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Variations in Morphology and Anatomy of Breadfruit (*Artocarpus altilis*) Based on Differences in Altitude

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ABSTRACT

Background: Breadfruit (*Artocarpus altilis* (Parkinson ex F.A. Zorn) Fosberg) is a versatile plant that humans can use. Breadfruit has morphological variations that are thought to be related to anatomical variations that are formed as an adaptation mechanism to survive in a different area. This plant has the ability to live in different altitude ranges, from coastal regions to upland sites. This research was conducted for eight months in areas with altitude ranges of <350 masl, 350-700 masl, and >700 masl in Banyumas, Purbalingga, and Cilacap Regencies. A sampling of plants was carried out randomly selected (purposive random sampling), then described their morphological characteristics. Furthermore, the leaves are made for anatomical preservation to determine the anatomical character. Breadfruit plants that grow at an altitude of fewer than 350 m above sea level have the characteristics of a higher, larger diameter stem, have a tighter branching, more sap production, a higher number of fruit and have a larger fruit size. The anatomical characteristics of breadfruit plants that grow at an altitude of less than 350 masl have stomata characters that are wider and longer than those of 350-700 masl and > 700 masl. The highest stomata and trichomata density at an altitude > 700 masl. The highest mean cuticle thickness, epidermis, palisade ratio and mesophyll thickness were highest in breadfruit leaves at altitudes <350 masl.

Variasi Morfologi Dan Anatomi Sukun (*Artocarpus altilis*) Berdasarkan Perbedaan Ketinggian Tempat

Kata kunci:
Anatomi;
Ketinggian Tempat;
Morfologi;
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ABSTRAK

Sukun (Artocarpus altilis (Parkinson ex F.A. Zorn) Fosberg) merupakan tanaman serbaguna yang dapat dimanfaatkan oleh manusia. Sukun memiliki variasi morfologi yang diduga berkaitan dengan adanya variasi anatomi yang terbentuk sebagai mekanisme adaptasi untuk bertahan hidup pada suatu wilayah yang berbeda. Tanaman ini memiliki kemampuan hidup dalam rentang ketinggian yang berbeda-berbeda, dari wilayah tepi pantai hingga daerah dataran tinggi. Penelitian ini dilakukan selama delapan bulan pada daerah dengan range ketinggian < 350 mdpl, 350-700 mdpl, dan >700 mdpl di Kabupaten Banyumas, Purbalingga, dan Cilacap. Pengambilan sampel tanaman dilakukan secara acak terpilih (purposive random sampling), kemudian dideskripsi ciri-ciri morfologinya. Selanjutnya bagian daun dibuat preparat awetan anatomi untuk mengetahui karakter anatominya. Tanaman sukun yang tumbuh pada ketinggian kurang dari 350 m dpl memiliki karakteristik lebih tinggi, batang berdiameter lebih besar, memiliki percabangan yang lebih rapat, produksi getah yang lebih banyak, jumlah buah yang lebih banyak dan memiliki ukutran buah yang lebih besar. Karakteristik anatomi tanaman sukun yang tumbuh pada ketinggian kurang dari 350 mdpl memiliki karakter stomata yang lebih lebar dan panjang dibandingkan ketinggian 350-700 mdpl dan > 700 mdpl. Kerapatan stomata dan trikomata tertinggi pada ketinggian > 700 mdpl. Rata-rata tebal kutikula, epidermis, rasio palisade dan tebal mesofil tertinggi pada daun sukun pada ketinggian tempat < 350 mdpl.

Introduction

There are many tropical areas such as Malaysia and Indonesia. The height of this plant can reach 20 meters. Breadfruit is a versatile plant that can be used by humans, and on the island of Java, this plant is used as a cultivated plant by the community. Breadfruit plants produce fruit with carbohydrates and high nutritional content, potentially as an alternative staple food ingredient instead of rice (Purwantoyo, 2007). Breadfruit has many morphological variations. The diversity is influenced by cross-pollination and seed, the diversity of breadfruit populations derived from breeding systems and natural selection associated with differences in local environment, evolution, and human intervention related to the anatomical variation of the plant formed as an adaptation mechanism for survival in a different region (Nayeem & Sushmita, 2013).

Breadfruit has a variety that gives rise to different characters to live in several types of habitats according to environmental conditions. The morphology of a plant is determined by environmental factors and genetic factors that interact with each other during the plant life cycle, giving rise to different phenotypes in individuals in one species. Plant development ranging from seeds to adults undergoes biochemical, physiological, anatomical, and morphological changes, for example, plants undergo plasticity, namely morphological changes influenced by environmental factors (Estalansa et al., 2018). The earth's surface consists of various reliefs, such as mountains, lowlands, hills and coastal areas, the difference in altitude is one of the factors that affect the distribution and development of plants. This is possible because the difference in the height of a region also causes differences in life-supporting factors such as plant breeding) that cause genetic and morphological variations. Morphological variations are thought to be temperature, humidity, rainfall, light intensity and nutrients available in the soil (Akanbi et al., 2009). The height factor of the place affects the plant's growth, the higher the planting place, the height of the plant and the size of the leaves decreases. The part of the plant that is influenced by environmental factors such as the height of the place one them is the anatomy of the stomata and trichomes. Stomata anatomy includes the type, size, density and index of stomata (Rehatta & Kesaulya, 2010).

The increase in altitude from above sea level in the mountains is directly proportional to the abiotic environmental checks received by plants, with increasing altitude it will cause REDUCED CO2, increased intensity of sunlight, UV-B radiation and drought. Differences in height and environment will be an important factor for fruit plants because it will determine the results of existing fruits, both quality and quantity. In response to the abiotic environment, plants need to adapt to various aspects such as physiological changes, anatomy and morphological changes (Streb et al., 1998).

Breadfruit research that has been conducted in Indonesia is about the diversity of breadfruit plants based on a morphological character in Yogyakarta (Estalansa et al., 2018). Morphological variations and nutritional content of breadfruit fruit (Adinugraha & Kartikawati, 2012). Research conducted by Akinloye et al., (2015); Palupi et al., (2021) on anatomical characters in breadfruit (Artocarpus altilis) and kluwih (A. communis) can be used to identify and describe both species, anatomical characters can be used to obtain special characters that can be used to limit 2 taka. Anatomical characters are specific to distinguish in Artocarpus altilis and A. Communis is the vascular tissue at the root, the tissue on leaf correction, the density of the trichromata, as well as the abaxial and adaxial epidermal cells.

Banyumas, Cilacap, and Banjarnegara districts have a diverse topography ranging from highlands to lowlands. This topographic difference can certainly cause morphological and anatomical variations in plants that grow in the region. Morphological and anatomical variations as a form of adaptation strategy are thought to also occur in breadfruit. Research on morphological and anatomical variations of breadfruit attributed to differences in altitude has not been done.

Information about morphological and anatomical variations of breadfruit that grows at different altitudes is expected to add information about the richness of germplasm and become a foundation in efforts to manage and develop its potential and benefits, especially for science and society in general. Based on the above information, formulated the problem of whether there are variations in the morphological and anatomical characteristics of breadfruit at different heights as a form of adaptation of different environments to get the information needed for the breadfruit development program so that its potential can continue to be improved. The specific purpose of the study was (1) to know the morphological variation of breadfruit based on the height of the place, and (2) to know the anatomical variation of breadfruit based on the height of the place.

Methods

A sampling of breadfruit plants will be conducted at locations with gradient ranges of different places (< 350 m dpl, 350-700 mdpl, and >700 m above sea level.) in Banyumas, Cilacap, and Purbalingga districts. Observation of morphological character was carried out at the Herbarium Faculty of Biology Unsoed (PUNS) and the preparation and observation of anatomical character was carried out in the Laboratory of Plant Structure and

Development of the Faculty of Biology, Universitas Jenderal Soedirman.

The ingredients used in this study are: breadfruit plants (Artocarpus altilis) taken from several locations of different heights. The petroleum materials used include: FAA fixative solution (Formalin, Acetic Acid, Alcohol), ETHANOL PA, xylol, 96% alcohol, paraffin, glacial acetic acid, formalin, glycerin, safranin, akuades, entelan, and transparent kutext. The tools used in the study include field tools including thermohygrometer, GPS, pH meter and altimeter. Laboratory tools include object glass, cover glass, flacon bottle, holder, staining jar, drip pipette, Bunsen, stirrer rod, tray, scalpel, razor, tweezers, thermostat, binocular microscope, stove, rotary microtom, beaker glass, erlenmeyer glass, objective micrometer, ocular micrometer, square micrometer, plastic bag, ice box, ruler, digital camera, stationery and label paper.

Method of sampling breadfruit plants with survey methods, with purposive random sampling patterns. The study used five trees in each location with five repeats. The sample is then described morphologically. Making Fresh Preparat leaves are samples of breadfruit leaves made preparing slices stretched. Observation of the anatomical character of the leaves is done by making preparations using the paraffin method, staining with 1% safranin in 70% alcohol. The manufacture of cross-leaf slices by the paraffin method is first cut for 1 cm long with a razor, then annexed with an FAA fixative solution for 24 hours. Dehydration with double-grade alcohol ranging from 70% alcohol to absolute alcohol for 30 minutes each. Dealcoholization with alcohol-xilol solution with a ratio of 3: 1, 1 : 1, and 1 : 3 each for 30 minutes. Infiltration with an xylol-paraffin mixture with a ratio of 1: 9 for 24 hours, then replaced with pure paraffin is done in the oven at a temperature of 57 oC. Making blocks of paraffin, made small boxes of cardboard paper, then liquid paraffin is poured on small boxes that have been smeared with glycerin. Pieces of breadfruit leaves are put in a box and placed in such a way.

The colded paraffin block is removed from the mold then cut and affixed to the holder in the rotary microtom. Slices of paraffin tape containing the preparation are placed on the glass of objects that have previously been dripped with glycerin and albumin and dried over the heating box until the paraffin tapes stretch. Staining by a dipping glass of objects that have contained preparations into pure xylol is repeated 2 times, then xilol-alcohol with a ratio of 3 : 1, 1 : 1, and 1 : 3, then treated with alcohol decreased from alcohol 100% to alcohol 70%. It is then incorporated into the 1% colour substance safranin in 70% alcohol for 1 - 2 hours. Washing with 70% alcohol and dehydration with 70% alcohol to 100% alcohol, alcohol-xilol with a ratio of 3: 1, 1: 1, and 1 : 3, then pure xylol repeated 2 times each 5 minutes. Closing or mounting is done using a entelan dripped on the preparation and covered with a glass cover.

The observed parameter is the morphological character of the breadfruit plant by observing its morphological features, including roots, stems, leaves, flowers and fruit. The 5th leaf located on the branch in the middle of the stem is taken and made anatomical preparations to find out the anatomical character. The observed anatomical characteristics include the thickness of the cuticle, the thickness of the epidermis, the thickness of the mesophile leaves, the size and density of the stomata, and the trichomes' density per 1 mm2 area. The data from morphological and anatomical observations obtained, then analyzed descriptively to obtain morphological and anatomical variations of breadfruit plants found at different altitudes.

Results

The results of observations on morphology and anatomy in the form of fresh preparation of leaves have been obtained, which amounted to 73 morphological characters of stems, leaves, flowers and fruit. Based on research conducted in the area of Banyumas Regency, Purbalingga Regency and Cilacap Regency. The results of characteristic morphological observations show that breadfruit plants grow at the height of less than 350 mL have Habitus breadfruit is a tree with a round stem shape. Plant height 17.5-24 m. The circumference of the stem is 120-145cm. The texture of the rods is rough or very rough. Brown stem skin colour with white patches. The direction of growing stems is perpendicular. The shape of the canopy is funneling or the pyramid widens. Vertical bar branching pattern. The density of branching is very tight. The colour of the white sap is thick. Production of sap is medium to many.

Roots appear slightly on the surface of the ground, Single leaf type with a reflection of the leaves. The shape of the egg-round leaves is egg-round. The width and length of the leaves are 23-58 x 18-48 cm. Shape the ends of the leaves blunt or tapered. The base of the leaves is blunt. The edges of the strands of the leaves are snuffed. The upper surface color of the leaves is dark green and the colour of the lower surface of the leaves is light green. The texture of the top surface of the shiny leaves. The texture of the surface under the leaves is coarsely hairy. The texture of the stalks of the leaves is smooth. The colour of the stalks of light green leaves. The length of the fruit is 16-23 cm. The shape of the fruit is round or round.

Breadfruit plants that grow at heights between 350-700 mdpl have a breadfruit habitus is a tree with a round trunk shape. The height of the plant is 15-20 m. The circumference of the stem is 125-130cm. The texture of the rods is rough or very rough. Brown stem skin color with white patches. The direction of growing stems is perpendicular. The shape of the pyramid canopy widens.

Vertical bar branching pattern. Density of branching tightly until very tight. The color of the white sap is thick. Medium sap production. Roots appear slightly at the surface of the soil. Single leaf type with a rectuating of the leaves. The shape of the egg-round leaves is egg-round. The width and length of the leaves are 20-43 x 16-38 cm. Shape the ends of the leaves blunt or tapered. The base of the leaves is blunt. The edges of the strands of the leaves are snuffed. The leaves' upper surface colour is dark green, and the leaves' lower surface colour is light green. The texture of the top surface of the shiny leaves. The texture of the surface under the leaves is coarsely hairy. The texture of the stalks of the leaves is smooth. The colour of the stalks of light green leaves. The length of the fruit is 17-20 cm. The shape of the fruit is round or round.

Breadfruit plants that grow at an altitude of more than 700 mdpl have a breadfruit habitus is a tree with a round trunk shape. The height of the plant is 15-19 m. The circumference of the stem is 120-128 cm. The texture of the rods is rough or very rough. Brown stem skin colour with white patches. The direction of growing stems is perpendicular. The shape of the pyramid canopy widens. Vertical bar branching pattern. The branching density is stretched until tight. The color of the white sap is thick. Production of sap slightly to moderately. Roots appear slightly at the surface of the soil. Single leaf type with a rectuating of the leaves. The shape of the egg-round leaves is egg-round. The width and length of the leaves is 21-430 x 15-35 cm. Shape the ends of the leaves blunt or tapered. The base of the leaves is blunt.

Figure 1. Plants, leaves and breadfruit that grow in areas that have a height of < 350 m above sea level

Figure 2. Plants, leaves and breadfruit that grow in areas that have a height of 350-700 m above sea level

Figure 3. Plants, leaves and breadfruit that grow in areas that have a height of > 700 m above sea level

The edges of the strands of the leaves are snuffed. The upper surface colour of the leaves is dark green and the color of the lower surface of the leaves is light green. The texture of the top surface of the shiny leaves. The texture of the surface under the leaves is coarsely hairy. The texture of the stalks of the leaves is smooth. The colour of the stalks of light green leaves. The length of the fruit is 16-18 cm. The shape of the fruit is round or round. The observed anatomical characteristics are the size and density of stomata and the density of trichomes per 1 mm2 area. Parameters are thick cuticle, epidermis thickness, palisade ratio, and mesophile thickness.

Stomata

Measurements of the length and width of the stomata of different heights were obtained at the height of the < 350 mdpl has the largest average stomata length of 18.90 µm, while the smallest stomata length is found at a place height of > 700 mdpl which is 14.55 µm. Measurements of the width of breadfruit leaf stomata at different heights showed results at altitudes where < 350 mdpl had the largest average stomata width of 7.4 µm, while the average width of the smallest stomata was found at the height where the > 700 mdpl was 6.65 µm. The results of measuring the density of stomata of breadfruit leaves at different heights were obtained at the height of places where > 700 mdpl had the largest average stomata density of 44.04, while the smallest stomata density is found at a place height of < 350 mdpl which is 37. The density of stomata on leaves affected by the height of the place will show higher results in areas with a height of > 700 mdpl.

Stomata are one of the epidermal derivates, fissures (holes) that form between the epidermal layers. Stomata play a role in the exchange of CO_2 and O_2 gases that play a role in the process of photosynthesis of leaves. In addition to being a place of gas inflow, another function of stomata is as a way for transpiration process used in regulating excess water that occurs in plant tissues due to excess water absorption and as temperature regulation on leaves due to the rise in environmental temperature by direct sunlight. Stomata breadfruit at each height have the same structure and are found only on the bottom of the leaves, these stomata are not found on the top of the leaves. Stomata are arranged in groups on the leaves, according to Croxdale, (2000) reports that the different distribution patterns of stomata on the surface of the leaves are the result of interactive processes that occur during leaf growth and may be caused by cellular interactions.

Trichomes

Based on paradermal incisions there are two types of trichomes found in breadfruit leaves: non-glandular, unicellular, tapered ends, rounded bases, and surrounded by several radial epidermal cells and glandular trichomes, multicellular head cells consisting of 4-8 cells, and surrounded by several epidermal cells radially. The base of the trichochroma is characterized by a hexagon shape with an oval shape in it. The base of the trichochroma on the paradermal incision is thought to be part of the stalk cells of the glandular trichomes when viewed transversely. Trichomes in plants show great variation in terms of shape and structure, among them unicellular or multicellular trichomes, glandular or non-glandular trichomes.

The results of measurements of the density of upper and lower trichomes on breadfruit leaves obtained results that have the largest average density of non-glandular trichomes at the height of < 700 mdpl which is 18.78 / mm2 and the smallest at a place height of 350-700 mdpl which is 18.30 / mm2. The average density of non-< > lower glands is 14.78 / mm2. The average density of the largest upper gland trichomes on breadfruit leaves at a height of > 700 mdpl is 12.75 /mm2 and the smallest at the height of the < 350 mdpl is 12.05 / mm2. The average density of the lower gland trichomes is the largest in breadfruit leaves at the height of the > 700 mdpl which is 14.78 / mm2 and the smallest at the height of the place < 350 mdpl which is 14.62 / mm2. The density of trichomes in leaves affected by the height of the place will show higher yields in areas with high elevations. According to Molina-Montenegro et al., (2006) the low density character of trichomes and thin leaves make the leaves preferred by herbivorous insects.

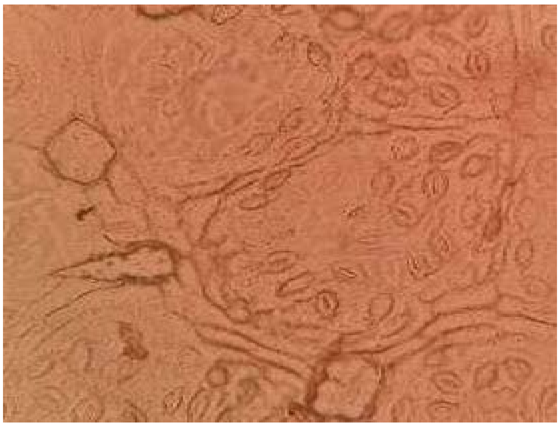

Figure 4. Lower epidermis of breadfruit plant leaves at a height of < 350 mdpl

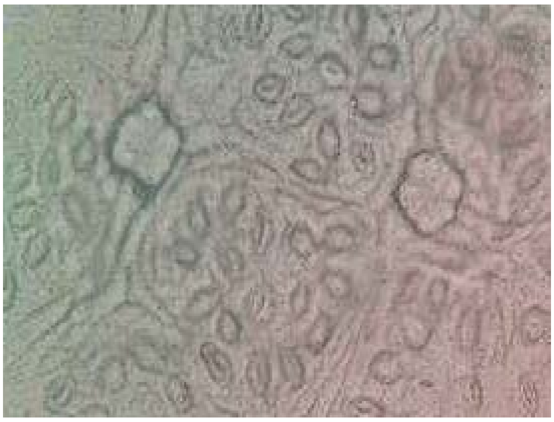

Figure 5. Lower epidermis of breadfruit plant leaves at an altitude of 350-700 mdpl

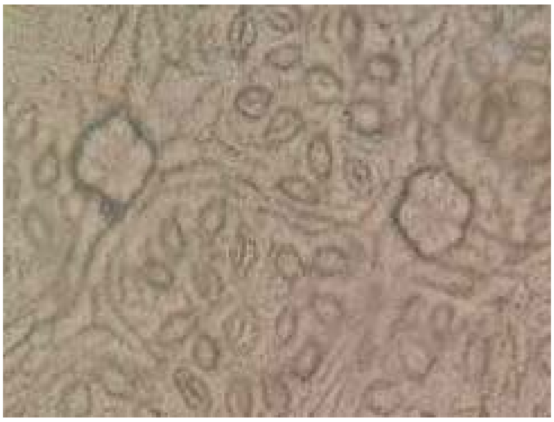

Figure 6. Lower epidermis of breadfruit plant leaves at an altitude of >700 mdpl

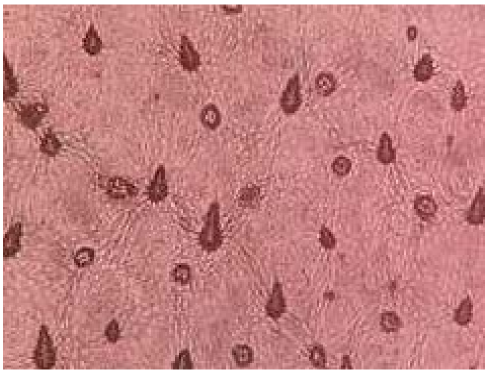

Figure 7. Upper epidermis of breadfruit plant leaves at high altitude < 350 mdpl

Figure 8. Upper epidermis of breadfruit plant leaves at high altitude 350-700 mdpl

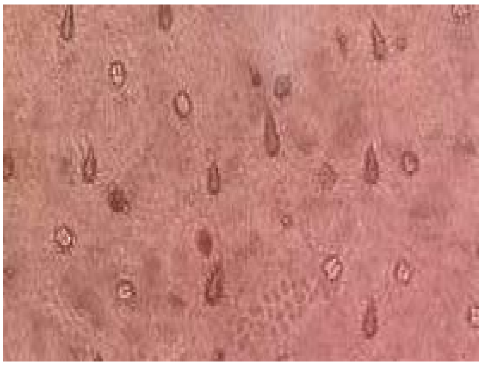

Figure 9. Upper epidermis of breadfruit plant leaves at high altitude >700 mdpl

Table 1. Average character length, width, and stomata density of breadfruit at different heights

Altitude (mdpl)	Length of stomata (µm)	Width of stomata (µm)	Stomata density (mm^2)
< 350	18,90	7,4	37
350-700	16.70	6,7	40,8
> 700	14,55	6,65	44,4

Table 2. Average density of glandular and non-glandular trichromata on breadfruit leaves

Altitude (mdpl)	Non-Upper Glands (mm^{-2})	Non-Lower Glands (mm^{-2})	Upper Glands (mm^{-2})	Lower Glands (mm^{-2})
< 350	18.54	14.78	12.05	14.62
350-700	18.30	15.20	12.56	14.68
> 700	18.78	15.78	12.75	14.78

Observation of Microscopic Preparations of Transverse Incisions

The results of the cross-the-road incision of breadfruit leaves at different heights show a similar structure. Breadfruit leaves have the structure of epidermis, mesophiles and vessels. In accordance with the function of leaves in plants that play a role in the process of photosynthesis, which turns solar energy into carbohydrates as an ingredient in growth and development. Leaves in plants are the organs most affected by environmental changes that are less beneficial because the leaves directly regulate water, photosynthesis, and respiration in plants. So that the leaves require adaptation mechanisms in the tissues to defend themselves against unfavorable environmental conditions. Cuticles on leaves are formed by changes in environmental factors that are less favorable to plants, the thickness of the cuticle in plants is formed as a form of adaptation in reducing the rate of transipiration in the leaves. The cuticle on the breadfruit leaves is found at the top of the leaf while there is no clear structure of the cuticle layer at the bottom of the leaf. The epidermis has different shapes and structures, all epidermises will always be tightly arranged with each other and form solid buildings with no space between cells. Cutler et al., (2007) added, in dicot plants generally mesophilic tissue will be differentiated into 2 different forms, namely the network of poles (palisade) and coral tissue (sponges) that have the same function as the place of photosynthesis. Palisades in dicot plants have different amounts in each plant because the number of palisade cells depends on the intensity of light obtained by plants during photosynthesis.

Cuticle

The results of measurements of the thickness of breadfruit leaves at different heights were obtained results at the height where < 350 mdpl has the largest average thickness of the cuticle which is 6.8 µm, while the smallest cuticle thickness is found at a height where the > 700 mdpl is 5.3 µm. Cuticles have a major role in reducing the occurrence of water evaporation on the surface of the leaves due to direct sun exposure and rising air temperature in the environment. In addition to reducing evaporation on the surface of the leaves, cuticles also play a role in reducing exposure to UV-B rays that are too high that can damage the leaves. The thickness of the cuticle will adjust to the temperature and humidity conditions around the plant. The thicker the cuticle, the reduction in transpiration rate in plants in water stress conditions can be prevented, so that plants can still hoard water as a backup for photosynthesis.

Menururt Ali et al., (2009) because in low areas the air temperature will increase and the humidity decreases and the pH of the soil is alkaline. The high temperature and low humidity of the air will cause water loss through transpiration in the leaves is getting bigger, so the plant will adapt by thickening the cuticle layer in protecting the leaves from direct sunlight exposure and minimizing the evaporation of water through the leaf surface.

Epidermis

Measurements of the thickness of upper and lower epidermis of breadfruit leaves at different heights were obtained at altitudes where < 350 mdpl had the largest average thickness of upper and lower epidermis at 12.00 μm and 7.50 μm, while the smallest upper and lower epidermis thicknesses were found at altitudes of 350-700 mdpl at 11.74 μm and 7.00 μm.

The epidermis of the leaves is found on the upper surface and the leaf, which has an important role in protecting the organ and protecting the tissues under it from both biotic and abiotic disorders from the environment. As the tissues locatedmost outside the epidermis form derivates such as stomata and trichomes that function in protection and aid in the process of photosynthesis and metabolism. The thickness of the epidermal layer becomes a determining factor of adaptation by the leaves in response to the environment, the thicker the epidermis that the leaves have can mean the high environmental checks received by the leaves directly.
The increase in the thickness of the epidermis over some plants dicots at different heights, according to Jian Jing et al., (2012) is caused by the intensity of light in the environment as protection from UV-B radiation, especially high areas and low areas that have high light intensity. A thick epidermal layer is thought to be associated with water storage functions in low-humidity environments. This is one indication that a plant has a wide and diverse habitat distribution in a variety of different environmental conditions. The thickness of the epidermis is usually supported also by the thickness of the cuticle layer due to its interrelated function in preventing the evaporation of water from tissues (Ali et al., 2009). The higher the air temperature and low humidity in the environment of a growing plant, the epidermis will experience thickening in preventing water loss in tissues.

Palisade Ratio

The results of measuring the palisade ratio of breadfruit leaves at different heights were obtained at the height where < 350 mdpl had the largest average palisade ratio of 8.87, while the smallest palisade ratio was found at a > altitude of 700 mdpl which is 7.45. The palisade ratio in breadfruit leaves that are influenced by the height of the place will show the lower the result of a place, the greater the palisade ratio. Palisade on breadfruit leaves is one of the mesophilic derivates that function in photosynthesis. Palisade cells are located under the upper epidermis to get full sunlight and contain many plastids (chloroplasts) that function in capturing light and the site of photosynthesis. Istiqomah et al., (2010) states that the interaction of plants with the availability of water and the intensity of light has a significant influence on the palisade ratio in plants. When the condition of an environment has less groundwater and water content in the air (moisture), the number of palisade cells in the leaves will increase to speed up and maximize the transport of water to the epidermis. In accordance with the conditions at the altitude of the < 350 mdpl which has a high temperature and low humidity so that it will increase the number of palisade cells in sufficient availability of water for photosíntesis and maintain turgor pressure on the tissues. This is because the water in the leaves is transported through the network of vessels and transported through the space between cells in the mesophile. Plants in an environment with full light intensity will also form additional palisade cells or increase the length of palisade cells to maximize the process of photosynthesis.

Mesophile

The results of measurements of the thickness of breadfruit leaf mesophiles at different heights were obtained at altitudes where < 350 mdpl had the largest average mesophile thickness of 280.20 μm, while the smallest mesophile thickness was found at a height where > 700 mdpl was 207.20 μm. Thick mesophiles on breadfruit leaves that are influenced by the height of the place will show results at low altitudes will get thicker. Mesophile or leaf meat is a basic tissue that fills the middle on the leaves. Mesophiles play a role in photosynthesis in which each mesophile cell contains plastids (chloroplasts). In addition to playing a role in photosynthesis, in the mesophile network there is a network of vessels that function in the transport of water and minerals from the soil to the leaves, so that the mesophil has an air cavity between its cells that allows water transport through gaps between cells to maximize water needs in photosynthesis.

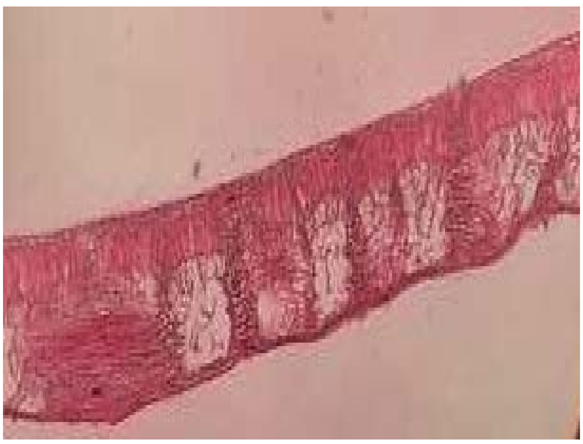

Figure 10. Anatomy of Breadfruit Plant Leaves at the height of < 350 mdpl

Figure 11. Anatomy of Breadfruit Plant Leaves at an altitude of 350-700 mdpl

Figure 12. Anatomy of Breadfruit Plant Leaves at an altitude of > 700 mdpl

Table 3. Average anatomical character of breadfruit thick of leaves at different heights

Latitude (mdpl)	cuticle (µm)	Upper Epider mis (µm)	Lower Epiderm is (µm)	Palisa de Ratio	Mesophyll (µm)
< 350	6,8	12,00	7,5	8,87	280,20
350-700	5,9	11,74	7,0	7,75	225,50
> 700	5,3	11,80	7,2	7,45	207,20

Conclusion

Morphological characteristics of breadfruit plants that grow at altitudes of less than 350 m above sea level (low) have the most superior character compared to heights of 350-700 mdpl (medium) and > 700 mdpl (high). Breadfruit plants can grow at various altitudes but are rarely found at altitudes of more than 1000 mdpl. Breadfruit plants that grow at heights of less than 350 m above sea level have higher characteristics, larger diameter stems, tighter branching, more sap production, more fruit numbers, and a larger fruit count. Anatomical characteristics of breadfruit plants that grow at altitudes of less than 350 m above sea level (low) have a wider and longer stomata character than heights of 350-700 mdpl (medium) and > 700 mdpl (high). The highest density of stomata and trichomes at an altitude of > 700 mdpl. The average thickness of cuticles, epidermis, palisade ratio and mesophile thickness highest in breadfruit leaves at the height of < 350 mdpl .

Declaration statement

The authors reported no potential conflict of interest.

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