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RESEARCH ARTICLE

TWO LOCAL CASSAVA (*MANIHOT ESCULENTA* CRANTZ) VARIETIES ON THE RESILIENCE IN DROUGHT STRESS

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ABSTRACT

Climate change is an escalating global challenge that threatens food security and agricultural livelihoods. Unpredictable climate phenomenon has happened in around the globe in recent years. In the tropical region, including Indonesia, between rainy and dry season has become uncertain. And, the distribution of raining is uneven. Consequently, some region has resulted in the limiting supply of water, such as in a couple part of Central Java, causing dryness. In the face of this phenomenon, cassava emerges as a promising crop with inherent resilience and adaptability. Cassava has been a staple food for millions, particularly in tropical regions. Its deep root system enables access to subsurface moisture during droughts, and its sturdy leaves and stems resist the impacts of extreme weather events and pest invasions. This paper studied the growth response of cassava seedlings at drought stress levels and cassava varieties. The experimental design used was a completely randomized design arranged in factorial (4x2) with 3 replications. The first treatment was drought stress (0%, 25%, 50%, 75%) and the second treatment was cassava varieties (Ketan, Mentega). CI-340 Handheld Photosynthesis System was used to analyse net photosynthetic rate. The results demonstrated that the level of drought stress decreased the net photosynthetic rate, leaf area, root fresh weight, dry root weight but increased root length. Dryness of 75% resulted in 45.06 cm of length root. Cassava variety grown on an extreme drought (75% dry) produced lower leaf area (50 cm2). Stem diameter was bigger on Ketan variety (20.56 mm) compared to Mentega variety (19.54 mm). Number of roots of Ketan variety (42.36) was greater than Mentega variety (24.08). Fresh root weight and dry root weight were correlated with the level of dryness. The drier of media was the lower of root weight, with the result of 8 g for fresh weight and 3 g for dry weight. In conclusion, Ketan variety is more resilient than Mentega variety.

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INTRODUCTION

Climate change due to global warming affects harvest area and crop yields as a result of the impact of increasing temperatures, changes in rainfall patterns or the indirect impact of extreme weather through soil, nutrients and increased pests (Pipitpukdee et al., 2020). Climate change,characterized by a decrease in rainfall and an increase in temperature, can result in a decrease in the production and productivity of food crops such as cassava. Cassava has the potential as a widespread food source (Adiele et al., 2020). Cassava is in third place as a carbohydrate producer after rice and corn (Allifah and Rijal, 2018). The demand for cassava continues to increase in line with the increase in population, increasing food needs and the rapid development of agro-industry. However, cassava production has decreased. Based on the Center for Agricultural Data and Information Systems (2020), cassava production in Indonesia in 2014 reached 23,436,384 tons, but in 2018 production fell to 19,341,233 tons.

The decline in cassava production from year to year and the high demand for cassava have limited the availability of cassava for food diversification and agro-industry. A prolonged dry season with minimal water availability is one of the obstacles that can limit the growth of cassava. This minimal water availability will disrupt the physiological and morphological activities of plants which will inhibit vegetative and generative growth due to drought stress. Drought stress is an environmental factor that causes water to be unavailable to plants which is caused by unavailability of water in the plant root area and large water demand in the leaves, as well as the rate of transpiration exceeding the rate of water absorption by the roots (Hamim, 2004). Drought stress is one of the environmental factors that has a negative impact on plant growth and cause a decrease in plant production (Jun-Feng et al., 2010). Drought is caused by changes in rainfall patterns, increasing temperatures and rapidly decreasing humidity, resulting in a water deficit in plants. This condition will trigger stress in plants and has the potential to cause biological pressure on physiological processes and functional activities due to environmental factors (Levitt, 1982 in Zlatev and Lidon, 2012). Drought stress affects the morphological condition of plants at each growth phase so that it can reduce plant productivity levels. Drought stress conditions can inhibit plant growth because water is an important element that supports plant growth. Drought stress on plants is influenced by plant genetic characteristics, morphology, anatomy and metabolism. There are cassava varieties that have been widely cultivated, such as Adira-1, Adira-4, Darul Hidayah, Malang-1, Malang-2, UK-1 Agritan, Sticky Rice, and Butter. However, these cassava varieties were not specifically developed to adapt to drought stress. Therefore, this research was conducted to obtain superior varieties that are tolerant to drought stress.

MATERIALS AND METHODS

The research was carried out from December 2022 to February 2023 at Kledung Research Park, Faculty of Agriculture, Tidar University, Kwadungan Village, Kledung District, Temanggung Regency at an altitude of 1,200 m above sea level.This research was carried out using a completely randomized design (CRD) arranged factorially. There were 2 treatment factors, each treatment combination was repeated 3 times, resulting in 12 treatment combinations. The treatment combination is:Factor I was drought stress level (C), with levels: C0 = stress level 0% of field capacity; C1 = stress level 25% of field capacity; C2 = stress level 50% of field capacity; C3 = stress level 75% of field capacity.Factor II was cassava varieties (V), consisting of: V0 = Mentega variety V1 = Ketan variety.Data were analyzed using Analysis of Variant (ANOVA) at the 5% and 1% levels. If different, continued with the orthogonal polynomial test for the level of drought stress and the least significant different (LSD) test for cassava varieties. Field capacity calculations were carried out every 2 weeks. The calculation was carried out by watering the planting medium placed on top of the reservoir (initial volume) and leaving it for 1 day. If there was no water dripping into the reservoir then the volume of water collected (final volume) was measured. The difference between the initial volume and the final volume was the amount of water with a field capacity of 100%. The treatment level of drought stress was obtained from multiplying the field capacity with the level of drought stress given to the treatment (Khaerana et al., 2008). Measuring the net photosynthesis rate was carried out by placing the third leaf from the shoot of a cassava plant as a sample of plant leaves to be tested in the leaf chamber of the CI-340 Handheld Photosynthesis System. The tool used is already on and the test indicator that appears on the LCD panel has been set according to the desired observation indicator, then start the option by pressing the start button and the tool will automatically carry out analysis. The analysis was carried out in the 8th week after planting, namely 6-7 February 2023 and started at 09.00-13.00 provided there was no rain or the weather was not sunny.

RESULTS AND DISCUSSION

The results of diversity analysis showed that the level of drought stress reduced the net photosynthesis rate, leaf area, fresh root weight, dry root weight but increased root length. The Ketan variety produced higher leaf area, stem diameter, number of roots, fresh root weight and dry root weight than the Mentega variety. Drought stress and cassava varieties reduced fresh root weight and dry root weight. The net photosynthetic rate of cassava showed highly significant results and then it was further tested using the orthogonal polynomial and presented in Figure 1. The further orthogonal polynomial test produced a graph with the equation y = -0.0012x2+0.0026x+9.3736 and R^2 = 0.9984. Based on this equation, the optimum point for drought stress used was 1.08% with a resulting photosynthesis rate of 9.38 μmol/m²/s. The availability of sufficient water to meet the water needs of plants was very important. Water plays a role in plant growth as a solvent for various organic and inorganic molecular compounds from the soil to the plant, transporting photosynthesis from source to sink, is the main constituent of protoplasm, regulates plant temperature, maintains cell turgidity including cell enlargement and opening of stomata (Salisbury and Ross, 1997).

Tabel 1. Result of analysis of variance observed Parameters

Parameter	F-Value		
	Stress level (C)	Variety (V)	Interaction (CxV)
Net photosynthetic rate	225.90**	1.04^{ns}	0.88^{ns}
Leaf area	25.01**	15.93**	1.95^{ns}
Leaf count	1.69^{ns}	1.04^{ns}	0.71^{ns}
Bud count	0.29^{ns}	0.00^{ns}	0.86^{ns}
Shoot diameter	2.18^{ns}	8.71**	0.08^{ns}
Root number	0.91^{ns}	268.92**	0.26ns
Root length	4.93*	0.96^{ns}	0.34^{ns}
Root fresh weight	17.22**	192.14**	4.02*
Root dry weight	24.37**	195.58**	5.81**

Source: Analysed data, 2023
**: Highly significantly different
*: Significantly different
ns:Non significant
C: Drought stress level
V: Cassava variety
CxV: Interaction of cassava variety and drought stress Level

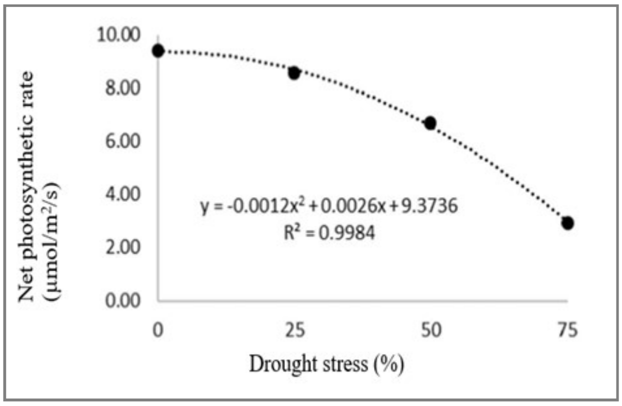

Figure 1. Drought stress effect on the net photosynthesis

Insufficient groundwater availability for plants results in water as a raw material for photosynthesis and the transportation of nutrients to the leaves is hampered, which will have an impact on the resulting production. Photosynthetic performance is highly dependent on stable and appropriate water content, combined with water transport capacity, water loss rate and the amount of plant water (Xiong and Nadal, 2020). Further orthogonal polynomial testing produces a polynomial graph with the equation y = -0.0105x2 + 0.0092x + 110.68 and R^2 = 0.9958. Based on this equation, the optimum point for drought stress used was 0.44% with a leaf area of 110.68 cm2. The 0% level of drought stress treatment showed the highest average leaf area of 111.33 cm2 compared to other levels of drought stress.

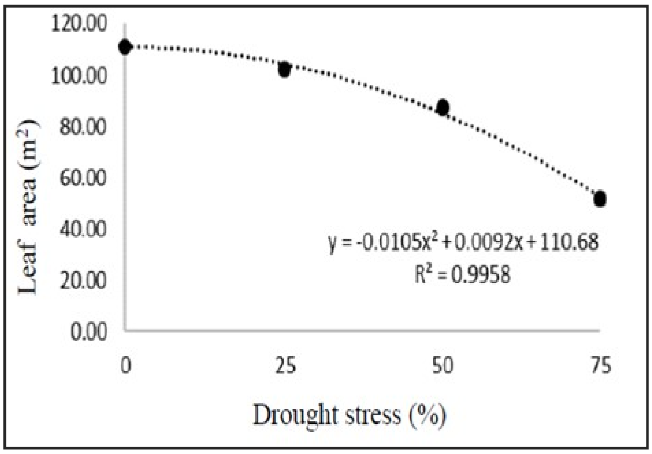

Figure 2. Drought stress on the leaf area of cassava

The results of further orthogonal polynomial tests in Figure 2 showed that leaf area decreases as the level of drought stress increases. The reduction in leaf area in plants experiencing drought stress is a plant adaptation mechanism to reduce water loss through the transpiration process. This is in line with Taiz and Zeiger (2010) who stated that drought stress can inhibit plant growth, one of which can be seen from a decrease in leaf area which is a plant response to drought. The development of leaf area during vegetative growth is a time that is very sensitive to water shortages. According to Arve et al., (2011), as long as plants experience drought stress, the plant's water content decreases, resulting in a decrease in cell turgor pressure, cell enlargement and elongation becomes disturbed, which causes leaf expansion to be hampered. This is in line with the statement by Okogbenin et al., (2013) that reducing leaf area in drought conditions is a strategy for cassava plants to reduce water loss through transpiration. Based on the results of further tests on the influence of environmental stress and cassava varieties, the optimum point was obtained at 14.44% and Ketan variety of cassava with the highest average fresh root weight was 26.02 g in the equation y = -0.0017x2+0.0491x+25.661 (Figure 3). Drought stress and cassava varieties had a significant effect on the addition of the best root fresh weight under 0% drought stress conditions (C0) in the Ketan variety (V1) amounting to 25.78 g. At a drought stress level of 25%, fresh root weight began to decrease in both Ketan and Mentega varieties as a result of the influence of available water content. The less water content available, the lower the fresh weight of the roots of the cassava plant.

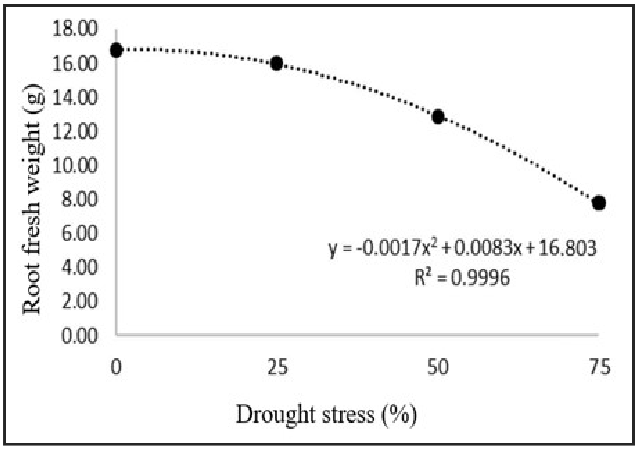

Figure 3. Drought stress and variety of cassava effect on root fresh weight (g)

The low fresh root weight in both cassava varieties was caused by a decrease in the net photosynthesis rate, intercellular CO2 concentration, stomatal conductance and transpiration rate which decreased with increasing drought intensity, which shows that limited ground water causes the closure of the stomata of cassava leaves. which sequentially reduces the influx of CO2 in leaf cells and then causes the resulting net photosynthesis rate to be low and translocation of photosynthate to the root area to be low (Shan et al., 2018). Based on the results of further tests, the optimum point of interaction between the level of drought stress and the cassava variety was obtained in the 10.96% drought stress treatment and Ketan variety of cassava with an average dry root weight of 10.75 g in the equation y = -0.0015x2 +0.0329x+10.517 (Figure 4). Drought stress and cassava varieties had a very significant influence on the increase in dry root weight with the highest yield in 0% drought stress conditions (C0) for cassava varieties Ketan (V1) amounting to 10.72 g. This means that the use of Ketan variety with the highest yield was a variety that tends to be resistant to drought stress so that it produces good growth as indicated by the accumulation of dry weight. Dry root weight of two cassava varieties showed a decrease at 25% drought stress. Plants experiencing drought stress will reduce the plant's dry root weight due to limited assimilate produced in the photosynthesis process.

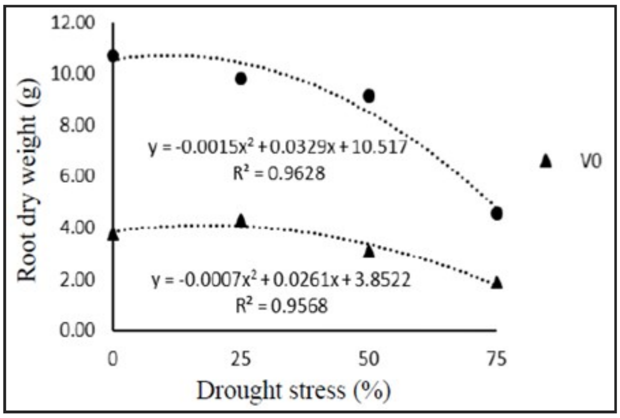

Figure 4. Drought stress and variety of cassava effect on the root dry weight (g)

Drought stress causes the assimilate produced in the photosynthesis process to be too low so that the translocation of assimilate to the root area is low. Cassava plants that have a high dry root weight tend to have a good level of tolerance because they have high metabolic activity even though they grow in drought conditions. This is in line with the statement by Taiz and Zeiger (2010) that dry weight is an indicator of plant metabolic processes. If the metabolic process increases, the resulting dry weight increases, conversely, a decrease in metabolic activity causes a decrease in plant dry matter.

CONCLUSION

Drought stress reduces net photosynthetic rate activity, leaf area, fresh root weight, dry root weight but increases root length of cassava plants. Ketan variety has better resistance to drought conditions compared to the butter variety. Ketan variety of cassava can be recommended for planting in the dry season. Field tests need to be carried out in areas that have lower rainfall of 0-100 mm/month.

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