarding the variety, Bioguma 3 indicated a better wet weight of 0.90 g, followed by Bioguma 2 and 1. For dry weight, Bioguma 1, 2, and 3 produced the same weight of 0.21 g. Sorghum varieties with higher fresh plant weight were presumed to have larger stems and diameters, taller plants, and more leaves. The highness of the plant is directly proportional to the freshness of the weight (Erawan et al., 2013). Research by Wijiyanti et al. (2019) indicated a direct relationship between the number of leaves and the wet weight. Additionally, sorghum varieties with heavier fresh weight were expected to have higher water content and stem sap levels.

CONCLUSION

Based on the results of experiment, we have found that there was an interaction between variety and fertilizer dose treatment on plant height and stem diameter, particularly Bioguma 2 and dose of urea at 100 kg/ha. The best effect of variety and fertilizer dose treatments is achieved in Bioguma 3 and urea 150 kg/ha for plant height, stem diameter, leaf length, leaf width, leaf number, as well as plant wet and dry weight, respectively. The best interaction of fertilizer dosage and variety is shown at a dosage of 150 kg/ha and the Bioguma 2 variety. Bioguma 2 Agritan sorghum has advantages such as reaching a height of ± 262 cm, with biomass potential of ± 54.30 ton/ha, resistance to leaf rust and spots, as well as moderate and high resistance to anthracnose and stem rot shows the growth conditions among superior varieties, and the plant height is almost the same each month. The highest plant height is in January 2023 for the Bioguma 3 variety. The interaction between the Bioguma 2 variety and a fertilizer dosage of 150 kg/ha resulted in the best interaction compared to the Bioguma 2 and 1 varieties. This finding is based on research conducted from October 2022 to January 2023.11.21 shows that all three varieties (Bioguma 1, 2, and 3) positively responded to urea fertilizer applied at 150 kg/ha in January 2023. These varieties are superior supported by research. The varieties were developed as improved versions of Numbu through irradiation with a 50 Gy gamma ray, cultivated through in vitro culture methods the results show that leaf parameters such as width and length are the metrics with the most significant growth. This growth is particularly evident from December to January when the width and length of the leaf increased rapidly from 0.5 mm to 4 mm and 25 cm to 40 cm. The effect of dosage and varieties on the wet and dry weights of sweet sorghum plants showed statistically insignificant differences. However, the application of urea fertilizer at 150 kg/ha resulted in a higher wet weight of 0.93 g, followed by the application of 100 kg/ha and 50 kg/ha urea with the same weight of 0.93 g. Similarly, the treatment at 150 kg/ha produced better dry weight with a weight of 0.24 g, while 100 kg/ha and 50 kg/ha resulted in 0.22 g and 0.20 g, respectively. Regarding the variety, Bioguma 3 indicated a better wet weight of 0.90 g, followed by Bioguma 2 and 1. For dry weight, Bioguma 1, 2, and 3 produced the same weight of 0.21 g.

REFERENCES

- Andriani, A., Isnaini M. 2013. Morfologi dan fase pertumbuhan sorgum. Dalam Buku Sorgum: Inovasi Teknologi dan Pengembangan. IAARD Press, Jakarta. pp. 47-68.
- Aulakh, M.S., Malhi, S.S. 2005. Interactions of Nitrogen with Other Nutrients and Water: Effect on Crop Yield and Quality, Nutrient Use Efficiency, Carbon Sequestration, and Environmental Pollution. *Adv. Agron.* 86: 341-409.
- Dicko, M.H., Gruppen, H., Traoré, A.S., van Berkel, W.J.H., Voragen, A.G.J. 2006. Sorghum grain as human food in Africa: Relevance of content of starch and amylase activities. *AJB.* 5(5):384-395.

- Dillon, S.L., Shapter F.M., Henry, R.J., Cordeiro, G., Izquierdo, L., Lee, L.S. 2007. Domestication to crop improvement: genetic resources for sorghum and saccharum (Andropogoneae). *Ann. Bot.* 100(5): 975–989. <https://doi.org/10.1093/aob/mcm192>.
- Du Plessis, J. 2008. Sorghum production. Department of Agriculture, Republic of South Africa . www.nda.agric.za/publications.
- Ferrazini, H., Leonel, A., Perazzini, M.T.B. 2021. The energy of activation, instantaneous energy consumption, and coupled heat and mass transfer modeling in drying of sorghum grains. *Biosyst. Eng.* 210(7-8):181–192.
- Gati, E. 2021. Deskripsi Varietas Sorgum Bioguma. Badan Litbang Pertanian, Jakarta, Balitbangtan.
- Silva, K.J., Santos, C.V., Menezes, C.B. de Sousa, S.M. 2021. Sorghum hybrid grown in hydroponics contrast for phosphorus use efficiency. *Braz. J. Biol.* 84:1-10. <https://doi.org/10.1590/1519-6984.253083>
- Sriagtula, R., Sowmen, S., Mardhiyetti, M. 2023. Produksi Sorgum Manis (*Sorghum bicolor* L. Moench) Tanaman Primerdan Raturun I Varietas Numbu dan CTY-33 di Tanah Ultisol. *JPI.* 25(1): 1-12.
- Morrissey, K.G., Thoma, G., Lopez, D.E. 2021. Life cycle impact assessment of biofuels derived from sweet sorghum in the U.S. *Biotechnol. Biofuels.* 14(166): 2993-2999. <https://doi.org/10.1186/s13068-021-02009-6>
- Li, Y., Mao, P., Zhang, W., Wang, X., You, Y., Zhao, H., Zhai, L. Liu, G. 2015. Dynamic expression of the nutritive values in forage sorghum populations associated with white, green and brown midrid genotypes. *Field Crops Res.* 184(2015): 112–122.
- Miller, F. R., Stroup, J.A. 2004. Growth and Management of Sorghums for Forage Production. *Proceedings National Alfalfa Symposium*, pp.1-10.
- OISAT. 2011. Sorghum. PAN Germany Pestizid Aktions-Netzwerk e.V. PAN Germany.
- Rahayu, M., Samanhudu, S., Wartoyo, W. 2012. Uji Adaptasi Beberapa Varietas Sorgum Manis Di Lahan Kering Wilayah Jawa Tengah Dan Jawa Timur Rahayu. *J. Sustain. Agric.* 27: 2577-2599
- Suminarti, N.E. 2019. Dampak pemupukan N dan zeolite pada pertumbuhan serta hasil tanaman sorghum (*Sorghum bicolor* L.) var. Super 1. *J. Agro.* 6(1): 1-14.
- Suminar, R., Purnamawati, H. 2017. Penentuan Dosis Optimum Pemupukan N, P, dan K pada Sorghum (*Sorghum bicolor* [L.] Moench). *JUPI.* 22(1): 6-12.
- Shoemaker, C.E., Bransby, D.I. 2010. Chapter 9: The role of sorghum as a bioenergy feedstock. In: R. Braun, D. Karlen and D. Johnson (Eds.) *Proceeding of the Sustainable Feedstocks for Advance Biofuels Workshop: Sustainable alternative fuel feedstock opportunities, challenges, and roadmaps for six U.S. regions.* Pp 149-160.
- Tabri, F. Zubachtirodin. 2013. Budi Daya Tanaman Sorgum. In: Sumarno et al. (Eds.) *Sorghum inovasi teknologi dan pengembangan.* Pusat Penelitian dan Pengembangan Tanaman Pangan, IAARD Press, Jakarta.