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Analysis of the Growth Response of Cassava Plants (Manihot Esculenta) to Variability in Water Availability

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Abstract

In recent decades, there has been a very pronounced climate change on earth. Reduced rainfall and the occurrence of long droughts are direct impacts that can trigger other problems in the agricultural sector such as crop failure and weakening food security. This will also have an impact on the process of growth and agricultural production in the Lampung Province area, especially on cassava plants. Water often limits the growth and development of cultivated plants. The response of plants to lack of water can be seen in their metabolic activity, morphology, growth rate, or productivity. Cell growth is the function of plants that are most sensitive to water shortages. Lack of water will affect cell turgor so that it will reduce cell development, protein synthesis, and cell wall synthesis. The cassava clones used in this study were Garuda Clones with 5 treatment levels, namely the first treatment (P1) 0L, the second treatment (P2) 0.5L, the third treatment (P3) 1L, the fourth treatment (P4) 1.5L, the fifth treatment (P5) 2L. The result of this study is that there is a cassava growth response to water availability in each treatment except for the variable number of shoots. In the variable plant height, significant response variations are obtained, and it is known that the availability of water needed is directly proportional to the response to plant height growth that also increases.

Keywords: cassava, garuda clone, water grip, growth, analysis.

Introduction

The impact of globalization causes many problems on earth, both social problems and natural balance problems. In recent decades, there has been a very pronounced climate change on earth. This is very influential on nature and human activities. One of them is that there are striking temperature deviations, which result in many natural phenomena such as global warming and El Niño and La Nina events.

The el-nino phenomenon has a strong influence on the climate in Indonesia. Reduced rainfall and the occurrence of long droughts are direct impacts that can trigger other problems in the agricultural sector such as crop failure and weakening food security. This will also have an impact on the process of agricultural growth and production in the Lampung Province area, especially on cassava plants.

BPS data (2015) shows that the cassava harvest area in Lampung is 310,441 ha with a total production of 8.29 million tons of sweet potatoes or overall productivity of 26.70 tons / ha. To be able to produce optimally, cassava requires rainfall of 150-200 mm at the age of 1-3 months, 250-300 mm at the age of 4-7 months, and 100-150 mm in the phase before and during harvest (Wargiono et al., 2006).

Water frequently restricts the expansion and maturation of domesticated plants. Plants' morphology, growth rate, productivity, and metabolic activity can all be used to gauge how they are responding to a water deficit. The function of plants most susceptible to water scarcity is cell development. Water deprivation reduces cell growth, protein synthesis, and cell wall formation by altering cell turgor (Gardner, 1991).

Smaller leaves form as a result of water deprivation during the vegetative stage, which may limit light absorption. Dehydration also decreases the production of chlorophyll and the activity of some enzymes (nitrate reductase, for example). Hydrolysis enzymes, such as amylase, are actually more active when there is less water present (Hsiao et al. in Gardner et al. 1991).

Plants have different needs for water based on their type and stage of growth. Due to a shortage of water in the root zone and evapotranspiration rates that are higher than the rate at which plants absorb water, plants frequently experience water stress during the dry season (Levitt, 1980). On the other hand, plants frequently suffer situations of water saturation during the rainy season.

According to Aina et al. (2007), cassava in Nigeria's drought-stricken fields saw a drop in stem height of 47%, trunk diameter of 15%, tuber number of 95%, and tuber yield of 87%. One of the things that can hinder cassava development and productivity is an extended dry season with little water available. The impact of water availability is contingent upon the degree of stress encountered, the type, and stage of growth of cassava cultivation. When it comes to size, drought-stricken plants are smaller than those that are not (Kurniasari et al. 2010).

Plant productivity, or biomass, can be negatively impacted by drought stress because of reduced primary metabolism, shrinking leaf area, and reduced photosynthetic activity. The reduction in biomass buildup brought on by water stress varies depending on the kind of plant. Each sort of plant's response has an impact on this. Plants differ in their ability to adapt to environmental stress due to genetic variables.

Garuda clone cassava plants are currently very popular with farmers in Lampung to be used as planting material, however, until now research data related to the growth and production of Garuda clones are still very few and difficult to find. Therefore, there is a need for research or trials on Garuda clones so that more valid data are obtained both in the vegetative and generative phases.

Research Method

The impact of globalization causes many problems on earth, both social problems and natural balance problems. In recent decades, there has been a very pronounced climate change on earth. This is very influential on nature and human activities. One of them is that there are striking temperature deviations, which result in many natural phenomena such as global warming and El Niño and La Nina events.

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Result and Discussion

The results of the analysis of various effects of treatment on observation variables (number of shoots, number of leaves, plant height, and stem diameter) at the level of 5% from one week after planting (1MST) to four weeks after planting (4MST).

Table 1. The results of the analysis of the various effects of water availability treatment on test variables

No	Plant Age	Number of buds	Number of leaves	Plant Height	Rod Diameter	Ftabel
		Fhit	Fhit	Fhit	Fhit	0,05
1	1MST	3,108tn	0,000	0,000	0,000	3,837
2	2MST	0.672tn	6,113*	5,977*	0,000	
3	3MST	4,540*	22,807*	20,402*	0,000	
4	4MST		57,070*	28,921*		

Information: ^{Mr} = unreal at α = 5%., * = real at α = 5%.

3.1.1 Number of Shoots

The results of the variance analysis on the variable number of shoots showed that at 1MST and 2MST between treatments given did not differ significantly at the level of 5%, but there was a real difference between treatments at 3MST.

The results of further tests with BNT level 5% with plant age 3MST variable number of shoots in treatment (P 2), (P3), (P4) and (P5) did not differ in number. In the treatment (P1) of the variable number of shoots, the least number of shoots was obtained.

Table 2. The effect of water availability treatment on the number of shoots at 3MST.

Treatment	Number of buds
P1 (0 L)	1.444a
P2 (0.5 L)	2.444b
P5 (2.0 L)	2.444b
P4 (1.5 L)	2.667b
P3 (1.0 L)	2.778b
BNT 5% = 0.810	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 3. The effect of water availability treatment on the growth rate of the number of shoots at 1MST to 3MST.

At observation 1MST to 3MST has a variable growth rate of the number of shoots. At 1MST, P4 treatment (1.5 L) has the highest growth rate of bud count and P2 treatment (0.5 L) the least. In 2MST, P4 treatment (1.5 L) still has the highest growth rate of the number of shoots, but P1 treatment (0 L) is the treatment with the least growth rate of the number of shoots. In the observation of 3MST, the growth rate of the number of shoots changed in order of the largest to the least as follows: treatment of P3 (1.0 L), P4 (1.5 L), P5 (2.0), P2 (0.5 L), and P1 (0 L). From observations it can be seen that the P3 treatment (1.0 L) has a better growth rate than other treatments.

3.1.2 Number of Leaves

The results of variance analysis on the variable number of leaves showed that at 2MST and 4MST between treatments given significantly different at the level of 5%.

Table 4. The effect of water availability treatment on the number of leaves on 2MST.

Treatment	Number of leaves
P2 (0.5 L)	0.833a
P1 (0 L)	1,000a
P3 (1.0 L)	1.333ab
P4 (1.5 L)	2,000b
P5 (2.0 L)	2,000b
BNT 5% = 0.722	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 5. The effect of water availability treatment on the number of leaves on 3MST.

Treatment	Number of leaves
P1 (0 L)	2.056a
P2 (0.5 L)	2.222a
P3 (1.0 L)	3.444b
P5 (2.0 L)	3.833b
P4 (1.5 L)	3.889b
BNT 5% = 0.604	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 6. The effect of water availability treatment on the number of leaves at 4MST.

Treatment	Number of leaves
P1 (0 L)	5.278a
P2 (0.5 L)	6,833b
P3 (1.0 L)	6.944b
P5 (2.0 L)	7,944c
P4 (1.5 L)	8,056c
BNT 5% = 0.482	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 7. The effect of water availability treatment on the growth rate of leaf count at 1MST to 4MST.

At growth rates of 2MST, 3MST, and 4MST P4 (1.5 L) and P5 (2 L) have a higher growth rate of leaf count than other treatments. In the P2 treatment (0.5 L) the best leaf growth rate was obtained when entering 4MST and the P1 treatment (0 L) became the treatment with the least leaf growth rate each week of observation.

3.1.3 Plant Height

The results of variance analysis on plant height variables showed that the 2MST and 4MST between treatments given were significantly different at the level of 5%.

Table 8. The effect of water availability treatment on plant height on 2MST.

Treatment	Plant Height
P2 (0.5 L)	1.344a
P1 (0 L)	1.356a
P4 (1.5 L)	2.467b
P5 (2.0 L)	2.822b
P3 (1.0 L)	3.033b
BNT 5% = 1.075	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 9. Effect of water availability treatment on plant height at 3MST.

Treatment	Plant Height
P1 (0 L)	2.578a
P2 (0.5 L)	3.933b
P4 (1.5 L)	4.778b
P5 (2.0 L)	5.022b
P3 (1.0 L)	6,122c
BNT 5% = 0.954	

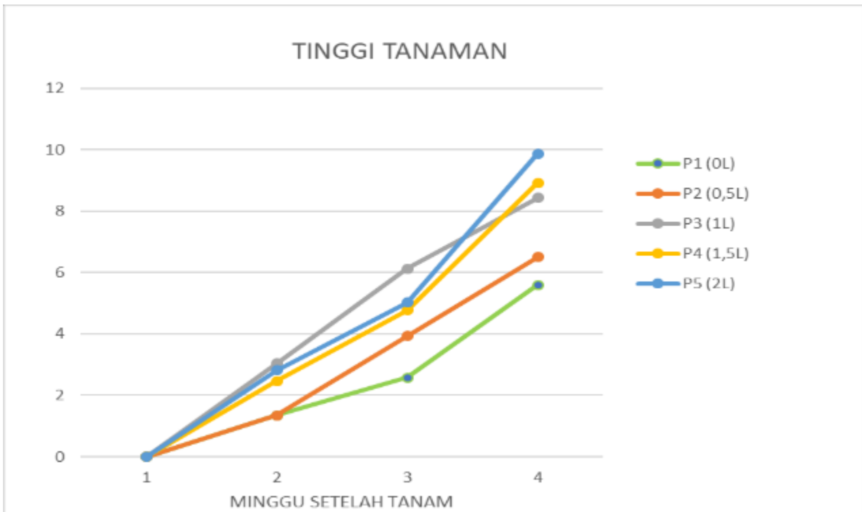
Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 10. Effect of water availability treatment on plant height at 4MST.

Treatment	Plant Height
P1 (0 L)	5,600a
P2 (0.5 L)	6,500a
P3 (1.0 L)	8.433b
P4 (1.5 L)	8,922bc
P5 (2.0 L)	9,867c
BNT 5% = 1.069	

Remarks: The middle value followed by the same letter is stated to be no different according to the BNT test at α = 5%.

Table 11. The effect of water availability treatment on plant height growth rate at 1MST to 4MST.



In the results of 2MST plant height observations, it can be seen that the P3 (1 L) treatment has the highest plant height growth rate but is not significantly different from the P4 (1.5 L) and P5 (2.0 L) treatments and the lowest P2 (0.5 L) treatment but also no different from P1 (0.5 L). In 3MST, P1 (0 L) treatment is the treatment with the lowest plant height growth rate and P3 (1.0 L) is the highest plant height growth rate.

In 4MST, there was a change in the direction of plant height growth rate with a significant increase in plant height growth rate, P5 treatment (2.0 L), along with P4 treatment (1.5 L) and P1 treatment (0 L) became the treatment with the lowest plant height growth rate.

Discussion

The results of observations and analysis of variety on the variable number of shoots show that the number of cassava shoots has grown from 1MST. The time of emergence of these shoots is faster than research conducted by Wasswa et al. (2010), showing that cassava buds are formed when 2-4 MST in some cassava cultivars. The emergence of cassava shoots itself has not been influenced by the availability of water in the soil. Cassava buds appear due to a response from hormones and use the ability of the food reserves available in the cuttings themselves.

Observations made up to 3MST did show a difference in the number of shoots that appeared. This is possible due to the difference in the number of buds themselves on the cuttings that become planting material. Observation of the number of shoots is carried out until the age of 3MST because to ensure that the two shoots that will be selected as observations of cassava growth are the shoots that have the best growth. Based on research by Sutrisno, et al (2023), it shows that the growth and production of cassava plants using cuttings of 2 buds is not significantly different from cuttings of 4 buds and 10 buds from 6BST to harvest.

In the results of observations on the number of leaves that began to be carried out at 2MST to 4MST, showed different results in P4 (1.5 L) and P5 (2 L) treatments had the highest number of leaves compared to other treatments. On the number of leaves, the availability of water is very influential. Water plays an important role in plant growth and development. Plant growth is very sensitive to water stress associated with decreased turgodity which can stop cell division and enlargement so that the size of plant organs becomes smaller (Manan and Mahfudz, 2015).

According to Gardner et al (1991), the leaf area and stem elongation of a plant during vegetative growth can be reduced when experiencing water shortage. In addition, the increase in area and number of leaves is influenced by the presence of the element Nitrogen (N). Nitrogen elements in plants function to stimulate overall growth (Lingga and Marsono, 2007).

One of the physical elements that is essential to the growth and development of plants in significant amounts is water. The fresh weight of tall plant cells and tissues is between 85 and 90 percent. Water serves as a solvent for nutrients, a component of protoplasm, a raw material for photosynthesis, and more. Dehydration in plant tissues can impact cell membranes, raise macromolecule concentrations, reduce cell turgor, and potentially change the chemical activity of plant water (Mubiyanto, 1997). Considering the significance of water, plants that lack it may encounter disruptions in their metabolic processes, which in turn may impact the rate at which the plants grow and develop. Water shortage stress has been shown to suppress photosynthetic activity and the assimilate's transport into reproductive organs (Harnowo, 1993).

Smaller leaves form as a result of water deprivation during the vegetative stage, which may limit light absorption. Dehydration also decreases the production of chlorophyll and the activity of some enzymes (nitrate reductase, for example). In fact, the absence of water makes hydrolysis enzymes (like amylase) more active.

Plants have different needs for water based on their type and stage of growth. Due to a shortage of water in the root zone and evapotranspiration rates that are higher than the rate at which plants absorb water, plants frequently experience water stress during the dry season (Levitt, 1980). On the other hand, plants frequently suffer situations of water saturation during the rainy season. As plant roots penetrate moist soil, water is drawn to them until the soil's critical water potential is achieved. Available water is the amount of water that plant roots can take in from the soil.

From the results of observations of 2MST to 4MST, water availability has become a differentiating influence in plant growth. In the observation of 4MST, it is very visible that the need for water for plants continues to increase and is directly proportional to the increase in plant growth rate.

Water frequently restricts the expansion and maturation of domesticated plants. Plants' morphology, growth rate, productivity, and metabolic activity can all be used to gauge how they are responding to a water deficit. The function of plants most susceptible to water scarcity is cell development. Water deprivation reduces cell growth, protein synthesis, and cell wall formation by altering cell turgor (Gardner et al., 1991).

The phrase "drought stress" describes the condition in which plants lack water as a result of receiving insufficient water from their surroundings, specifically the planting media. Even when groundwater is sufficiently available, plants may experience drought stress due to inadequate water supply in the root zone and excessive water demand from the leaves as a result of evapotranspiration rates that are higher than those of water absorption. In general, plants that face a shortage of water are smaller than those that grow regularly. Lack of water significantly reduces output and can even be fatal to plants (Nio, S. et al, 2011).

Plant height growth is affected by soil moisture content. That is because the process of plant height that begins with the process of bud formation is a process of cell division and enlargement. Both of these processes are affected by the turgor of the cell. The process of cell division and enlargement will occur when cells undergo turgidity whose main element is the availability of water (Samanhudi 2010). A decrease in turgidity can stop cell enlargement and result in plant dwarfing.

Water-stressed plants may respond by changing at the molecular and cellular levels, as seen by changes in growth rate, leaf area, and header-root ratio. A number of variables, such as the severity of the drought, how long it lasts, and the stage of growth at which plants experience drought, affect the amount of plant loss brought on by a lack of water. Plants can respond to drought in two ways: by adjusting the distribution of new nutrients and by controlling the extent of stomata opening. The ability of roots to absorb water can be increased by altering the distribution of new assimilate, which will encourage root growth rather than header growth and prevent header growth to lower transpiration. Setting the degree of opening of the stomata will inhibit water loss through transpiration.

Conclusion

Based on the results of observations and discussions, it can be concluded as follows:

1. There is a cassava growth response to water availability in each treatment except for the variable number of shoots.
2. In the variable number of leaves, it was found that the P4 treatment (1.5 L) had a more cassava growth response than other treatments but was not significantly different from the P5 treatment (2.0 L).
3. In the variable plant height, significant response variations are obtained, and it is known that the availability of water needed is increasing directly proportional to the response to plant height growth that also increases.

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