

**ANALYSIS OF THE GROWTH, PRODUCTIVITY AND NUTRITIONAL CONTENT OF JARAK TOWO VARIETY CASSAVA AT VARIOUS FERTILIZERS AND ALTITUDES IN KARANGANYAR REGENCY, INDONESIA**

**ANALISIS PERTUMBUHAN, PRODUKTIVITAS DAN KANDUNGAN NUTRISI SINGKONG VARIETAS JARAK TOWO PADA BERBAGAI PEMUPUKAN DAN KETINGGIAN TEMPAT DI KABUPATEN KARANGANYAR, INDONESIA**

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**ABSTRAK**

Pengembangan singkong Jarak Towo meningkatkan ketersediaan bahan baku olahan pangan dan pendapatan petani. Hal ini karena keunggulan rasa dan tekstur halus dengan harga mencapai 3 sampai 4 kali lipat dari varietas lain. Sebagai bahan baku industri pengolahan pangan, harus didukung dengan kandungan gizi yang berkualitas. Penelitian ini bertujuan untuk mengetahui produktivitas, parameter pertumbuhan, kandungan gizi singkong Jarak Towo dengan perlakuan dosis pupuk P dan K serta ketinggian tempat yang berbeda. Penelitian ini menggunakan percobaan rancangan acak kelompok lengkap dengan faktorial kombinasi dosis pupuk P dan K. Dosis pupuk P tiga level berupa SP36 yaitu 0 kg ha<sup>-1</sup>, 100 kg ha<sup>-1</sup>, dan 200 kg ha<sup>-1</sup>, sedangkan dosis pupuk K berupa KCl tiga level yaitu 0 kg ha<sup>-1</sup>, 150 kg ha<sup>-1</sup>, 300 kg ha<sup>-1</sup> sehingga diperoleh sembilan kombinasi perlakuan yang diulang di tiga lokasi yaitu Desa Kemuning, Sepanjang, dan Wonorejo pada ketinggian 700 mdpl, 927 mdpl, and 1034 mdpl. Hasil penelitian menunjukkan bahwa singkong Jarak Towo yang dibudidayakan di Desa Kemuning memiliki kadar air dan lemak tertinggi 54,28 ± 2,76% dan 0,78 ± 0,21%. Kandungan karbohidrat dan protein tertinggi diperoleh di Desa Wonorejo 15,74 ± 4,25% dan 2,42 ± 0,23%. Perlakuan pupuk P dan K tidak berpengaruh signifikan terhadap parameter pertumbuhan, produktivitas dan nutrisi dalam singkong Jarak Towo.

Kata Kunci : Karbohidrat, Lemak, Protein, Singkong, Varietas Jarak Towo

**ABSTRACT**

The development of Jarak Towo cassava increases the availability of processed food raw materials and farmers' income. This is because of the superiority of taste and smooth texture with prices reaching 3 to 4 times that of other varieties. As a raw material for the food

processing industry, it must be supported by quality nutritional content. This study aimed to determine productivity, the growth parameters, nutritional content of Jarak Towo cassava with different doses of P and K fertilizers and altitudes. This research used a completely randomized block design trial with a factorial combination of P and K fertilizer doses. The dose of P fertilizer at three levels in the form of SP36 was 0 kg ha<sup>-1</sup>, 100 kg ha<sup>-1</sup>, and 200 kg ha<sup>-1</sup>, while the dose of K fertilizer in the form of KCl 3 levels was 0 kg ha<sup>-1</sup>, 150 kg ha<sup>-1</sup>, 300 kg ha<sup>-1</sup> in order to obtain nine treatment combinations repeated in three locations, namely Kemuning, Sepanjang, and Wonorejo Villages at an altitude of 700 masl, 927 masl, and 1034 masl. The results showed that Jarak Towo cassava cultivated in Kemuning Village had the highest water content and fat content of 54.28 ± 2.76% and 0.78 ± 0.21%. The highest carbohydrate and protein content were obtained in Wonorejo Village 15.74 ± 4.25% and 2.42 ± 0.23%. The treatment of P and K fertilizers had no significant effect on the growth parameters, productivity and nutrition in Jarak Towo cassava.

Keywords: Carbohydrate, Cassava, Fat, Jarak Towo Variety, Protein

## INTRODUCTION

Cassava (*Manihot esculenta*) is the second most significant carbohydrate source after rice in tropical and underdeveloped regions, as well as the fifth most important staple plant globally, and the productivity in 2019 was 10.545 kg ha<sup>-1</sup> (Food and Agriculture Organization of The United Nations, 2019). Indonesia ranks second among cassava-producing countries in Asia and makes cassava an important commodity for food security (Food and Agriculture Organization of the United Nations, 2018). The demand is high, but domestic product supply decreases, resulting in an increase in imports (PUSDATIN, 2016). The parts can be used, from the tubers and leaves to the peel. Furthermore, it can be processed into flour, various processed foods, and fermented tapioca. Processing cassava into various food products can also increase its economic value (Hartini & Martono, 2015). Therefore, it can be utilized in various aspects following the potential of becoming an important food ingredient in the future.

Cassava is the commodity with the largest yield after rice and corn in the Karanganyar Regency (Badan Pusat Statistik, 2022). The potential for its development as diversification of carbohydrate sources other than rice is immense. The 2020 yields in Karanganyar Regency reached 30.66 tons ha<sup>-1</sup> (Badan Pusat Statistik, 2021), with an increased harvested area of 2,401 ha to 2,413.7 ha (Badan Pusat Statistik, 2022).

Karanganyar Regency consists of an area with an altitude of 95-1,200 masl (Badan Pusat Statistik, 2021b). Various cassava varieties are cultivated in Indonesia, but the Jarak Towo species is a typical variety of Karanganyar Regency. Cassava tuber yields are strongly influenced by altitude, high yields and adaptive to the environment are cultivated at an altitude of more than 800 m asl. Jarak Towo cassava can initially be found in mountainous areas of the regency with good quality in cultivation at an altitude of ±1000 masl (Mujiyo et al., 2021). The variety has been registered on a local patent certificate number 1656/PVL/2021 by the Ministry of Agriculture (Ministry of Agriculture, 2021). The local community

gave the name Jarak Towo or Jalak Towo because the flowers and leaves are shaped like *Jatropha* flowers and seeds (Irianto et al., 2021). The unique taste and smooth texture are suitable for various processed traditional food products such as Gethuk, as well as modern foods such as cakes and brownies. The opportunity to be processed into various processed foods makes the prices 3 to 4 times higher than that of other varieties. However, not all fields can produce the same grade of Jarak Towo cassava.

Food diversification based on local products should pay attention to nutritional value, quality, and consumer preferences (Ikhrum & Chotimah, 2022). The nutrients contained in 100 grams of cassava tubers include 0.3-3.5 g protein, 0.003-0.5 g fat, 0.1-3.7 g fiber, and 35-38 g carbohydrate (Bechoff, 2017). Cassava leaves grown in the highlands (>700 m asl) has the highest nutrient content, namely 31.87% dry matter, 23.39% C fiber, and 0.62% P (Rochana et al., 2018). Research on the nutrients contained in Jarak Towo cassava tubers that grows at various altitudes has never been done. It is important to know which tubers have the most nutrients from varying altitudes. The nutritional content is different depending on the part of the plant, environmental conditions, variety, and age (Salvador et al., 2014).

The development of Jarak Towo cassava as a raw material for the food processing industry with high economic value and sustainability should be supported by good nutritional content. Previous research on Jarak Towo cassava was conducted by Irianto et al., (2021) regarding a comparative study of Jarak Towo cassava farming in the mountainous

areas of Karanganyar Regency in supporting the availability of raw materials for food processing industry and research conducted by Mujiyo et al., (2021) regarding sustainable development and planning land suitability assessment for cassava var. Jarak Towo, using determinant factors as the strategy fundament in hilly area Jatiyoso-Indonesia. There has been no research related to the nutritional content in Jarak Towo cassava and differences P and K fertilizers. Therefore, this research aimed to analyze productivity, and the growth parameters and also the nutritional content of Jarak Towo variety cassava to the differences in P and K fertilization treatments, as well as the different altitudes in the Karanganyar Regency. Cassava plants require sufficient P and K elements for tuber formation. Lack of P nutrients will result in disruption of metabolic processes in plants, inhibit the absorption of K elements, also the process of tuber formation (Tumewu et al., 2015).

## RESEARCH METHODS

This research was conducted in Kemuning, Sepanjang, and Wonorejo Village at an altitude of 700 masl, 927 masl, and 1,034 masl, Karanganyar Regency, Central Java, Laboratory of Chemistry and Soil Fertility, as well as Laboratory of Soil Biology and Biotechnology, Faculty of Agriculture, Sebelas Maret University in March 2021 to January 2022.

This research used a completely randomized block design trial with a factorial combination of P and K fertilizer doses. The treatment dose of P fertilizer was given in form of SP36 at three levels namely 0 kg ha<sup>-1</sup> (P0), 100 kg ha<sup>-1</sup> (P1), 200 kg ha<sup>-1</sup> (P2), while K fertilizer was given in

form of KCl at 0 kg ha<sup>-1</sup> (K0), 150 kg ha<sup>-1</sup> (K1), 300 kg ha<sup>-1</sup> (K3). The treatment combination was conducted between three levels of P and K fertilizers. Hence nine combinations of P0K0, P1K0, P2K0, P0K1, P1K1, P2K1, P0K2, P1K2, and P2K2 were obtained. Each combination was repeated in three blocks, including Kemuning (Block I), Sepanjang (Block II), and Wonorejo (Block III), to obtain 81 samples. Kemuning Village is located at 700 m asl, Sepanjang 927 m asl, and Wonorejo at 1034 m asl. The experimental plot size used was 8 m x 8 m with cropping distance of 2 m x 2 m.

The plant growth parameters observed included main stem height, second stem height, number of branches, number of leaves, and productivity. Cassava tubers var. Jarak Towo analyzed was tuber that had been peeled. The nutritional content analyzed in this study were protein, fat, water content, and carbohydrate. Water content was determined by weighing bottle method. 10 g of peeled cassava placed into a pre-weighed the weighing bottle and weighed. Dried in an oven at 110°C for 24 hours, After removing the samples from the oven, then reweighed (Sudarmadji et al., 2010).

Carbohydrate content was determined by Nelson Somogyi method. A standard glucose solution (10 mg glucose anhydrous/100 ml) was prepared, six dilutions were made to obtain a glucose solution with concentrations of: 2, 4, 6, 8 and 10 mg 100 ml<sup>-1</sup>. Seven clean test tubes were prepared, each filled with 1 ml of the standard glucose solution mentioned above. One tube was filled with 1 ml of distilled water as a blank. To each tube the above 1 ml Nelson reagent was added and all tubes were heated in a boiling water

bath for 20 minutes. All the tubes were taken and immediately cool them together in a beaker containing cold water so that the temperature of the tubes reaches 25°C. After cooling, 1 ml of Arsenomolybdat reagent was added, the did shaking until all the Cu<sub>2</sub>O precipitates were dissolved again. After all Cu<sub>2</sub>O precipitates were completely dissolved, 7 ml of distilled water was added, then was shaken until homogeneous.

Determination of reducing sugar in the sample. A sample solution was prepared that had a reducing sugar content of about 2.8 mg 100 ml<sup>-1</sup>. It was shaken with aquadest then let it sit until it's clear. One ml of the clear sample solution was pipetted into a clean test tube. Nelson's reagent of 1 ml was added, and then treated as in the standard curve preparation above. Heated, after cooling, add 1 ml of arsenmolybdate, shaken, then add 7 ml of distilled water. After that shot by sepctrophotometry (Sudarmadji et al., 2010).

Fat content was determined by Soxhlet method (Sudarmadji et al., 2010). First, the filter paper was dried using an oven at 105 degrees for ± 1 hour. The filter paper was cooled in a desiccator for 15 minutes then weigh (W1). Weigh the sample as much as 2 grams and wrap it in filter paper then weigh it again (W2). The extraction apparatus was assembled from the heating mantle, lemat flask, soxhlet and condenser. Put the sample into the Soxhlet and add solvent petroleum ether until it is sufficient for 1.5 cycles. Extraction lasts for ± 6 hours until the solvent drops back down through the siphon into a clear fat flask. Extract the results into the oven for 1 hour and then weighed (W3). Calculate % fat content with the formula:

$$\% \text{ fat} = \frac{(W3 - W1)}{(W2 - W1)} \times 100\%$$

Protein content was determined used Kjeldahl method. One gram of mashed cassava sample was weighed and put it in the Kjeldahl tube. Two grams of a mixture of  $\text{CuSO}_4$  and  $\text{K}_2\text{SO}_4$  (1:20 ratio) was added, then added 15 concentrated  $\text{H}_2\text{SO}_4$ . All the ingredients were heated in the Kjeldahl flask in a fume hood until it was smokeless. Turn off the fire and wait for the sample to cool. 100 mL of aquadest was added and a few plates of Zn. Then 50 mL of 50% NaOH were slowly added, then attach the Kjeldahl flask to the distillator. Did preparation and installment of the distillate in an Erlenmeyer containing 50 ml of standard HCl solution (0.1 N) and 5 ml of methyl red. The Kjeldahl flask was heated until the distillate was accommodated as much as 75 ml. Did titration the distillate with 0.01 N NaOH. A blank solution was made with aquadest material and distillation destruction and titration like sample material. This was then converted to protein by using the factor 6.25 based on the assumption that the average of protein contains about 16% nitrogen (Sudarmadji et al., 2010). The protein content (%) of the samples was calculated by using the following equation:

$$\%N = \frac{\text{sample titre} - \text{blank titre}}{\text{sample weight} \times 1000} \times 100 \times 14,008 \times 0,01$$

$$\% P = \% N \times 6,25$$

The research data were analyzed using the ANOVA test with a 95% confidence level. Duncan's Multiple Range Test (DMRT) was further tested when the results were significantly affected. Furthermore, a Pearson correlation test

was conducted to determine the relationship between the research location and the nutritional content of Jarak Towo cassava. Statistical analysis was performed using the SPSS 25 application.

## RESULTS AND DISCUSSION

Fertilization treatment showed had no pattern of influence on the growth parameters, productivity and quality of Jarak Towo cassava. The ANOVA results showed that the application of P fertilizer had no significant effect on the quality of Jarak Towo cassava including water content, carbohydrate, fat, and protein (Table 1). The application of P fertilizer also had no significant effect on the growth parameters, including the main stem height, second stem height, number of branches and number of leaves also productivity (Table 2). Based on the ANOVA test results, shown in the Table 3 and 4 that the application of K fertilizer had no significant effect on the growth parameters of Jarak Towo including the main stem height, the second stem height, the number of branches, and number of leaves. The application of K fertilizer also had no significant effect on productivity and the quality of Jarak Towo cassava including water content, carbohydrate, fat, and protein. In general, the application of P and K fertilizers did not have a significant effect, but research locations had a significant effect on the growth parameters, productivity and quality of Jarak Towo cassava. The doses of P and K fertilizers used in this research had no significant effect on Jarak Towo cassava, so it may require an increase in dose in order to have an effect. Cassava is a tuber plant that require a high enough K element in

order to be able to produce tubers with high weight and starch content. The research conducted by Wahyuningsih and Sutrisno, (2019) showed that differences in fertilizer inputs had no significant effect on the growth and productivity of cassava. The combination dose of fertilizer given was 100 kg Urea + 125 kg SP36 + 75 kg KCl, 125 kg Urea + 150 kg SP36 + 100 kg KCl, and 150 kg Urea + 200 kg SP36 + 125 kg KCl. In the research of Najib et al., (2020) it was stated that the addition of KCl fertilizer doses of 200 Kg ha<sup>-1</sup> and 300 Kg ha<sup>-1</sup> did not show a significant effect on cassava productivity. The application of P and K fertilizers that did not have a significant

effect could be caused by the history of land management, soil fertility, and different soil types in each location (Gizachew et al., 2018).

The ANOVA test results showed significant differences between research locations, including Kemuning, Sepanjang, and Wonorejo Villages, on several parameters, such as water content, carbohydrate, and protein. Meanwhile, the research locations with different altitudes showed a significant difference based on the ANOVA test results on the fat content. However, the difference showed no significant effect on the yield of Jarak Towa cassava.

Table 1. ANOVA test results between fertilizer P with water content, carbohydrate, fat, and protein

Variable	Sum of Square	Mean Square	Mean Square error	F value	Significance
Water content	144.620	72.310	37.932	1.906	0.155
Carbohydrate	80.630	40.315	13.241	3.045	0.053
Fat	0.062	0.031	0.042	0.733	0.484
Protein	20.629	10.314	14.142	0.729	0.485

Table 2. ANOVA test results between fertilizer P with the growth parameters and productivity

Variable	Sum of Square	Mean Square	Mean Square error	F value	Significance
Main stem height	634.988	317.494	1084.703	0.293	0.747
Second stem height	660.840	330.420	1045.282	0.316	0.730
Number of branches	41.580	20.790	62.980	0.330	0.720
Number of leaves	119.185	59.593	868.831	0.069	0.934
Productivity	6.667	3.333	5.496	0.607	0.548

Table 3. ANOVA test results between fertilizer K with water content, carbohydrate, fat, and protein

Variable	Sum of Square	Mean Square	Mean Square error	F value	Significance
Water content	101.768	50.884	38.482	1.322	0.272
Carbohydrate	64.016	32.008	13.454	2.379	0.099
Fat	0.033	0.017	0.043	0.391	0.678
Protein	1.170	0.585	0.552	1.060	0.351

Table 4. ANOVA test results between fertilizer K with the growth parameters and productivity

Variable	Sum of Square	Mean Square	Mean Square error	F value	Significance
Main stem height	117.506	58.753	1091.337	0.054	0.948
Second stem height	140.914	70.457	1051.948	0.067	0.935
Number of branches	32.099	16.049	63.102	0.254	0.776
Number of leaves	252.667	126.333	867.120	0.146	0.865
Productivity	1.024	0.512	5.568	0.092	0.912

Table 5. The average value for the effect of the region on the nutritional content of Jarak Towo cassava in Karanganyar Regency

Region	Variable			
	Water content (%)	Carbohydrate (%)	Fat (%)	Protein (%)
Kemuning	54.28 ± 2.76 b	12.51 ± 1.98 a	0.78 ± 0.21 B	1.11 ± 0.19 b
Sepanjang	46.25 ± 4.37 a	11.88 ± 3.45 a	0.64 ± 0.16 A	0.87 ± 0.39 c
Wonorejo	45.50 ± 6.59 a	15.74 ± 4.25 b	0.73 ± 0.22 AB	2.42 ± 0.23 a

Note : Different lowercase letter superscripts (a-b) in the same column show a very significant difference ( $P < 0.01$ ) in water content, carbohydrate, fat, and protein in Jarak Towo cassava. Different capital letter superscripts (A-B) in the same column showed significant differences ( $P < 0.05$ ) in fat content.

Table 6. ANOVA test results between regions with water content, carbohydrate, fat, and protein

Variable	Sum of Square	Mean Square	Mean Square error	F value	Significance
Water content	1280.131	640.066	23.374	27.383	0.000
Carbohydrate	231.067	115.534	11.312	10.213	0.000
Fat	0.289	0.144	0.039	3.660	0.030
Protein	37.813	18.906	0.082	230.189	0.000

### Growth Parameters

Based on the ANOVA test results, the differences in the region had a very significant effect on the growth parameters of Jarak Towo cassava, including the main and second stem heights, as well as the number of branches and leaves. The average value of main stem height from the highest to the lowest was  $186.11 \pm 29.29$ ,  $173.37 \pm 29.06$ , and  $138.37 \pm 17.53$  for Kemuning, Wonorejo, and Sepanjang, respectively. The average value of the second stem height from the highest to the lowest was  $176.11 \pm 29.29$ ,  $167.96 \pm 27.54$ , and  $130.52 \pm 17.81$ . Kemuning produces Jarak Towo cassava with a higher main stem than other villages.

This result is higher than (Biratu et al., 2018), which produced cassava with a stem height of 133.3 cm and 20.4 cm in the Mansa and Kabangwe area. Hmwe et al. (2022) stated that the stem height of cassava studied was only around  $136.77 \pm 3.07$ cm, lower than in Kemuning, Sepanjang, and Wonorejo Villages. Stem height is influenced by several factors, such as environmental conditions. This is because Kemuning Village is located at an altitude of 700 masl, where stable rainfall increases plant height. The height of the plant stem will affect the number of branches into which the leaves come out. Therefore, the stem height is directly proportional to the number of leaves and the assimilation process. Assimilate



content in plants can increase cell division, affecting the growth of cassava height. Farmers cultivate Jarak Towo cassava to obtain tubers and stem that will later be used as propagation material by cuttings (Lawal et al., 2021). Furthermore, the average number of branches from the highest to the lowest was  $19.59 \pm 8.16$ ,  $7.19 \pm 2.82$ , and  $7.04 \pm 2.86$  for Wonorejo, Sepanjang, and Kemuning, respectively. The number of branches obtained is inversely proportional to the leaves produced. The low number of branches indirectly affects the dry matter produced, reducing the amount of yield. The quantity of cassava branches is essential for developing leaves and boosting yield as photosynthesis builds up in tubers. Meanwhile, the average number of leaves from the highest to the lowest was  $85.37 \pm$

$27.51$ ,  $49.15 \pm 17.94$ , and  $36.48 \pm 13.98$  for Kemuning, Wonorejo, and Sepanjang, respectively. The number of leaves is closely related to the height of the cassava stem, where the higher the stem, the more the number of leaves. The number of leaves on cassava is closely related to its photosynthetic ability. Additionally, the growth of stems and leaves is maximum at the age of 6 months after planting. Above 6 months, the photosynthesis results are not used for plant growth but cassava tuber development, increasing yield. This is consistent with the research conducted in Kemuning Village, which had higher growth parameters, including main stem height, second stem height, and the number of leaves compared to other villages, increasing the yield of Jarak Towo cassava.

Table 7. The average value for the effect of region on the growth parameters of Jarak Towo cassava in Karanganyar Regency

Region	Variable			
	Main Stem Height (cm)	Second Stem Height (cm)	Number of Branches	Number of Leaves
Kemuning	$186.11 \pm 29.29$ b	$176.11 \pm 29.29$ b	$7.04 \pm 2.86$ a	$85.37 \pm 27.51$ c
Sepanjang	$138.37 \pm 17.53$ a	$130.52 \pm 17.81$ a	$7.19 \pm 2.82$ a	$36.48 \pm 13.98$ a
Wonorejo	$173.37 \pm 29.06$ b	$167.96 \pm 27.54$ b	$19.59 \pm 8.16$ b	$49.15 \pm 17.94$ b

Note : Different lowercase letter superscripts (a-b) in the same column showed very significant differences ( $P < 0.01$ ) in the main stem height, second stem height, number of branches, and number of leaves in Jarak Towo cassava.

### Productivity

The highest yield was obtained in Kemuning at  $8.35 \pm 1.96$  tons  $ha^{-1}$ , followed by Sepanjang at  $6.15 \pm 1.97$  tons  $ha^{-1}$  and Wonorejo at  $4.84 \pm 1.57$  tons  $ha^{-1}$  (Table 8). Based on the ANOVA test results, each region has a significantly different effect on the productivity of cassava var. Jarak Towo (F value = 25.041; significance = 0.00). Furthermore, cassava's weight and harvest age also influence the increase in yield. The better plant growth will yield cassava with a larger size because plant production is

very much determined in the vegetative growth phase (Rusbadila et al., 2020). However, the productivity of Jarak Towo cassava is lower than other varieties. This is because the three studied villages' high rainfall and altitude are higher than the required average for cassava productivity. Prayoga (2018) stated that 0-800 m asl is the optimal altitude for cassava, accompanied by 760-2,500 mm/year rainfall. Therefore, high rainfall can reduce the yield of Jarak Towo cassava due to water content on the tuber.



Table 8. The average value for the effect of the region on the yield of Jarak Towo cassava in Karanganyar Regency

Region	Productivity (tons ha <sup>-1</sup> )
Kemuning	8.35 ± 1.96
Sepanjang	6.15 ± 1.97
Wonorejo	4.84 ± 1.57

#### Water content of cassava tuber

The statistical analysis results showed that the research village had a very significant effect ( $P < 0.01$ ) on the water content in Jarak Towo cassava. The water content in Kemuning, Sepanjang, and Wonorejo Villages ranged from  $54.28 \pm 2.76\%$ ,  $46.25 \pm 4.37\%$ , and  $45.50 \pm 6.59\%$ , respectively (Table 5). Kemuning shows the highest value because this village has higher rainfall than the other two. Rainfall affects the availability of water in the soil as well as helps in the decomposition of organic matter and the formation of structures in the soil, hence the absorption of nutrients in organic matter can be optimal (Prasetyo et al., 2021). Water availability affects the photosynthesis process in cassava, and one of the available sources comes from rainfall. The increase is influenced by the accumulation of photosynthetic results from leaves to be translocated for tuber formation. Tubers with a high water content can be processed into flour or starch (Ariani et al., 2017).

Cassava with high water content is more susceptible to damage. It has a relatively short shelf life ranging from 2 to 5 days, causing its quality to decrease (Sagala & Suwanto, 2017). Therefore, there is a need for advanced processing of Jarak Towo cassava to prevent rotting during its storage period (Purwanti et al., 2017). The

water content in plants is related to their level of dry matter. Kemuning Village has an average temperature of 22-27°C, optimal for cassava growth. According to previous research, cassava can grow at an average temperature of 25-29 °C (Mujiyo et al., 2021). This was also supported by Tomlins et al. (2021), who stated that the recommended temperature for cassava to grow optimally is 25-35°C.

#### Carbohydrate content of cassava tuber

Based on the ANOVA test, the differences in the region had a very significant effect on the carbohydrate content in Jarak Towo cassava. The average value from highest to lowest was  $15.74 \pm 4.25\%$ ,  $12.51 \pm 1.98$ , and  $11.88 \pm 3.45$  for Wonorejo, Kemuning, and Sepanjang, respectively (Table 5). The carbohydrate content of Jarak Towo cassava has a value comparable to the study of Bechoff (2017), which stated that cassava contains 35-38 grams of carbohydrates, equivalent to 12%. One of the factors that affects to high carbohydrate content in Jarak Towo cassava of Wonorejo is caused by the low water content. Carbohydrate and water contents in cassava are inversely related. About 80% of the dry matter in cassava tubers contains carbohydrates in the form of starch (Awoyale et al., 2021). Carbohydrates result from the photosynthesis process and are primarily stored in the roots or tubers of cassava (Nurcahyani et al., 2019). Furthermore, they are the second-largest content after water in cassava. These nutrients play a role in determining the characteristics of cassava, such as taste, color, texture, and others (Putri & Sumardiono, 2020). The content increases with the increasing age of cassava plants (Oluwaniyi and Oladipo,

2017). Additionally, cassava aged 6-9 months enters the translocation phase of carbohydrates to tubers, hence the highest dry matter accumulation rate is in tubers (Beja & Apelabi, 2019).

#### **Fat content of cassava tuber**

The analysis results showed that the differences in the region had a significant effect on the fat content in Jarak Towo cassava tuber based on ANOVA test and Duncan Multiple Range Test. The average fat from highest to lowest was  $0.78 \pm 0.21\%$ ,  $0.73 \pm 0.22\%$ , and  $0.64 \pm 0.16\%$  for Kemuning, Wonorejo, and Sepanjang, respectively (Table 5). The results obtained were higher than the fat content of  $0.41 \pm 0.03$  and  $0.41 \pm 0.03$  studied by Gnamien (2022) and Manano et al. (2017). The Food Security Agency stated that the fat content in cassava is 0.3%. Therefore, the fat content of Jarak Towo was higher than that of the cassava studied by Bechoff, 2017). This causes cassava to easily experience a rancid odor (Suherman et al., 2021). The high-fat content is capable of causing a rancid odor and makes cassava have a shorter shelf life. Compared to staple foods such as corn and rice, cassava is low in fat but higher than potatoes. The low-fat content can result in reduced fat-soluble vitamins. The fat in cassava is nonpolar and contains various glycolipids, especially galactose diglycerides. Subsequently, the dominant fatty acids are palmitic and oleic (Bayata, 2019).

#### **Protein content of cassava tuber**

The analysis results showed that the differences in the region had a very significant effect on the protein content in Jarak Towo cassava. The average protein from highest to lowest was  $2.42 \pm 0.23\%$ ,

$1.11 \pm 0.19\%$ , and  $0.87 \pm 0.39\%$  for Wonorejo, Kemuning, and Sepanjang, respectively (Table 5). The high dry matter and low water contents influence the protein in the cassava from Wonorejo. The results obtained in Jarak Towo cassava were higher than the 1.71% and 0.92% protein in Gatotkaca and Gambyong varieties studied by Dewi et al. (2020). The protein contained in cassava consists of arginine, glutamate, and aspartate (Bechoff, 2017). Meanwhile, the dry matter that accumulates in tubers in the form of carbohydrates, proteins, and vitamins is produced from the photosynthesis process. The process of forming protein and carbohydrates requires nutrients in the form of nitrogen. Protein in plants can be seen in the nitrogen content, and it is a compound consisting of chains of amino acids linked by peptide bonds. This nutrient functions to form new and maintain existing tissue, as well as forms substances that regulate the body. The low protein content in cassava (<3%) cannot be used as a source for the community even when consumption exceeds caloric needs.

#### **Research Sites**

Kemuning is located at an altitude of 700 masl with an average air temperature of 22-27°C. Rainfall in this village is in the range of 3,000-4,000 mm/year, with an area of 496.22 ha. The slope varies from 3-8% (declivous), 8-15% (slightly sloping), 15-30% (sloping), 30-45% (slightly steep), 45-65% (steep), and > 65% (very steep). Ngargoyoso Sub-district is located at 7°34'00" - 7°38'00" South Latitude and 111°4'00" - 111°12'00" East Longitude. It is directly adjacent to Jenawi Sub-district in the north, Ngawi Sub-district in the east, Tawangmangu Sub-district in the south,

and Karangpandan Sub-district in the west (Central Statistics Agency, 2020).

Sepanjang is located at an altitude of 927 masl with an average air temperature of 20-27°C, with rainfall ranging from 1,000-3,000 mm/year. The slope varies from 8-15% (slightly sloping), 15-30% (sloping), 30-45% (slightly steep), and >65% (very steep). Tawangmangu Sub-district is located between 4°48'53" - 4°20'16" East Longitude (BT) and 7°39'17" - 7°39'49" 50 South Latitude (LS). Ngargoyoso Sub-district is directly adjacent to Jenawi Sub-district in the north, Tawangmangu Sub-district in the east, Karangpandan Sub-district in the south, and Mojogedang Sub-district in the west (Central Statistics Agency, 2021b). Wonorejo is located at an altitude of 1,034 masl with an average air temperature of 18-20 °C, with rainfall ranging from 2,000-3,000 mm/year. The slope of Wonorejo varies from 3-8% (declivous), 8-15% (slightly sloping), 15-30% (sloping), 30-45% (slightly steep), 45-65% (steep), and > 65% (very steep). Jatiyoso Sub-district is one of the areas located in the Karanganyar Regency. From an administrative point of view, it is bordered by Tawangmangu Sub-district in the north; Girimarto Sub-district (Wonogiri) in the south; Jatipuro Sub-district in the West; and Magetan Regency (East Java) in the east. The astronomical location is at coordinates 111°02'14.0" - 111°12'12.2" East Longitude and 7°41'51,2" - 7°45'1.6"

South Latitude, with a total area of 6,697.28 ha. This research was conducted in Wonorejo Village, Jatiyoso Sub-district, Karanganyar Regency at coordinates 111°8'12.5" - 111°8'21.0" East Longitude and 7°41'59.3" - 7°42'0.8" South Latitude (Central Statistics Agency, 2021a). Data about soil fertility in the Districts of Kemuning, Sepanjang, and Wonorejo are not yet available. The previous planting site was used to grow annual crops such as beans, soybeans, and sweet potato.

### Correlation Between Variables

The determinants of nutritional content in cassava were obtained through a correlation test between villages. The table shows the correlation values between the observed villages and the nutritional content of cassava. R is a Pearson value that indicates the strength and weakness of the correlation. Based on Table 9, the correlation test showed that water content was negatively correlated with the region (R= -0.579\*\*; Sig. 2-tailed = 0.000), carbohydrate was positively correlated with the region (R= 0.355\*\*; Sig. 2-tailed = 0.001), and protein was positively correlated with the region (R= 0.727\*\*; Sig. 2-tailed = 0.000). Protein was negatively correlated with water content (R= -0.266\*\*; Sig. 2-tailed = 0.017) and positively correlated with carbohydrate (R= 0.375\*\*; Sig. 2-tailed = 0.001) (Table 9).

Table 9. Correlation results between regions and the nutritional content of Jarak Towo cassava

Region	Water content	Carbohydrate	Fat	Protein	
Region	1				
Water content	<b>-.579**</b>	1			
Carbohydrate	<b>.355**</b>	-.192	1		
Fat	-.105	.186	.011	1	
Protein	<b>.727**</b>	<b>-.266*</b>	<b>.375**</b>	.056	1

The low water content in Wonorejo Village indicates a negative correlation with carbohydrates. This implies that the water content is inversely proportional to the carbohydrate in Jarak Towo cassava. High yield will produce low dry matter weight (Julianto et al., 2020), which is influenced by the water content in cassava. The correlation test showed that carbohydrate was positively correlated with the region ( $R=0.355^{**}$ ; Sig. 2-tailed = 0.001) (Table 9). Therefore, the region is directly proportional to the carbohydrate content. The difference between protein, fat, and carbohydrate lies in the nitrogen content not owned by the two nutrients (Resthi & Zukryandry, 2021).

Kemuning produces higher water and fat content yield than other villages but is not matched by optimal nutritional content. Meanwhile, Wonorejo produces Jarak Towo cassava with a lower yield but higher carbohydrate and protein content than Kemuning and Sepanjang. Wonorejo is located at an altitude of >1,000 masl, in line with Mujiyo *et al.* (2021), who stated that Jarak Towo cassava cultivated in areas with an altitude of >1,000 masl can produce optimal quality. In the future, Jarak Towo cassava production is expected to be one of the efforts to diversify food based on local products. This variety should contribute to the expansion and development of the agro-industry, particularly in Wonorejo Village, and can thus boost the nutritional value of non-rice food crop commodities.

### CONCLUSION

1. Fertilization treatment of P and K didn't show a pattern of influence on the growth parameters, productivity

and quality of Jarak Towo cassava but fertilization showed significant differences between research locations.

2. The results showed that Jarak Towo cassava cultivated in Kemuning Village had the highest productivity specifically  $8.35 \pm 1.96$  tons  $ha^{-1}$ . Kemuning produced Jarak Towo cassava with a higher main stem and second stem than other villages specifically  $186.11 \pm 29.29$  cm and  $176.11 \pm 29.29$  cm. Jarak Towo cassava cultivated in Kemuning Village had the highest fat content, specifically  $0.78 \pm 0.21\%$ .
3. The highest number of branches and number of leaves was obtained from Jarak Towo cassava cultivated in Wonorejo Village, specifically  $19.59 \pm 8.16$  and  $49.15 \pm 17.94$ . The highest carbohydrate and protein content was obtained from Jarak Towo cassava cultivated in Wonorejo Village, specifically  $15.74 \pm 4.25\%$  and  $2.42 \pm 0.23\%$ . The lowest water content was obtained from Jarak Towo cassava cultivated in Wonorejo Village, specifically  $45.50 \pm 6.59\%$ .
4. Therefore, the location that has the potential to develop sustainable Jarak Towo cassava productivity is Wonorejo Village with an altitude 1.034 masl. This is because it can produce cassava with high carbohydrate and protein content but low water content. The results showed that cassava var. Jarak Towo is best cultivated in areas with high altitude.

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