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The Effect of Boron Fertilizer Treatment and Planting Distance on Cassava Plant Productivity (*Manihot esculenta* Crantz)

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Abstract:- The cassava plant is a food crop and from year to year its needs are increasing but the productivity of the cassava plant nationally is still low. One of the efforts made to increase productivity is through fertilization and spacing. This study aims to determine the effect of Boron fertilizer treatment and planting distance on the productivity of cassava plants. There are 2 treatments in this study, namely Boron fertilization and planting distance, so there are 4 combinations of treatments, namely Boron fertilization with a planting distance of 1.4 m x 0.8 m, without Boron fertilization with a planting distance of 1.4 m x 0.8 m, Boron fertilization with a planting distance of 1.4 m x 1 m, without Boron fertilization with a planting distance of 1.4 m x 1 m. The results of this study of fertilizing Boron with a planting distance of 1.4 m x 0.8 showed the highest productivity of other treatments, namely 27,859 kg/ha. The starch content of cassava aged 11 months (at harvest time) in the treatment without Fertilization of Boron is higher than the treatment of Fertilizing Boron. These results show that the use of Boron fertilizer can increase the productivity of cassava, but it can reduce its starch levels.

Keywords:- *Boron, Planting Distance, Productivity, Cassava.*

I. INTRODUCTION

Cassava plants can grow optimally in areas with rainfall of 1,500-2,500 mm/year, air humidity of 60-65%, and at an altitude of 10-700 meters above sea level. The minimum air temperature for the growth of cassava is around 10 degrees Celsius and the need for sunlight irradiation is about 10 hours/day. The most suitable soil for cassava is one that has crumbly, loose, not too clay and not too shafty soil and is rich in organic matter. The soil pH suitable for cassava cultivation ranges from 4.5-8.0 (Purwono and Purnamawati, 2007).

Cassava is a food crop whose needs are increasing from year to year. This is because the use of this plant is not only as a food ingredient but also as an industrial raw material. Industries that use cassava as raw materials include the food industry, pharmaceutical industry, chemical industry, building materials industry, paper industry, and biofuel industry.

According to Hilman, *et al*. (2004), the cassava crop nationwide is not a priority commodity of the government. This can be seen from the lack of investment support from all aspects, namely research and development, counseling, procurement of facilities and infrastructure, as well as in arrangements and services besides that itis also because this crop is a food and trade crop (*cashcrop*). Therefore its role in the national economy is constantly declining. As a result, the area of the harvested area is constantly decreasing and productivity is not significantly increased. According to BPS data in 2015 the national cassava productivity was 22.95 tons/ha, for Lampung Province the productivity was higher at 26.45 tons/ha. Meanwhile, based on the description of the variety issued by Balitkabi, the potential of cassava can reach 30-40 tons/ha.

According to Sinar Tani (2011), several components of production technology that are important points in efforts to increase cassava productivity are the use of superior varieties, quality seedlings, planting time settings, planting population and distance, fertilization, and harvesting.

One of the efforts to increase the productivity of cassava plants is to fertilize. Cassava is a plant that is very responsive to fertilizer application. This is because this plant is a plant that produces high carbohydrates (Radjit, 2014). Nevertheless, the plant has a high level of tolerance to drought, soil acidification, and suboptimal nutrient availability. Compared to other plants, cassava is more tolerant of Al saturation by 70 to 80 percent, (Howeler 2002). Even with a high tolerance ability, cassava plants still need optimal nutrients for the growth and production of their tubers. Currently, fertilizing cassava plants, especially in dry land, is not following the nutrient needs of the soil and plants, causing low productivity, this occurs due to low fertility rates (low nutrient content of N, P, and K as well as organic matter). Often cassava is considered a plant that can grow anywhere without having to be intensively maintained. The need for cassava fertilizer in each region is very diverse, depending on the level of soil fertility. Meanwhile, soil fertility is largely determined by the presence of nutrients in the soil, both primary macronutrients, secondary macronutrients, and micronutrients. Primary macronutrients include nitrogen (N), phosphorus (P), potassium (K), carbon (C), hydrogen (H), and oxygen (O). Secondary macronutrients include calcium (Ca), magnesium (Mg), and sulfur (S). While micronutrients include iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), chlorine (Cl), and boron (B). Micronutrients are essential elements that are always needed by plants, even in small quantities (Sudarmi, 2013).

The nutrients carried away by the cassava harvest at a yield level of 30 t/ha were 147.6 kg N/ha; 47.4 kg of P2O5/ha; and 179.4 kg K2O/ha. Efforts are made to obtain high yields without reducing the level of soil fertility by replacing nutrients carried over during harvest through fertilization every season. The level of soil fertility will decrease without being balanced with fertilization because of nutrient drainage. Irrational and unbalanced fertilization can also damage soil fertility. (Roja, 2009).

Fertilization is an effort to add nutrients needed by plants. One of the micronutrients needed by plants to increase productivity is the element Boron. Boron has been known since 1923 as an essential micronutrient for higher plants (Blevins and Lukaszewski, 1994 Sudaryono (2017). The role of boron for plants is to support metabolic processes and the transport of sugars, meristematic tissues, cell wall formation, lignification, membrane integrity, DNA synthesis, root elongation, pollen formation, and pollination (Alloway, 2008). Bellaloui's (2010) research on soybean plants showed that the use of boron through leaves at a level of 0.45 kg/ha applied through leaves increased seed protein by 13.7% and fatty acids by up to 30.9%, increased seed production and seed quality in alfalfa plants (Dordas, 2006) and sugar beets (Dordas et al., 2007).

According to Mattielo (2009) in Sugianto et al., (2014) Boron is one of the microelements that can increase plant productivity, but the number of Boron elements in the soil is very limited, especially in tropical soil types. Therefore, it is necessary to fertilize to increase the amount of availability of these nutrients in the soil.

Another effort made to increase crop productivity is by spacing the planting distance. Sistem planting, variety, and land fertility are factors that affect the spacing of cassava. The right spacing makes the utilization of sunlight for the photosynthesis process will be maximized. Another purpose of spacing is to avoid plant competition in water absorption, nutrients, and competition with disturbing plants. (Gerry Dian, 2004 in kartika, (2018)). Spacing is related to the population. An optimum population using proper spacing will result in maximum production (Djauhari et al.,1987) Kartika, (2018). The selection of this spacing depends on the type of variety used and the level of soil fertility. For fertile soils used row spacing 1 m x 1 m; 1 m x 0.8 m; 1 m x 0.75 m or 1 m x 0.7 m. As for poor soils, dense planting distances are used, namely 1 m x 0.5 m, 0.8 m x 0.7 m (Roja, 2009) Spacing is related to population. An optimum population employing proper spacing will result in maximum production (Djauhari et al.,1987) Kartika, (2018). In addition, an adequate plant population increases the yield of cassava with the efficiency of energy use and soil nutrients and sunlight (Amarullah (2015)).

This study aims to determine the effect of Boron fertilizer treatment and planting distance on the productivity of cassava plants.

II. RESEARCH

- **Research site**. This research was conducted in the Experimental Garden of the Pati Lampung Tengah Technology Center. The research was conducted from May 2019 – May 2020.
- **Ingredients**. The materials used in this study were UJ-5 variety cassava (Kasesart), cow manure organic fertilizer, Urea fertilizer, TSP fertilizer, KCl fertilizer, Boron fertilizer, and herbicides
- **Tool.** The tools used in this study were tractors, machetes, courts, tunnels, tarpaulins, sprayers, and plant sprinklers, as well as for measuring vegetative and production parameters using meters/rulers, calipers, scales, digital starch content detection tools.
- **Method**. This research was conducted on an area of 1.5 ha. There are 2 treatments, namely Boron buildup and planting distance. The combinations are as follows:
  AY: Fertilizing Boron with Planting Distance 1.4 m x 0.8 m
  AZ: No boron fertilization with distance planting 1.4 m x 0.8 m
  BY: Fertilizing Boron with Planting Lessons1.4 m x 1 m
  BZ: Without fertilization Boron with distance planting 1.4 m x 1 m
- **Research Phase.** Planting is carried out by sticking cassava cuttings measuring 20-25 cm into the ground perpendicularly. After 1 month of age, fertilization I am carried out with a dose of Urea 100 kg/ha, TSP 100 kg/ha, and KCl 50 kg/ha. After 5 months fertilization II is carried out with a dose of Urea 100 kg/ha, TSP 100 kg/ha, and KCl 150 kg/ha. After 7 months of age, III fertilization is carried out with a dose of KCl 100 kg/ha and Boron 15 kg/ha. Plant care includes manual and chemical weeding using systemic herbicides at the time before fertilization II and III at a dose of 3 liters / Ha, and watering at the time of fertilization to II. Watering is carried out because the rainfall at the time of the study is very low so to optimize the absorption of nutrients, watering is carried out. The parameters observed consisted of vegetative plants, namely plant height, and stem diameter as well as tuber morphology consisting of tuber range, tuber length, tuber diameter, number of tubers, tuber weight, and starch content. Vegetative measurements are carried out from the age of the plant from 2 months to 10 months, while the morphology of the tubers begins to be carried out when the plant is 6 months to 11 months old.

III. RESULTS AND DISCUSSION

The percentage of growing plants at the time of the study was high because it used good seedlings, namely seedlings derived from cuttings of the middle stem with a stem diameter of 2-3 cm, a length of 15-20 cm, and without storage. Planted cuttings are also in a vertical (upright) position. According to Roja (2009), planting vertically with a depth of about 15 cm gives the highest yields both in the rainy and dry seasons. Planting cuttings in a vertical position can also spur root growth and spread evenly in the processed layer. For cuttings planted in an inclined or horizontal (horizontal) position, the roots are not evenly distributed like vertically planted cuttings at a depth of 15 cm and low density. In addition, the speed of germination is also influenced by the planting position. The eyes of vertically and obliquely planted shoots germinate faster than with horizontally planted cuttings. Since horizontally planted cuttings germination is inhibited by the eyes of the shoots covered with soil (Sundari, 2012).

Cassava cultivation with boron treatment is expected to increase the amount of productivity of cassava plants. Cassava plants can be seen in significant plant height growth. This can be proven by several parameters that were observed during the study conducted. The parameters observed consisted of vegetative plants, namely plant height, and stem diameter as well as tuber morphology consisting of tuber range, tuber length, tuber diameter, number of tubers, tuber weight, and starch content.

Plant height is one of the indicators of the growth and development of a plant. The high profile of the plant and the diameter of the stem of the cassava plant on various treatments are shown in Figures 1 and Figure 2. From the results of measuring plant vegetative parameters, namely plant height, planting distance treatment data of 1.4 meters x 1 meter higher than the planting distance treatment of 1.4 meters x 0.8 meters, this also occurs in the stem diameter of the planting distance treatment of 1.4 meters x 1 meter has a larger stem diameter compared to the planting distance treatment of 1.4 meters x 0.8 meters. However, the diameter of the stem is more than 3 cm makes the stem not good enough to be used as cutting material for the next growing season. The ideal diameter of the stem for cuttings is 2-2.5 cm. Optimal vegetative growth of plants, where the plant height and stem diameter according to the characteristics of the plant will play a positive role in plant metabolism. Plants with good vegetative growth can synthesize amino acids and proteins and optimally compile chlorophyll so that the photosynthesis process runs efficiently which will result in the translocation of photosynthetic to plant parts that can run well. This will increase the weight of tubers and crop production.

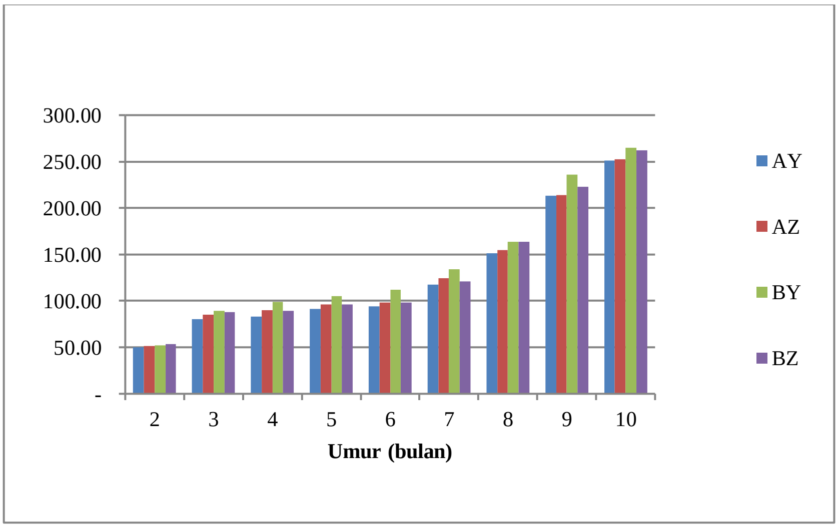

Fig. 1: High-profile cassava plants up to 10 months of age on various treatments

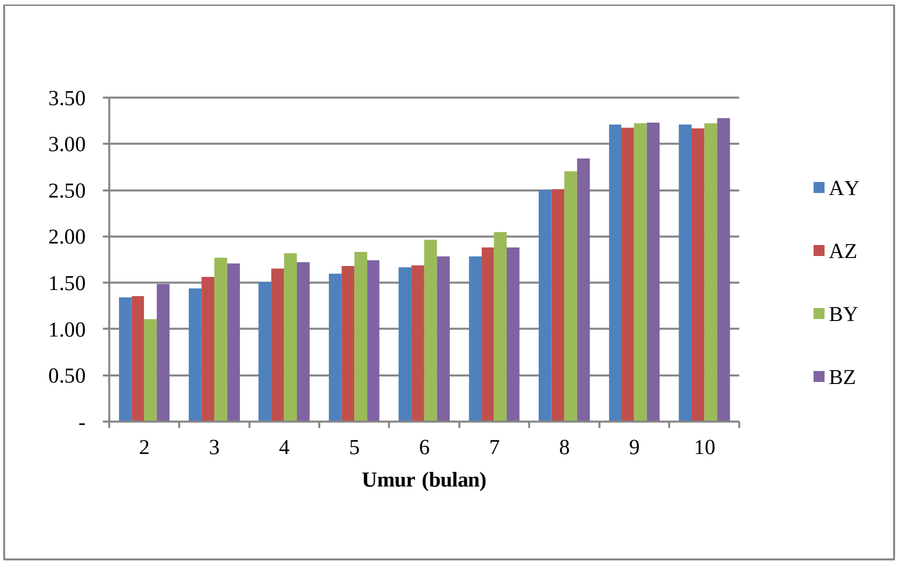

Fig. 2: Diameter profile of cassava plant stems up to 10 months of age on various treatments

After the plant is 6 months old and begins to be measured the parameters of cassava tubers consist of the weight of the tubers, the span of the bulbs, the number of tubers, the length of the tubers, and the diameter of the tubers. Measurements are carried out at the age of 6 months because at that age the cassava has entered the generative period. Aged 6 months cassava has entered the Phase of Translocation of Carbohydrates to Tubers. In this use occurs a period of development of the tuber, the rate of accumulation of dry matter is highest in the tuber and the process of leaf aging begins to occur so that the leaves begin to fall.

Cassava can be harvested when the plant is 7-9 months old and the starch content is in optimal condition (Prihandana, 2008). The measurement of the tuber range aims to see the effect of planting distance on the growth of cassava tubers. In general, it shows that the range of tubers will increase at a wider planting distance. The range of cassava tubers at a planting distance of 1.4 m x 0.8 meters ranges from 55 cm – 80.80 cm, while at a planting distance of 1.4 m x 1 meter it ranges from 56.6 cm – 85.6 cm (Figure 3.). However, the span of tubers is not correlated with increasing crop production if it is not followed by an increase in the weight of the tubers. According to (Kartika, 2018) planting distances that are too wide can cause reduced utilization of sunlight, and nutrients by plants because some of the light will fall to the soil surface and nutrients will be lost due to topping and washing. This will lead to reduced efficiency of photosynthesis. So it will reduce the results of photosynthetic distribution to the tubers.

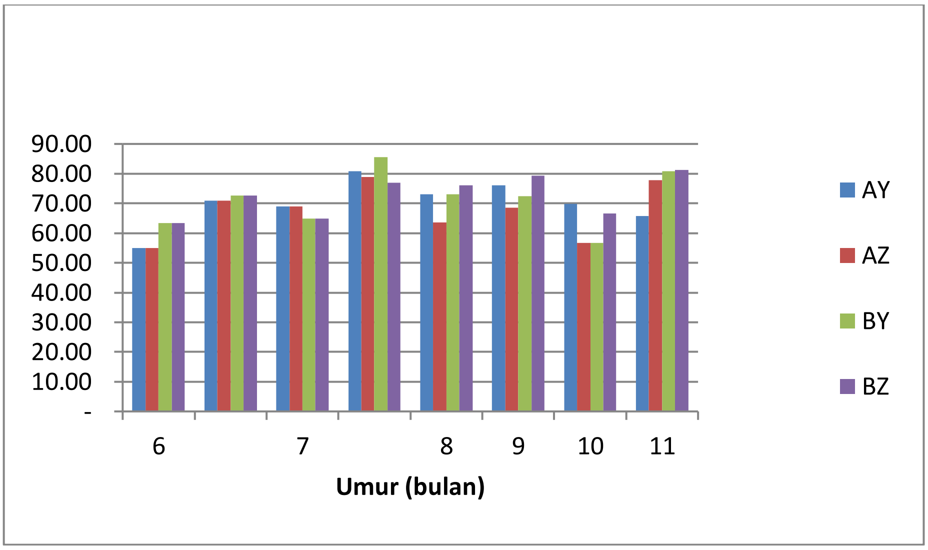

Fig. 3: Profile of the tuber range of cassava plants aged 6-11 months on various treatments

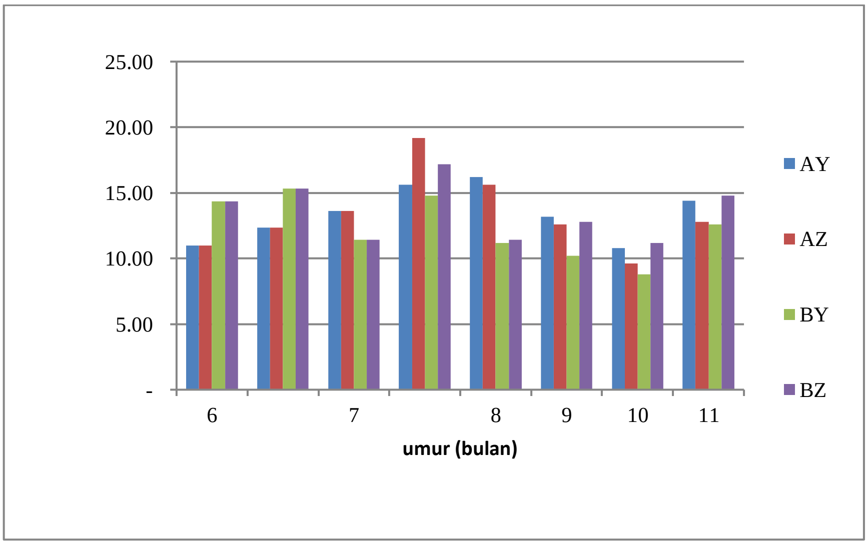

Fig. 4: Profile of the number of tubers of cassava plants aged 6-11 months on various treatments

Menurut Onwueme (1994) dalam Rosyadi *et al.* (2014), Jumlah umbi merupakan banyaknya umbi yang terbentuk dari hasil metamorfosa akar serabut, yang semula berperan aktif dalam penyerapan hara, beralih fungsi sebagai tempat penampungan fotosintat. Dari hasil pengukuran diperoleh data jumlah umbi pertanaman terendah yaitu 8,80 buah/tanaman dan tertinggi 19,2 buah/tanaman (Gambar 4.). Jumlah umbi pertanaman setiap bulan sangat bervariasi karena sampel jumlah umbi yang dimbil setiap bulan diambil dari tanaman yang berbeda. Dari hasil pengamatan jumlah umbi tidak selalu berkorelasi positif dalam peningkatan berat umbi. Pada jumlah umbi yang banyak,

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tetapi tidak diikuti dengan perkembangan umbi yang baik sehingga umbi kecil dan tidak berbobot. Jumlah umbi dan panjang umbi akan mempengaruhi produktivitas tanaman apabila jumlah umbi masuk dalam kategori jumlah umbi ekonomis. Menurut Rosyadi *et al* (2014), Jumlah umbi ekonomis merupakan banyaknya umbi ubi kayu yang dihasilkan pada setiap tanaman yang memiliki nilai ekonomis, biasHal yang dapat mempengaruhi perkembangan jumlah dan bobot umbi adalah persaingan dengan gulma. Kelemahan ubi kayu pada fase pertumbuhan awal adalah tidak mampu berkompetisi dengan gulma. Periode kritis atau periode tanaman harus bebas gangguan gulma adalah antara 5 - 10 minggu setelah tanam. Bila pengendalian gulma tidak dilakukan selama periode kritis tersebut, produktivitas dapat turun sampai 75% dibandingkan kondisi bebas gulma. Untuk itu, penyiangan diperlukan hingga tanaman bebas dari gulma sampai berumur sekitar 3 bulan. anya diukur dari panjang umbi lebih dari 20 cm.

The length of the bulbs each month varies for each treatment, this is because the samples taken each month are from different plants. The shortest tuber length is 16.96 cm while the longest tuber is 29 cm (Figure 5.). This shows that the length of the tuber is also not always positively correlated with an increase in the weight of the tuber.

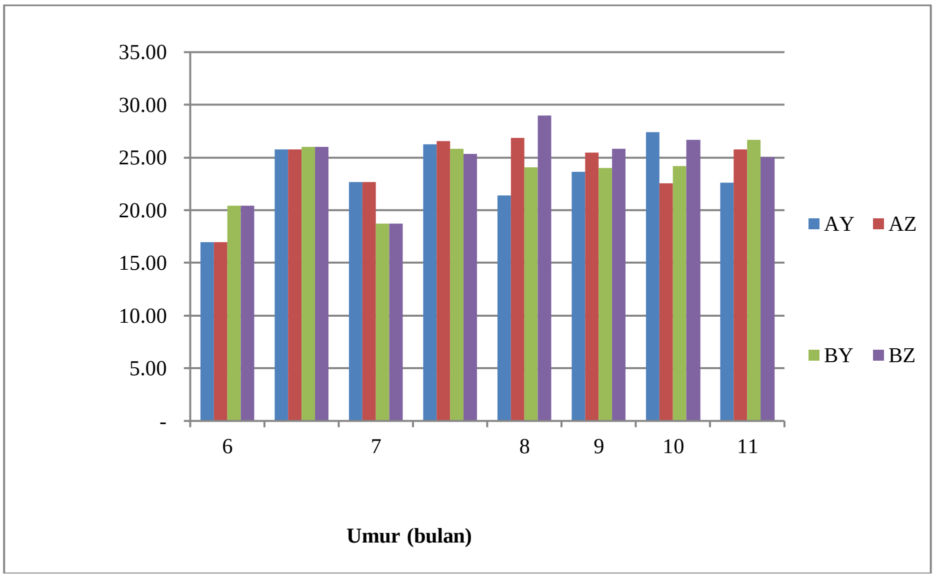

Fig. 5: Long profile of tubers of cassava plants aged 6-11 months on various treatments

On the measurement of the diameter of the tuber, the diameter is positively correlated with the weight of the tuber. The larger the diameter of the tuber indicates that the tuber is developing and will increase the weight of the tuber. The planting distance treatment of 1.4 meters x 1 meter, shows a larger diameter, which is an average of 4.64 cm from the planting distance treatment of 1.4 meters x 0.8 meters, which is 4.11 cm.

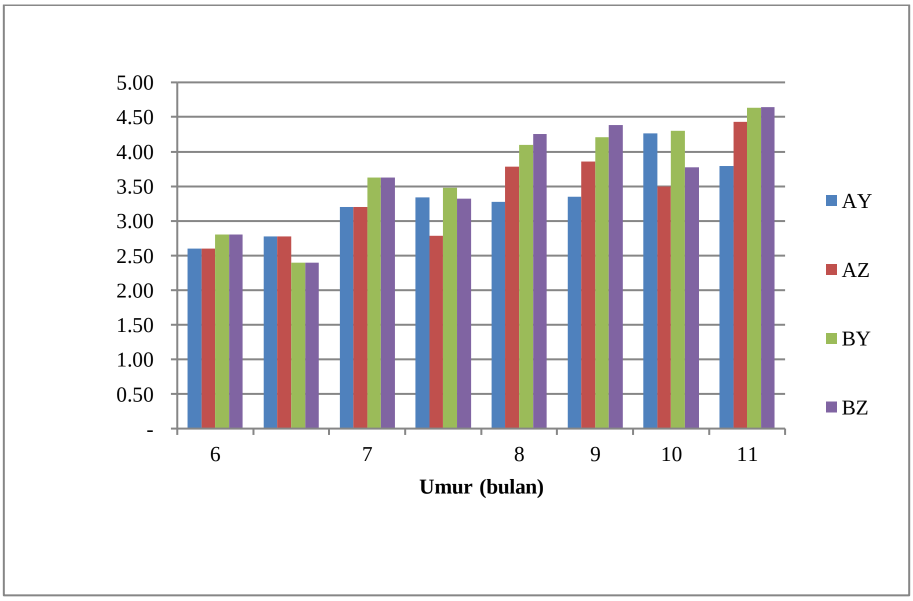

Fig. 6: Profile diameter of cassava plants aged 6-11 months on various treatments

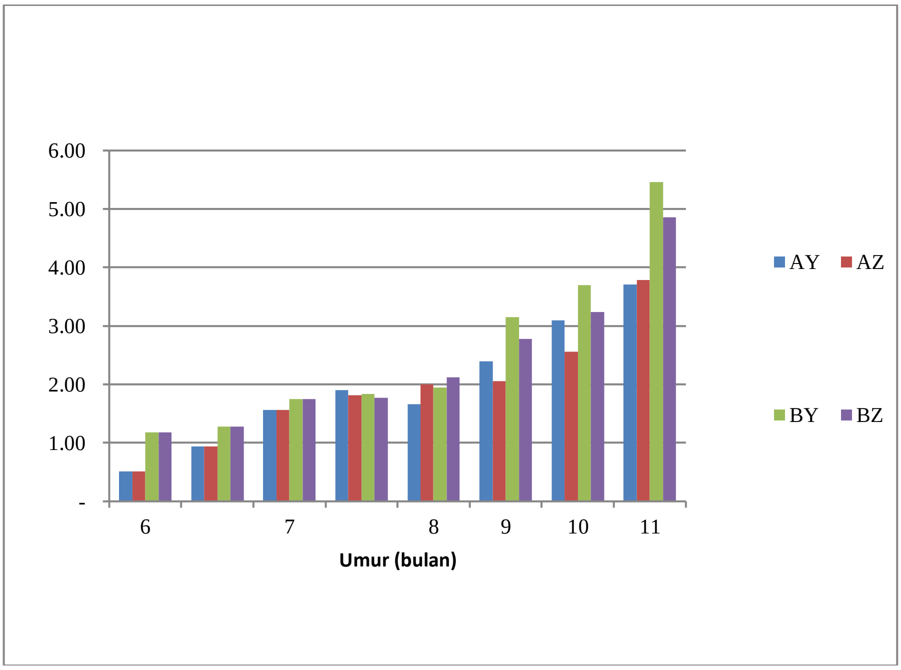

Fig. 7: Weight profile of tubers of cassava plants aged 6-11 months on various treatments

The weight of the bulbs increases every month, but the increase in the weight of the bulbs in the 2019-2020 growing season is very slow because the growing season occurs in a long dry season. Cassava plants need sufficient water, especially in the phase of tuber formation. Water becomes one of the important materials in the process of photosynthesis and transport of photosynthesis to the tubers. The weight of the bulbs at a planting distance of 1.4 meters x 1 meter shows higher yields than the planting distance of 1.4 meters x 0.8 meters.

Fertilizing Boron is carried out after the plant is 7 months old. In the first month after the application of boron fertilizer, the results obtained have not been significant. After 2-4 months after application, there is a difference in the weight of the bulbs on the treatment of Boron fertilizer and without Boron fertilizer. In the 11th month at the time of harvest, the increase in the weight of the tubers from the previous 1 month, namely at the treatment of planting distances of 1.4 meters x 1 meter with Boron fertilization, there was an increase in the weight of the bulbs by 67.77%, while at the same planting distance without boron fertilization there was an increase of 66.67%. At a row spacing of 1.4 meters x 0.8 meters. There was a higher increase, namely in the application of Boron fertilization by 83.65%, while without Boron by 67.72%. From these data, it shows that boron fertilizer plays a role in increasing the weight of planting tubers. This is according to Matas et al. (2009) in Sugianto et al. (2014) The rate of nutrient absorption of plants increases with the application of Boron. In addition (Gardner et al., 1991). Ningsih et al. (2017) suggested cell development and sugar transport and the formation of polysaccharides can be influenced by Boron. Based on an article from Pontianak city (2018), Boron's function is to transport carbohydrates into the plant body and help plant parts to grow actively. In addition, the results obtained show the determination of the right planting distance also greatly affects the results obtained. In low population numbers and increasingly stretched planting distances (exceeding optimum limits), the area of the soil surface that is not shaded by plants is wider so that soil evaporation is higher and the elements contained in the soil evaporate more than they are absorbed by plants. As a result, plants experience nutrient deficiencies so their growth becomes disturbed. However, in the spacing treatment of 1 m x 0.8 m without boron fertilizer, the increase in tuber weight achieved was not as high as in the treatment of planting distances of 1 m x 0.8 m with boron fertilizer, this was influenced by the condition of the planting area adjacent to the tree, some parts of the plant were shaded, so that plant growth was less optimal. The cassava plant is a plant that is included in the category of not requiring shading.

The element Boron is absorbed by plants in the form of H_3BO_3. This element in the soil is in the form of boric acid (Matoh, 1997) Sudaryono (2017). The role and function of boron for plants are crucial. The function of boron for plants, among others, plays a role in the metabolism of nucleic acids, carbohydrates, proteins, phenols, and auxins, this was stated by Wahyudi (2013) in Sudaryono.

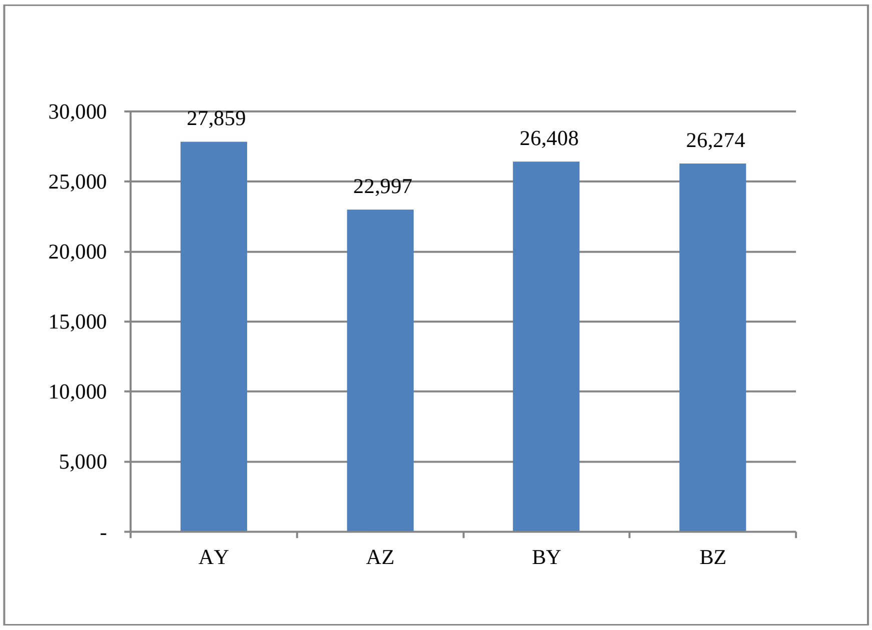

Fig. 8: Productivity profile of 11-month-old cassava plants on various treatments

From the harvest, the productivity of cassava plants was obtained, for fertilizing Boron with a planting distance treatment of 1.4 meters x 1 meter, the productivity of 26,408 kg/hectare was obtained while without fertilization boron 26,274 kg/ha. In the boron fertilization treatment with a planting distance of 1.4 meters x 0.8 meters, productivity was obtained at 27,859 kg/ha, and without Fertilization Boron was 22,997 kg/ha (Figure 8.). These results show that the population plays a role in increasing productivity. At a planting distance of 1.4 meters, x 1 meter the population per hectare amounts to 7,120 plants while at a planting distance of 1.4 meters x 0.8 meters the population per hectare amounts to 8,900 plants. Planting distance is closely related to the number of populations. The more the population, the higher the potential for results obtained.Planting at a certain planting distance aims to make the plant population get an equal share of the necessary nutrients and sunlight, and facilitate maintenance (Probowati 2014).

According to Haryadi (1988), plant density affects the appearance and production of crops. In general, production per unit area is high can be from certain populations that can make the most of the use of light. According to Gardner et al. (1996), the regulation of plant density aims to minimize intrapopulation competition so that the canopy and roots of plants can make optimal use of the environment. sparse planting distances (low population) can improve the growth of individual plants, but provide opportunities for the development of weeds.

Fertilizing Boron increases the weight of the bulbs so that it can increase productivity. This is because Boron has a role in carbohydrate transport, so the addition of Boron can increase plant growth and development (Robinson, 1995 *in* (Julita HD *et al.* (2016)), In addition, Boron is also able to increase the chlorophyll content and the number of stomata to affect photosynthesis so that it can produce optimal assimilation (Sakya *et al.*, 2008 *in* (Julita HD *et al.* (2016)) as well as increasing food reserves in seeds. Boron is also an important inorganic component of the arrangement of cell walls. The addition of Boron nutrients will bring positive benefits in the right amount, the availability of boron in the soil is 0.5 – 2 ppm but only 0.5 – 2.5% is available for plants. So it needs addition from the outside, but the addition must be with the right dose because if available in excessive quantities it will be toxic (Hanafiah, 2007 *inside* (Julita HD *et.* (2016)).

Other factors affect the productivity of cassava plants such as rainfall and light intensity. Rainfall is related to the availability of water. For plants, water is needed to maintain the hydration of the protoplasm, transport food, and mineral elements, and influence the uptake of nutrients by the roots. Cassava plants produce optimally if the water needs are sufficient. 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 *in* Nugraha, *et al* (2015)). In addition, during the dry season, the light intensity is very high, while the maximum photosynthesis efficiency is achieved at low light intensity (Lakitan, 2000). At the time of this cultivation, there is a long dry season. No rains occurred for 4 months. At this time the cassava plant is in the phase of growth and the beginning of the formation of tubers. So that the formed tubers become inhibitedand result in a decrease in plant productivity. According to the description of Balitkabi (2012), the potential yield of cassava varieties UJ-5 or Kasesart is 25 – 38 tons/ha of fresh tubers.

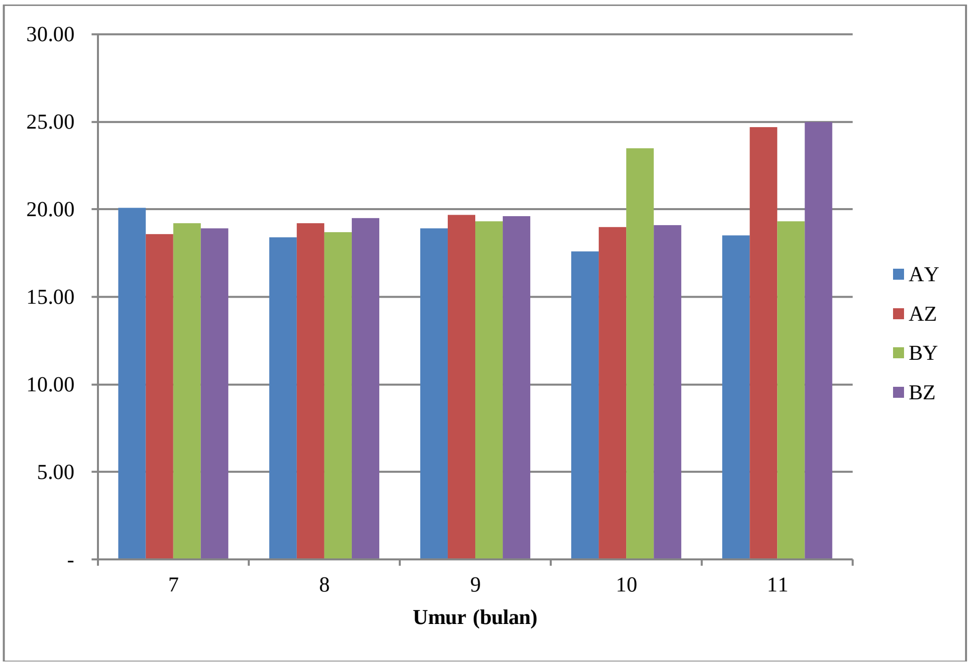

Fig. 9: Starch content profile of cassava plants aged 7-11 months on various treatments

The application of Boron fertilizer is carried out when the age of the cassava plant is 7 months. From figure 8 above at the age of 7-10 months, Boron has not shown its effect on the level of starch levels. But after the age of 11 months, there is a significant difference between plants that get the addition of boron elements in their fertilization. The highest starch content produced in the treatment without boron was BZ 25% and followed by AZ 24.7%, while the Boron treatment in BY showed results of 19.30 and AY 18.5%. In the description of cassava according to Balikabi (2012), the starch content of the UJ-5 variety (Kasesart) is 19-30%. The high starch content, in addition to being genetically influenced, is also influenced by plant physiology. According to (Li *et al.* (2016) *in* Subekti *et al.* 2018), the high capacity of stem *transport stem flow rate* (SFR), high starch synthesis (influenced by enzymatic activity) in the stem, and low degradation in the roots, as well as high expression of genes related to sugar transport on the stem are things that can affect the content of starch levels accumulated in the roots (*fresh root*).

IV. CONCLUSIONS AND SUGGESTIONS

The conclusion obtained in this study was that Boron fertilization with a planting distance of 1.4 m x 0.8 showed the highest productivity of other treatments, namely 27,859 kg/ha. The starch content of cassava aged 11 months (at harvest time) in the treatment without Fertilization of Boron is higher than the treatment of Fertilizing Boron. These results show that the use of Boron fertilizer can increase the productivity of cassava, but it can reduce its starch levels.

SUGGESTION

Further testing of cassava planting with Boron fertilization in the ideal growing season is required.

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