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Examining the Impact of Cultivated Land Distance from Riparian Areas on the Growth and Quality of Red Kratom Alkaloids

Muhammad Pramulya[1,*], Ulfa Salsabila[2], Tris Haris Ramadhan[2] and Cico Jhon Karunia Simamora[2]

[1]Department of Agriculture Cultivation, Faculty of Agriculture, Universitas Tanjungpura, Indonesia;[2]Department of Agriculture, Faculty of Agriculture, Universitas Tanjungpura, Indonesia Studies Center of Ethic, Racial and Culture Heritage, Tanjungpura University, Indonesia.
[*]Corresponding author's e-mail: muhammad.pramulya@faperta.untan.ac.id

The Kratom plant, a valuable forest species with medicinal potential, thrives in the Riparian area of Empangau Village, Kapuas Hulu District. This study explores the correlation between Kratom cultivation land distance from the river and alkaloid content. Employing a survey method, the research focuses on two locations: one situated 20-50 meters from the river (location 1) and another 580-650 meters away (location 2). Utilizing a quantitative approach and gravimetric methods, the study analyzes alkaloid content in Kratom extracts. The study reveals significant influences on pH, organic carbon, total nitrogen, phosphorus (P2O5), calcium, magnesium, potassium, sodium, cation exchange capacity (CEC), base saturation, and alkaloid compounds, contingent on the distance from the riparian area. Location 2 exhibits superior attributes, boasting a plant height of 6.02 m, stem diameter of 8,532 m2, 30 primary branches, leaf area of 262,576, and a total alkaloid content of 15,491%, surpassing location 1 with an average plant height of 5.66 m, stem diameter of 8,286 m2, 26.6 primary branches, and leaf area of 257,586. Variations in environmental conditions, vegetation, temperature, humidity, and nutrient availability contribute to these differences in alkaloid growth and quality, highlighting the potential for optimized Kratom cultivation in specific Riparian areas.

Keywords: Alkaloids, distance, kratom, plant growth, quality, riparian, soil nutrients, agricultural optimization, environmental conditions.

INTRODUCTION

Kratom (*Mitragyna speciosa*) is a Southeast Asian medicinal herb that can be found in Indonesia, Malaysia, and Thailand (Hassan, 2013). This plant thrives on alluvial soil rich in organic matter (Rudorff *et al*., 2014; Florida *et al*., 2023) and near river flows. Kratom has great promise as a grown medicinal plant in Indonesia's Kapuas Hulu Regency. An updated evidence on the therapeutic value of kratom as an agent for the treatment of pain, mental health, and other chronic/benign health conditions (Prevete *et al*., 2023). This is due to the continued strong demand for raw materials and items derived from kratom on both the domestic and international markets. Farmers in Kapuas Hulu Regency are capitalizing on this prospect.

Kratom leaves are a plant part that can be used. It is typically consumed by chewing or making tea. Kratom leaves can also be used as an herbal medication to treat muscular discomfort, diarrhea, loss of appetite, and fever. Kratom plants are known to contain potential bioactive compounds classified as alkaloids, such as Mitragynine and 7-hydroxy mitragynine (7-HMG), painantein, speciogìnin, speciocylitatin, several types of flavonoids, terpenoids, saponins, and glycosides, as well as 40 other compounds with opioid and pain-relieving properties (Warner, 2016). This bioactive compound's potential determines selling prices and high demand, therefore it has a affects the livelihoods and economic well-being of the people in that region.

According to prior studies, alkaloid chemicals are the primary components of plants that have therapeutic significance (Zandavar, 2023). Alkaloids are well-known for their physiological properties and activities (Patel, 2021; Hossain, 2023) and are frequently utilized in medicine. Some of the health advantages of alkaloids include nervous system stimulation (Buchanan, 2023), blood pressure alterations (Sengnon, 2023), and resistance to microbial infections (Solomon, 1980; Carey, 2006; Lopez 2021). Masyarakat di Kapuas Communities in Kapuas Hulu Kratom is frequently

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cultivated in riparian regions (near river flows). In contrast to upland ecosystems, riparian habitats are distinguished by copious water and soil rich in organic matter (Brinson, 1981). The purpose of this study is to determine how planting distance in riparian regions affects the growth of kratom plants and the quality of alkaloids in Empangau Village, Kapuas Hulu.

MATERIALS AND METHODS

The research, conducted at the Integrated Laboratory of Tanjungpura University, employed a purposive sampling strategy in Empangau Village, Bunut Hilir Sub District, Kapuas Hulu Regency. The selection of plant samples was guided by their proximity to the Riparian Area, with two distinct locations identified for study. Location 1 encompassed kratom cultivation fields situated within 20-50 meters of the river, while Location 2 comprised fields positioned at a distance of 650-580 meters from the riverbank. Within each location, researchers identified 5 representative plots, ensuring a comprehensive coverage of the kratom plant population. These plots, each measuring 3m x 3m, were strategically spaced 5-10 meters apart to minimize bias and capture the variability of plant growth across the study area. Key variables such as plant height, stem diameter, number of primary branches, leaf area, and soil characteristics surrounding the plants were meticulously observed and recorded. Through this sampling approach, the researchers aimed to assess the influence of proximity to the river on the growth and development of kratom plants, thereby providing valuable insights into their ecological dynamics in riparian environments.

***Sample Preparation of Plant Material*:** Plant samples are dried to the point where the leaves can be broken off. The sample must be well dry, so that when pressed it will crumble readily. If the sample is dry, then crush it using a blender until it becomes a fine powder, which feels soft when touched (Huliselan, 2015).

***Preparation of Condensed Extract*:** A total of 5 grams of kratom leaf powder was macerated with 500 ml of distilled water. After that, filter the distilled water; if the volume drops to less than 500 ml, add more distilled water until it does. Next, it was heated until 40°c in a heat coat in a 500 ml beaker, until the steeping volume becomes 100 ml. Thicken the brew of kratom leaves until the volume reaches 10 ml. Then the thick extract can be used to test total alkaloid levels.

***Quantitative Analysis of Total Alkaloids with Gravimetric Methods*:** The sample was weighed as much as 0.5 grams of thick extract and dissolved in 10 ml of 10% HCl solution (in ethanol). The solution was shaken for 4 hours with a magnetic stirrer before being filtered until a filtrate was achieved. The filtrate was then evaporated to a volume of 10 ml. Then, in a test tube, drip ammonium hydroxide over it until an alkaloid precipitate appears. Weigh the filter paper to be used to filter the sediment first. Then the precipitate is filtered and if there is still extract in the test tube, it is washed using 1% ammonium hydroxide solution. The precipitate-containing filter paper was heated in an oven for 30 minutes at 60ºC until it was dry, then cooled in a desiccator. After cooling, the precipitate was weighed until a steady weight was attained. The yield of alkaloids is calculated by dividing the weight of the alkaloid sediment obtained by the initial weight of the sample (Saifudin, 2011). The percentage of alkaloid content is calculated using the following equation: [F1]

$$\% \text{ Alkaloid} = \frac{B}{C} \times \frac{(E-D)}{A} \times 100$$

Where : A = kratom leaf powder (g), B = total extract obtained (g), C = extract used (g), D = empty filter paper of known weight (g), E = filter paper + precipitate (g)

RESULTS AND DISCUSSION

***Plant height*:** Plant height is an indicator used to assess plant growth response. The results of observations of plant height from two locations have values that are not much different. However, the average height is at location 2, namely 6.02 ± 0.576 m. The average plant height at Location 1 is 5.66 ± 0.502 m.

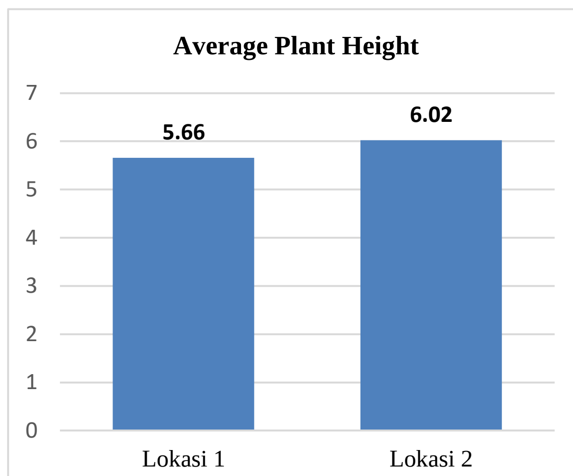

Figure 1. The plant height at each location.

Figure 1 shows that the plant height in the samples has an average value that is not much different. At location 1, the average was 5.66 m, while at location 2 it was 6.02 m. Plant height is influenced by the N and P elements contained in the soil (Darmawan, 2015). It is evident in the results of the soil analysis (Figure 3) that the total N element at location 1 is 1.76 (%), at location 2 it is 1.10 (%), while the P element at location 1 is 186.72 (%), and at location 2 was 209.13 (%). If the availability of the nutrient phosphorus (P) is optimal, root growth will also be optimal, contributing to the efficiency of absorption of other macro and micronutrients (Darmawan, 2015). Nitrogen in plants plays a crucial part in the development of chlorophyll in leaves. Chlorophyll generated by leaves improves photosynthate production, which favorably impacts plant height development. Nitrogen itself is an essential element in the formation of amino acids, proteins, and chlorophyll which are needed in the process of forming new cells. Apart from that, the role of potassium is also crucial in plant height growth since it assists in glucose metabolism and increases the formation of meristematic tissue (Siregar 2015; Fitriana, 2016). The results of the soil analysis show that, at location 2, the K element is greater at 0.32, compared to 0.06 at location 1.

***Leaf Area*:** The results of leaf area observations from the two locations have values that are not much different. The average leaf area at location 2 is 262,576 ± 43,006 cm^2, while the average at location 1 is 257,589 ± 52,903 cm^2.

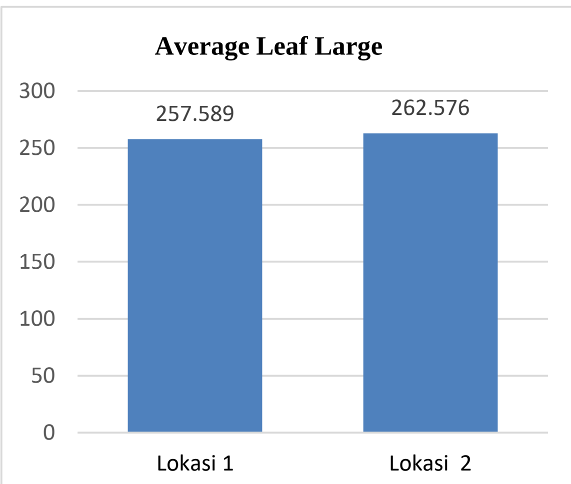

Figure 2. Leaf large in each location.

As the organs where photosynthesis takes place, leaves are frequently used to gauge a plant's growth (Loveless, 1991; Rozentsvet, 2022) The environment is one of the factors that encourage leaf area growth. Nutrient availability for plants, temperature, humidity, soil acidity level, biotic variables, and energy radiation are all environmental parameters that can be detected. The soil at the research site is recognized to have adequate nitrogen availability. This can be seen in the soil study data (Figure 3), where the total N concentration reached 1.76% at position 1 and 0.88% at location 2. Because nitrogen promotes the development of shoots and leaves, its availability should enhance the vegetative growth phase of leaves (Mulatsih, 2003).

However, the leaf area at location 2 is greater than that at location 1. Meanwhile, the N-total value at location 1 is greater than the N-total value at location 2. Light intensity is another component that promotes plant leaf area development. Inadequate lighting can reduce the rate of photosynthesis, hence inhibiting plant development and increasing leaf area. Light levels below optimal circumstances can reduce the number of branches and impact leaf properties such as size (Fanindi, 2010).

***Soil at the sample location*:** The observations of the soil around the plants from the two locations yielded varied results. The research results shown in Figure 3 reveal that the soil pH (pH H_2O and pH KCl) at the two research locations is in the 4.00 - 6.00 range. This state can be induced by a variety of circumstances, including the presence of considerable organic material on the soil's surface combined with soil minerals. Microbes can produce sulfuric acid and nitric acid during the breakdown process. The maximum soil N-total value found at location 1 was 1.76%, while the total N value obtained at location 2 was 0.88% (Figure 3).

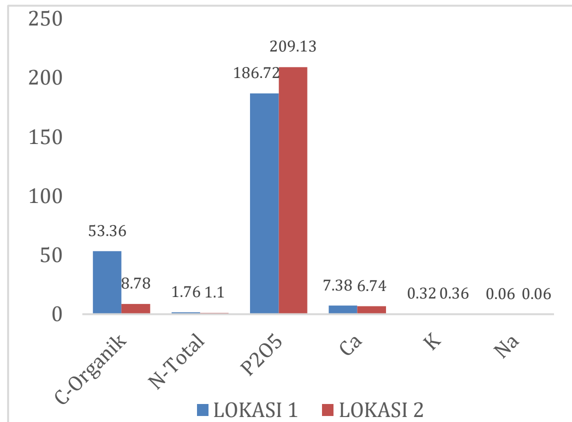

Figure 3. The result of soil analysis in each location.

The increase in total N in the soil originates from the mineralization process of organic materials. Nitrogen loss in the soil can be induced by mineral absorption in the form of NH4+, which is bound by waxy clay minerals and cannot be used by plants. In addition, N can be in the form of NO3-, which is easily leached by rainwater. Flooded soil with inadequate drainage and a lack of air circulation might result in denitrification processes and the volatility of N in the form of NH_3 (HIDAYAT *et al*., 2002).The results of laboratory analysis of soil organic C levels at the research sites from each location were classified as very high with values ranging from 7.05 to 53.36 (%) (Figure 3). The high content of C-organic organic matter suggests that the research soil produces a lot of organic matter. Soil organic matter content is a determinant of soil fertility, and the high C-organic values in the research soil can be linked to the presence of a lot of vegetation. Organic C production in soil occurs through numerous steps of organic material degradation. External factors such as soil type (Sebastian, 2023), rainfall, temperature, organic matter from above-ground biomass (Yao, 2023), human activities, soil management practices, and CO_2 content in the atmosphere influence C status -soil organics (Hairiah, 2001; Hairiah, 2011; Yulnafatmawita, 2011; Raza, 2023). Soil organic C values increase with increasing plant age and agricultural activities that implement best management practices (Haron, 1998; Ivezić, 2022; Matichenkov, 2020), land use such as secondary forests is more from agroforestry and monoculture (Rinady,2023) by adopting environmentally friendly and conservation-oriented practices in management to increase and maintain soil organic carbon levels in the long term. Phosphorus is a nutrient that plants require because it is a fundamental component of growth. However, the phosphorus that can be absorbed by plants is limited because it is trapped in the soil and is influenced by chemical, physical, and biological processes, especially interactions with Al and Fe (Ibrahim, 2022). Minerals such as chlorine, aluminum, and iron can bind phosphorus in soil. Soil with a low pH improves the solubility of Al and Fe ions, which can lead to higher phosphorus fixation. This can stifle plant growth and lower its quality. Phosphorus (P) is not easily lost from soil by leaching, and this varies depending on the soil management procedure, plant cultivation activities, and soil properties. (Borrow, 1972; Dierolf, 2001; Ortiz, 2023). Low P retention and 20-80% fluxes through groundwater and surface water are typical in areas with high rainfall and sandy soils (Matichenkov, 2020). The P element remains linked to the surface of the soil colloids under these conditions. Incorporating soil additives such as charcoal and wood ash is one strategy for balancing nutrient inputs and avoiding toxicity throughout multiple planting cycles (Johan, 2021). The presence of calcium is often associated with soil acidity because it contains cations that can reduce the effects of acidity. Calcium will decrease if the pH is outside the range of 7-8.5, while it will increase in the pH range of 7.0-8.5 (Sugiarto, 2013). This can be seen in Figure 3 that the Ca value at location 1 is 7.38 (cmol(+)kg-1) and the cation exchange capacity (CEC) value is 110.61 (cmol(+)kg-1), while at Location 2 the Ca value amounted to 6.74 (cmol(+)kg-1) and the CEC value was 30.47 (cmol(+)kg-1). Low CEC can also be a cause of low total soil calcium values. According to (Barber, 1984) who stated that the higher the soil CEC, the soil Ca generally will also be higher and vice versa. In riparian areas, the nutrient elements at each location can vary, because in general, the concentration of nutrients in the stream decreases when the water discharge is high. Watersheds (DAS) lose N and P due to the amount and intensity of rainfall and different types of land use. The duration of rainfall affects the amount and time of transport of nutrients to the surface during rainfall (Heryani, 2013; Wang, 2023) When rainwater infiltrates into a water-saturated zone, it dissolves CO2 in groundwater, causing the groundwater to turn acidic (Huang, 2021). While increasing discharge and rainfall, acidic groundwater can dissolve minerals to generate Na, Ca, and Mg. There is an interesting phenomenon related to the Hydrogen (H) content in water. Initially, the correlation between H, Cl, and SO_4 concentrations is positive. During the dry season, however, oxidation occurs, causing the dissolution of Cl and SO_4 compounds in the soil and therefore increasing the concentration of these anions in the water. During the rainy season or at high tide, a reduction occurs, resulting in a rise in water quality with Cl and SO_4 compounds at the beginning of the rain. This content, however, dropped after a few days due to dilution by additional rains. (Anderson, 1997).

***Number of Primary Branches*:** The number of primary branches of plants from the two observation locations did not differ much in value. The average number of primary branches at Location 1 is 26.6 ± 12,561. Meanwhile, the average for Location 2 is 30 ± 8,544.

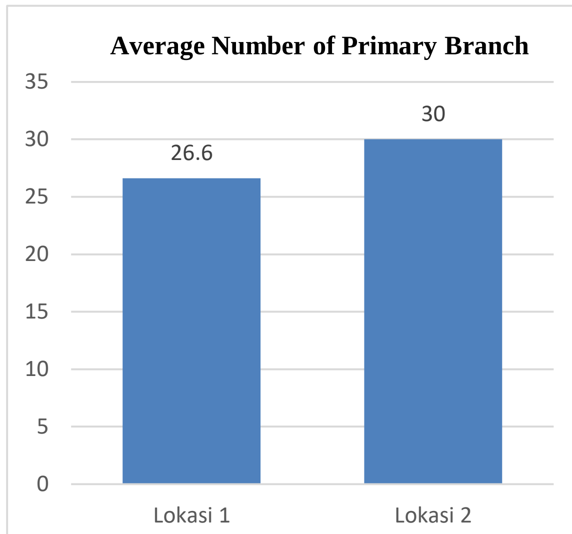

Figure 4. The number of primary branch in each location.

The nutrient used to support the growth of the main branches is nitrogen (Remans *et al*., 2006; Zhu *et al*., 2023). Soil organic matter, moisture levels, temperature, and nitrogen fixation activity by soil bacteria all influence nitrogen availability in soil. The availability of nitrogen in the soil has a considerable influence on plant height, and the role of nitrogen in plant growth entails boosting general growth, particularly in the stem, branches, and leaves (Rusmana and Salim, 2003). Nitrogen nutrients have a substantial effect on the number of secondary branches, but not on the number of main branches. This result is ascribed to plant genetic elements, which differ between plants and impact the number of main and minor branches that sprout. As a result, comprehensive knowledge of this genetic element remains a difficulty because each plant has its genetic complexity (Pamungkas and Supijanto, 2017).

***Stem Diameter*:** Observing the diameter of the stem of red kratom, it was found that the stem diameter from the two locations did not have a significant difference in value. The stem diameter at Location 1 is 8.286 ± 0.581, while at Location 2 it is 8.532 ± 1.375.

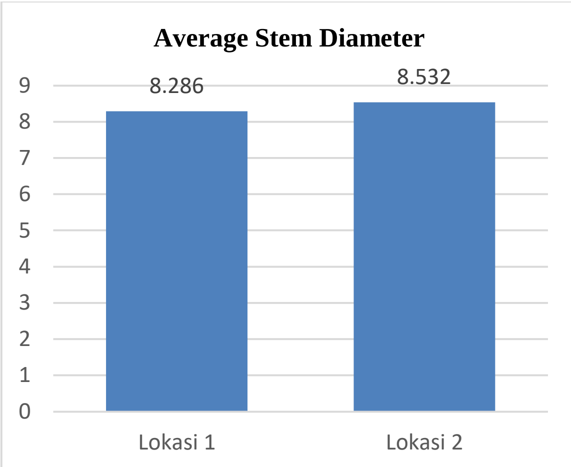

Figure 5. The stem diameter in each location.

The elements nitrogen (N), phosphorus (P), and potassium (K) offer adequate nutrition to maintain plant growth and meet their requirements. Nitrogen is required for protein synthesis as well as the production of other essential components. The availability of nitrogen elements promotes chlorophyll generation, protein synthesis, and cell proliferation, all of which can contribute to increased plant stem diameter (Li, 2023). Meanwhile, the element phosphorus (P) has an important role in stimulating plant root growth, allowing roots to more efficiently absorb nutrients needed for the formation of new tissue, including increasing the diameter of plant stems (Satria, 2015; Khan, 2023; Sakineh, 2023). The soil analysis findings show that the P element value at Location 1 is 186.72 and 209.31 at Location 2 (Figure 3). This discrepancy is assumed to be the reason for Location 2's higher average diameter compared to Location 1. The stem is the primary growth area in plants, especially in the early stages of development. The availability of substances that promote vegetative development, such as chlorophyll production in leaves, can speed up photosynthesis in this zone. As a result, the photosynthate produced increases the circumference of the plant stem (Jumin, 2002). The overall development of plant organ dimensions is the outcome of an increase in plant organ size, which is induced by an increase in cell tissue due to cell size growth (Salisbury, 1997). The availability of phosphorus (P) is an important catalyst in stimulating root growth, contributing significantly to increasing the efficiency of inorganic phosphate (Pi) absorption by roots (Ren, 2023) Plants can absorb more nutrients when their roots grow stronger. Meanwhile, potassium (K) plays an important function in growing the diameter of plant stems, particularly in the tissue that connects roots and leaves (Leiwakabessy, 1998). The results of soil analysis (Figure 3) show that the element K content at location 2 is higher than at location 1.

***Total Alkaloid Content*:** Observation of Total Alkaloid Levels of Red Kratom. The two locations have a significant difference in values. The average total alkaloid content at Location 1 was 13.5738% ± 2.643, while the average for Location 2 was 15.4914% ± 2.338.

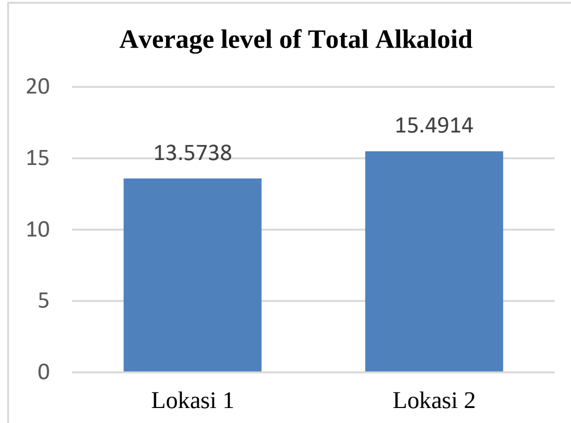

Figure 6. The level of total alkaloid in each distance.

Alkaloids are the most abundant secondary metabolite compounds found in plant and animal tissues (Al-Khayri, 2023; Lamponi, 2021; Viera-Escareño, 2023). One of the constituent ingredients of alkaloids is the element nitrogen (Gardner, 1991; Hamid, 2017; Olofinsan,2023). Low nitrogen availability has been associated with low alkaloid production (Alami, 2023). Similar to the research conducted by (Rolandani, 2001), the highest alkaloid levels were not related to high nitrogen content in plants. In this context, it is suspected that plants tend to produce higher levels of secondary metabolites in soil conditions that lack nutrients (Paponov, 2023). It can be seen that at location 2, the nitrogen element has a value of 0.88% (Figure 3) which may cause the average alkaloid content at location 2 to be higher than location 1 which has a nitrogen element of 1.76% (Figure 3). Based on the results of the correlation test, plant height, and total alkaloid content were negatively correlated (p= -0.0635), stem diameter and total alkaloid content were positively correlated (p= 0.0547), number of primary branches and total alkaloid content was correlated (p= - 0.2286), and leaf area had a positive correlation with total alkaloids (p= 0.0001).
Characters with a real positive correlation with other characters are stem diameter and leaf area with alkaloid chemicals. The plant's stem diameter and leaf area have an impact on the generation of alkaloid chemicals. Tropane alkaloids are found in greater quantities in stems than in leaves, flowers, or seeds (Dey, 2020). Plants that receive sufficient nitrogen (N) in physiological response grow larger and expand their surface area, although the alkaloid content of the leaves varies widely (Höft, 1996; Zhang, 2020)

Conclusion**:** According to the research results, the distance between red kratom cultivation land and the Riparian area had differences in plant growth such as plant height, leaf area, stem diameter, number of primary branches, and alkaloid levels. Because each distance has various environmental conditions such as vegetation, temperature, humidity, and nutrient leaching. As a result, the growth and quality of alkaloids differ. The average plant height at Location 2 was (6.02 m), stem diameter (8.532 m^2), number of primary branches (30 units), leaf area (262.576), and total alkaloid content (15.491%). Meanwhile, Location 1 had an average plant height (5.66 m), stem diameter (8.286 m^2), number of primary branches (26.6 units), leaf area (257.586), and total alkaloid content (13.5738%).

Authors contributions statement**:** Muhammad Pramulya, Ulfa Salsabila, Tris Haris Ramadhan, Cico Jhon Karunia Simamora have analyzed the data and have written the manuscript.

Conflict of interest**:** The authors declare no conflict of interest.

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Availability of data and material**:** We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

Code availability**:** Not applicable.

Consent to participate**:** All authors participated in this research study.

Consent for publication**:** All authors submitted consent to publish this research. Article in JGIAS.

SDG's Addressed**:** Good health and well-being, Responsible consumption and production.

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