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RESEARCH ARTICLE

CHANGES IN WATER CONTENT AND BULK DENSITY OF SOIL THROUGH APPLICATION ON RICE HUSK ORGANIC FERTILIZER ON SHORGHUM

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ABSTRACT

Sorghum is one of the secondary crops that has important potential as a source of carbohydrates for food, feed, and export commodities, so various aspects of cultivation are needed to increase its production. Efforts to increase sorghum production can be done by providing organic rice husk fertilizer. The objectives of this study were to: 1) determine the effect of sorghum varieties and doses of organic rice husk fertilizer and their interactions on changes in soil Water Content and Bulk Density, 2) determine the treatment that will provide the best effect on soil Water Content and Bulk Density, and (3) determine the correlation between the dose of organic rice husk fertilizer, Water Content and Bulk Density of the soil with the growth and yield of two sorghum plant varieties. The study was conducted from July to November 2021 in Iloheluma Village, Tilongkabila District, Bonebolango Regency, Gorontalo Province. This study was designed based on a 2-factor Factorial Randomized Block Design (RBD). The first factor is the sorghum variety which consists of two levels: 1) the Kawali variety, and 2) the Numbu variety. The second factor is the dose of organic fertilizer consisting of 3 levels: 1) without organic fertilizer, 2) organic fertilizer with a dose of 25 tons ha-1, and 3) organic fertilizer with a dose of 50 tons ha-1. Data analysis was carried out using ANOVA (Analysis of Variance) and BNJ further tests, as well as correlation analysis to determine the relationship between the dose of organic rice husk fertilizer, Water Content and Bulk Density with the growth and yield of sorghum plants

KEYWORDS

Sorghum; Organic Fertilizer; Rice Husk;Wwater Content; Bulk Density

1. INTRODUCTION

The growth and production of sorghum plants are largely determined by soil properties that support optimal growth and production. Soil properties can include physical, chemical, and biological properties. Physical soil properties such as Water Content (WC) and Bulk Density (BD) significantly influence the achievement of maximum sorghum production. Soil water content is closely related to the soil's ability to supply water to plants. The analysis plants experiencing water shortages will experience a decrease in the rate of photosynthesis, which ultimately impacts plant growth (Nugraheni et al., 2018). Conversely, if photosynthesis increases, the amount of photosynthates distributed to the leaves or crown of the plant will increase. BD is closely related to the ability of roots to penetrate the soil structure. A higher WC value indicates a denser soil, making it difficult for plant roots to penetrate and inhibiting root growth. Research shows that increasing soil density has been shown to have a significant effect on plant height and root length (Haridjaja et al., 2010). In addition to soil physical properties, sorghum plant growth and yield are also influenced by the variety used in cultivation.

Soil water content and bulk density are two key factors that play a crucial role in agriculture. The amount of water present in the soil directly affects plant growth and crop yield, as it determines the availability of water for plants to uptake (Bhattacharya, 2021). On the other hand, bulk density refers to the compactness of the soil, which can impact root growth, nutrient uptake, and overall soil health (Sunny and Mohammad, 2024). Understanding and managing these two factors is essential for optimizing agricultural productivity and sustainability. By monitoring and adjusting soil water content and bulk density, farmers can ensure that their crops receive the right amount of water and nutrients for healthy growth. Proper irrigation and soil management techniques can help maintain optimal soil conditions, leading to improved crop yields and reduced environmental impact. In conclusion, paying attention to soil water content and bulk density is crucial for successful and sustainable agriculture practices. Each sorghum variety has distinct root system characteristics, which can affect soil properties in the root zone. More roots will increase the organic matter content in the soil, which in turn can affect soil density and its ability to absorb water. Soil density and water absorption are largely determined by the organic matter content in the soil. Therefore, to reduce high soil density (high BD), it is necessary to add organic matter or use organic fertilizers. This not only helps reduce soil density (lowering BD) but also improves plant growth and yield. Soils with low density and high organic matter content tend to absorb water more easily and have a better water supply capacity for plants than dense soils with low organic matter. As a study suggested that BD is influenced by soil texture, organic matter, and compaction (Widjayanto et al., 2016). Furthermore, research showed that the addition of organic matter in the form of cow dung and rice husk ash significantly affected soil field capacity, permeability rate, and increased organic carbon (C-organic) content in the soil by (Panda et al., 2021).

The soil at the research site is classified as dense with low organic matter content, so efforts are needed to reduce the soil density level to support optimal plant growth and production yields. One method to reduce soil

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density, which is indicated by a decrease in the bulk density (BD) value, is by adding organic matter to the soil. Various types of organic matter can be utilized, one of which is organic fertilizer from rice husks. Therefore, this study aims to examine the effect of providing organic rice husk fertilizer to two sorghum varieties on changes in soil water content and BD values, as well as to analyze the relationship between water content and BD, organic fertilizer dosage, and grain weight per hectare, the relationship between organic fertilizer dosage and BD, and the relationship between BD and grain weight per hectare.

2. Methods Of Biofortification

2.1 Time and Location

This research was conducted from July to November 2021. The research location was in Iloheluma Village, Tilongkabila District, Bonebolango Regency, Gorontalo Province, Indonesian.

2.2 Materials And Tools

The materials used in this study were rice husks, fine bran, water molasses, and Microorganism Effectiveness (EM4). The tools used to support this study included: hoes, shovels, ropes, buckets, sacks, plastic bags, measuring tape/rulers, sample rings, knives, labels, ovens, scales, aluminum cups, desiccators, and stationery

2.3 Research Method

This research was designed in a 2-Factor Randomized Block Design (RBD-Factorial), the first factor was the sorghum variety which consisted of 2 levels, namely V1 = Numbu Variety and V2 = Kawali Variety. The second factor was the dosage of rice husk organic fertilizer, which consisted of three levels: P0 = No rice husk organic fertilizer, P1 = 25 tons ha-1, and P2 = 50 tons ha-1. The treatment combinations were as follows:

V1P0 = Numbu variety without rice husk organic fertilizer

V1P1 = Numbu variety with 25 tons ha-1 rice husk organic fertilizer

V1P2 = Numbu variety with 50 tons ha-1 rice husk organic fertilizer

V2P0 = Kawali variety without rice husk organic fertilizer

V2P1 = Kawali variety with 25 tons ha-1 rice husk organic fertilizer

V2P2 = Kawali variety with 50 tons ha-1 rice husk organic fertilizer

Each treatment combination was replicated three times, resulting in 18 experimental units in the field. The research data were processed using Analysis of Variance (ANOVA). If the treatment had a significant effect, a further 5% BNJ test was conducted to determine the treatment that provided the best effect. Correlation analysis was conducted to see the relationship between water content and Bulk Density with the growth and yield of sorghum plants.

2.4 Research Procedures

2.4.1 Making Organic Fertilizer From Rice Husks

The preparation of organic fertilizer from rice husks using EM4 as a simulator follows the procedure in research (Suji's, 2014).

Ingredients:

- 200 kg of rice husks
- 50 kg of rice bran
- 500 ml of EM4
- 40 tablespoons of molasses/granulated sugar
- Sufficient water

Preparation:

- Dissolve the EM4 and sugar in water
- Mix the rice husks and bran thoroughly
- Slowly pour the EM4 solution into the mixture until the water content reaches 30%. When the mixture is kneaded, no water should escape, and when the dough is released, it will expand.
- Mound the mixture on a dry surface to a height of 15-20 cm, then cover it with a sack for 3-4 days.
- Maintain the temperature of the mound at 40-50°C. If the temperature exceeds 50°C, open the sack, turn the mixture over, and then cover it again.
- After approximately 2 - 5 weeks, the bokashi fertilizer has fermented and is ready to be applied.

2.4.2 Land Preparation And Soil Cultivation

Before land preparation, the land to be used for research was first surveyed. The land was then cleared of weeds and plant debris. It was then hoed, plowed twice, then harrowed and leveled. Drainage channels were installed around the land to prevent waterlogging. Next, research plots measuring 2.5 m x 1.5 m were created.

2.4.3 Planting

The varieties planted were the Kawali and Numbu varieties, planted at a distance of 70 cm x 25 cm with 2-3 seeds per planting hole.

2.4.4 Fertilization

The fertilizer given is organic rice husk fertilizer according to the treatment dose, namely 25 and 50 tons ha-1 converted according to the plot area, namely 9.375 and 18.75 by applying it by mixing it evenly with the soil a week before planting

2.4.5 Plant Maintenance

Plant maintenance includes: watering, replanting, thinning, weeding, and hilling. Watering is done in the morning between 7:00 AM and in the afternoon around 4:30 PM if there is no rain. Replanting is done three days after planting, or when the plants have begun to grow. Thinning is done at two weeks old, leaving only two plants per clump. Weeding is done weekly by removing weeds growing in the experimental plot. Hilling is done two weeks after planting.

2.4.6 Soil Sampling

Sampling is done using a sample tube/ring. The soil surface is leveled and cleared of grass or litter. The sample ring is placed perpendicular to the soil surface, then using a small block placed on the surface of the sample ring, it is pressed until three-quarters of the way into the soil. Another sample ring is placed on top of the first sample ring and pressed until it is 1 cm into the soil. The upper sample ring is separated from the lower sample ring. Dig the sample ring using a shovel. When digging, the tip of the shovel must be deeper than the tip of the sample ring so that the soil beneath the sample ring is also removed. Excess soil is first carefully sliced so that the soil surface is level with the surface of

2.5 Observation Variables

2.5.1 Soil Water Content

Measuring soil water content using the gravimetric method, namely direct measurement through measuring water loss by weighing soil samples before and after drying at a temperature of 105ºC in an oven.

2.5.2 Bulk Density (BD)

Determination of Bulk Density (BD) value using the ring method. The soil sample that has been taken is dried in an oven at a temperature of 105ºC for 24 hours until a constant weight is achieved. Then put it in a desiccator for approximately 10 minutes before being weighed. Weigh the dry weight of the soil (Ms + ring weight (Mr) + cup weight (Mc). Determine the inner volume of the ring (Vt) and calculate BD:

$BD = Ms/Vt = ((Ms+Mr+Mc)-(Mr+Mc))/Vt$

Where:

BD = Bulk Density (g cm-3)

Ms = Oven dry weight of soil (g)

Ms = Ring weight (g)

Mc = Weight of the cup

Vt = Total volume of soil

2.5.3 Measurement Of Sorghum Production

Determination of seed weight per hectare (ton ha-1) is calculated based on seed weight per plot

3. Result And Discussion

3.1 Soil Water Content (%) and Bulk Density (g cm-3)

The results of the analysis of variance showed that the variety treatment had no significant effect on soil water content, but had a significant effect on soil density. Meanwhile, rice husk organic fertilizer significantly affected soil water content and density. There was no interaction between the variety and rice husk organic fertilizer on changes in soil water content and density. The average values of soil water content and density for each treatment are presented in Table 1.

The data in Table 1 shows that the soil water content in treatment V1 (Numbu variety) was not significantly different from the water content in treatment V2 (Kawali variety). The P2 rice husk organic matter treatment (50 tons ha-1) provided a significantly higher water content value than the control, but was not significantly different from P1 (25 tons ha-1). The treatment without rice husk organic fertilizer P0 (control) had the lowest water content value, but was not significantly different from P1. The high soil water content in treatment P2 was influenced by the high organic matter content in the soil. The high organic matter plays a role in increasing the soil's capacity to retain water. The results of research by showed that the application of rice husk ash as a combination treatment was able to increase soil water holding capacity, with water content at field capacity reaching 68.63%. In this study, the water content obtained was P0 at 47.57%, P1 at 54.85%, and P2 at 64.33%. This shows that the application of 50 tons ha-1 of organic rice husk fertilizer is effective in increasing the soil's water-holding capacity. Increasing the soil's water-binding capacity directly improves water availability for plants (Panda et al., 2021).

Table 1: Soil water content and BD with various organic fertilizer treatments on two varieties

Treatment	Water Content (%)	Bulk Density (g cm^{-3})
Varietas VI V2	54,90 56,27	1,34 b 1,04 a
BNT	-	0,12
Pupuk organik P0 (without organic fertilizer) P1 (25 ton ha^{-1}) P2 (50 ton ha^{-1})	47,57 a 54,85 ab 64,33 b	1,30 b 1,22 b 1,05 a
LSD	10,01	0,13

Note: Numbers followed by different letters in the same column indicate significant differences at the 5% BNJ test level.

Based on the data in Table 1, the BD value was significantly lower in the V2 (Kawali) variety compared to the V1 (Numbu) variety. The rice husk organic matter treatment at a dose of P2 (50 tons ha^{-1}) resulted in a significantly lower BD value compared to the control treatment (P0), but did not show a significant difference compared to the P1 treatment (25 tons ha^{-1}). The treatment without the addition of organic fertilizer (P0) showed the highest BD value and was not significantly different from P1. The low BD value in the P2 treatment was caused by the high organic matter content in the soil, which increased soil porosity and looseness, thereby reducing soil density. This research BD reflects the level of soil density (Hardjowigeno, 2007). The denser the soil, the higher the BD value, while looser or less dense soil will have a lower BD value.

Rice husk organic fertilizer is an organic material derived from agricultural waste, specifically rice husks. Its use as a fertilizer has significant potential to improve soil quality, including physical properties such as water content and bulk density (R. and I., 2007). Soil water content (SWC) refers to the amount of water stored in soil pores. This is a crucial parameter because water is the primary medium for nutrient transport to plant roots and plays a direct role in photosynthesis (Juan et al., 2021). Adding organic matter to soil, including rice husks, will cause a decrease in bulk density (Matt et al., 2023). This is because organic matter has a much lower density than soil mineral particles. When organic matter is incorporated into the soil, it fills the spaces between mineral particles, increasing the total volume of the soil without a corresponding increase in mass, ultimately reducing bulk density (R. et al., 2017).

3.2 The Relationship Between BD, Organic Fertilizer Dosage, And Sorghum Yield With Water Content

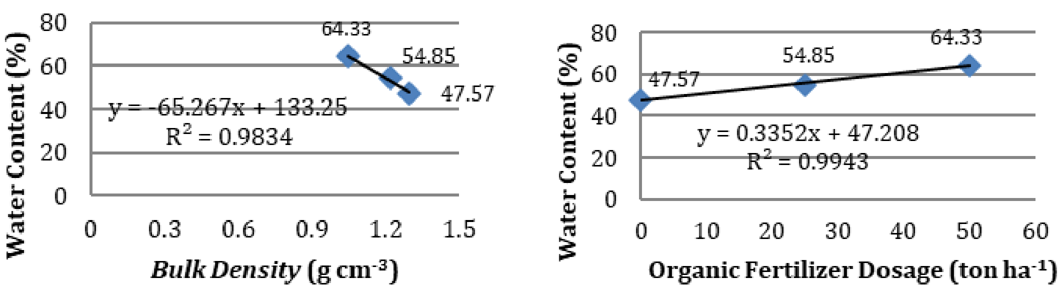
Water content is a soil physical property influenced by bulk density (BD) and organic fertilizer dosage, and plays a significant role in determining crop yields. The relationships between BD and water content, organic fertilizer dosage and water content, and water content and sorghum grain weight were analyzed using simple linear regression, as shown in Figure 1.

The influence of BD on soil water content occurs indirectly, with a direct relationship to the number of soil pores available at a certain BD level. Soil with a low BD value has a larger pore volume, so water can more easily seep into the soil. The research results of show that the higher the total soil pores, the water content available to plants will also increase (Murtilaksono and Wahyuni, 2004).

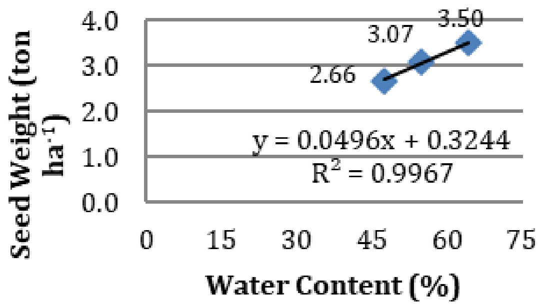
The results of the simple linear regression analysis shown in Figure 1(b) show a positive linear relationship between the dose of rice husk organic fertilizer and soil water content. This means that increasing the dose of rice husk organic fertilizer will be followed by an increase in soil water content. The regression equation y = 0.3352x + 47.208 indicates that every addition of organic fertilizer by one unit (1 ton ha^{-1}) will increase soil water content by 0.3352%. The coefficient of determination (R^2) value of 0.9943 indicates that 99.43% of the variation in soil water content can be explained by changes in the dose of rice husk organic fertilizer given. This finding is in line with the results of research by which showed that the application of organic materials such as chicken manure and compost to clay-textured soil can increase water content and available water capacity, as well as reduce BD values (Intara et al., 2011). In addition, compost is known to be more effective in maintaining available water capacity than manure.

Simple linear regression analysis in Figure 1(c) shows a positive linear relationship between soil water content and seed weight per hectare. This means that the higher the soil water content, the higher the sorghum grain yield. The regression equation y = 0.0496x + 0.3244 shows that every 1% increase in soil water content will increase grain weight by 0.0496 tons per hectare. The coefficient of determination (R^2) value of 0.9967 indicates that 99.67% of the variation in the increase in sorghum seed weight can be explained by changes in soil water content. This increase in water content is closely related to the increase in the dose of organic fertilizer, as explained previously in Figure 1(b). This finding is in line with the research results of which showed that the application of 40 tons of water hyacinth organic material ha^{-1} significantly increased sorghum production (Nurmi et al., 2023).

Bulk density refers to the mass of soil per unit volume, and soil water content is the amount of water present in the soil. Understanding the relationship between these two factors is crucial for various reasons. Firstly, bulk density can impact soil structure, porosity, and compaction, which in turn affects water infiltration and retention. Additionally, soil water content plays a vital role in plant growth, nutrient availability, and overall soil health (Manish et al., 2024). By comprehending how bulk density and soil water content interact, farmers and land managers can make informed decisions to improve soil quality and productivity. Overall, the management of bulk density and



(a) (b)



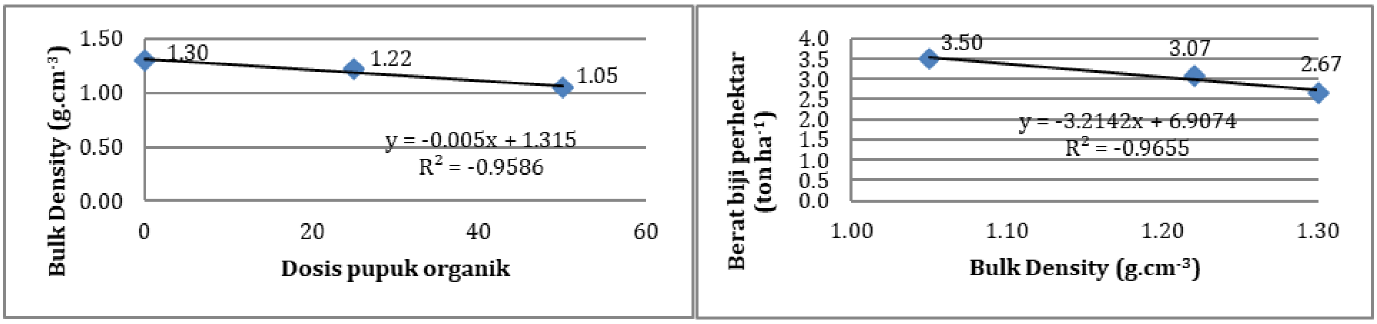
(c)

Figure 1: Relationship between BD and water content (a), organic fertilizer dose and water content (b), and water content and seed weight per hectare (c) in sorghum cultivation.

Soil water content can greatly impact crop yields, erosion prevention, and overall ecosystem health (Yi-ke et al., 2020). By taking proactive measures to monitor and maintain these factors, farmers can optimize soil conditions for healthy plant growth and sustainable land use. This understanding also allows for the implementation of conservation practices that can help mitigate the impacts of climate change and promote long-term soil health and productivity. In conclusion, the relationship between bulk density and soil water content is a fundamental aspect of soil science that has far-reaching implications for agricultural sustainability and environmental stewardship (Kaushal, 2023).

Soil water content and organic fertilizer dosage are closely related and influence each other in agricultural systems. Optimal water content is crucial for the effectiveness of organic fertilizers, as the decomposition process by soil microorganisms requires adequate moisture. If the soil is too dry, microbial activity is inhibited and nutrients are difficult to release, preventing optimal fertilizer utilization. Conversely, organic fertilizers, especially at the right dosage, play a significant role in increasing the soil's water-holding capacity by increasing the spongy organic matter content, improving soil structure, and reducing bulk density. This means that organic fertilizer applications not only provide nutrients but also significantly improve the soil's ability to store and manage water, creating a more stable environment for plant growth and increasing overall water-use efficiency. Soil water content olso has a crucial and direct relationship with crop production. Water is a key component required by plants for photosynthesis, nutrient transport from the soil to all parts of the plant, maintaining cell turgor, and temperature regulation. If soil water levels are inadequate (drought), plants will experience water stress, which inhibits nutrient uptake, reduces photosynthesis, causes wilting, and ultimately significantly reduces growth and yield. Conversely, excessive water content (waterlogging) can also be detrimental by creating anaerobic conditions in the root zone, inhibiting root respiration, triggering disease, and causing damage or even death to the plant, ultimately leading to decreased production. Therefore, maintaining optimal soil water levels is key to achieving high and sustainable crop production (Mehdi et al., 2021; Rehan et al., 2024).

3.3 The Relationship Between The Dose Of Organic Fertilizer And BD With Seed Weight Per Hectare



(a) (b)

Figure 2: Relationship between organic fertilizer dose and BD (a) and the relationship between BD and seed weight per hectare (b) in sorghum cultivation

Bulk density of soil is one of the physical properties of soil that can be influenced by the organic matter content of the soil, and BD can influence the growth and yield of a plant. The results of the linear regression analysis to see the relationship between the dose of organic fertilizer with BD and the relationship between BD and seed weight per hectare are presented in Figure 2.

The results of the linear regression analysis in Figure 2(a) show a negative linear relationship between the dose of rice husk organic fertilizer and the soil BD value. This means that the higher the dose of organic fertilizer given, the lower the soil BD value will be. The regression equation y = -0.005x + 1.315 shows that every addition of organic fertilizer of 1 ton ha^{-1} will reduce BD by 0.005 g cm^{-3}. The coefficient of determination (R^2) value of 0.9586 indicates that 95.86% of the change in BD can be explained by variations in the dosage of rice husk organic fertilizer in the soil. This result is in line with the findings of which stated that the application of organic materials can effectively reduce the BD value of the soil (Intara et al., 2011).

Simple linear regression analysis in Figure 2(b) reveals a negative linear relationship between soil bulk density (BD) and seed weight per hectare. This shows that the higher the BD value, the lower the crop yield tends to be. The regression equation y = -3.2142x + 6.9074 states that every 1 unit increase in BD will cause a decrease in crop yield of 3.2142 units. In other words, an increase in BD by 0.1 g cm^{-3} will result in a decrease in production of 0.32142 tons per hectare. The coefficient of determination (R^2) value of 0.9655 indicates that 96.55% of the variation in crop yield can be explained by changes in soil BD. The high influence of soil bulk density on crop production is due to soils with high bulk density. Compacted soils cannot support proper root development, thus disrupting plant nutrient absorption. Disrupted nutrient absorption in the soil will have implications for reduced crop production. Research on peanut cultivation showed that increasing soil density affected plant height and root length by (Haridjaja et al., 2013). Research found that low-yielding land had a bulk density of 1.36 g.cm-3 at a depth of 0-20 cm, and high-yielding land had a bulk density of 1.29 g.cm-3 by (Holihullah et al., 2015). Furthermore, according to research showed that the number, length, biomass, surface area and density of sengon plant roots are influenced by the density of the soil in the growing medium (Rusdianan et al., 2000). The higher the soil density, the lower the number, length, biomass, surface area and density of roots.

The application rate of organic fertilizers significantly impacts soil bulk density. Higher doses of organic materials, such as well-decomposed rice husk, introduce more low-density organic matter into the soil matrix. This incorporation lightens the soil, effectively reducing its bulk density by increasing total pore space and promoting the formation of stable soil aggregates. Consequently, a lower bulk density indicates a less compacted, more aerated soil, which in turn facilitates better root penetration, water infiltration, and nutrient uptake, ultimately fostering healthier plant growth and improved overall soil health (Lal and Shukla, 2021; Zhang et al., 2023). Soil bulk density plays a critical role in seed yield per hectare. A high bulk density, indicating compacted soil, severely restricts root growth by increasing mechanical impedance, limiting access to water and nutrients, and reducing pore space essential for aeration. This impediment to root development directly translates to reduced plant vigor, inefficient resource uptake, and ultimately, lower seed production per plant and consequently, per hectare (Lal and Shukla, 2021; Zhang et al., 2023). Conversely, a lower bulk density facilitates robust root proliferation and optimized soil conditions, leading to healthier plants and higher seed yields.

4. Conclusion

I. Organic fertilizer treatment plays a role in reducing the BD value and increasing soil water content.

II. The Kawali variety produces the lowest Bulk Density value, and the application of 50 tons ha-1 of rice husk organic fertilizer produces the lowest Bulk Density value and the highest water content value compared to other treatments.

III. There is a negative linear correlation between water content, organic fertilizer dose, and seed weight per hectare with Bulk Density, and there is a positive linear correlation between organic fertilizer dose and seed weight per hectare with soil water content.

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Reference

Bhattacharya. 2021. Effect of soil water deficits on plant–water relationship: A review. https://link.springer.com/ chapter/10.1007/ 978-981-33-6276-5_1

Hardjowigeno, S., 2007. Soil Science. Jakarta: Akademika Presindo.

Haridjaja, O., Hidayat, Y., and Marhamah, L. S., 2010. The Effect of Soil Bulk Density on Soil Physical Properties and Seed Germination of Peanuts and Soybeans. Indonesian Journal of Agricultural Sciences. 15(3): 147-155.

Haridjaja, O., Baskoro, D. P. T., and Setianingsih, M., 2013. Differences in Field Capacity Water Content Values Based on the Alhricks, Free Drainage, and Pressure Plate Methods in Various Soil Textures and Their Relationship to Sunflower (Helianthus annuus L.) Growth. Journal of Soil and Environmental Science, 15(2), Pp. 52. https://doi.org/10.29244/jitl.15.2.52-59

Intara, Y. I., Sapei, A., Sembiring, N., and Djoefrie, B., 2011. The Effect of Organic Matter Application at Clay and Clay-Loam Soil Texture on Water Holding Capacity. Indonesian Journal of Agricultural Sciences, 16(2), Pp. 130–135.

Juan, A., Juan, L., Paula, and Micaela, 2021. Interrelations of nutrient and water transporters in plants under abiotic stress. https:// onlinelibrary.wiley.com/doi/abs/10.1111/ppl.13206

Lal, R., and Shukla, M. K., 2021. Principles of Soil Physics. CRC Press.

Manish, Akshay, Rupeshkumar, Nagesh, Dhananjay, and Sindhu. 2024. Soil health and nutrient management. https://www.researchgate.net/ profile/Rupeshkumar-Choudhari/publication/379774417_Soil_Health _and_Nutrient_Management/links/6626ce5743f8df018d21ba7a/Soil -Health-and-Nutrient-Management.pdf

Johnson, M., Petrova, A., and Tan, A., 2023. Rice husk and husk biochar soil amendments store soil carbon while water management controls dissolved organic matter chemistry in well-weathered soil. https://www.sciencedirect.com/science/article/pii/S03014797230 07247

Murtilaksono, K., and Wahyuni, E. D., 2004. The Relationship Between Soil Water Availability and Basic Soil Physical Properties. Journal of Soil and Environmental Science, 6(2), Pp. 46–50. https:// doi.org/ 10.29244/jitl.6.2.46-50

Mehdi, Ali, and Abdolmajid. 2021. Effect of liquid organic fertilizers and soil

moisture status on some biological and physical properties of soil. https://journals.umcs.pl/pjss/article/ view/11475

Nugraheni, F.T., S. Haryanti, and E. Prihastanti, 2018. The Effect of Different Planting Depths and Water Volumes on Germination and Growth of Sorghum Seeds (Sorghum Bicolor (L.) Moench). Anatomy and Physiology Bulletin, 3(2); Pp 223-232

Nurmi, Musa, N., and Angry, P,S., 2023. Growth and Production of Two Varieties of Sorghum (Sorghum bicolor) with the Application of Water Hyacinth (Eichhornia crassipes) Organic Material Growth and Production of Two Varieties of Sorghum (Sorghum bicolor) with the Application of Water Hyacinth (Eichhornia crassipes). 11(3), Pp. 161–166.

Holilullah, Afandi, and Novpriansyah, H., 2015. Soil Physical Characteristics on Low-Production Land. 3(2), Pp.278–282.

Panda, N. D., Jawang, U. P., and Lewu, L. D., 2021. The Effect of Organic Material on Water Holding Capacity in Dryland Ultisol Soil. Journal of Soil and Land Resources, 8(2), Pp. 327–332. https://doi.org/10.21776/ub.jtsl.2021.008.2.3

R., and I., 2007. Utilization of rice husk as an organic fertilizer to improve productivity and water use efficiency in rice fields. https://www.cabidigitallibrary.org/doi/pdf/10.5555/20103268527

Thomas, R., and Peter., 2017. Predicting soil particle density from clay and soil organic matter contents. https:// www. sciencedirect.com/ science/article/pii/S001670611630636X

Rusdiana, O, Y., Fakuara, C., Kusmana, and Hidayat, Y., 2000. Root Growth Response of Sengon (Paraserianthes falcataria) Plants to the Density and Water Content of Red-Yellow Podzolic Soil. Journal of Tropical Forest Management, 6(2), Pp. 43–53.

Rehan, A., Muhammad, A., Mohamad, A., Syed, A., and Rasul, A., 2024. Managing water resources for sustainable agricultural production. https://link.springer.com/chapter/10.1007/978-3-031-63430-7_3

Sunny and Mohammad. 2024. Factors affecting soil bulk density: a conceptual model. http://karyailham.com.my/ index.php/sea/ article /view/134

Zhang, H., Tang, X., Zhang, H., Liu, S., Li, Y., Zhao, Y., and Chen, G., 2023. Effects of long-term organic fertilizer application on soil physical properties and crop yield. Journal of Environmental Management, 343, Pp. 118476.

Yi-ke, Zhen, Jin-bin, Chang, Dong-wen, Chen-di, Huan-yuan, Ji-chang, and Yan., 2020. Effects of conservation tillage on soil physicochemical properties and crop yield in an arid Loess Plateau, China. https://www.nature.com/articles/s41598-020-61650-7